Atlantic Salmon Recovery & Conservation Plan for the South River Watershed

The Antigonish Rivers Association

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Acknowledgments

The development of the South River Plan was supported and accelerated by the Antigonish Rivers Association's (ARA) participation in the Gulf Rivers Priority Project, a collaborative initiative coordinated by the Nova Scotia Salmon Association (NSSA) and funded in part by the Canada Nature Fund for Aquatic Species at Risk.

The ARA thanks the NSSA's continued support on this watershed management plan, sharing resources and expertise in planning, assessment, monitoring, data management and analysis. Temperature data collection and analysis would not have been possible without their assistance. The Local Knowledge Survey they developed allowed us access to first-hand information from local anglers on the South River and its major tributaries. The project yielded valuable historical data, allowing us to document environmental changes within the South River watershed over the years.

The Antigonish Rivers Association acknowledges that the watershed and all it's watercourses within is located in Mi'kma'ki, the ancestral and unceded territory of the Mi'kmaq People. This recognition of land is an expression of gratitude and appreciation to those whose territory we currently reside on. It is a way of honoring the Indigenous people who have been living and working on the land from time immemorial. Mi'kma'ki includes all of Nova Scotia, Prince Edward Island, part of New Brunswick, the Gaspé region of Quebec, part of Maine, and southwestern Newfoundland.

This land is governed by the treaties of Peace and Friendship, first signed by the Mi'kmaq, Wolastoqey, Peskotomuhkatiyik, and the British Crown in 1726. These treaties did not implicate or affirm the surrender or transfer of land to the British, but recognized Mi'kmaq and Wolastoqey title and set the rules for what was to be a long-standing relationship between nations, initially preventing war and facilitating trade. We are all Treaty people and have responsibilities to each other and this land.

Introduction

This document has three objectives; (1) to provide an overview of current instream habitat conditions in the South River watershed, (2) to provide a stepwise plan using established river restoration techniques to address issues of habitat degradation and to improve productivity and (3) to outline a sufficient monitoring plan to measure the effectiveness of restoration and to better inform the Antigonish Rivers Association (ARA) and stakeholders about the status of Atlantic salmon in the river. This report recommends the implementation of a five-year restoration program designed to enhance the recovery of instream habitat.

The South River drainage basin covers an area of approximately 190 km^2, making it the second largest watershed in Antigonish County, Nova Scotia. The South River watershed has been used for agriculture, forestry and milling since early European settlement. During the 1800s the landscape of the South River watershed changed dramatically; the uplands were converted from mature forest to pastured land and floodplains were converted from marshland characterized by saturated soils into well-drained farmland used for cropping and hay production. These changes reduced river ecosystem functions, resulting in a significant loss of Atlantic Salmon and Brook Trout habitat.

Atlantic Salmon populations have been observed to be declining in the South River since the early 1960's, although it is quite likely that Atlantic salmon numbers experienced significant declines between 1850 and 1900 as was common throughout the Gulf Region of Nova Scotia during that period (Dunfield, 1985). It has been broadly recognized that the declines in Atlantic Salmon were related to habitat degradation and over-harvesting. Declines in both habitat and Atlantic Salmon populations since the 1960's can be in part attributed to the introduction of industrial scale forest harvesting and industrial agriculture. Many of the forestry operations during this period were permitted to clear streamside vegetation and to channelize streams to accommodate road construction. Farm operations utilized bulldozers and backhoes to straighten out channels and install drainage ditches. These practices destroyed spawning habitat, holding pools and over-wintering habitat. The resulting conditions created instream conditions that were prone to drought and increasingly warm summer water temperatures. These conditions were observed during 1985 and recorded in *A Plan Outlining the Potential for the Rehabilitation and Enhancement of the South River in Antigonish, Nova Scotia* written by Darlene Burton, a biology student at St. Francis Xavier University and a summer intern with the Nova Scotia Department of Fisheries.

At the present time (2022) many of the impacts of the previous century's land-use practices are still contributing to habitat degradation as well as new impacts associated with modern farming practices and residential developments continue to emerge. This document will provide the ARA with a road map for addressing these issues through established river restoration techniques coupled with monitoring fish populations and habitat within a strong scientific context.

1.1 Overview of The Watershed & Tributaries

The river system drains a mixture of upland forests, agricultural floodplains, and residential settlements. South River is also home several rural developments, numerous farms, several forestry operations, a fish hatchery, and a municipal wastewater treatment facility. The South River begins in Guysborough County, flowing north into Antigonish County along Highway 337 through the rural communities of Upper South River, Fraser's Mills, Dunmore and into St. Andrew's towards Lower South River where the mouth of the river drains into the southeastern arm of the Antigonish Harbour.

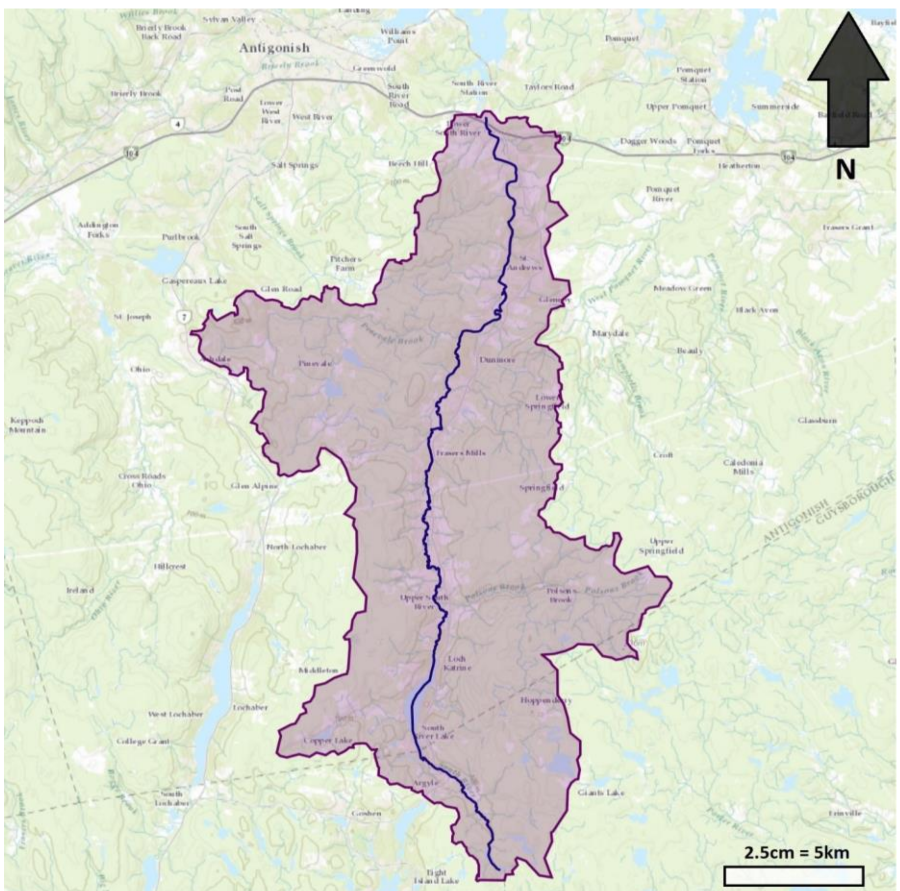

Figure 1: Topographic map of the South River watershed with the main channel highlighted in blue

Historically, the numbers of returning Atlantic Salmon to the South River have been declining since the early 1970's as noticed by anglers and the federal Department of Fisheries & Oceans (DFO). Atlantic Salmon stock status reports dating back to 1993 reference the South River, but the main focus for Antigonish was the West River system. Reasons for the decline in Atlantic salmon can likely be attributed to the changes to the watershed landscape and alterations to the instream habitat during the past century. Changes to fish populations like that experienced in the South River in the 1970's to the early 2000's are like the result of habitat degradation that occurred much earlier (1940's to 1970). There is generally a lag time in fish population response to changes in habitat quality. Conversely, the recovery of fish populations also lags the recovery of instream habitats.

The landscape of the South River watershed has changed drastically since the beginning of European Settlement; the cumulative effects of these changes have created conditions whereby important habitat features for Atlantic Salmon have been diminished to the point where each stage of the Salmon's life cycle is negatively affected. Atlantic Salmon are cold-water fish species, preferring peak water temperatures below 20°C. Water temperature monitoring throughout the South River in 2020 and 2021 found that summer water temperatures frequently exceed 24°C, and events of lethal water temperatures were experienced at multiple sites. High water temperatures are being driven by changes to channel morphology that have created a wide and shallow stream that contains highly simplified and uniform channel characteristics.

Changes to floodplain and channel habitat that have resulted in habitat degradation include the loss of large woody debris (LWD), in particular large log jams, beaver dams and historical channel migration to accommodate road building, agriculture and forestry activities. In many reaches of the South River the channel was bulldozed into straight runs along property lines and to allow for agricultural expansion. Other changes to the floodplain include the loss of the floodplain forests and in some cases the absence of any form of vegetated riparian zone. The absence of instream LWD and adjacent floodplain vegetation has reduced the ecological resiliency of the South River and has created a negative feedback loop that will continue to impact cold water fish species if recovery actions are not taken soon. LWD creates "channel roughness" which can help absorb energy during high-flow events and vegetated buffer zones create bank strength and reduce erosion.

Above the floodplains of the South River much of the watershed's landscape has been changed significantly by agriculture and other human activities. Cleared fields, roads and ditches and historical drainage of upland swamps and wetlands has created a watershed that is “flashy” and as a result devastating floods and prolonged periods of critically low water are diminishing fish habitat and productivity. Improving habitat features in the South River will require a watershed approach to restoration which should be guided by a focus on improving the hydrological cycle.

For the purposes of restoration planning, the watershed has been divided into manageable sections which contain similar topography, have similar landform patterns and may contain numerous channels and feeder streams. Each section will contain multiple reaches of stream. Reaches are defined as sections of river along which controlling conditions are sufficiently uniform.

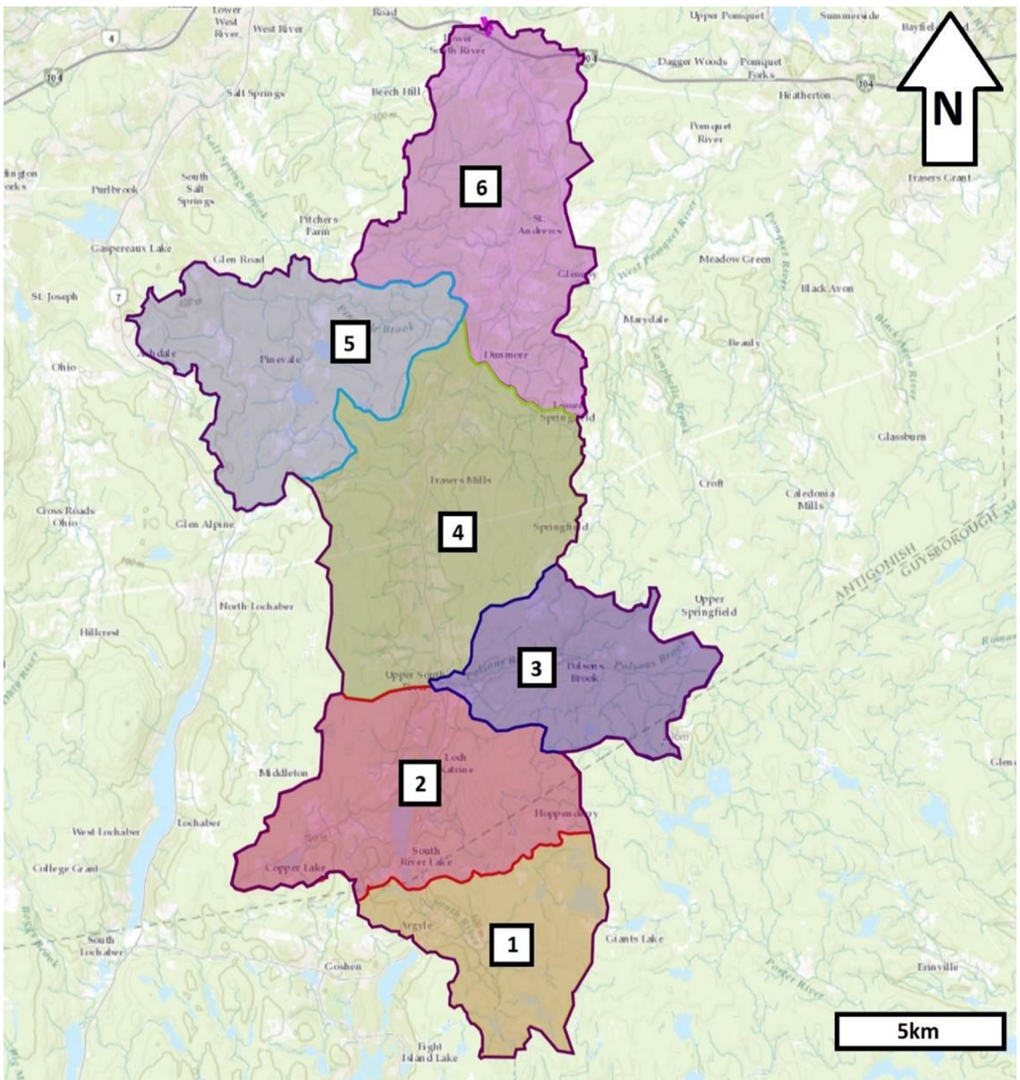

Figure 2: Topographic map of the South River watershed with the main branch sections and major tributaries delineated and numbered to correspond with the table below

Table 1: Overview of spatial planning units

Spatial Planning Unit	Section Name	Watershed Size	Main Channel Length	Potential Area for Habitat Restoration	Number of Road Crossings
1	Headwaters	21.55 km^2	5942.13 m	41,005.15 m^2	21
2	Upper	34.73 km^2	6058.79 m	52,832.65 m^2	21
3	Polson's Brook	22.73 km^2	7593.15 m	58,543.19 m^2	25
4	Middle	46.26 km^2	11811.32 m	114,334.81 m^2	83
5	Pinevale Brook	33.38 km^2	12,607.75 m	108,678.81 m^2	47
6	Lower	39.77 km^2	10,547.33 m	101,543.05 m^2	81
Total		**198.42 km^2**	**54,560.47 m**	**476,937.66 m^2**	**278**

1.2 Previous Restoration Work Completed

Along the main branch of the South River, there are several sites where farmers have taken it upon themselves to fortify the river banks that run along their agricultural fields using large rock and cement slabs. This technique can help in the specific site where installed but can cause further damage directly downstream as the energy of the flow is being shifted, not dissipated. In 2019, the ARA successfully completed a major bank stabilization site. Due to the project's success, funding was secured for similar projects in 2020 and 2021.

Table 2: Overview of previous restoration Work completed

Year	Site Location	Restoration Techniques	Area Restored
2019		• Bank stabilization using armour stone and incorporating rock kickers and deflectors • Riparian zone tree planting	2,400m^2
2020		• Bank stabilization using armour stone and incorporating rock kickers • Riparian zone tree planting	3,000m^2
2021	MacMillan's Farm on the Highway #316 in Upper South River, Antigonish County	• Bank stabilization using armour stone and incorporating large tree root wads • Riparian zone tree planting	2,250m^2
Total			**7,650m^2**

Figure 3: MacMillan's Farm site pre-restoration (2021)

Figure 4: MacMillan's Farm site during restoration (2021)

Figure 5: MacMillan's Farm site during tree planting (2021)

Figure 6: MacMillan's Farm site post-restoration (2021)

2.0 Habitat Assessment

The condition of habitat in the South River can be attributed to the interactions between human development both historically and presently. Prior to 1950 much of the watershed had been cleared for pastoral agriculture and many tributaries and reaches of the South River had been altered during log drives and through the construction of dams. Like most watersheds in Nova Scotia, the most productive farmlands found in river valleys and floodplains have been maintained to varying degrees. The conversion between grazing agriculture and machine harvesting has played an important role in the present-day conditions and issues found within the watershed. Historical grazing practices made little consideration for watercourses and thus most riparian zone corridors were impacted by vegetation loss and animal impact. Due to the mechanized nature of modern agriculture many riparian zones have been able to establish strips of woody vegetation along the streambanks however streambank erosion is prevalent throughout these reaches due to the relatively young age of the trees and shrubs. The resistance to erosion along streambanks is directly related to the age and width of buffer zones. Where streambank erosion was observed either the vegetation was too young, or the buffer zone was too narrow to slow down erosion rates. In most cases where severe bank erosion was found there was a complete absence of streambank vegetation.

Given the relative immaturity and spatial coverage of the floodplain and riparian forests, the recovery of instream fish habitat has been compromised. Streambank erosion is a natural process which can maintain pools and rejuvenate spawning grounds with new gravels and cobbles. The issue with streambank erosion in the South River is that the rate of erosion has hastened and the benefits of erosion such as the accumulation of large woody debris are not occurring as a beneficial rate. These two factors can lead to a preponderance of instream silts, extensive channel migration and disruption of pool, riffle and run sequences. Addressing streambank erosion via traditional techniques such as armor rocking can eliminate issues such as siltation, but they also limit the future recovery of the broader ecosystem. Therefore, bank stabilization projects should be limited to reaches of stream where channel migration cannot be tolerated such as bridge crossings and some agricultural areas. To maximize the benefits of banks stabilization projects should incorporate large woody debris (e.g., root wads) wherever possible and low-impact options for stabilization such as log revetments and hand-built log cribs should be completed wherever permission is granted. Benefits to low-impact approaches include less financial investment, a focus on manual labour (e.g., jobs) and a greater potential for long-term ecosystem recovery.

On a broader-scale issues affecting hydrology are present throughout most of the watershed. The activities for these changes are primarily related to clearcutting practices which disrupt and alter hydrologic regimes creating changes to flow volumes during bankfull discharge events also known as channel forming flows. Changes to the landscape that alter vegetation cover have a direct and immediate impact on the rate of surface runoff, a driver of bankfull discharge volumes. Within the sub-watersheds, large clearcuts can have a significant impact on hydrologic conditions leading to channel instability. It is important to recognize that the condition of instream habitat is a direct result of the hydrologic inputs (flow rate and volume) and how the river responds to those inputs within the confines of geological characteristics (valleys) and the presence, absence, or abundance of biological communities such as forests and wetlands. The full recovery of our aquatic ecosystems is dependent on the development of biological communities and minimizing significant macro-level changes.

The South River watershed is known for having a shallow groundwater table which has an impact on low flow volumes and temperatures. These same conditions also create an environment where heavy rains and floods can have more extreme flows. Drought conditions during the summer amplify stresses on juvenile Atlantic Salmon while increased flood severity can be detrimental to the survival of developing eggs. Furthermore, much of the South River's channel has been consolidated into a single threaded channel. An analysis of LiDar data and historical aerial photographs indicates that many reaches of the South River once contained over-flow channels, split channels and back-channels. These channel "breaches" as they are often referred to are critically important habitat features for juvenile salmonids, providing refuge during high flow events and over-wintering habitat.

The findings of this report suggest that the largest gain for habitat improvement could be achieved by focusing on extensive instream restoration of the tributaries using low-tech structures (e.g. digger logs and riparian zone plantings). Instream restoration within the main channel can be accomplished by focusing on high-priority sites where existing land-use and infrastructure (bridges and roads) will limit the ability for instream habitat recovery to occur naturally. Just as fish population response lags habitat degradation so to does the response of the population to improved habitat conditions.

2.1 Historical Assessments

It is widely accepted that past ecological conditions were much more conducive to the Atlantic salmon's life cycle. It is important to conceptualize what those pre-European settlement environments would have looked like. Some evidence can be found in historic maps of Nova Scotia from 1867 and through new LiDar imaging technology. While it is difficult to get a quantitative description of habitats and fish populations it is obvious that the historic and highly productive ecosystems were characterized by wetlands, fully saturated floodplains, and braided channels. While re-establishing historic aquatic ecosystems throughout the entire watershed is limited by infrastructure such as roads, dwellings, and agriculture there are also many places where full ecosystem recovery is possible.

2.1.1 Previous Research

In 1985, Darlene Burton was employed by the Nova Scotia Department of Lands & Forests Wildlife Division compiled a report titled "*A Plan Outlining the Potential for the Rehabilitation and Enhancement of the South River in Antigonish, Nova Scotia*". The report focuses on the loss of valuable salmonid habitat in the South River Watershed in 1985 and provides detailed recommendations to implement conservation and rehabilitation activities. During the time this report was written, streambank stabilization, channelization and debris clearance projects were being implemented by the N.S. Dept. of Environment to protect agricultural lands. Burton notes that the public's ecological awareness was growing, and more community groups were making connections between poor land-use practices and the loss of fish habitat and criticizing the Dept. of Environment on the protection programs. Despite not having historical surveys to compare with the 1985 survey data collected, community outreach provided valuable information that raised concerns for fisheries management. It was well known by the community that the South River no longer supported the large salmonid populations it once did which was expressed through stories of wagon-loads of trout being taken from the river as well as the major salmon spawning runs that were quite the spectacle. Fisheries management decided to begin research on habitat loss in the South River, which funded Burton's rehabilitation report. The report is broken down as such: watershed profile, assessment of salmonid habitat, evaluation of habitat issues and recommendations for improvement. Although there is a 37-year gap between Burton's report and this document, many of the issues around Salmon habitat degradation remain the same – channelization, poorly installed bridges/culverts, unnatural rates of erosion, intense forestry practices, and significant agricultural land-use. Burton's recommendations for the rehabilitation of the South River Watershed are also similar to the conservation activities outlined in this report with the main difference being that there is much more research backing specific restoration techniques as well as the experience that ARA has in implementing small- and large-scale projects. The 1985 report recommends streamside planting to stabilize banks, provide canopy coverage to reduce extreme water temperature fluctuations, and regulate stream flow and can be used with fencing to keep livestock and farming equipment off of the new plantings. Another recommendation for bank stabilization is to install stone rip rap or log cribbing which can also provide cover for juvenile salmonids. Log deflectors are mentioned as a possibility, but Burton notes that their use in a river with the flows of the South might not be useful. Boulder placement in-stream is mentioned as a means to contribute cover, insect habitat and to dislodge silt from the substrate, but can also cause the current to be deflected towards the banks causing more erosion. Debris removal, which was a common practice in the 1980's, was advised to be done with caution as not to take too much LWD from in-stream because it is an important component of the river system. Cleaning up garbage, old vehicles/parts and any other litter is also mentioned as well as the continuation of monitoring along the South River and its tributaries. Public education was included as an important component of a successful rehabilitation plan through raising awareness of how land-use directly impacts aquatic habitats.

Habitat Unlimited, a group responsible for many in-stream restoration projects in Antigonish County, funded a report in 2015 titled "*Preliminary Report on South River Watershed Planning*". The report provides background information on the South River including historical land-use, forestry operations, identifying communities and other developments along the river. In order to gain historical perspective of the South River, reviews of published evidence on fish population/migration, water quality, and habitat assessments were done to compare with data collection done at the time the report was written. Although the document does not provide any quantitative data, it does note what was involved in the assessments which included identification of tributaries, in-stream assessment of all tributaries and the main branch to collect data on substrate, temperature, habitat features, and land-use practices. Consultations were conducted with stakeholders representing the angling community, local and provincial governments and there were attempts to arrange for consultations to be held with the agricultural community, the planning commission and the Paqtnkek First Nation without success. The report results concluded that there were 5 main issues identified in the South River watershed: temperature and flow, siltation and infilling, fish passage, riparian zone health, and habitat restoration and preservation. There are recommendations at the end of the report that include upgrading the 2 dams along the main branch on the South River to include temperature reduction devices and properly installed fish ladders, tree planting to aid in the development of vegetated buffer zones, local government and land owner engagement in appropriate land-use practices to lessen the siltation and infilling within the river, and the installation of restoration structures.

2.2 Geology & Soil Types

Surficial Geology

The oldest surficial geology in the area of study is fragmented rock residuum overlain with till formed prior to the most recent glaciation. This geology resides near the mouth of the South River. During the most recent glaciation silty till plains and drumlins were formed. The till formed during this period is silty, compact material derived from local and distant sources. The drumlins are much siltier than the till and were derived from distant red clay. Kame fields were also form during this period and consist of gravel, sand, and silt layers. The youngest surficial geologic structures have been formed post glaciation from marine deposits and can be found in both the upper and headwater portions of the South River. These deposits are gravel, silt and clay overlain by peat and salt marshes.

Bedrock Geology

The bedrock in the area of study ranges from 300-392 million years old. The mouth of the South River consists of Upper Windsor Group mudstone, sandstone, and small gypsum deposits as well as shallow limestone. Moving upstream there are deposits of Mabou Group formations Pomquet and Hastings. These two formations contain fluvial siltstone, sandstone, and shale, along with minor lacustrine limestone. Following the Mabou Group is an area of undivided Horton Group (fluvial sandstone, siltstone, conglomerate, shale, and limestone, alluvial conglomerate, wacke, and siltstone, and lacustrine, and felsic volcanic rocks). Lastly, in the headwaters area, are Fountain Lake Group formations Clam Harbour, Glenkeen, and Sunnyville. These formations contain siltstone, sandstone, wacke, basalt, andesite, and rhyolite.

Soil Types

The soil at the mouth of the South River is imperfectly drained, moderately fine-grained Queens soil with slow permeability. The lower and middle sections of the South River are Wolfville soils which are well to moderately drained, medium to moderately fine-grained soils that also permeate slowly. The upper section and headwaters of the South River contain Barney, Gibraltar, and Cobequid soil that all have similar properties. They are well drained, medium coarse grained with rapid permeability.

2.3 South River Field Assessments

Warm water temperatures that exceed 20° Celsius can create issues for Atlantic salmon and Brook trout as both species are adapted to cold-water environments. Each life stage of fish development has its own threshold for tolerating warm water. Adult salmon and trout are sensitive to water temperatures that exceed 20° C while Atlantic salmon and trout fry may tolerate temperatures over 25° for short periods of time (> 12 hours). While all life stages of salmonids are capable of migrating towards cooler water, issues such as over-widened channels and barrier culverts may reduce the ability of salmonids to reach necessary cold-water refugia areas. Furthermore, the wide-reaching effects of habitat degradation have limited the quantity and quality of cold-water refugees while creating an over-abundance of channel habitats that intensify increases in water temperature (e.g. the absence of shade producing trees). The under-lying geology found within the South River watershed is characterized by having a very porous groundwater table, known for poor retention of soil moisture. While this characteristic has provided a benefit to the local agriculture community it has amplified the loss of baseflow volumes and reduced the amount of available cold water.

The same factors (e.g. land-clearing, road construction and agriculture) that contribute to the decreased levels of baseflow volumes and warmer water temperatures in the summer have also created conditions that promote flooding and streambank erosion. The changes within the landscape have dramatically altered the local hydrology through increased runoff rates during rain events. Furthermore, the transition from a forested land-cover to a mixture of forest and clearings has increased the rate of snow pack melt which is contributing to an increase in flood intensity throughout the South River. The loss of streambank vegetation has also left the near stream landscape particularly vulnerable to erosion. Together these issues are amplifying the rate of change within the river and pose real threats to fish populations and agricultural production.

In order to describe the extent of habitat loss and to identify potential sites for restoration, ARA conducted a series of instream inspection throughout each section of the South River watershed. In total the watershed was broken into 6 spatial planning units (SPU). Habitat assessments were completed in 2021 through each SPU as well as drone flights and evaluating historical aerial photographs. An analysis of LiDar data and historical aerial photographs indicates that many reaches of the South River once contained over-flow channels, split channels, and back-channels. These channel "breaches" as they are often referred to are critically important habitat features for juvenile salmonids, providing refuge during high flow events and over-wintering habitat. This section of the report will provide an overview of the issues found within each SPU as well as providing site specific examples. Where restoration is feasible, this section will outline the available tools for restoring instream habitat. The changes to the South River landscape have decreased the resilience of the aquatic ecosystem, therefore the recommendations found in this report will focus on restoring long-term ecosystem resilience.

2.3.1 South River Spatial Planning Units

The majority of restoration work involved along the main channel will be bank stabilization and riparian zone tree planting projects as well as pre- and post- restoration monitoring. Such projects have been completed between 2018 and 2021 with a high level of success and have garnered landowner support to continue these projects.

2.3.1.1 Headwater Section

In the headwater section of the South River, there are 4 reaches identified. Throughout reaches 3 and 4 there has been significant clearing of wooded areas by forestry operations that have left the riparian zones either bare or with very few mature trees intact. Forestry in the area has created single aged forests with little species diversity needed for ecosystem resilience. In reaches 1 and 2, land use practices include agricultural fields that have been cut up to the riverbank or if there is a riparian zone it is typically too narrow, between 2-3 meters wide. Running parallel to the South River on the eastern side is the Argyle Road that leads almost to the headwaters of the South River and at times is in extremely close proximity to the channel.

Figure 7: Argyle Road runs in close proximity to the South River with no buffer zone between

Table 3: Overview of headwater reaches

Reach #	Stream Length	Average Calculated Bankfull Width	Estimated Habitat	Downstream Coordinates
1	2376.32m	7.60m	18060.30m^2	45.2343996N -61.5620431W
2	1942.32m	7.60m	14761.63m^2	45.2258051N - 61.55716W
3	723.62m	7.60m	5499.51m^2	45.229996N -61.5447265W
4	353.12m	7.60m	2683.71m^2	45.2148279N - 61.5440619W
Total	**5395.38m**	**7.60m**	**41005.15m2**	**-**

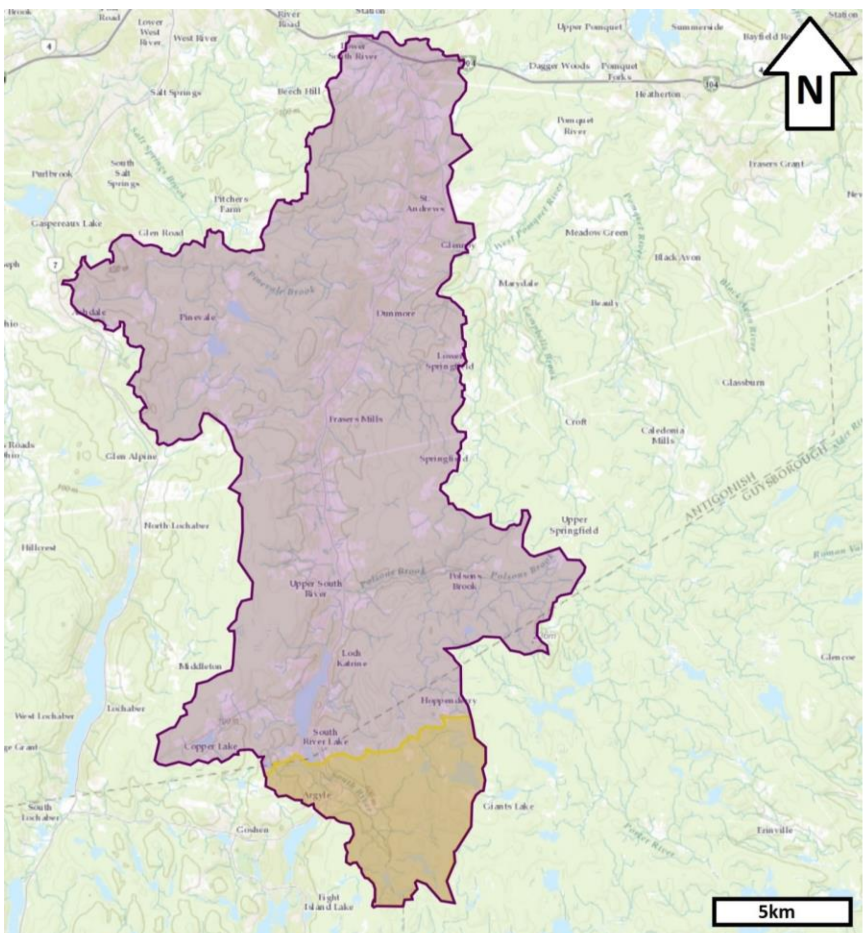

Figure 8: Headwater spatial planning unit highlighted in yellow

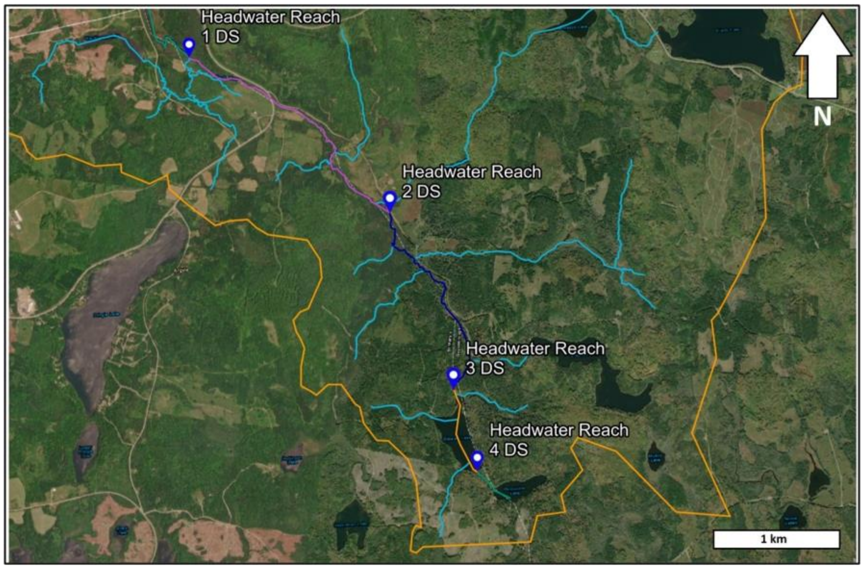

Figure 9: Reaches within the Headwater spatial planning unit highlighted

Figure 10: Highway 316 bridge in Reach 1 of Headwater Spatial Planning Unit

2.3.1.2 Upper Section

The upper section has been divided into 2 reaches, one of which is the entire South River Lake (Reach #2). The South River Lake outlet in Loch Katrine has a secondary dam installed that belongs to the Fraser's Mills Fish Hatchery and it is not a fish passage barrier (see Figure #). Throughout Reach #1, there is a sufficiently wide riparian buffer zone on either side of the river for approximately ¾ of the reach, but the other ¼ has little to no riparian zone with agricultural field cut to the banks. At the downstream end of Reach #1 near the McPhee Cross Road, there has been a significant amount of beaver activity which is a natural part of a river ecosystem and poses no great threat to the conservation of Atlantic Salmon in the South River. Along the East and West banks of the South River run 2 roads – the paved Highway 316 (east) and the gravel West Side South River/Dunmore Road. Both roads travel the entire length of the river downstream to the outlet in the Antigonish Harbour. In this upper section there is significant agricultural land-use on the east side and mainly forestry and rural housing developments/cottages on the west side.

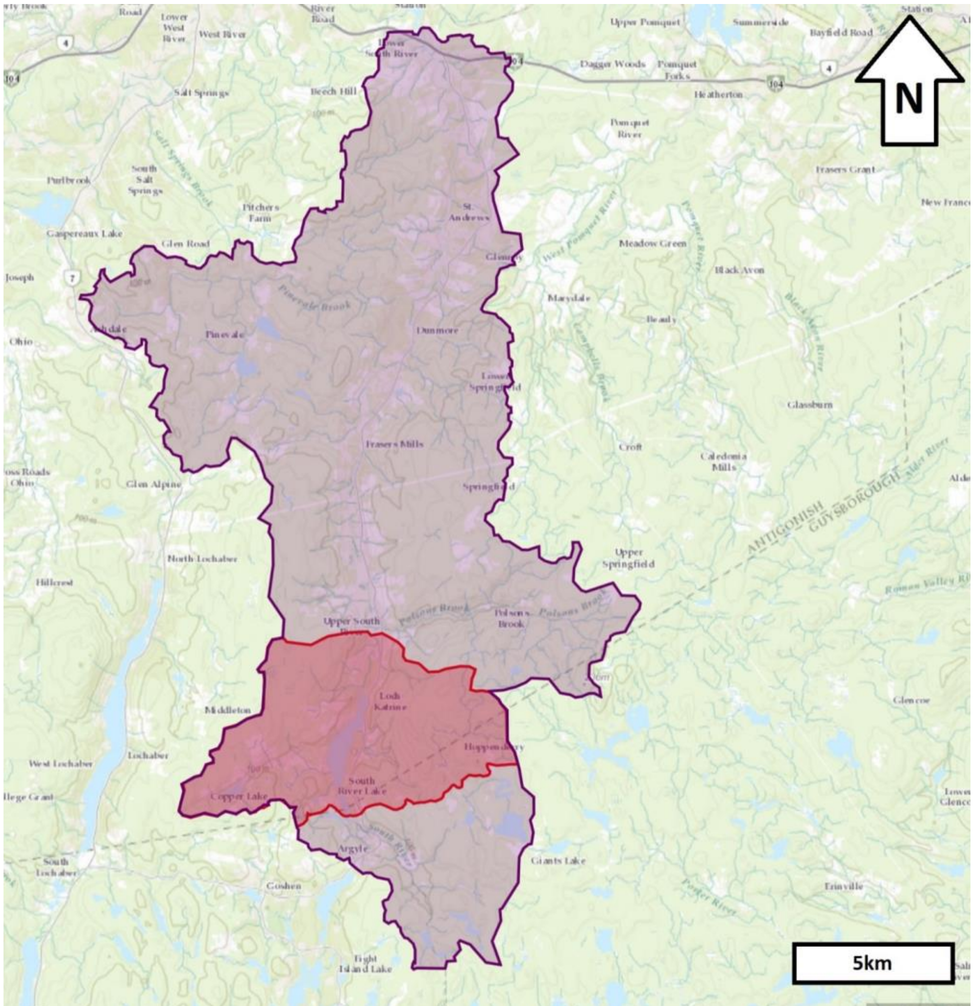

Figure 11: Upper South River spatial planning unit highlighted in red

Table 4: Overview of Upper SPU reaches

Reach #	Stream Length	Average Calculated Bankfull Width	Estimated Habitat	Downstream Coordinates
1	2040.74m	7.84m	15999.40m^2	45.2813989N -61.563628W
2	4535.80m	7.84m	35560.67m^2	45.2552568N -61.5612814W
Total	**6576.54m**	**7.84m**	**51560.07m^2**	

Figure 12: The dam location at the outlet of South River Lake in Loch Katrine

Hattie Millstream

Hattie Millstream Brook is the smallest major tributary in the South River drainage basin and is within the Upper South River SPU. It provides a cold-water source that flows into the South River Lake. A significant portion of the watercourse has an efficient riparian buffer zone on either side which provides shade and a food source for aquatic life. There are very few road crossings throughout this sub watershed allowing it to flow more freely and limiting fish passage barriers to migrating salmon.

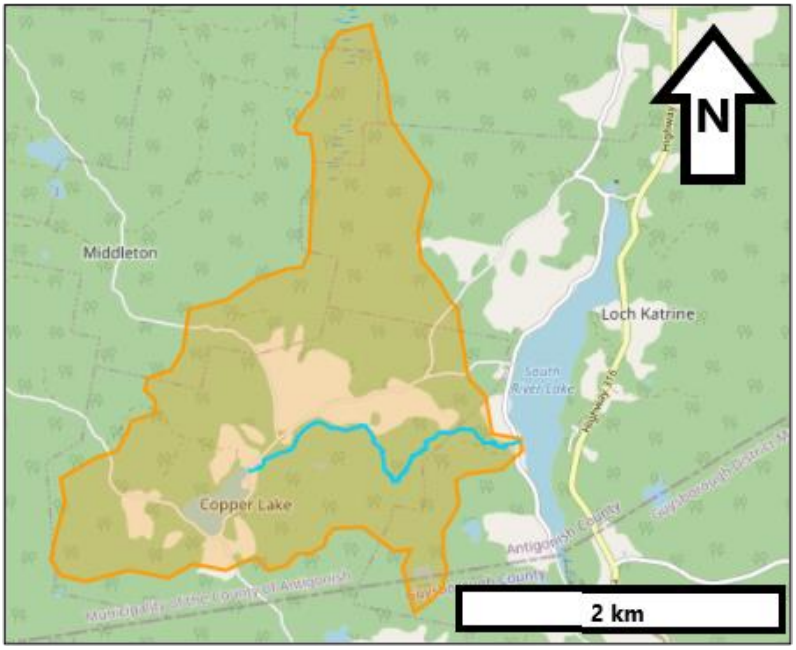

Figure 13: Hattie Millstream area, main channel highlighted in blue

Table 5: Overview of Hattie Millstream		
Watershed Characteristics	**Applicable Restoration Techniques**	**Challenges with Implementing Restoration**
• The middle reaches are largely wetland habitat. • The north side of the river is heavily cleared for agriculture while the South side is sufficiently vegetated with mature trees that provide a large buffer zone (figure #). • A natural meander pattern with the normal hydrological sequence of pool-riffle-run is present, but could be enhanced through the installation of log and rock structures that will improve habitat for all life stages of Atlantic Salmon.	• Tree planting and riparian zone protection • Log structures such as digger logs and log deflectors • Rock sills and deflectors • Potential for wetland restoration in middle reaches • Bank Stabilization	• Access poses an issue for the field crew as there are few road crossings the entire length of the river. • Landowner cooperation is not always available.

Table 6: Hattie Millstream hydrology calculations				
Drainage Area (km^2)	**Avg Calculated Bankfull Width**	**Stream Length**	**Estimated Habitat**	**Downstream Coordinates**
10.67	6.20m	3705.59m	22974.66m^2	45.2433159N -61.5654727W

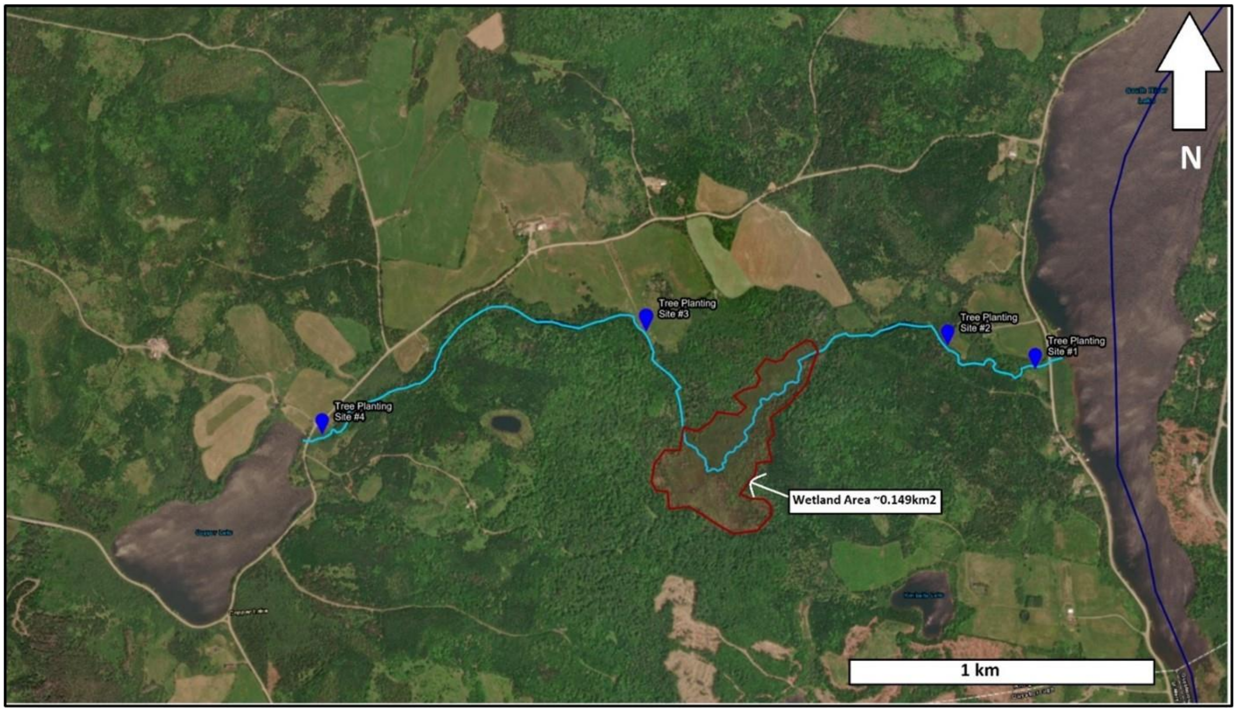

Figure 14: Aerial map of Hattie Millstream tree planting sites and wetland area

2.3.1.3 Polson's Brook

There is a major natural barrier waterfall approximately 1km upstream from its confluence with the South River. There is potential for some type of fish ladder to be installed at this site as the Polson's Brook is a cold-water tributary that has significant potential for upstream Atlantic Salmon spawning habitat, however, further assessments need to be completed in order to determine the feasibility of installing a fish ladder. The barrier waterfall limits full restoration potential for most of Polson's Brook at this time, but the restoration plan does include riparian zone tree planting in the lower reaches to stabilize the banks and provide a buffer zone between the agricultural fields and the river.

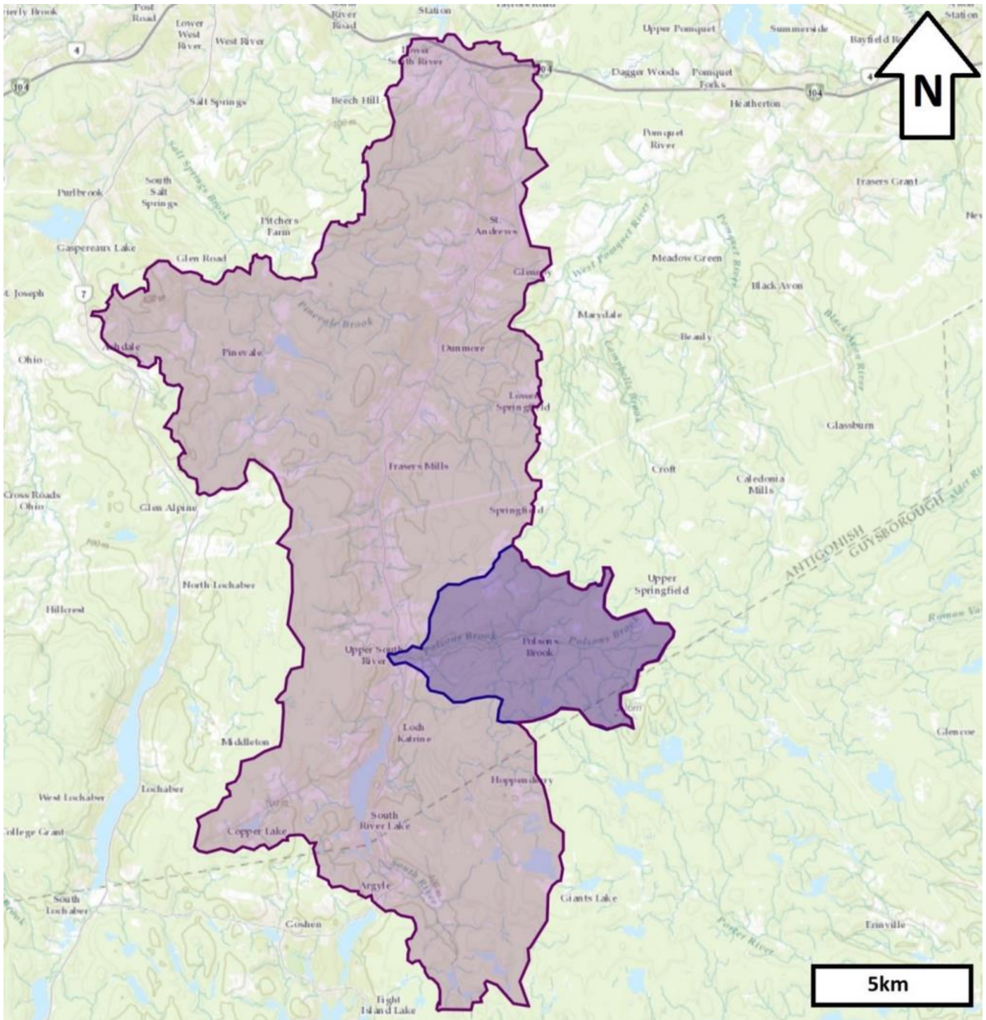

Figure 15: Polson's Brook spatial planning unit highlighted in blue

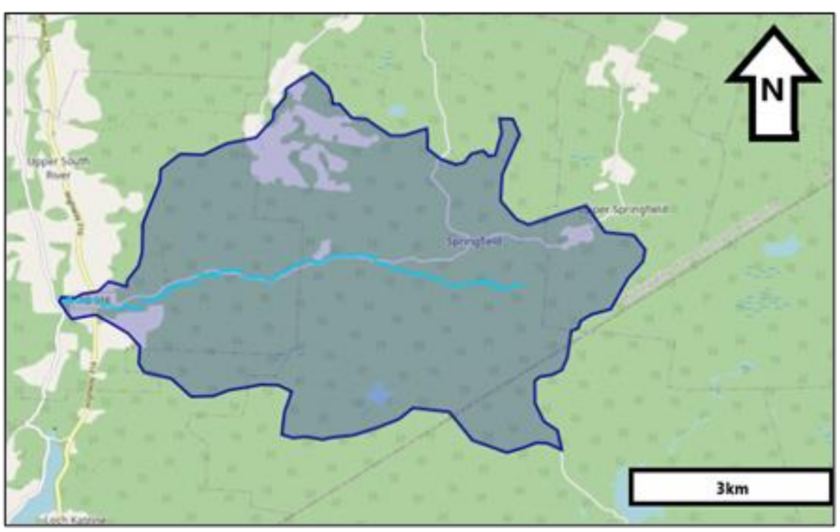

Figure 16: Polson's Brook main channel highlighted in light blue

Table 7: Overview of Polson's Brook		
Watershed Characteristics	**Applicable Restoration Techniques**	**Challenges with Implementing Restoration**
• Land-use practices are agriculture in the lower reaches and forestry in the upper reaches. • Long-term ecosystem resiliency can be attained by tree planting mainly in the lower and upper reaches.	• Tree planting and riparian zone protection • Potential fish ladder installation on natural barrier falls	• Approximately 1 km upstream from the mouth of the river, there is a barrier waterfall that will limit restoration to the upper reaches of the watershed.

Table 8: Polson's Brook hydrology calculations					
Watershed Size (km^2)	**Avg Calculated Bankfull Width**	**Stream Length**	**Estimated Habitat**	**Downstream Coordinates**	**Upstream Coordinates**
22.73	7.71m	7593.15m	58543.19m^2	45.264851N -61.568407W	45.2655962N -61.5116195W

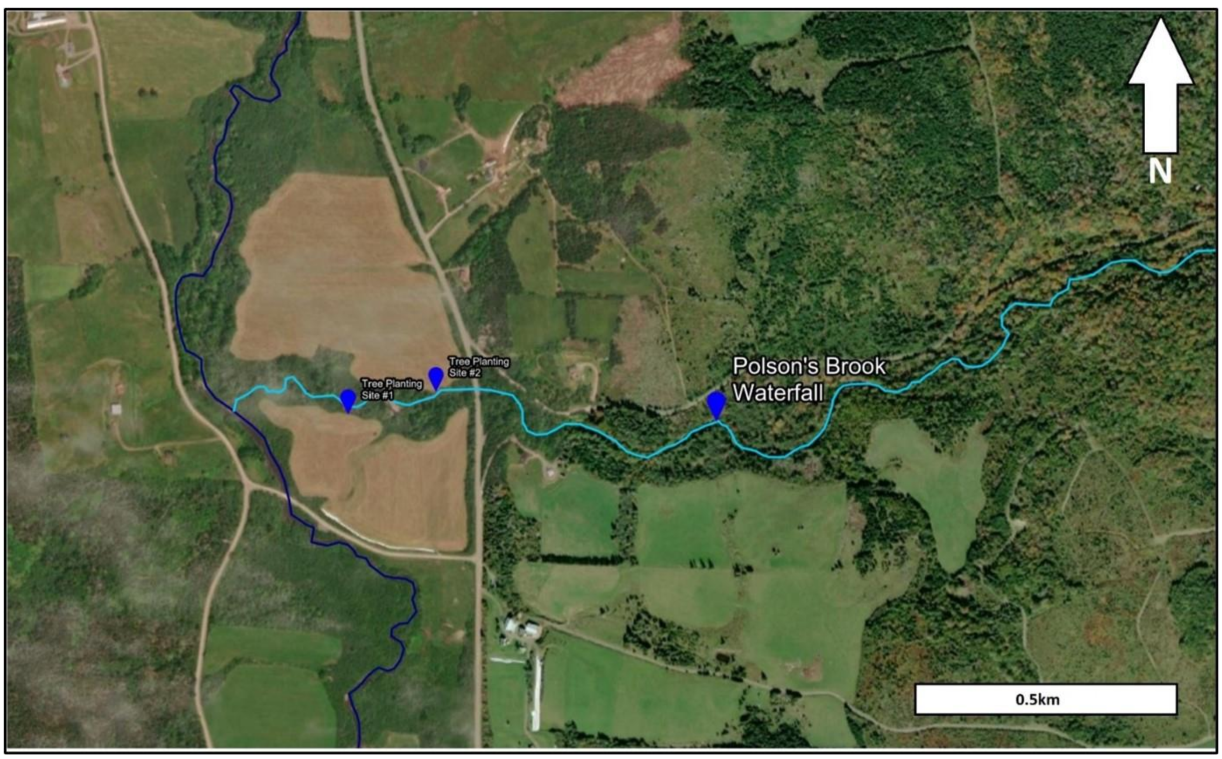

Figure 17: Aerial map showing tree planting sites and Polson's Brook falls

Figure 18: Polson's Brook falls

2.3.1.4 Middle Section

There are 3 reaches identified in the middle section of the South River main branch. Agricultural fields become the dominant land-use in Reach #1 where the river has been channelized to fit between the Dunmore Road to the west and the Highway 316 to the East, ensuring maximum area for pastoral and haylage fields. In Reach #2, the Fraser's Mills Fish Hatchery has been in operation for over 30 years and the primary water reservoir dam upstream from the hatchery has been present in some form or another on the South River since the early 1800's when it was originally used as a mill dam. There is minimal riparian buffer zones along the entire section, however there is notably significant less riparian zones along the South River in Reach #3 as seen in figure 19 below.

Table 9: Overview of Middle SPU reaches

Reach #	Stream Length	Average Calculated Bankfull Width	Estimated Habitat	Downstream Coordinates
1	4765.22 m	9.47 m	45126.63 m^2	45.3137523N -61.5539224W
2	3277.89 m	9.47 m	31041.62 m^2	45.2941252N -61.5618334W

3	4030.26 m	9.47 m	38166.56 m^2	45.2813989N -61.5622954W
Total	**12073.37m**	**9.47m**	**114334.81m^2**	

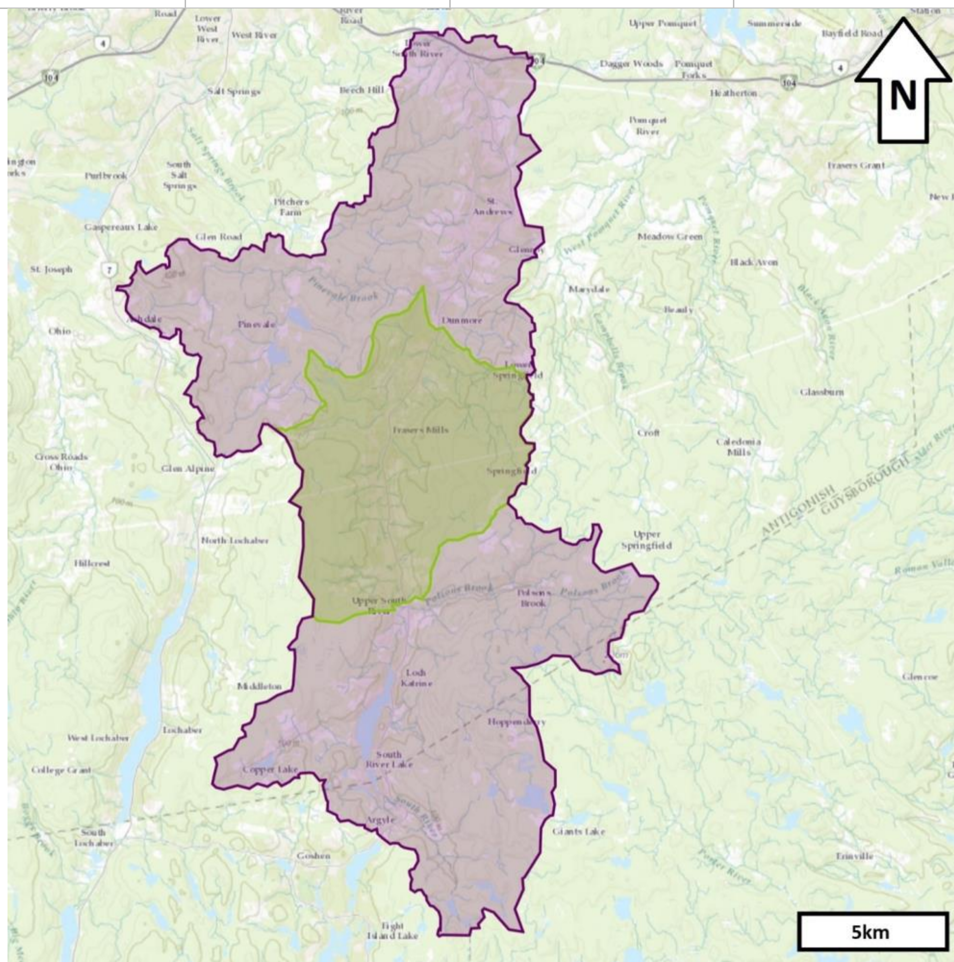

Figure 19: Middle South River SPU highlighted in green

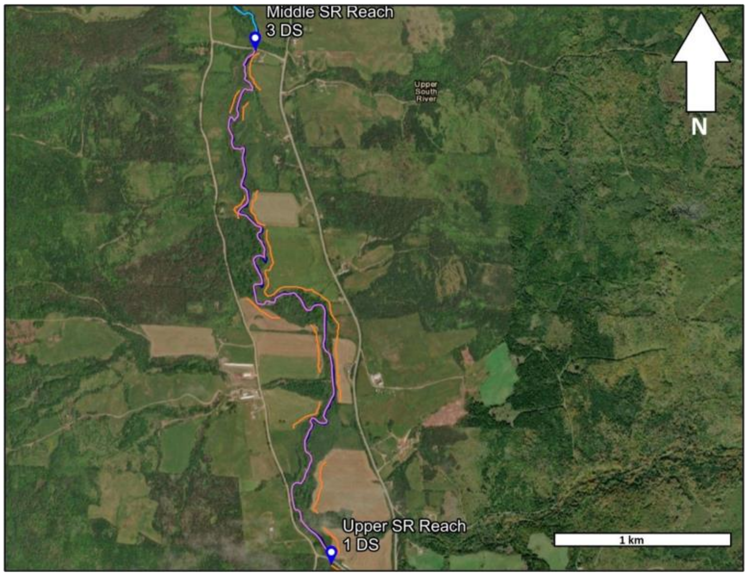

Figure 20: Aerial map of Reach #3. River highlighted in pink and bank lacking riparian zone highlighted in orange

<u>Middle South River Aerial Photo Series</u>

Table 10: Aerial Photo Series Observations		
Date Range	**Figure #**	**Observations**
1974 – 1979	**21-22**	1974 shows a well defined channel. By 1979 the channel has widened and on turns in the stream there are high levels of erosion leading to braiding of the stream. No signs of riparian zones are left on the farm fields.
1979 – 1990	**22-23**	The previously formed channels are becoming the main channels and the river is widening drastically. Riparian zone depletion continues which is speeding up the erosion.
1990 – 1997	**23-24**	The old channels have dried up and the previously formed channels are now the main channel. There are sharper meanders however overall, the channel is straightening out.
1997 – 2018	**24-25**	The channel remains intact, but erosion and even sharper meanders continue to occur. There are more wooded buffer zones on the river banks downstream from the farm fields.

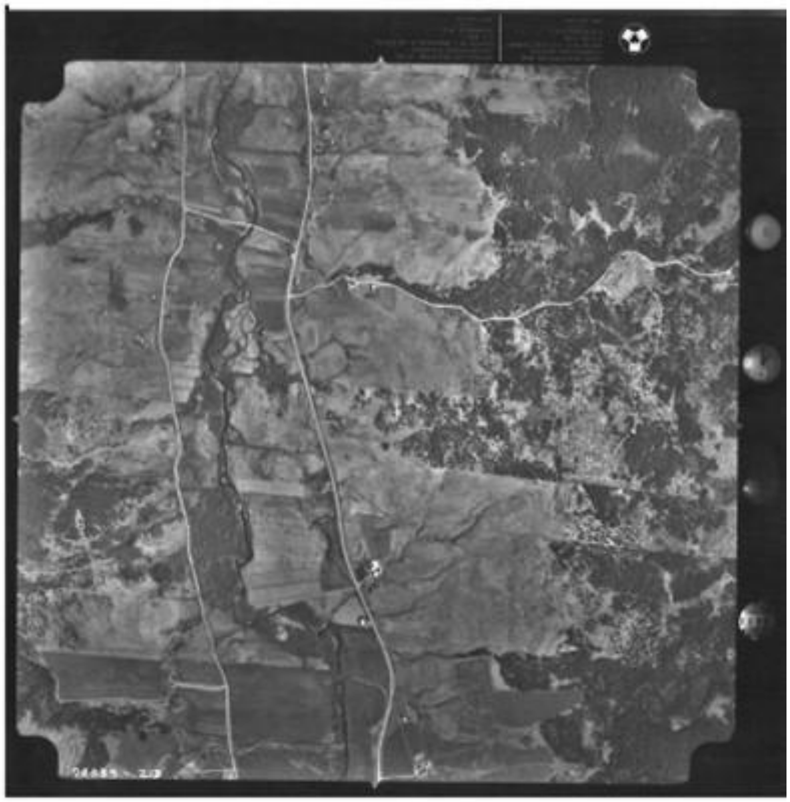

Figure 21: Middle South River (1974)

Figure 22: Middle South River (1979)

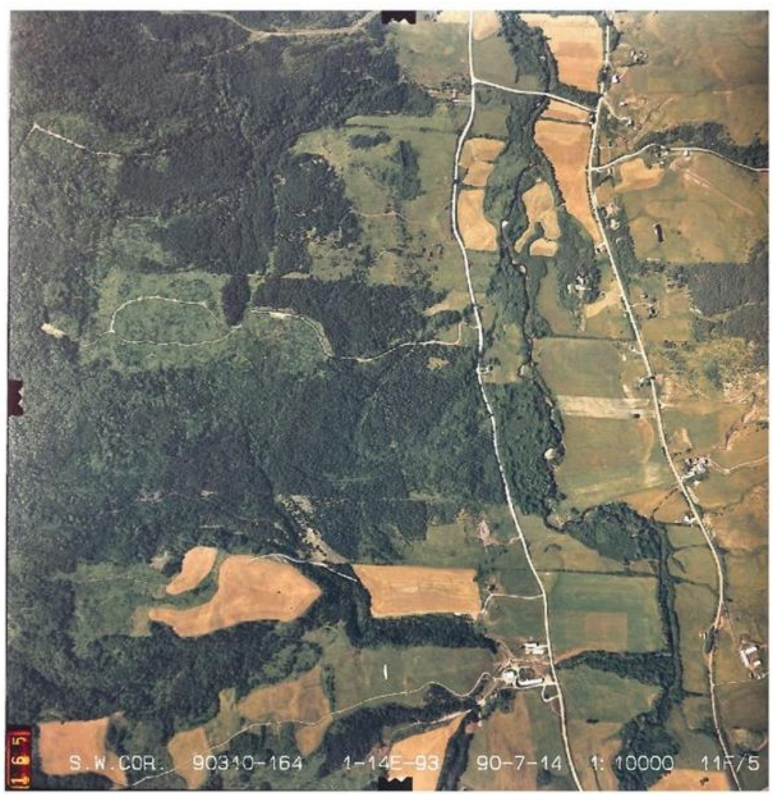

Figure 23: Middle South River (1990)

Figure 24: Middle South River (1997)

Figure 25: Middle South River (2018)

2.3.1.5 Pinevale Brook

The Pinevale Brook is the largest sub-watershed in the South River Watershed with a drainage area of approximately 33km^2. Plans for restoration activities are set to begin in 2022 beginning downstream from the Dunmore Road crossing and working upstream approximately 3km. The lower section of the Pinevale Brook poses accessibility issues as there are no public roads to access the river for about 4.5km. There will be open communication between ARA and the landowners in the area to try and gain access to private roads along the specific stretch.

Table 11: Overview of Pinevale Brook		
Watershed Characteristics	**Applicable Restoration Techniques**	**Challenges with Implementing Restoration**
• Primary land-use practices include rural developments surrounded by young forests that are grown up agricultural fields. • The lower reaches have had a significant amount of beaver activity, but in recent years the dams have become inactive, and the river is flushing itself of the fine sediments that accumulated. • A meander pattern with the natural river sequence of riffle – run – pool could be improved through the installation of log structures providing habitats for various life stages of Atlantic Salmon. • Cameron Lake is an important lake in the upper reaches of Pinevale Brook and historically has been heavily stocked with salmonids.	• Tree planting and riparian zone protection • Log structures such as digger logs and log deflectors • Potential for wetland restoration in upper reaches • Mitigation of barrier culverts • Bank Stabilization	• The section from the Pitchers Farm Road downstream to the Dunmore Road poses access challenges for the field crew due to few road crossings and steep slopes on either side of the river. • Small sections in the upper section are low gradient with less than 1% slope limiting the use of some restoration structures. • Certain sections highly impacted by beaver activity have a fine sediment substrate which is not suitable for log structures. • Landowner cooperation is not always available.

Table 12: Pinevale Brook hydrology calculations					
Watershed Size (km^2)	**Avg Calculated Bankfull Width**	**Stream Length**	**Estimated Habitat**	**Downstream Coordinates**	**Upstream Coordinates**
33.38	8.62m	12607.75m	108678.81m^2	45.320015N -61.5528839W	45.2951525N -61.5948095W

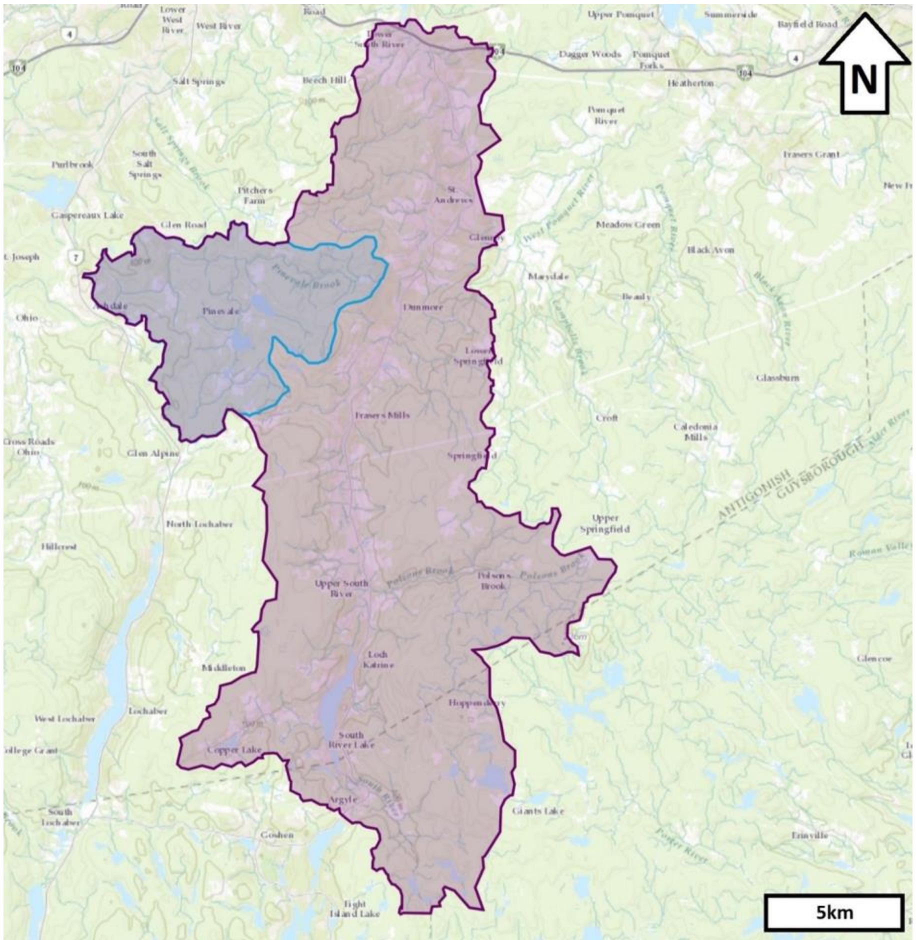

Figure 26: Pinevale Brook SPU highlighted in light blue

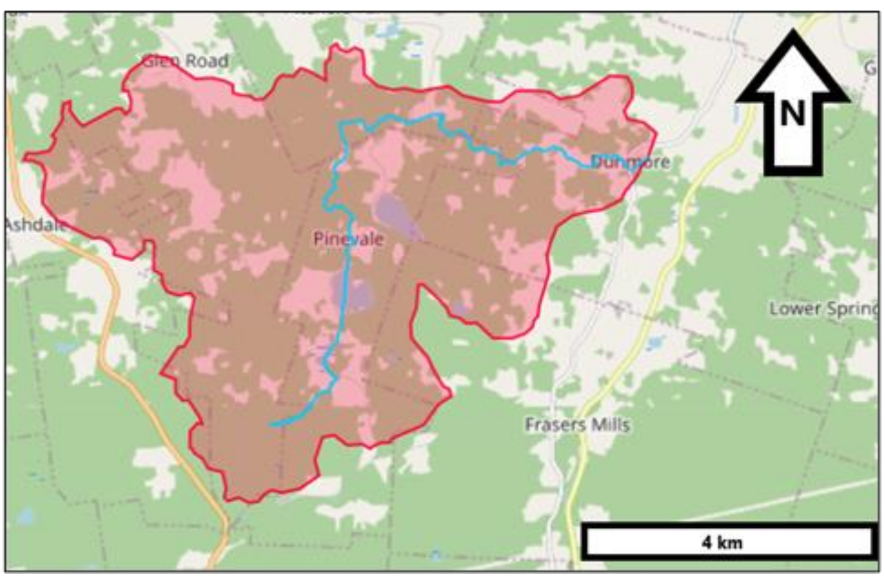

Figure 27: Pinevale Brook SPU with main channel highlighted in blue

Figure 28: Downstream view of the Dunmore Road crossing, beaver activity observed

Figure 29: Upstream view from Dunmore Road crossing where beaver activity has caused back flow and fine sediment deposit in the substrate

Pinevale Brook Confluence Aerial Photo Series

Table 13: Aerial Photo Series Observations		
Date Range	**Figure #**	**Observations**
1979-1990	**30-31**	There is more riparian zone vegetation at the bottom of Pinevale Brook which has stabilized the stream. The channel is more well defined. Upstream from the mouth of Pinevale Brook on the main branch of the South River there has been a reduction in riparian zone vegetation and the land to the east has been deforested for agricultural purposes. The removal of riparian zone vegetation upstream could result in erosion and the deposition of sediment towards the mouth of Pinevale Brook.
1990-2007	**31-32**	There are no notable changes in adjacent land use. There is, however, noticeably more riparian zone vegetation which will further strengthen the channel's integrity.
2007-2018	**32-33**	Three houses have been developed to the south of the Pinevale Brook mouth and the channel is beginning to widen. Further upstream Pinevale there has been development on the first sharp meander after the road crossing. This development near the stream along with the removal of riparian zone vegetation presents more rapid erosion potential.

Figure 30: Pinevale Brook Confluence (1979)

Figure 31: Pinevale Brook Confluence (1990)

Figure 32: Pinevale Brook Confluence (2007)

Figure 33: Pinevale Brook Confluence (2018)

Upper Pinevale Brook (Cameron's Lake) Aerial Photo Series

Table 14: Aerial Photo Series Obsevations		
Date Range	**Figure #**	**Observations**
1979-1990	**34-35**	Along the bank as Pinevale Brook enters Cameron's Lake there is substantial deforestation. There was a riparian zone vegetation buffer left intact. At the southernmost end of the lake, early signs of erosion are apparent and as the stream exits Cameron's Lake braiding has begun to occur.
1990-2007	**35-36**	The area that has previously been deforested has since been replanted. Erosion at the southern point of the lake continues and braiding of the stream is still visible.
2007-2018	**36-37**	Thicker tree cover is visible on the properties adjacent to Pinevale Brook and Cameron's Lake. The braiding of the channel as the brook exits the lake has resulted in the widening of the channel.

Figure 34: Upper Pinevale Brook (1979)

Figure 35: Upper Pinevale Brook (1990)

Figure 36: Upper Pinevale Brook (2007)

Figure 37: Upper Pinevale Brook (2018)

2.3.1.6 Lower Section

There are 4 reaches within the lower section of South River, all of which flow through highly developed land that includes agricultural fields, forestry operations, and dense rural communities. The river is channelized through each reach due to the centuries of extensive land-use in this section with the river hugging the Dunmore Road to the west (see figure#) not allowing for flows to enter the floodplain. Due to this channelization, throughout the entire section, there are long, straight, and wide runs with no defined thalweg and unnatural rates of erosion which can also be contributed to the lack of sufficiently vegetated buffer zones. In Reach #1 there is in operation a water treatment facility and a wastewater facility as well as the highway 104 crossing. There are several well-known pools throughout the lower section, but due to high sediment loads flowing downstream there is infilling occurring. There is virtually no riparian zone through Reach #1 and reach #4, but efforts have been made by the ARA in 2021 to plant along the lower section of Reach #1 a stretch of approximately 100m of riverbank. Tree planting projects continue to be a vital component of watershed stewardship for ARA.

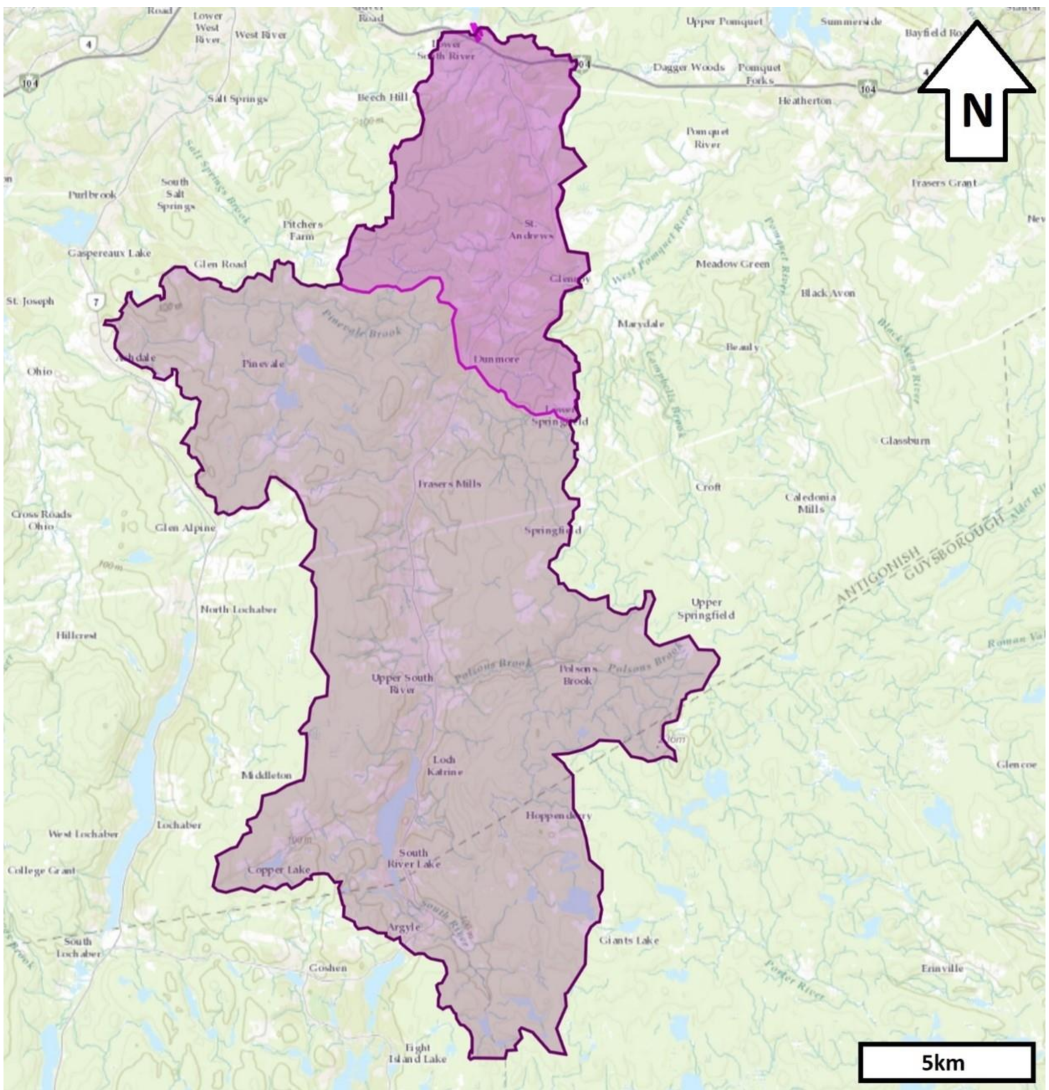

Figure 38: Lower South River SPU highlighted in pink

Table 15: Overview of Lower SPU reaches				
Reach #	**Stream Length**	**Average Calculated Bankfull Width**	**Estimated Habitat**	**Downstream Coordinates**
1	3512.84 m	9.07 m	31861.46 m^2	45.360147N -61.5451513W
2	2219.14 m	9.07 m	20127.60 m^2	45.3438885N -61.5416781W
3	3195.93 m	9.07 m	28987.09 m^2	45.3333906N -61.5414189W
4	2267.57 m	9.07 m	20566.86 m^2	45.3217388N -61.5429129W
Total	**11195.48m**	**9.07m**	**101543.01m2**	

Figure 39: The Dunmore Road runs in close proximity to the South River

Figure 40: Adopt-A-Stream funded riparian zone restoration at the South River ball field

Figure 41: Adopt-A-Stream funded riparian zone restoration at the South River ball field

Lower South River Aerial Photo Series

Table 16: Aerial Photo Series Observations		
Date Range	**Figure #**	**Observations**
1974 - 1979	**42-43**	There are no notable changes with property use adjacent to the river, however, upstream from the farm there is early signs of erosion and widening of the channel.
1979 - 1990	**43-44**	At the aerial photo site, land on both sides of the river has been deforested and turned into fields for farming purposes. A buffer of riparian zone vegetation was left, preventing rapid erosion potential. Land northwest of the farm site has also been clear cut. At this site, there was complete removal of riparian zone vegetation. This will speed up erosion processes and can be very detrimental as the site is on a sharp meander in the river.
1990 - 2018	**44-45**	The fields across the river from the farm site contain more vegetation, as one of the fields has returned to being entirely trees. Immediately downstream, a small quarry has been built. Approximately 1km upstream from the farm, the stream is beginning to braid. This could be due to housing development along the river.

Figure 42: Lower South River (1974)

Figure 43: Lower South River (1979)

Figure 44: Lower South River (1990)

Figure 45: Lower South River (2018)

Farm Crossing (Upstream from Blacksmith Valley Bridge) Aerial Photo Series

Table 17: Aerial Photo Series Observations		
Date Range	**Figure #**	**Observations**
1979-1990	**46-47**	There are no notable changes with adjacent land use, however, upstream there are more distinct gravel bars being formed and the stream is beginning to braid.
1990-2007	**47-48**	Downstream from the farm crossing, there is less riparian zone vegetation. There is visibly less meander in the steam and degradation of the previously formed gravel bars upstream.
2007-2018	**48-49**	The grassy land on the east side of the farm crossing site has been turned into a field for agriculture use. Upstream, the gravel bars are beginning to regenerate.

Figure 46: Farm Crossing (1979)

Figure 47: Farm Crossing (1990)

Figure 48: Farm Crossing (2007)

Figure 49: Farm Crossing (2018)

2.4 South River Road Crossing Assessments

Often times, road crossings pose various barriers to fish passage and need to be assessed regularly to ensure upstream migration to spawning habitats is accessible. Barriers that are common in the South River Watershed include, but are not limited to:

Channelization: Prior to environmental regulations protecting watercourses, it was common practice to physically move a river to accommodate a new road crossing. This would involve heavy equipment moving the channel to ensure a perpendicular flow to the new road crossing, which causes many issues such as an over-widened channel with shallow water and no defined thalweg as well as disrupting the natural hydrological pattern of the watercourse. This method of moving the watercourse was also used in the agricultural setting so farmers could get the most land coverage from the floodplain where crops are typically grown. When channelization occurs, it also cuts the watercourse off from its surrounding floodplain which can cause severe flooding events damaging property as well as inhibiting the floodplains from soaking up the extra water to dissipate the flowing velocity as well as recharging the groundwater stores that are crucial for keeping water in landowners wells.

Raised Culverts: On smaller feeder streams within the watershed, road crossings would often utilize wooden box culverts or metal culverts to allow the water to flow under the crossing. As mentioned above, prior to environmental regulations protecting watercourse, these culverts were installed without any idea of the natural flow of the stream. The culverts were typically too small for the peak flows, and this can cause severe bank erosion and flooding on the upstream side of the road crossing while also creating a pool below the culvert that over time, becomes too far of a drop from the outflow of the culvert for any fish to make it through.

Culvert Sedimentation: Sedimentation build up in culverts poses another hurdle. Agricultural land use and urbanization are two factors that speed up erosion processes which in turn provide a higher amount of sediment transport within the channel. Urbanization, if not properly regulated, can alter the natural slop and flow path on a property resulting in increased run off. This means that during a storm event there will be more erosion on the stream bank and an increase in peak flow. For agricultural land, if there are improperly installed drains and a lack of riparian zone vegetation (as seen along the South River), there will also be more sediment transport and run off during peak flow. As there are both urbanization and expanding agricultural fields within the South River watershed, culvert sedimentation can be considered an issue for the purpose of this study. If culverts are not designed to withstand these increased levels of sediment load, it can cause a buildup and inhibit both water flow and fish passage.

The road crossing conditions for the main stem of the South River are well known and easily accessible for assessments. Below there is a map with a corresponding table showing the road crossing sites along the main channel broken up by section. The road crossings for the smaller tributaries are not as accessible for assessments as a significant number of them are forestry or private woodlot roads. Assessments will be done for all road crossings within the coming years, but the main focus of this document is to identify barriers on the main stem of the South River as well as the main channels in the major tributaries (table and maps below).

Table 18: Overview of South River main channel road crossings		
Section	**Total Road Crossings**	**Main Channel Road Crossings**
Lower South River	81	1
Middle South River	83	3
Upper South River	21	2
Headwaters	21	2
Total	**206**	**8**

Figure 50: Looking downstream towards the Blacksmith Valley Road bridge

As seen in the above photo, the river was historically channelized in order the achieve the perpendicular flow to the bridge. This has caused over-widening of the channel resulting in shallow water with no defined thalweg. The water temperatures during the summer months reach above 20°C, which is he point when Atlantic Salmon begin to really feel the stress and often times will die. Another reason for the extreme temperatures in the summer is lack of riparian vegetation to provide shade. During the winter months, the shallowness of the entire width of the channel causes freezing down to the substrate in some sections which can kill off the fertilized eggs in the salmon redds that are buried in the substrate. The floodplains provide many functions in a river system, one of them being an overflow for ice sheets in the winter, but due to the loss of connection between channel and floodplain, the ice sheets stay in the channel and cause jams along the river that scour the substrate down to bedrock in some areas. When a salmon senses the lack of pools along its upstream migration route (bedrock bottom), they will not try to go any further and instead build the redds in the lower reaches along with the other salmon and this can lead to a high density of salmon fry leading to extreme competition for already limited food and shelter.

The bridge on this section of the South River is too narrow for the peak flows of the South River and as a result there is severe bank erosion (seen to the right). What happens here is the water gets backed up due to the narrowness of the bridge and it creates a whirlpool that will eat away at the upstream bank – especially if there is not enough large vegetation to hold the soil in place. This site, similar to the previous photo, was channelized when this road crossing was built and has caused similar issues of over-widening, and shallow, warm water. The winter ice jams can be quite severe in this upstream section because they cannot flow freely under the bridge, and they are not able to be deposited into the floodplain so they get backed up and cause more erosion along both sides of the river upstream.

Figure 51: Looking downstream at the Cumming Mills Crossing Road bridge

The road crossings on the main channels in each of the major tributaries are mainly culvert crossings with either steel culverts of wooden box culverts installed. Fortunately, there are regulations in place now that require any road crossing reconstruction to install specially made cement culverts that have baffles inside of them so during low flows the water will be backed up creating a deeper channel through the culvert for fish to move through with ease. With the installation of these special culverts there will be an increase of fish passage and spawning further up into the South River watershed.

Table 19: Overview of major tributary road crossings

Sub Watershed	Total Road Crossings	Main Channel Road Crossings
Pinevale Brook	47	7
Polson's Brook	25	4
Hattie Millstream Brook	15	3
Total	**87**	**14**

3.0 Restoration Planning

This document proposes to restore fish habitat in the South River by implementing a watershed-scale restoration plan that systematically addresses shortcomings in habitat features (e.g., absence of LWD etc.) by using established-restoration techniques such as digger logs, bank stabilization and riparian zone planting, log deflectors and rock sills. The selection of techniques will depend on habitat features and upstream catchment size for each restoration site. Work in the main channel is expected to focus on using bank stabilization techniques including armour stone banking using rip rap and large tree root wads as well as riparian zone planting. Work in the tributaries will focus on digger logs, deflectors, rock sills and hand-rocking banks. This project also proposes significant community and landowner consultation and education in hopes of reducing harmful activities within the floodplain such as land-clearing, specifically near important buffer zones.

It is important to note that not all reaches are suitable for restoration activity, reaches with less than 4.0 km^2 in upstream watershed area or with stream gradients greater than 3% are not deemed suitable for the work proposed in this document. The recovery of habitats outside these specifications is best achieved through natural processes. ARA can promote the natural recovery of these reaches through community engagement and education. Typically, steep slopes are found within confined valley bottoms and intrusion by human activities is not common. Reaches with steep gradients (<3%) are best managed and improved by promoting less harmful land-use practices in the adjacent floodplain. Streams with smaller drainage areas lack the hydrological force required for digger logs and other structures to influence instream habitats. The calculation of available habitat for restoration only counted habitat that was suitable for instream restoration.

3.1 Restoration Techniques

Commonly applied techniques for restoring fish habitat in Nova Scotia include the installation of LWD structures which are designed to mimic the natural function of embedded LWD. These structures which generally include digger logs, deflectors and artificial over-hanging banks are designed to create a stable meander pattern in the channel which should contain a channel sequence of run, riffle and pool habitat types. Each habitat type in a naturally occurring meander pattern provides habitat niches for various life-stages of salmonids. A survey of tributaries to the South River in 2019 by Adopt a Stream found that many of the smaller tributaries were running dry during the summer months. According to landowners along the South River it was quite common in years past to see adult salmon spawning in these little streams. If salmon are continuing to use these streams as spawning nurseries, then it is quite likely that much of the progeny of those fish aren't surviving their first summer. Restoring year-round flow to these small brooks can be achieved by increasing upstream water storage capacity by installing artificial beaver dams, a restoration technique that is growing in popularity in the United States and the United Kingdom.

When planning any restoration activity there are always challenges that need to be worked around. For the main stem of the South River, access to restoration sites will not be a major issue as the majority of surrounding land is active or old agricultural fields, but this however does limit the potential for full restoration. Working in the tributaries can be more challenging accessibility-wise, however, there is no large machinery or material required for the restoration work in the smaller watercourses, so it is a matter of finding access points for the field crews to unload equipment ad material for installing in-stream structures and tree planting. Another challenge at times is land-owners who, for the most part are quite willing to give permission for the restoration to go ahead, but some are hesitant due to the thought of losing some of their agricultural land or their cleared view of the river bank.

3.2 Breakdown of Watershed Stewardship Plan

The conservation activities presented in this plan are prioritized based on several metrics including landowner permission, severity of degradation and the potential to prevent serious adverse effects to occur or exacerbate. While restoration work is proposed in several tributaries within the South River, not all the tributaries had potential for restoration work therefore priority for assessment and planning work were given to streams and reaches within the South River watershed that had potential for instream restoration work.

This conservation plan is focused on providing a step-wise year to year plan for the Antigonish Rivers Association to guide their future river restoration activities. The plan focuses specifically on what is possible to complete in the next five years (2022-2026) assuming similar levels of volunteer commitment and financial support that have been typical for their organization over the past decade. A five-year plan also represents the most feasible time frame for river restoration work to be planned for. The changing nature of river systems generally makes planning specific activities in the long term a difficult task.

Table 20: Overview of 5-year budget

Year	Planned Conservation Activity	Financial Budget
2022	**South River Main Branch:** Restoration will be completed to address stream bank erosion and to establish a wooded riparian zone vie tree planting of native floodplain species. The restoration techniques used to stabilize the riverbank will use armour rock and root wads. This will improve summer water temperatures and minimize sediment supply that is impacting	$20,000

	downstream spawning habitat.	
	South River Main Branch (Monitoring): HSI Surveys (20 sites), Temperature Probes deployed (12), Electrofishing (4 sites), CABIN Studies (2 sites) – with the goal to collect sufficient baseline data in order to measure restoration progress and efficiency.	$14,000
	South River Main Branch (Tree Planting):	$5,000
	Pinevale Brook (Monitoring): HSI Surveys (30 sites), Temperature probes deployed (5), Electrofishing (4+ sites), CABIN Studies (2 sites) - with the goal to collect sufficient baseline data in order to measure restoration progress and efficiency.	$14,000
	Pinevale Brook (In-Stream Restoration): Work will be completed using a field crew to install digger logs and deflectors below and above the Dunmore Road Bridge. The restoration site is ~3km long with the goal of decreasing channel width, improving spawning habitat, and increase pool habitat.	$20,000
	Wetland Restoration: To enhance water storage capacity within the watershed to address issues such as low summertime base flow and flood mitigation.	$7,500
	Total	$80,500
2023	**South River Main Branch:** Restoration will be completed to address stream bank erosion and to establish a wooded riparian zone vie tree planting of native floodplain species. The restoration techniques used to stabilize the riverbank will use armour rock and root wads. This will improve summer water temperatures and minimize sediment supply that is impacting downstream spawning habitat.	$20,000
	South River Main Branch (Monitoring): Temperature Probes deployed (12), Electrofishing (4 sites), CABIN Studies (2 sites) – with the goal to collect sufficient baseline data in order to measure restoration progress and efficiency.	$10,000
	Pinevale Brook (Monitoring): Temperature probes deployed (5), Electrofishing (4+ sites), CABIN Studies (2 sites) - with the goal to collect sufficient baseline data in order to measure restoration progress and efficiency.	$10,000
	Pinevale Brook (In-Stream Restoration):	$10,000
	In-Stream Maintenance:	$7,500
	South River Main Branch (Tree Planting):	$5,000
	Wetland Restoration: To enhance water storage capacity within the watershed to address issues such as low summertime base flow and flood mitigation.	$15,000
	Total	$77,500
2024	**South River Main Branch (Monitoring):** Temperature Probes deployed (12), Electrofishing (4 sites), CABIN Studies (2 sites) – with the goal to collect sufficient baseline data in order to measure restoration progress and efficiency.	$10,000

	Pinevale Brook (Monitoring): Temperature probes deployed (5), Electrofishing (4+ sites), CABIN Studies (2 sites) - with the goal to collect sufficient baseline data in order to measure restoration progress and efficiency.	$10,000
	South River Main Branch: Restoration will be completed to address stream bank erosion and to establish a wooded riparian zone vie tree planting of native floodplain species. The restoration techniques used to stabilize the riverbank will use armour rock and root wads. This will improve summer water temperatures and minimize sediment supply that is impacting downstream spawning habitat.	$20,000
	Polson's Brook (In-Stream Restoration):	$10,000
	In-Stream Maintenance:	$10,000
	South River Main Branch (Tree Planting):	$5,000
	Wetland Restoration: To enhance water storage capacity within the watershed to address issues such as low summertime base flow and flood mitigation.	$15,000
	Total	$75,500
2025	**South River Main Branch (Monitoring):** Temperature Probes deployed (12), Electrofishing (4 sites), CABIN Studies (2 sites) – with the goal to collect sufficient baseline data in order to measure restoration progress and efficiency.	$10,000
	Pinevale Brook (Monitoring): Temperature probes deployed (5), Electrofishing (4+ sites), CABIN Studies (2 sites) - with the goal to collect sufficient baseline data in order to measure restoration progress and efficiency.	$10,000
	South River Main Branch: Restoration will be completed to address stream bank erosion and to establish a wooded riparian zone vie tree planting of native floodplain species. The restoration techniques used to stabilize the riverbank will use armour rock and root wads. This will improve summer water temperatures and minimize sediment supply that is impacting downstream spawning habitat.	$20,000
	In-Stream Maintenance:	$10,000
	South River Main Branch (Tree Planting):	$5,000
	Wetland Restoration: To enhance water storage capacity within the watershed to address issues such as low summertime base flow and flood mitigation.	$15,000
	Total	$70,000
2026	**South River Main Branch (Monitoring):** HSI Surveys (20 sites), Temperature Probes deployed (12), Electrofishing (4 sites), CABIN Studies (2 sites) – with the goal to collect sufficient baseline data in order to measure restoration progress and efficiency.	$14,000
	Pinevale Brook (Monitoring): HSI Surveys (30 sites), Temperature probes deployed (5), Electrofishing (4+ sites), CABIN Studies (2 sites) - with the goal to	$14,000

	collect sufficient baseline data in order to measure restoration progress and efficiency.	
	South River Main Branch: Restoration will be completed to address stream bank erosion and to establish a wooded riparian zone vie tree planting of native floodplain species. The restoration techniques used to stabilize the riverbank will use armour rock and root wads. This will improve summer water temperatures and minimize sediment supply that is impacting downstream spawning habitat.	$20,000
	In-Stream Maintenance:	$10,000
	South River Main Branch (Tree Planting):	$5,000
	Wetland Restoration: To enhance water storage capacity within the watershed to address issues such as low summertime base flow and flood mitigation.	$15,000
	Total	$78,000
2022-2026	**Total**	$381,500

Table 21: Overview of main channel restoration work

Site #	Coordinates	Length	Area Restored	Overview of Restoration Required
1	45.4615249N, -61.9391565W	80m	1,600m^2	Bank stabilization using armour stone rip rap and tree root wads, riparian zone enhancement
2	45.4630997N, -61.9400201W	70m	1,190m^2	Riparian zone restoration, bank rock using armour stone rip rap
3	45.4714533N, -61.9394696W	30m	570m^2	Bank stabilization using stone rip rap and root wads, installation of armour stone kickers, riparian zone enhancement
4	45.4725314N, -61.9402011W	30m	180m^2	Riparian zone restoration
5	45.4735043N, -61.9420337W	40m	240m^2	Riparian zone restoration
6	45.5082775N, -61.9359251W	275m	46,750m^2	Major riparian zone enhancement – tree planting entire field
7	45.5338261N, -61.9176563W	60m	300m^2	Riparian zone enhancement
8	45.5488285N, -61.9074298W	75m	450m^2	Riparian zone restoration
9	45.5500202N, -61.9078287W	30m	180m^2	Riparian zone restoration

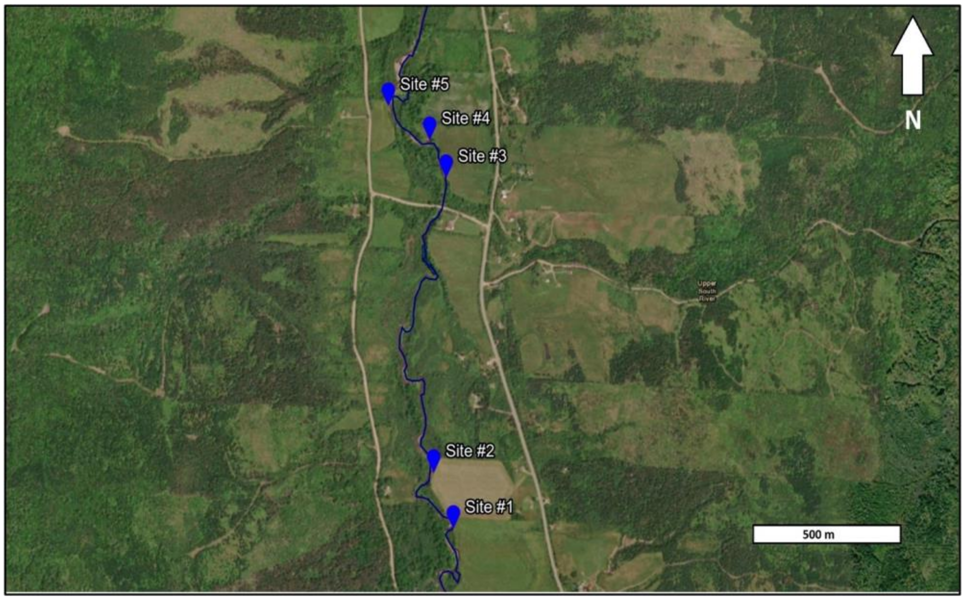

Figure 52: Aerial Map of South River main channel work sites 1-5

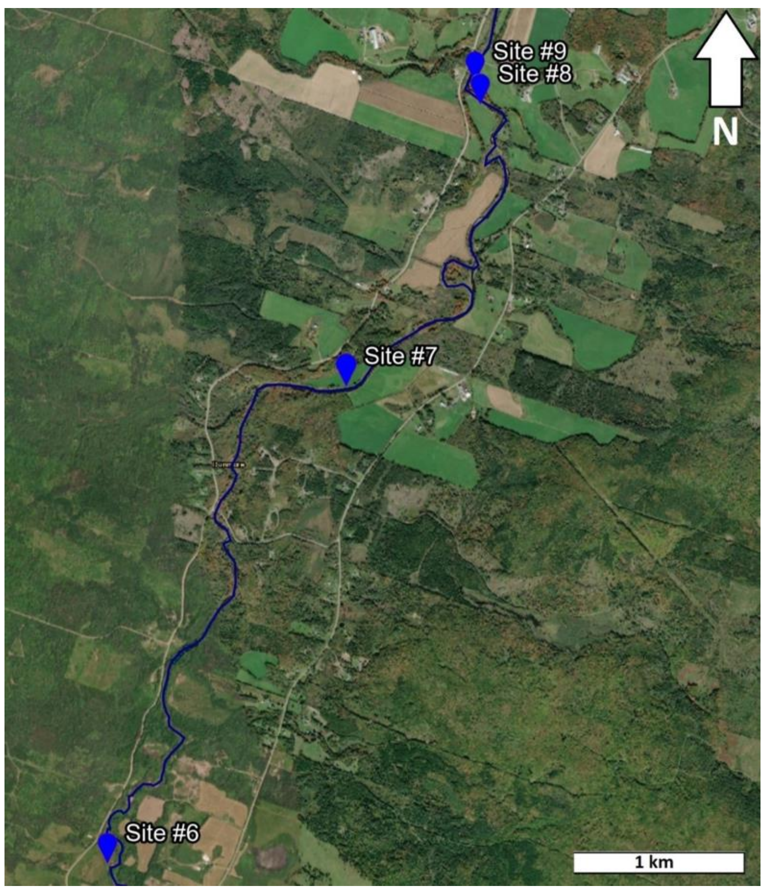

Figure 53: Aerial map of South River main channel work sites 6-9

4.0 Monitoring Program

A common critique of instream restoration projects is that they are conducted without sufficient baseline data and the post-project results are seldom measured. Furthermore, when it comes to data related to Atlantic salmon populations in the South River watershed, information is quite scarce and only one entity is completing any annual monitoring. Therefore, a key component to this restoration plan is to provide ARA with a stepwise monitoring program that utilizes equipment that the group has acquired or is able to take out on loan from the Atlantic Water Network. The ARA has also sponsored some employees to obtain specific monitoring certificates from the DFO that they will be putting to use.

Monitoring will focus on electrofishing data, which primarily measures juvenile salmon abundance. This technique is widely used by DFO, NS Inland Fisheries and the Nova Scotia Salmon Association. The density of young of the year (YoY) fry are an indicator of the past season's spawning success and spatial distribution. While the density of Atlantic salmon parr and smolts is an indicator of juvenile survival and age class distribution. Metrics such as fork length (i.e., length of fish) can provide information regarding growth rates and primary productivity in each site. Another important metric to monitor is water temperature. Deployable water temperature probes should be installed in the major tributaries, and several should be installed in the main channel. There will also be supplemental monitoring data collected via CABIN surveys, HSI Assessments and Salmon redd count surveys.

4.1 Water Temperature Logging Surveys

Water temperatures were recorded using HOBOware Deployable loggers which are programmed to record water temperatures every fifteen minutes for a specific time frame which we typically set for June 1st to October 1st annually. Setting the temperature loggers to cover this specific time span will help us identify trends in temperature ranges through the hottest months of the year. Issues for salmon begin when water temperatures exceed 23°C for periods of time greater than 24 hours. Atlantic salmon fry are more resilient to water temperatures and can withstand brief periods (less than 24 hours) of temperatures at or below 27° C.

Restoration of instream habitat will promote the formation of gravel bars and the natural meander pattern associated with healthy aquatic ecosystems. These features promote downwelling to occur near the tail-end control of pools which is the driving force behind the surface – ground water interchange. As the structures create deeper pools and narrower channels over time, it is expected water temperatures will cool during the summer months and daily high temperatures should be reduced.

Temperature loggers are provided by the NSSA, who also carry out the data analysis and provides the ARA with corresponding data tables.

4.1.1 2020 Temperature Surveys

Table 22: Overview of 2020 temperature probes

River	Probe #	Probe ID#	Coordinates	Location Description
South River	1	2085570	45.49201N, -61.933787W	Downstream from Hatchery Dam
South River	2	2085574	45.50786N, -61.93575W	Dunmore Road downstream from Marsh Crossing Road
Hattie Millstream	3	20855876	45.26023N, -61.0903W	Marsh Crossing Road
Polson's Brook	4	20863382	45.44714N, -61.92942W	West Side South River Road
South River	5	20855900	45.49084N, -61.93875W	Downstream from Heuvaldale Farm
South River	6	20855913	45.44298N, -61.93191W	Downstream from Pinevale Road Bridge
South River	7	20855925	45.47132N, -61.93949W	Heuvaldale Farm Bridge
South River	8	20863378	45.45793N, -61.93932W	McPhee Cross Road
South River	9	20863384	45.56085N, -61.90402W	Downstream from Blacksmith Valley Road crossing
South River	10	20863385	45.49732N, -61.9393W	Fish Hatchery dam
South River	11	20863392	45.51125N, -61.93523W	West Side South River Road
South River	12	20863542	45.53401N, -61.92294W	Downstream from Cumming Mills Cross Road

Table 23: 2020 temperature probe data

Probe #	Avg. Temp (°C)	Min. Temp (°C)	Max Temp (°C)
1	20.84	11.5	44
2	20.47	7.5	38.5
3	N/A	N/A	N/A
4	21.5	1.5	47.5
5	21.12	11.5	40.5
6	21.7	8.5	42
7	20.43	7.5	40.5
8	20.78	8	38
9	21.63	11	36.5
10	20.64	11.5	43
11	20.61	11.5	37.5
12	20.8	12	37.5

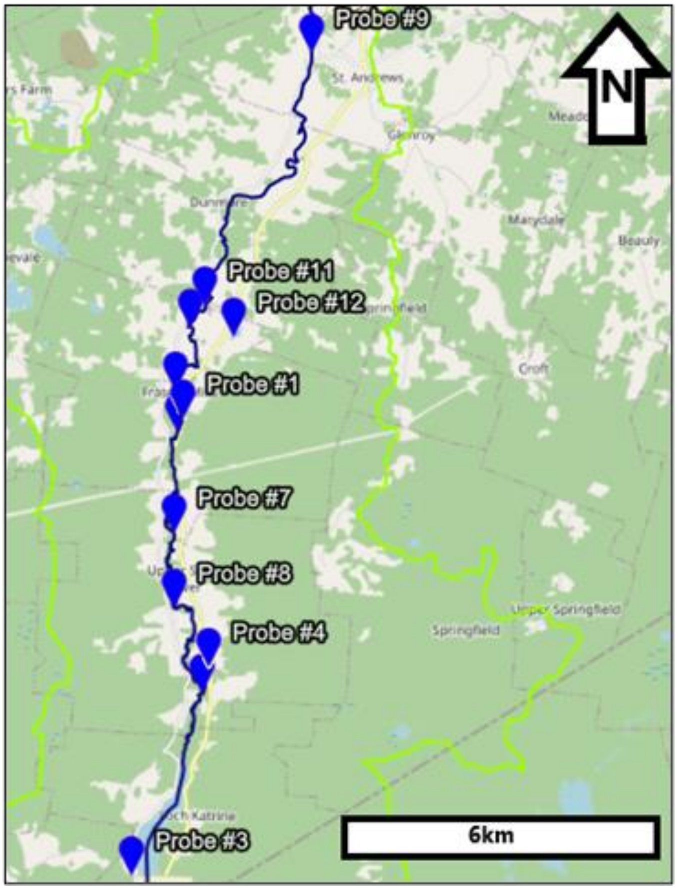

Figure 54: 2020 South River main channel temperature probe locations

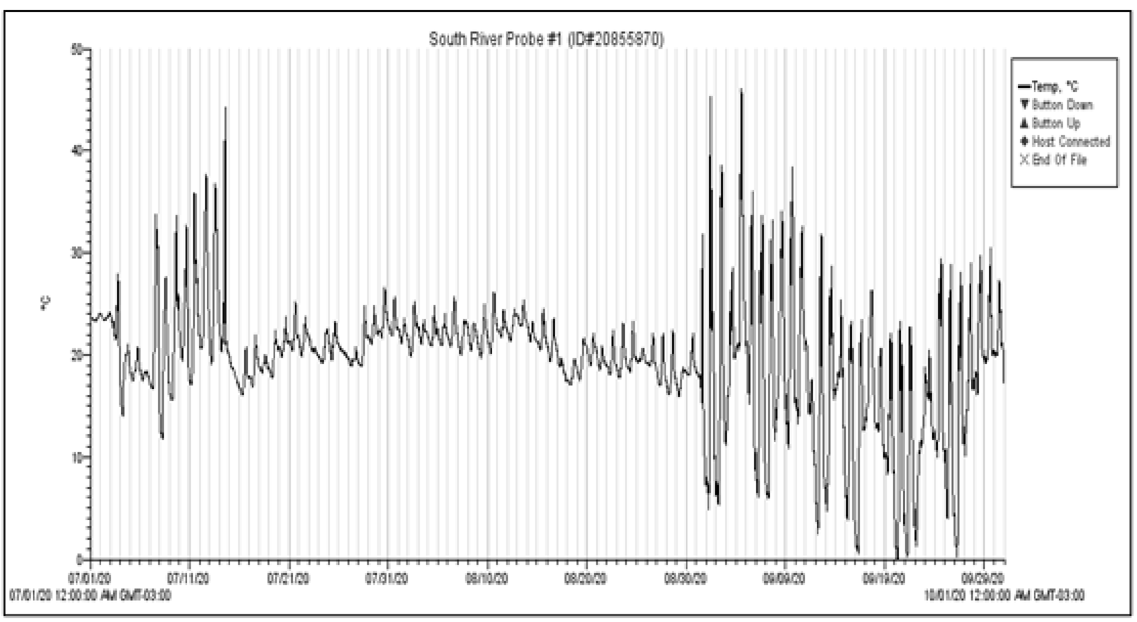

Figure 55: 2020 SR probe #1

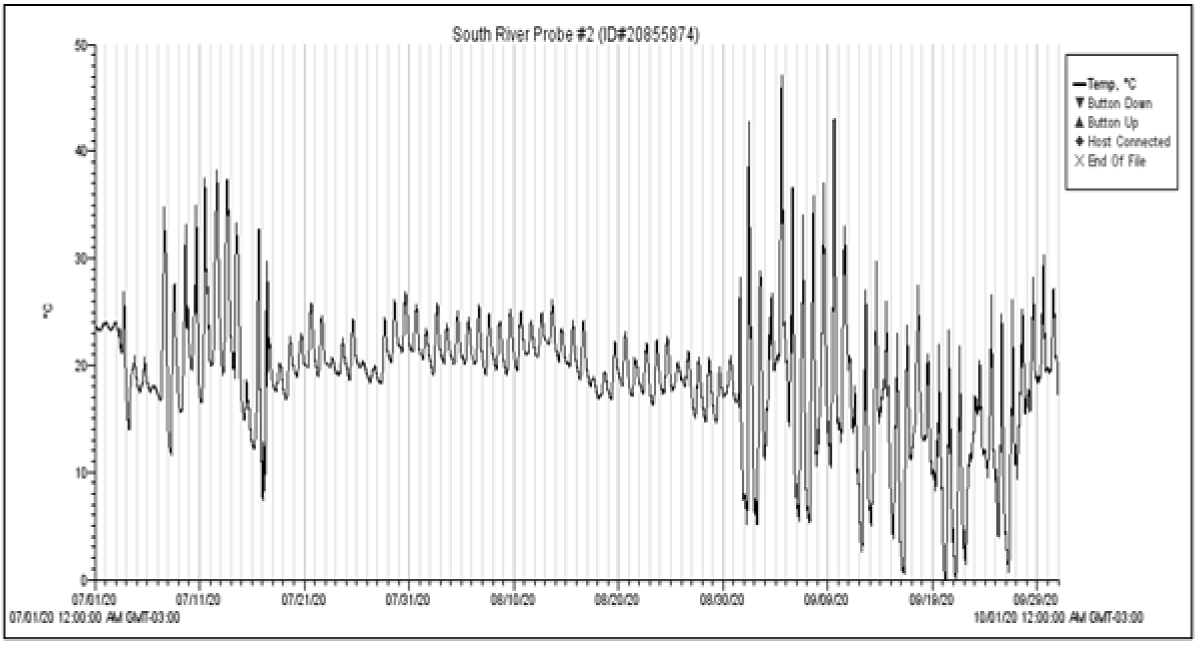

Figure 56: 2020 SR probe #2

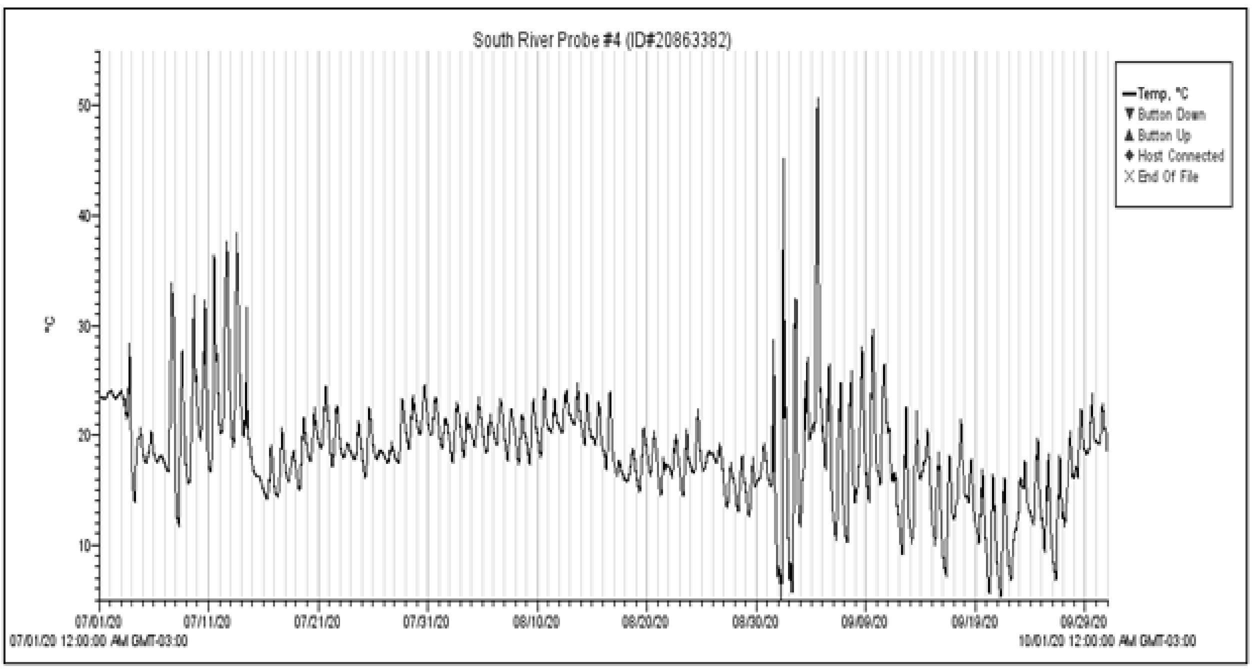

Figure 57: 2020 SR probe #4

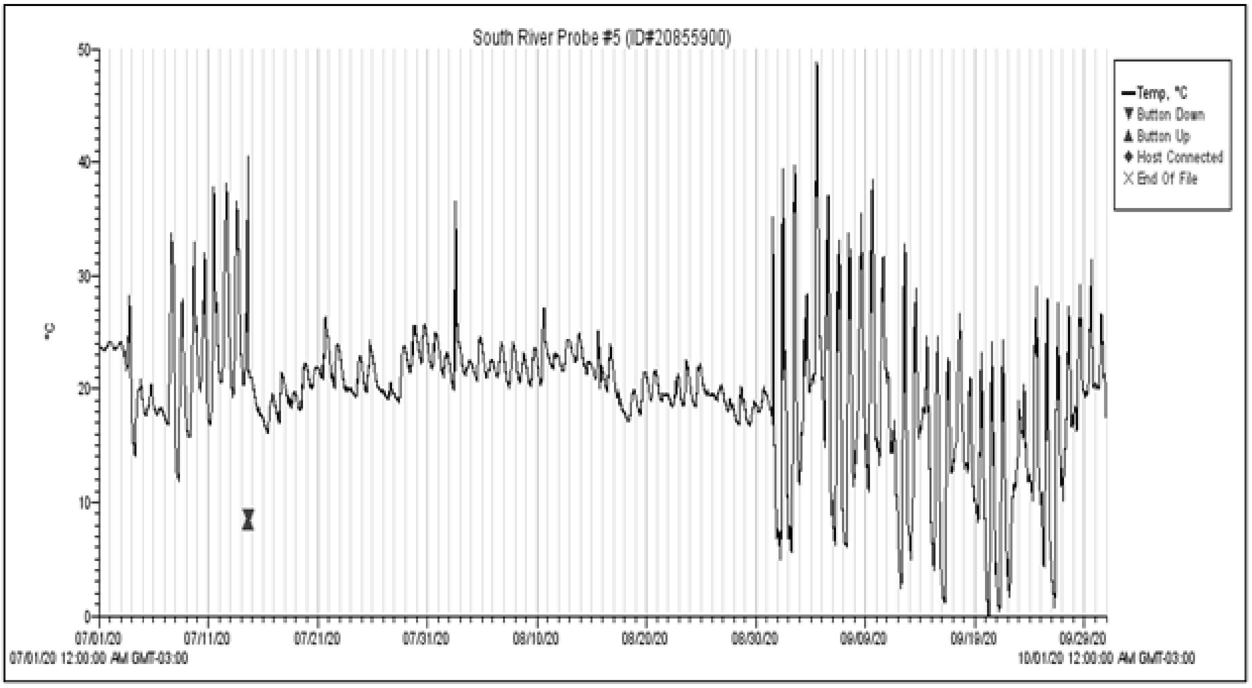

Figure 58: 2020 SR probe #5

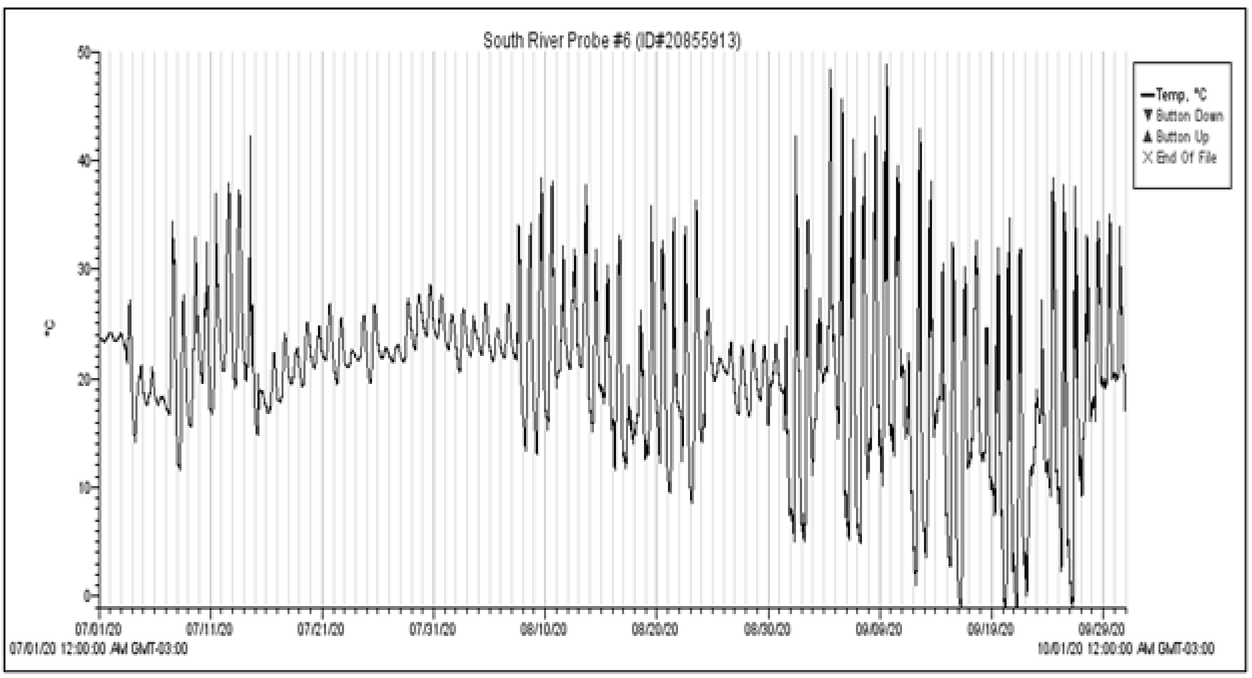

Figure 59: 2020 SR probe #6

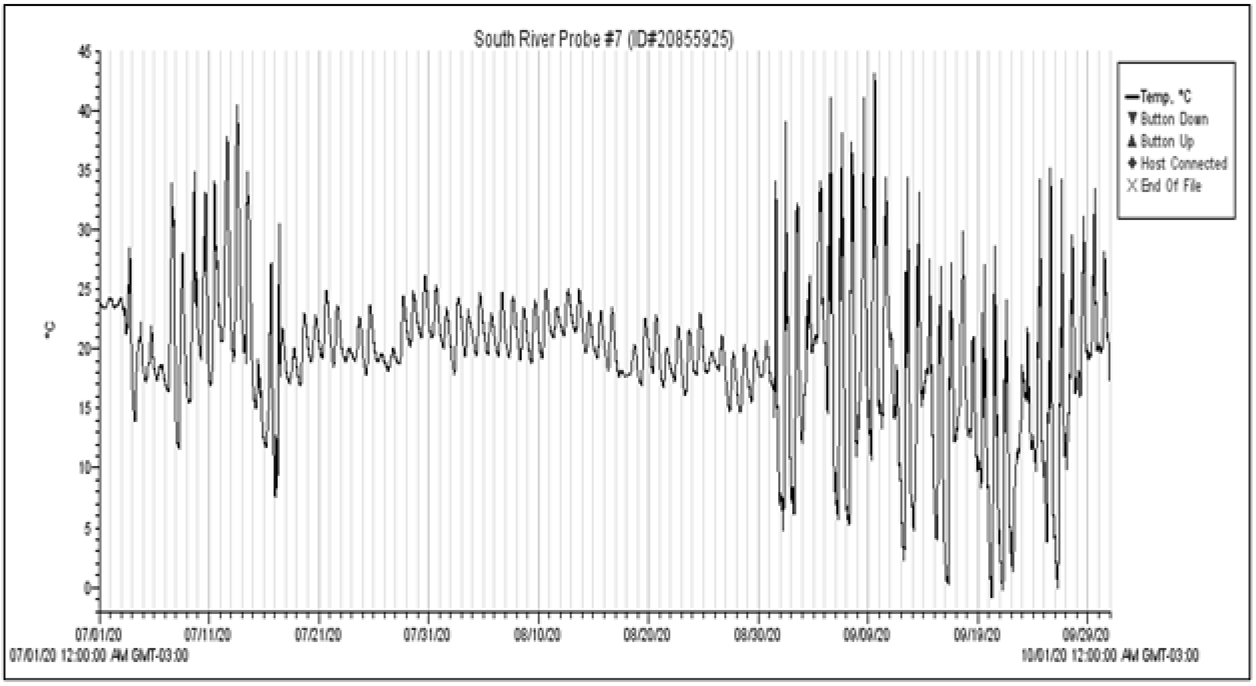

Figure 60: 2020 SR probe #7

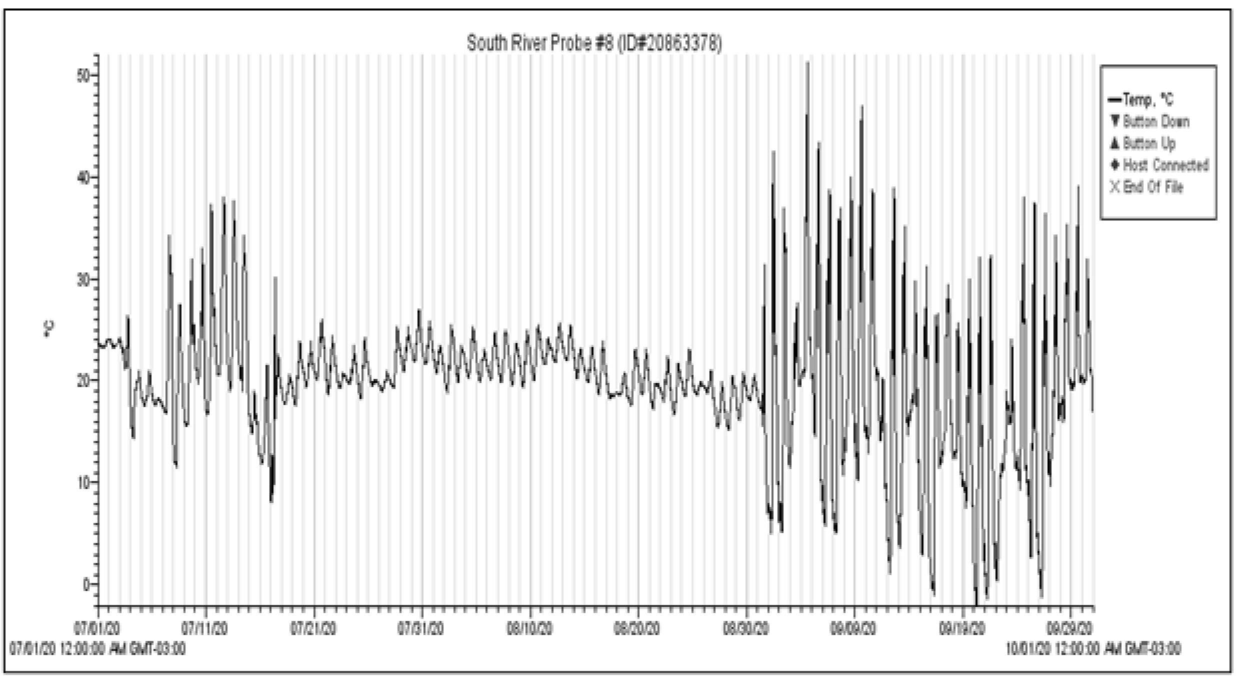

Figure 61: 2020 SR probe #8

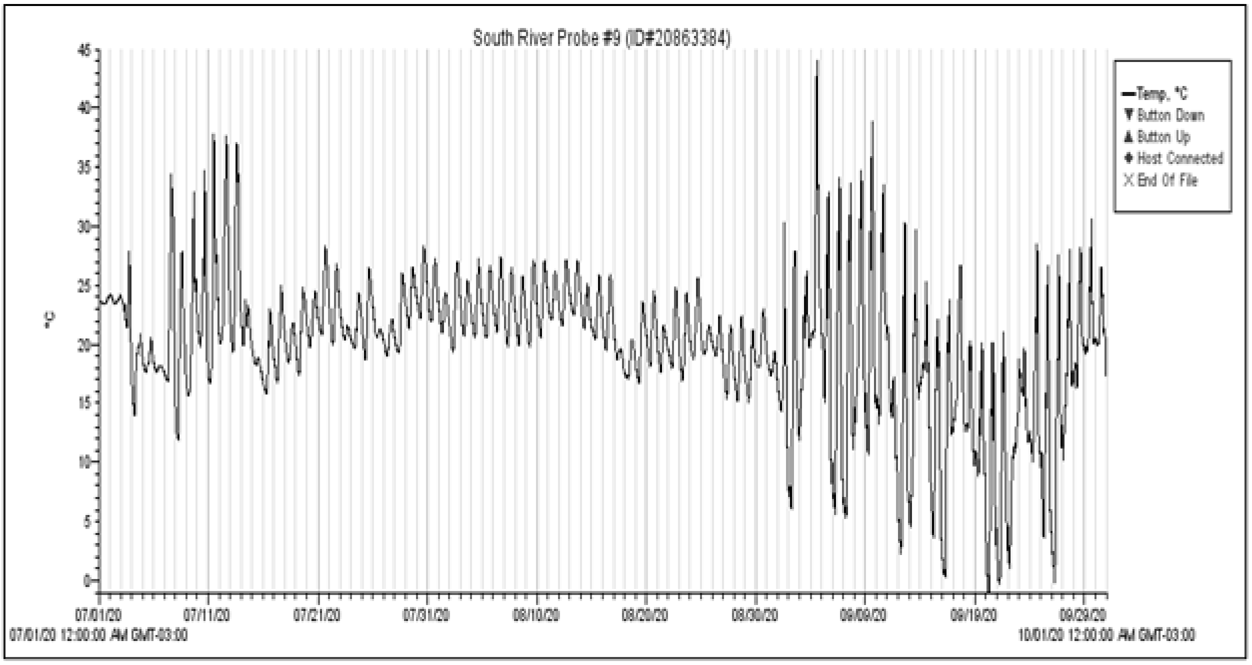

Figure 62: 2020 SR probe #9

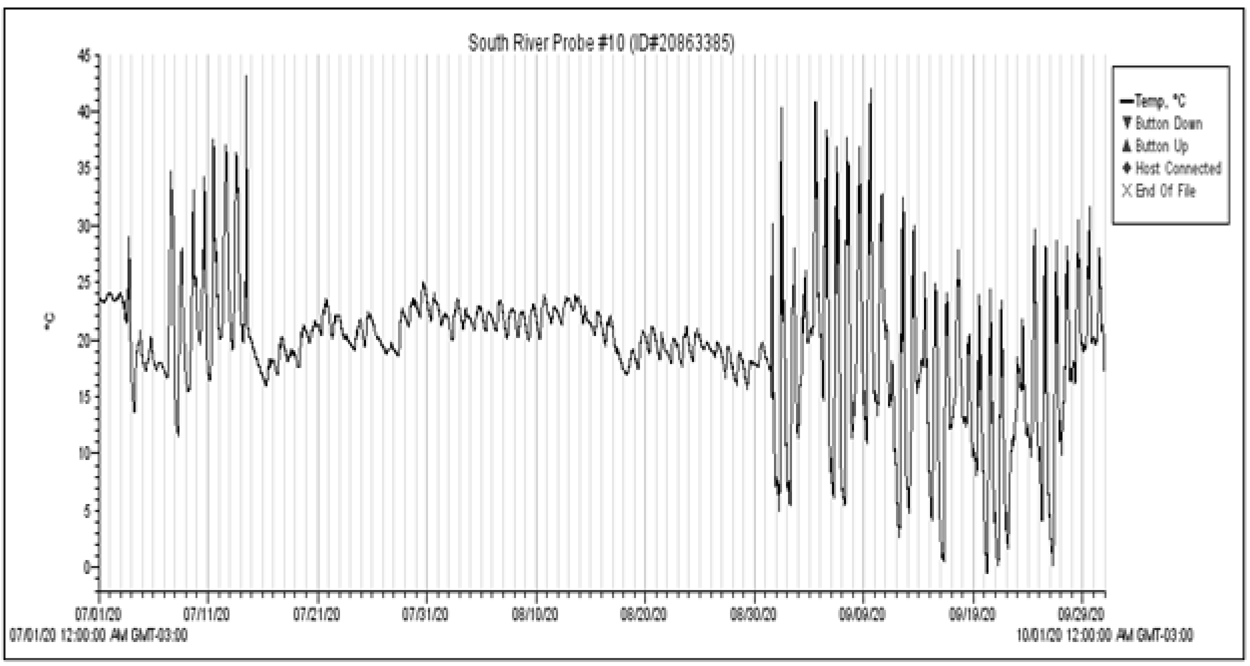

Figure 63: 2020 SR probe #10

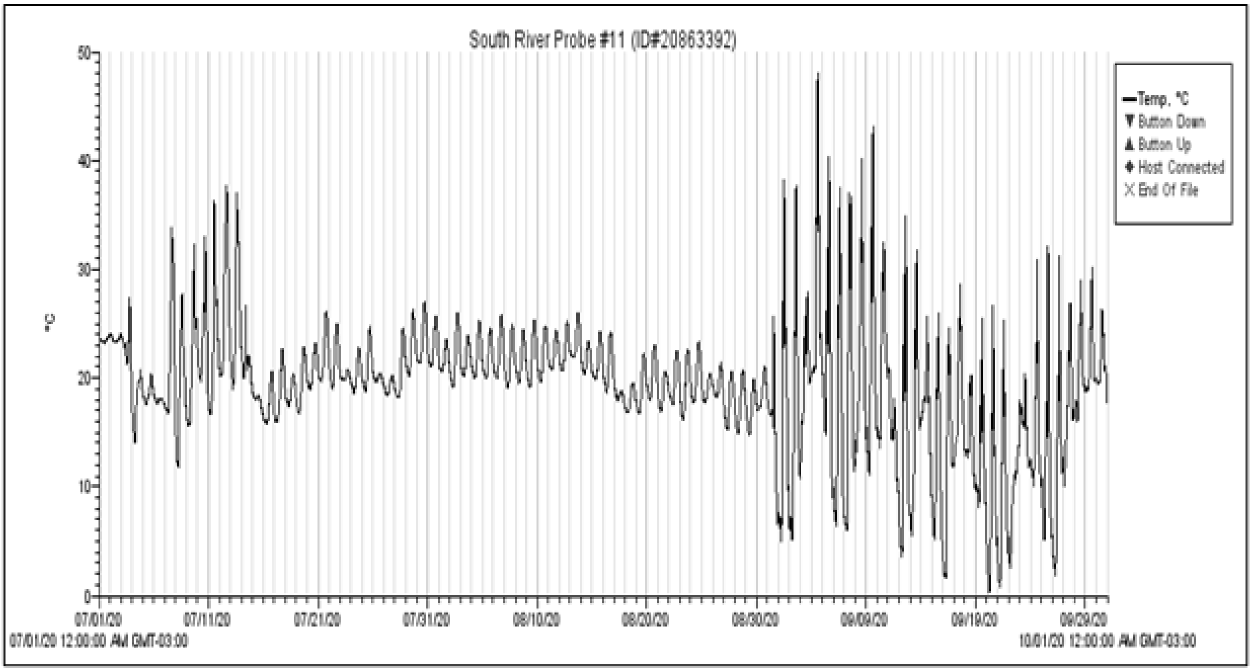

Figure 64: 2020 SR probe #11

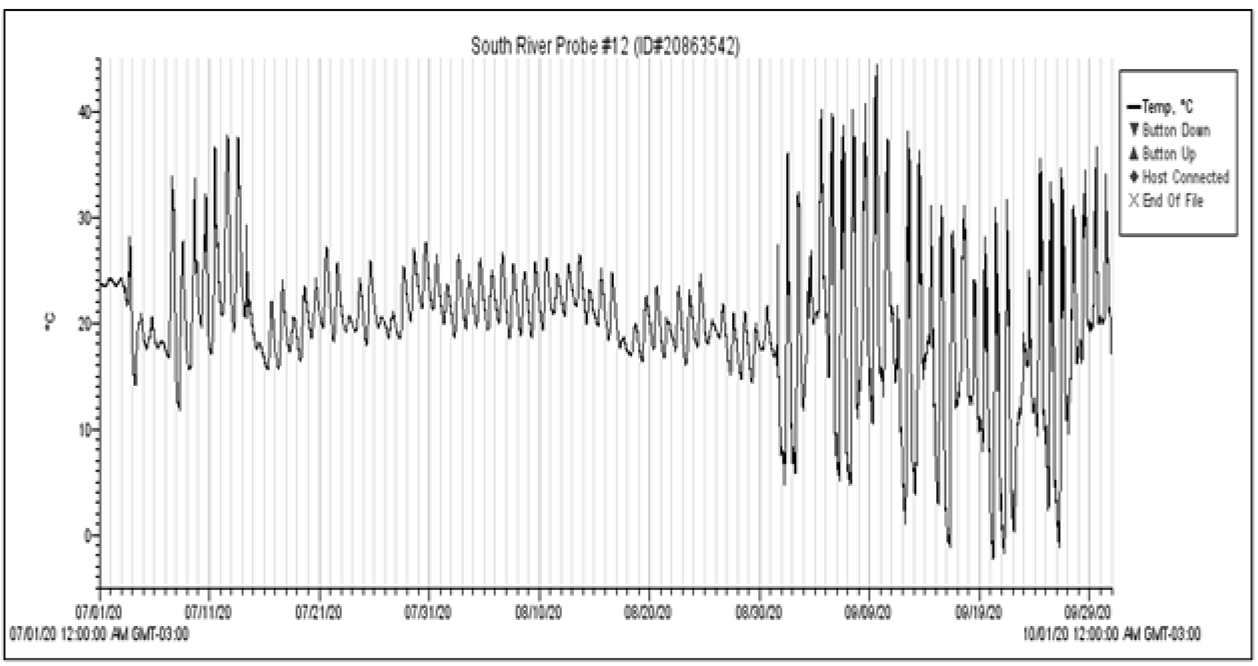

Figure 65: 2020 SR probe #12

4.1.2 2021 Temperature Surveys

Within the South River there was little variation in average summer temperature across sites, with nearly all sites recording an average summer temperature below 20 ^{0}C (Figure 66B). SOU144 (teal green boxplot), was the only site that recorded an average summer temperature of 20 ^{0}C (Figure 66B).

All sites recorded temperatures greater than 25 ^{0}C, at some time within the summer, but it was less common in upstream sites as indicated by the darker lines on the boxplots (Figure 66B). The highest maximum temperature reached was 28.61 ^{0}C, which was recorded at SOU144 in August. SOU144 Spent approximately 70% of August greater than 20 ^{0}C, and a quarter of August greater than 23 ^{0}C.

Overall, the vertical profile of the mainstem within the South River showed little to no variation within average temperatures, but high variation in temperatures at sites where temperatures went from 11-28 ^{0}C throughout the summer (Table 25; Figure 66B).

Table 24: Overview of 2021 temperature probes

River	Site ID	Probe ID #	Coordinates	Location Description
South River	SOU144	20863369	45.5609531N -61.9040358W	DS from Blacksmith Valley Rd Bridge
South River	SOU148	20855873	45.5338123N -61.9238515W	Dunmore Rd
South River	SOU147	20863376	45.5262774N -61.9267639W	Marsh Cross Rd
South River	SOU146A	20863389	45.5114042N -61.9349150W	West Side South River Rd DS
South River	SOU146B	20863382	45.5078071N -61.9358199W	West Side South River Rd US
South River	SOU149A	20855913	45.4980322N -61.9395370W	DS from Old Pinevale Rd. Bridge
South River	SOU149B	20855880	45.4920668N -61.9377748W	DS from Hatchery Dam
South River	SOU149C	20863386	45.4908914N -61.9385741W	Hatchery Dam
South River	SOU150A	20863542	45.4713469N -61.9395666W	Cummings Mills Cross rd.
South River	SOU150B	20855900	45.4579344N -61.9393474W	DS from Heuvaldale Farm
South River	SOU160	20855920	45.4539393N -61.9392418W	Heuvaldale Farm

South River	SOU152	20863381	45.4432299N -61.9315485W	MacPhee Crossing

Table 25: 2021 temperature probe data			
Site ID	**Avg. Temp (°C)**	**Min. Temp (°C)**	**Max Temp (°C)**
SOU144	19.53	11	29
SOU148	18.90	10.75	29
SOU147	18.67	11	26
SOU146A	18.87	12	26.5
SOU146B	18.66	11.5	26.5
SOU149A	N/A	N/A	N/A
SOU149B	18.83	11.5	28.5
SOU149C	N/A	N/A	N/A
SOU150A	18.85	10.5	26
SOU150B	N/A	N/A	N/A
SOU160	16.74	10.1	26.4
SOU152	N/A	N/A	N/A

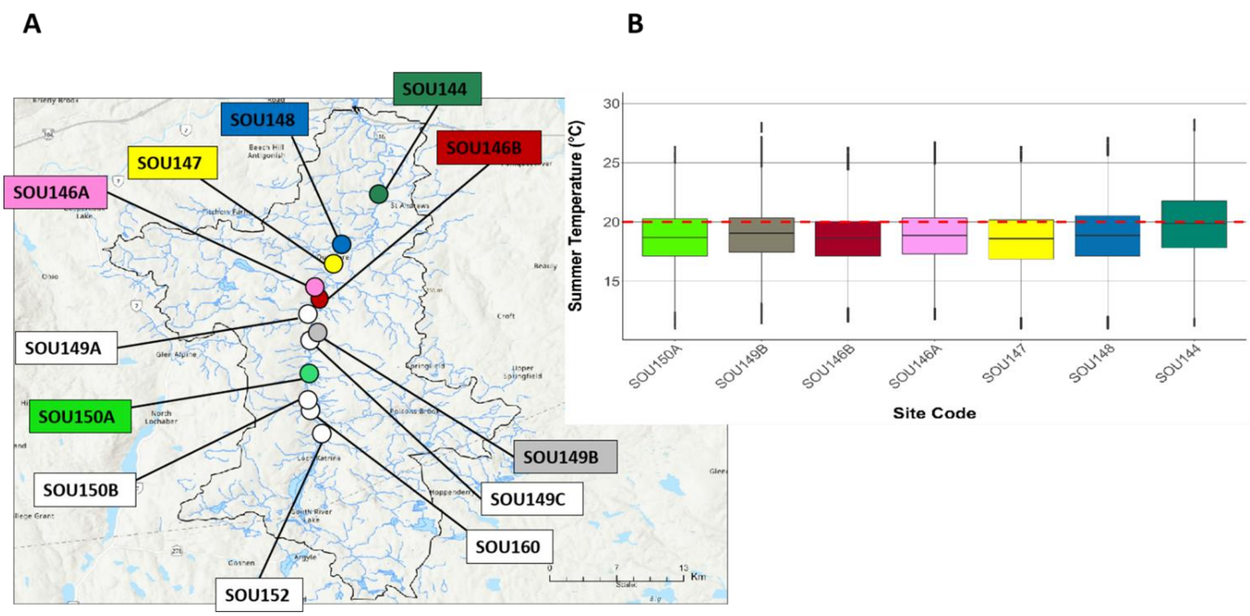

Figure 66: A: South River temperature probe locations. B: Corresponding boxplot graphs.

Colours in figure 66A are coordinated with the boxplots presented in figure B. Sites coloured white are ones that were not included in the final data set. The boxplots represent a summary of summer temperature, June -September 2021, within South River Antigonish watershed. Boxplots represent temperature at individual sites, and are ordered moving upstream to downstream, from lime green to dark green. Dashed red line at 20 ^{0}C identifies temperatures outside tolerance range of Atlantic salmon.

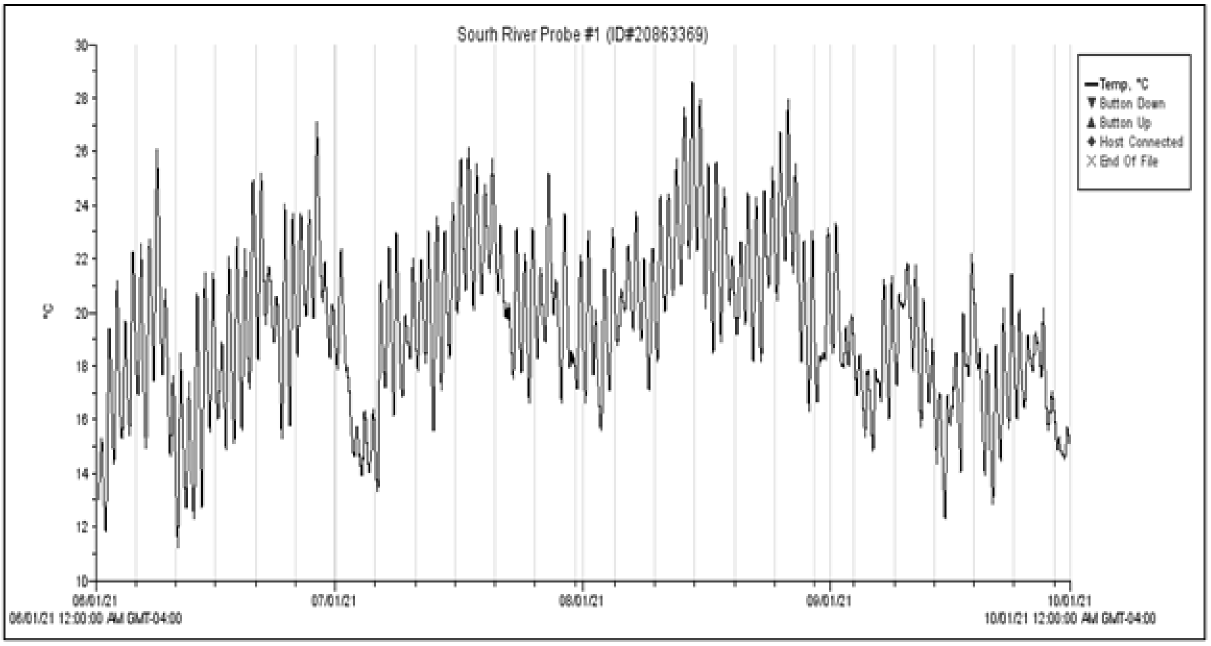

Figure 67: 2021 SR probe #1

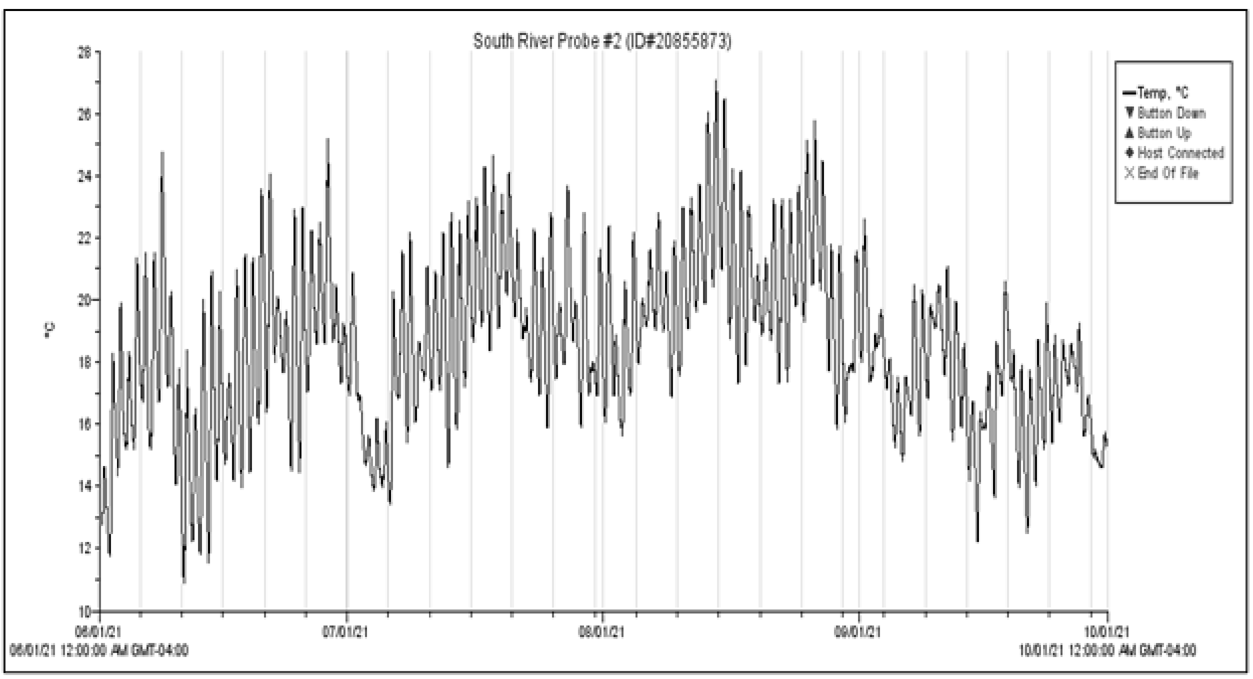

Figure 68: 2021 SR probe #2

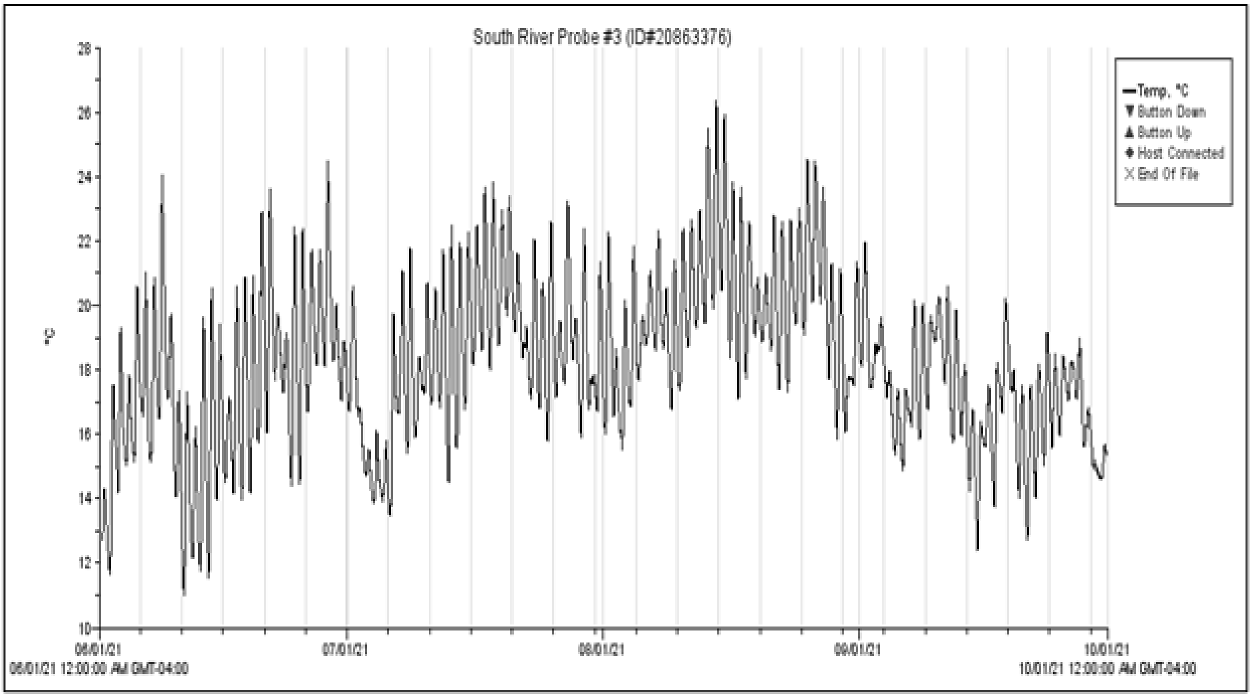

Figure 69: 2021 SR probe #3

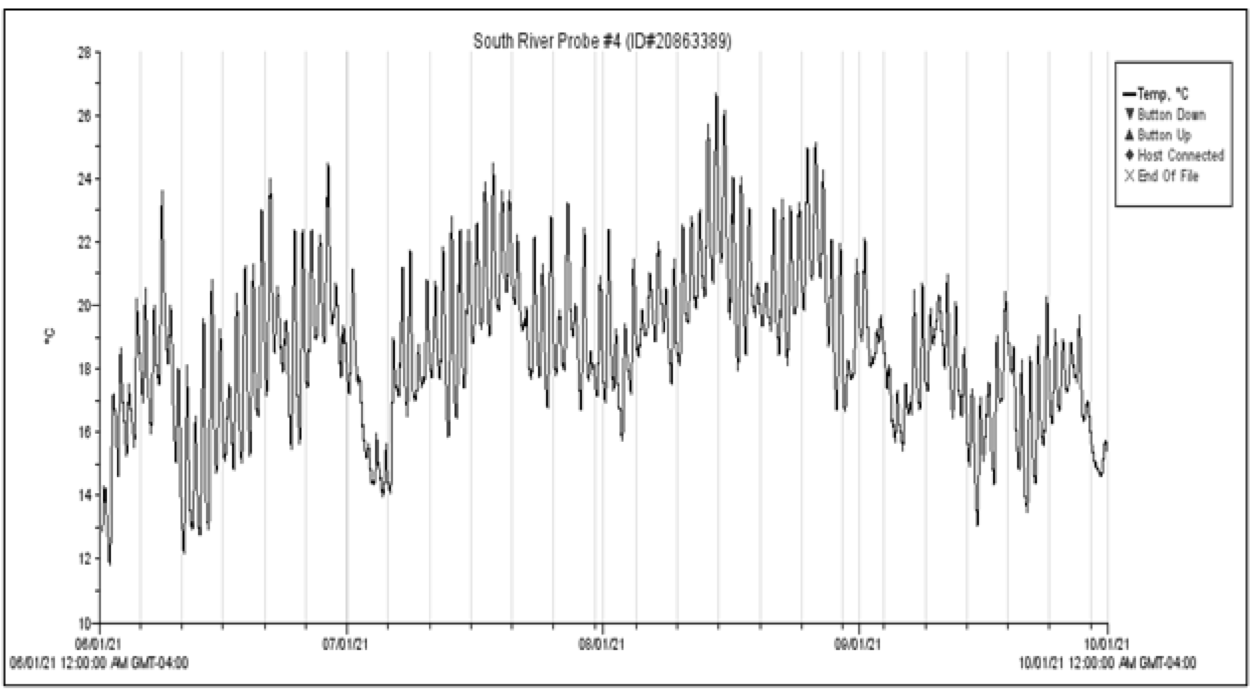

Figure 70: 2021 probe #4

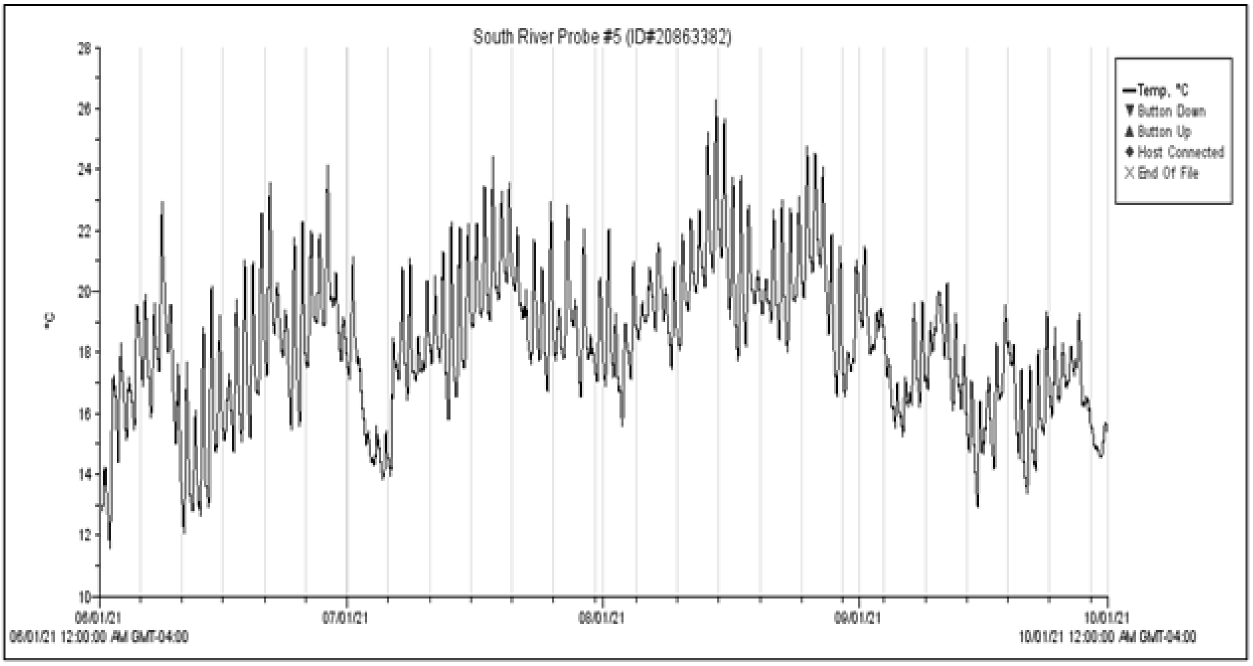

Figure 71: 2021 SR probe #5

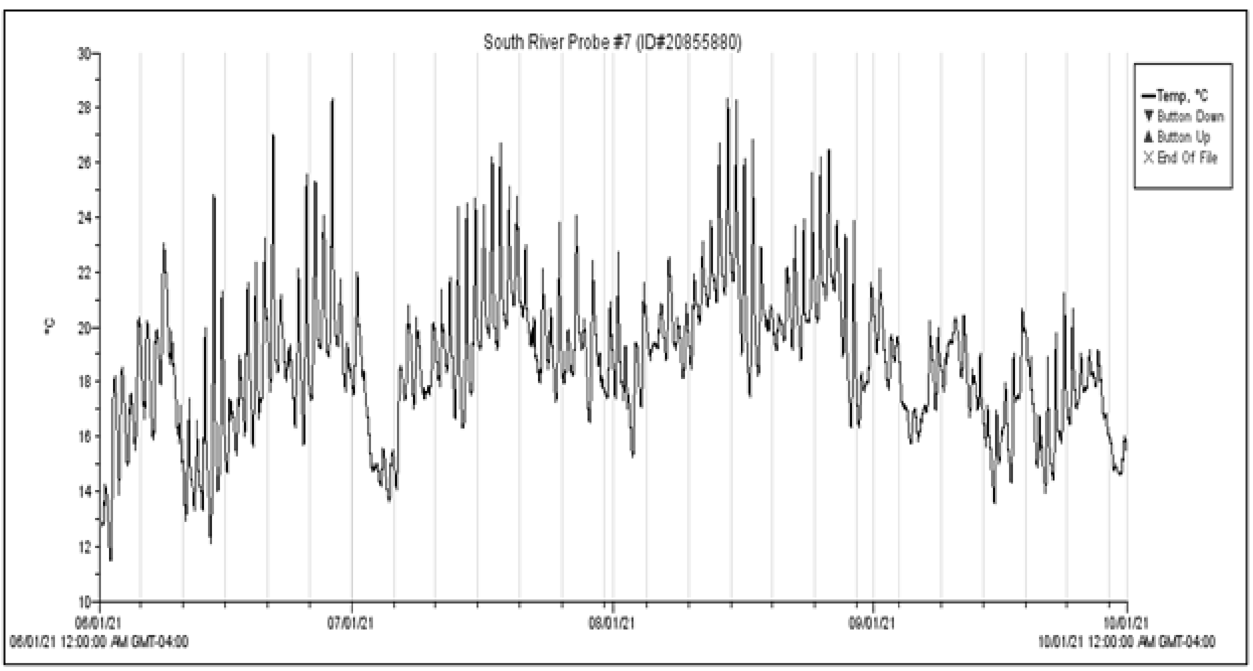

Figure 72: 2021 SR probe #7

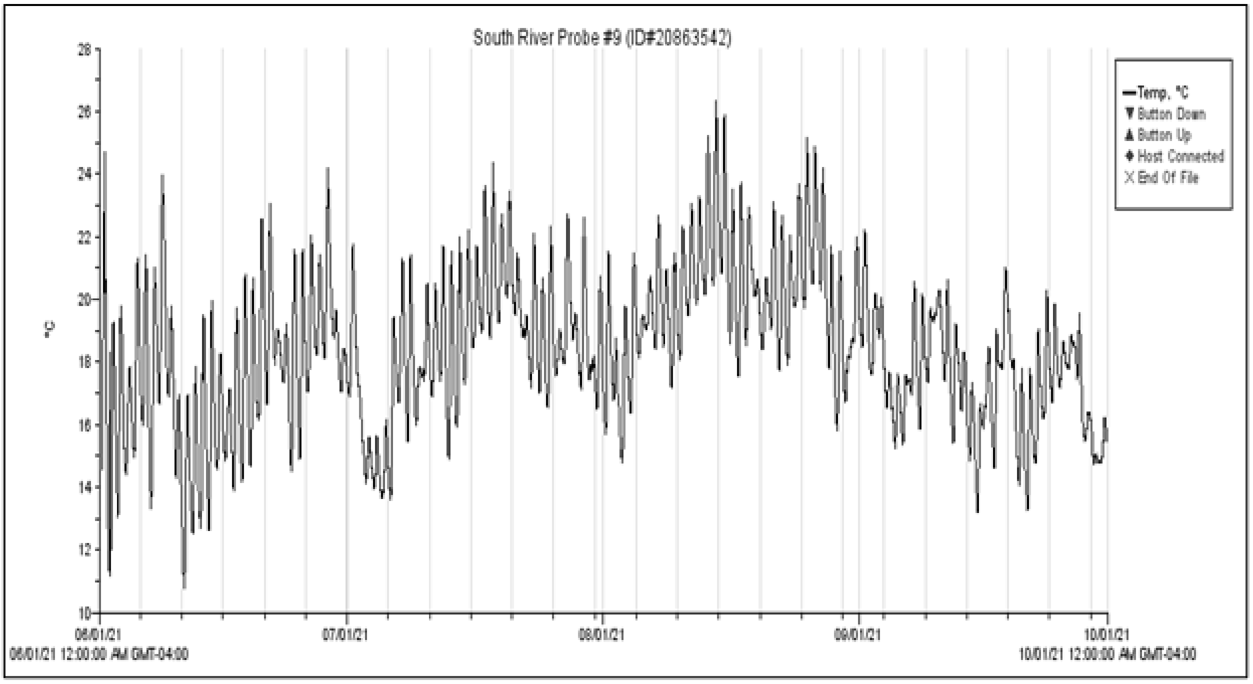

Figure 73: 2021 SR probe #9

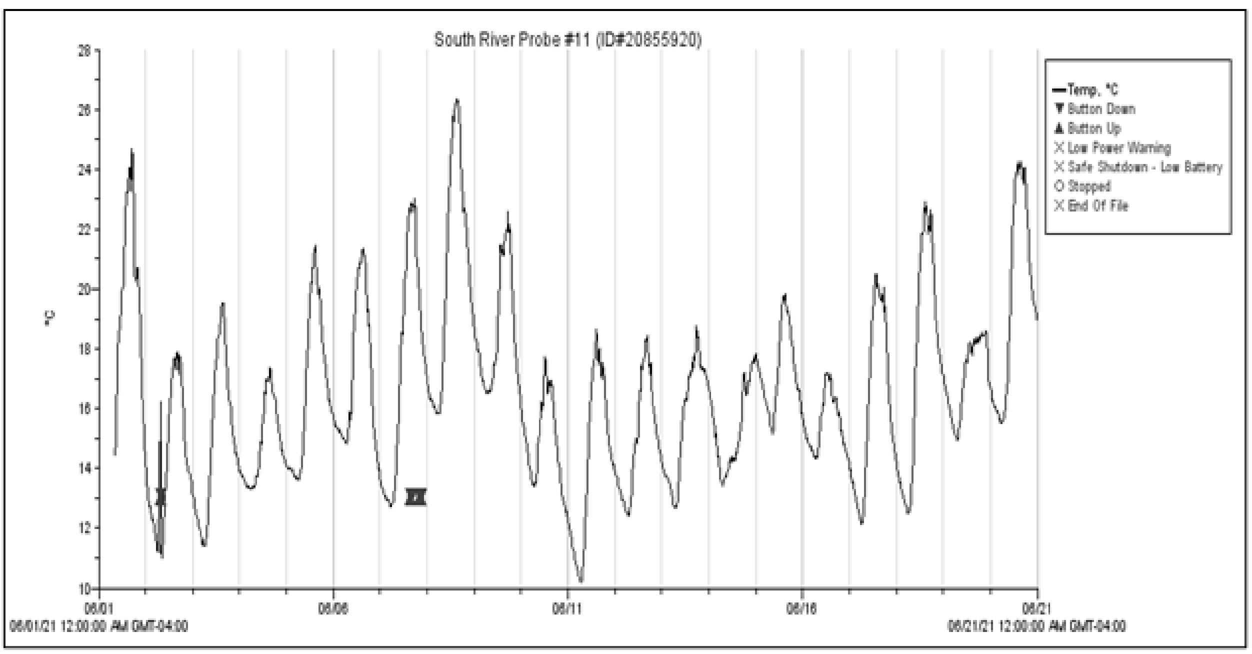

Figure 74: 2021 SR probe #11

4.2 Electrofishing Surveys

Electrofishing is a labour-intensive process as it requires two people to hold the barrier nets (one downstream and one upstream), two field technicians are required to scoop shocked fish and a fifth person is required to operate the electrofishing unit. The Zippen method, sometimes referred to as the removal method will be used to conduct electrofishing surveys. This method requires that each electrofishing site be sectioned off with barrier nets at both the downstream and upstream extent of the survey site to ensure that fish are unable to exit or enter the site while the survey is being conduct. Three sweeps of each survey site are conducted, with fish counted and measured after each sweep. The Zippen method requires that each subsequent sweep shows a declining in the number of fish captured, otherwise additional sweeps are required until consecutive sweeps with declining catches are completed. The 6 sites identified in this monitoring plan should take a crew of five field technicians 1 complete week to complete. For optimal results the electrofishing surveys should be completed in early July.

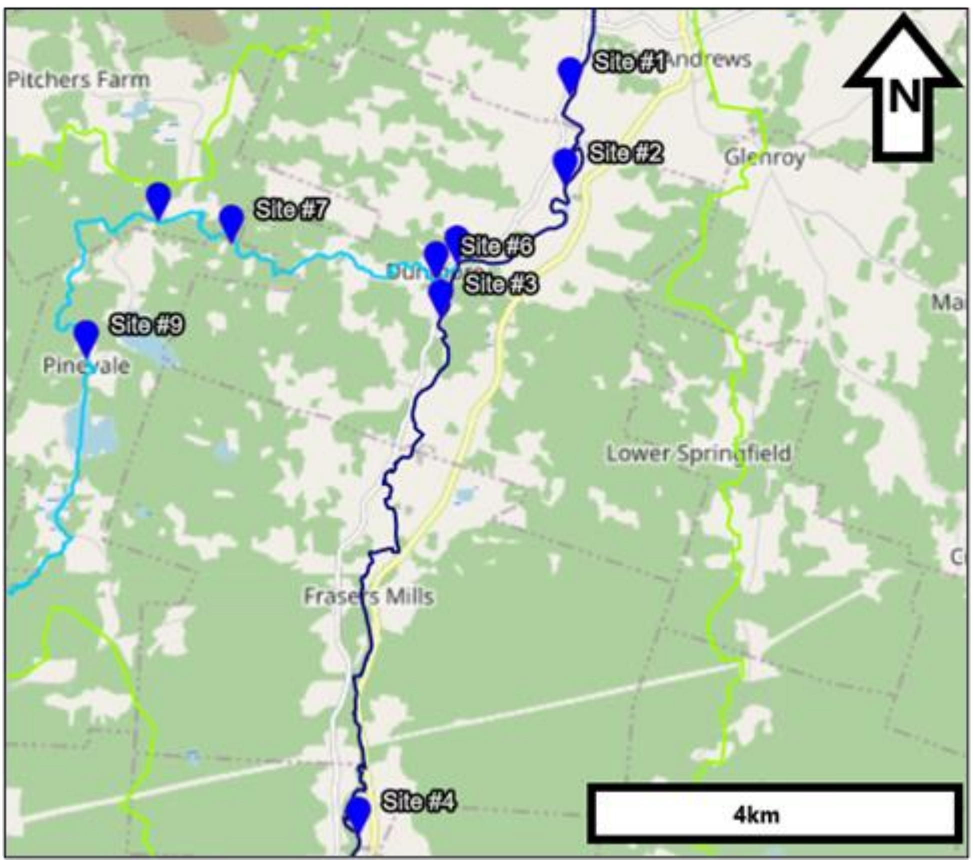

Figure 75: South River watershed 2022 electrofishing sites

Table 26: Overview of 2022 electrofishing sites			
Site #	**Watercourse**	**Site Description**	**Coordinates**
1	South River	800m US from Blacksmith Valley Rd Bridge	45.335906N -61.5426777W
2	South River	Tree Replanting Site behind Cemetery	45.3230115N -61.5429309W
3	South River	Marsh Cross Rd	45.3138911N -61.5538132W
4	South River	MacMillan's Farm field	45.281827N -61.5622699W
5	Pinevale Brook	Pinevale mouth	45.32065N -61.5529525W
6	Pinevale Brook	DS from Dunmore Rd crossing	45.3154292N -61.5540455W
7	Pinevale Brook	1 km DS from Pinevale bridge	45.32874N -61.5731909W
8	Pinevale Brook	DS from Pinevale bridge	45.3215958N -61.5814396W
9	Pinevale Brook	Most US spawning habitat	45.3123705N -61.5852904W

4.3 Canadian Aquatic Biomonitoring Network (CABIN)

The CABIN program was developed by the federal government to ensure a nationally standardized method to assess the ecological condition of freshwater in Canada. Biomonitoring methods complement chemical and physical water quality monitoring predictions by using the presence of organisms living at a site as an indicator of the ecosystems condition. Biological indicators include benthic macroinvertebrates (stream bottom-dwelling insects), periphyton (algae) and macrophytes (aquatic plants) – all of which are indicator organisms that can assist in identifying issues within the aquatic habitat. Periodic water quality sampling can provide information on water quality occurring at that specific time, but when you incorporate biomonitoring, more context can be given to the conditions of the site.

ARA has set aside funding to pay for CABIN certification programs for its Field Technicians. Training will be completed at the end of the summer and CABIN surveys will commence mid-September and will require a crew of 3 people about 2 days to complete. There are 2 sites along the main stem of the South River where CABIN surveys will be conducted which will correspond to 2 of the electrofishing sites chosen. The data from the CABIN survey will complement the electrofishing data collected from the sites to identify biological community trends.

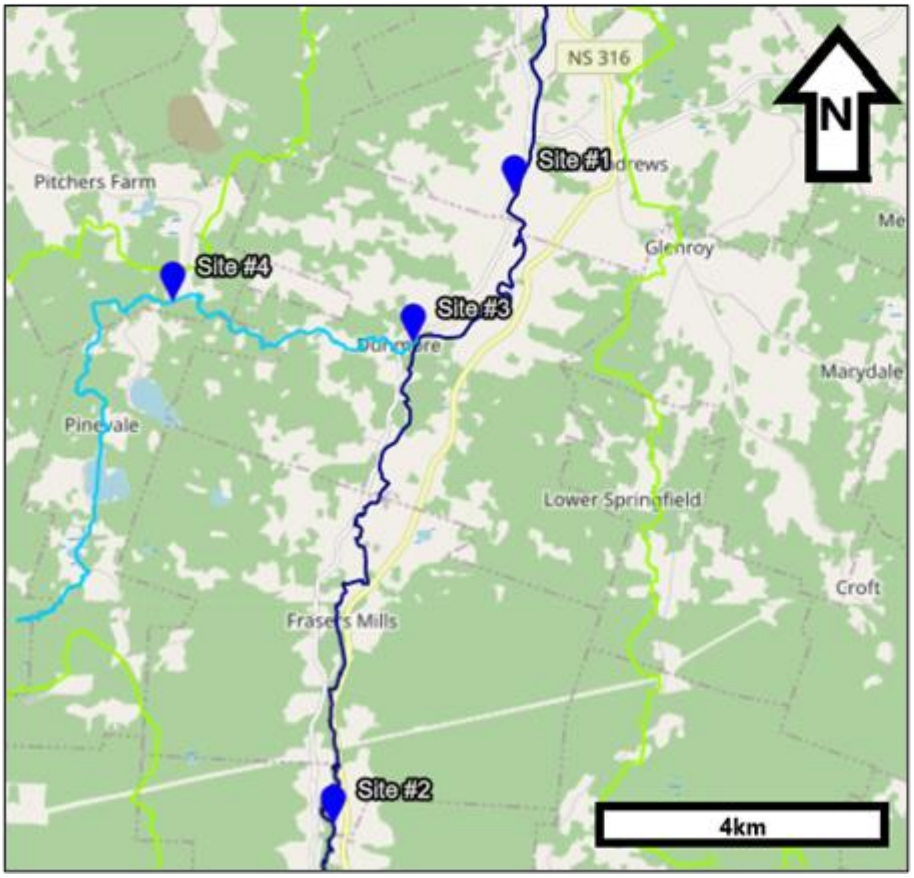

Figure 76: South River watershed 2022 CABIN sites

Table 27: Overview of 2022 CABIN sites			
Site #	**Watercourse**	**Site Description**	**Coordinates**
1	South River	800m US from Blacksmith Valley Rd Bridge	45.335906N -61.5426777W
2	South River	MacMillan's Farm field	45.281827N -61.5622699W
3	Pinevale Brook	Pinevale Mouth	45.315797N -61.553196W
4	Pinevale Brook	DS from Pinevale bridge	45.321656N -61.587904W

4.4 Habitat Suitability Index Assessments (HSI)

HSI surveys will be completed to evaluate instream physical parameters. The surveys are used to characterize instream metrics such as pool quality, pool frequency, spawning habitat quality, spawning habitat frequency, invertebrate diversity, and instream cover. Each category of habitat is evaluated and receives a suitability score between 0 and 1 based on the data collected during the survey. A suitability score of less than 0.4 represents highly degraded habitat. A rating between 0.4 and 0.8 is classified as marginal habitat. Categories that score 0.8 or higher are considered high quality habitat that is conducive to salmonoid activity. The HSI Assessments will take place between June and October.

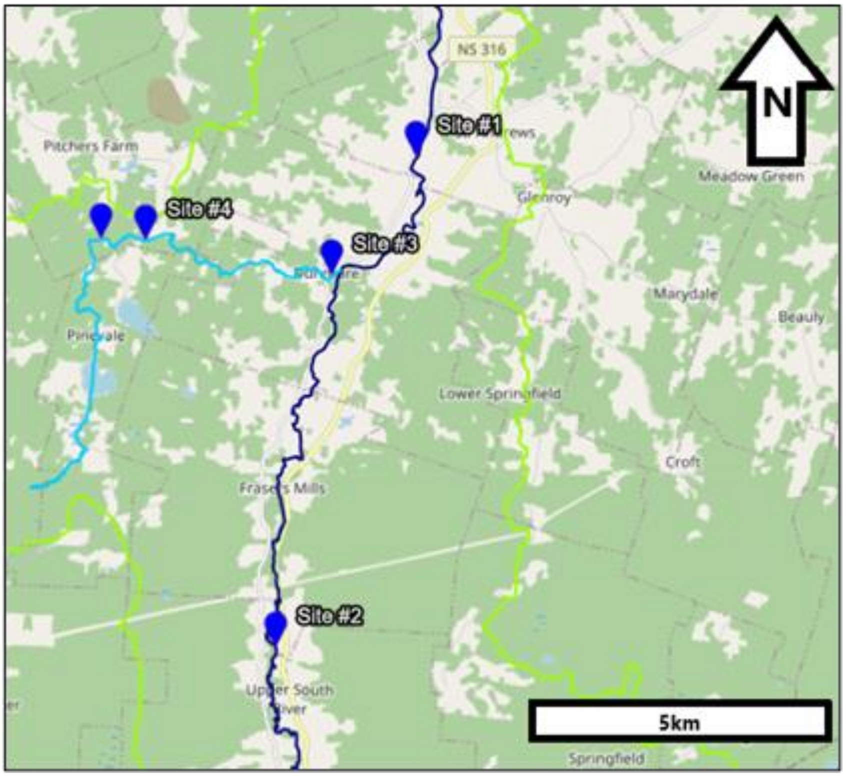

Figure 77: South River watershed 2022 HSI sites

Table 28: Overview of 2022 HSI Sites			
Site #	**Watercourse**	**Site Description**	**Coordinates**
1	South River	800m US from Blacksmith Valley Rd Bridge	45.335906N -61.5426777W
2	South River	MacMillan's Farm field	45.281827N -61.5622699W
3	Pinevale Brook	DS from Dunmore Rd Culvert	45.3155935N -61.55368W
4	Pinevale Brook	DS from Pinevale Bridge	45.3216242N -61.5812104W
5	Pinevale Brook	US from Pinevale Bridge	45.3216898N -61.5849832W

4.5 Atlantic Salmon Redd Count Surveys

An important component of this monitoring program is the redd count surveys conducted from November to December each year. During the redd counts, a trained guide will walk specific stretches of the river and identify and keep track of salmon redds. A redd is essentially a nest the female salmon creates in the substrate. The female will choose a location, typically located in a riffle section of the watercourse and she will excavate a pit with her tail creating a depression in the gravel bottom where she will lay her eggs. Once the eggs are laid and fertilized, she will cover the pit with gravel to protect them. The disturbed gravel stands out very clearly against the darker colored, undisturbed substrate around it.

These surveys are conducted to determine how many adults are returning to spawn. Because we don't walk the entire stretch of river and tributaries counting redds, we choose specific sites and then use the redd count numbers to determine a density per 100m^2. Below is a map and table highlighting the sites chosen for our redd count surveys.

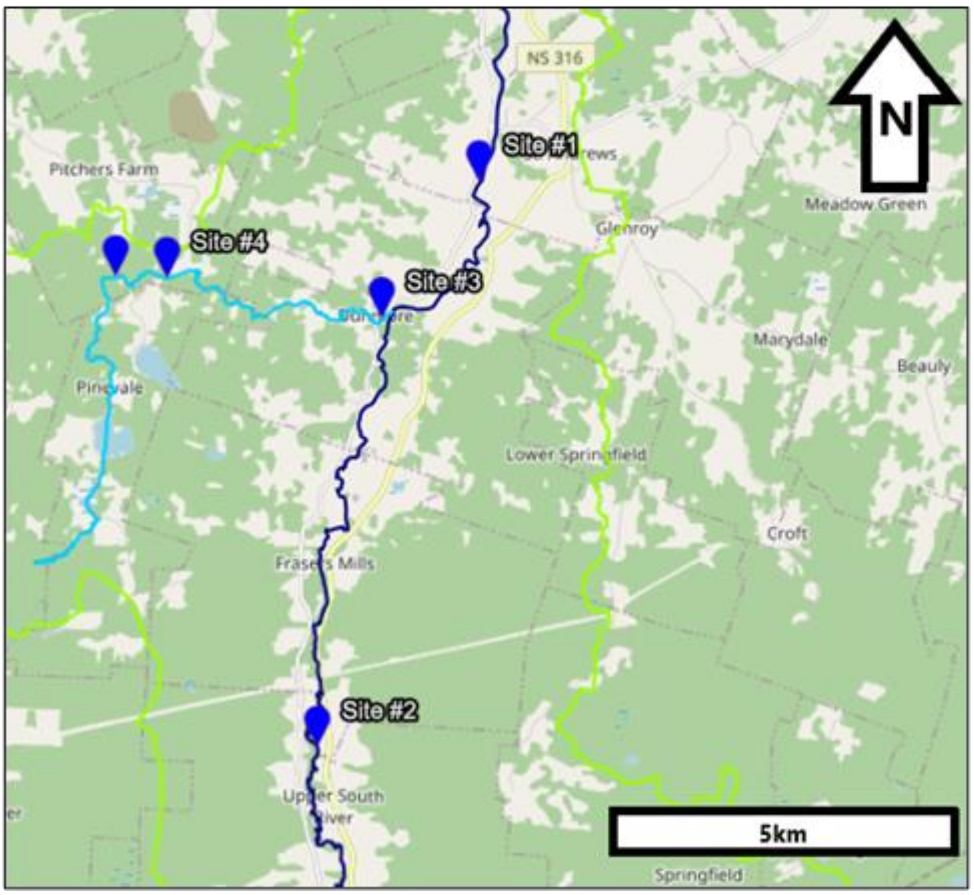

Figure 78: South River watershed 2022 Redd count sites

Table 29: Overview of 2022 Redd count sites			
Site #	**Watercourse**	**Site Description**	**Coordinates**
1	South River	800m US from Blacksmith Valley Rd Bridge	45.335906N -61.5426777W
2	South River	MacMillan's Farm field	45.281827N -61.5622699W
3	Pinevale Brook	DS from Dunmore Rd Culvert	45.3155935N -61.55368W
4	Pinevale Brook	DS from Pinevale Bridge	45.3216242N -61.5812104W
5	Pinevale Brook	US from Pinevale Bridge	45.3216898N -615849832W

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Appendix A

Geology & Soil Maps of Nova Scotia

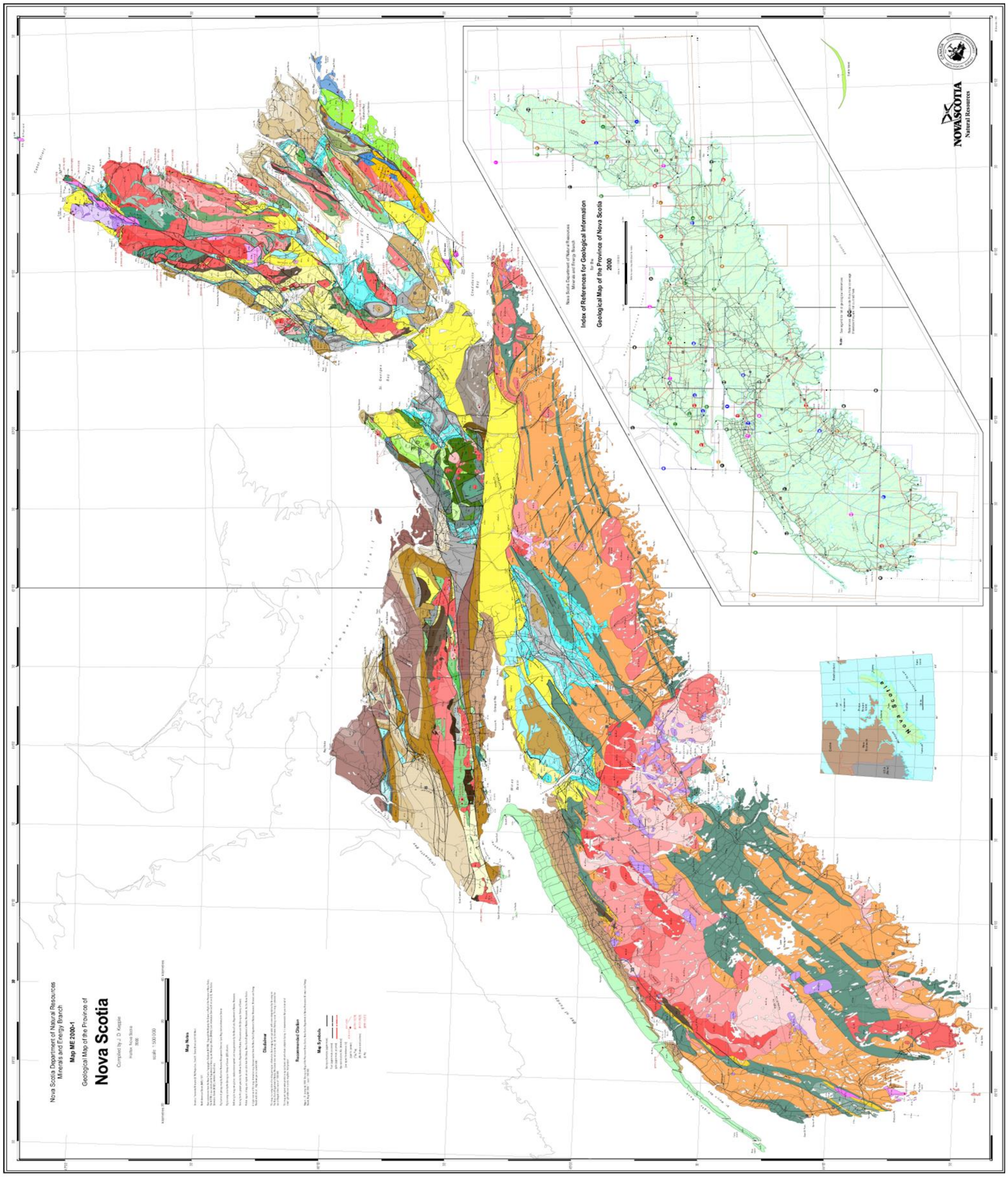

Figure 79: Bedrock geology map of Nova Scotia

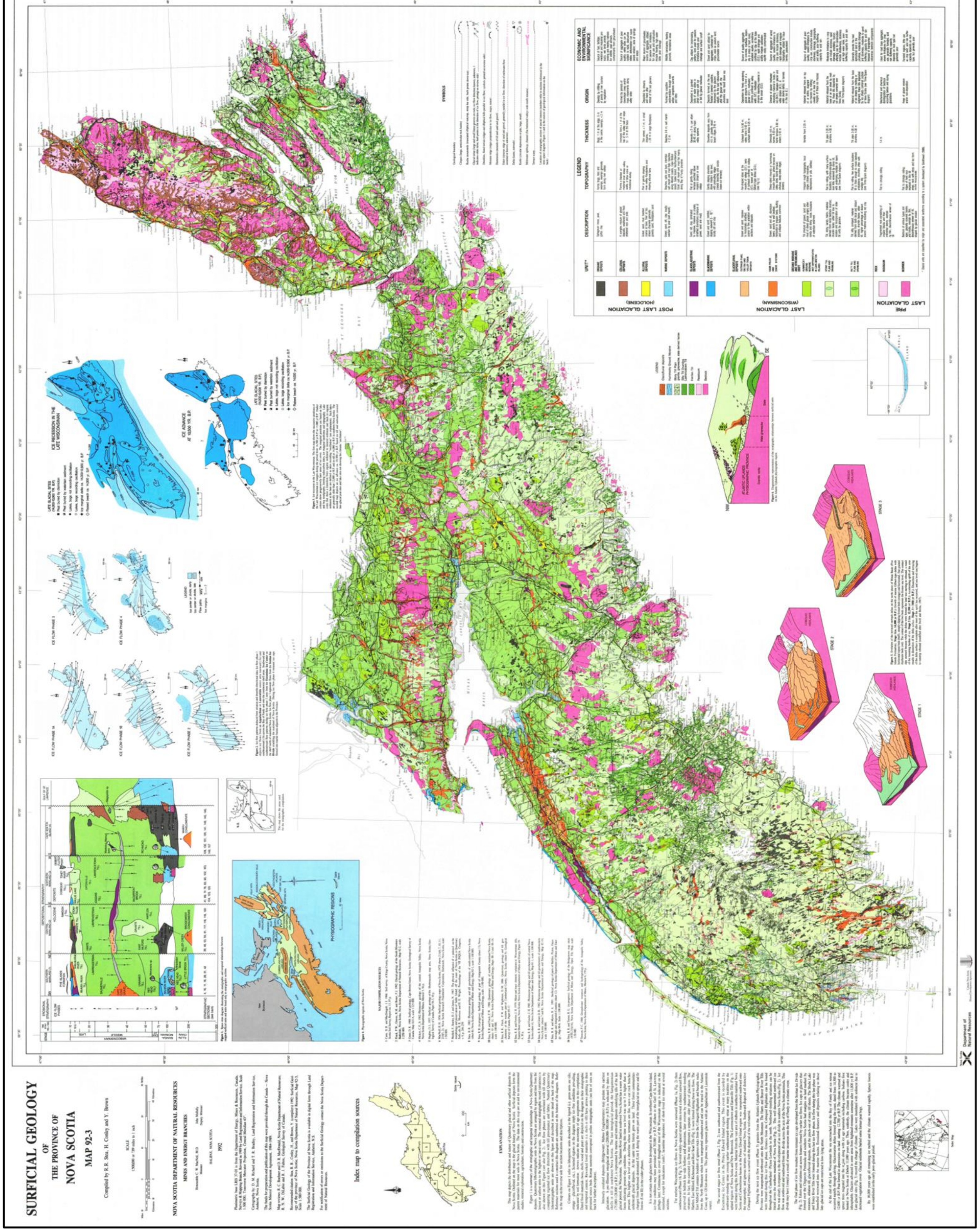

Figure 80: Surficial geology map of Nova Scotia

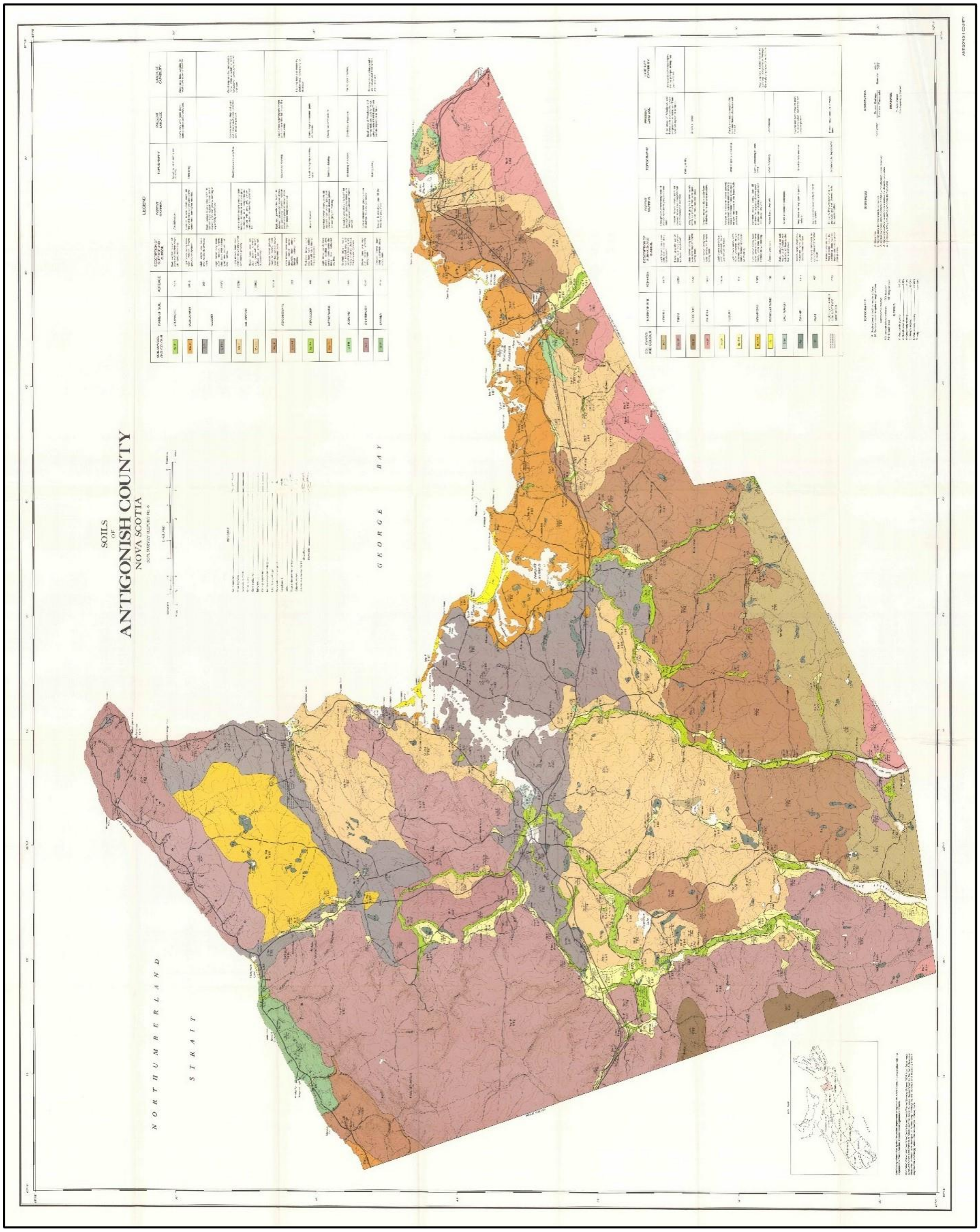

Figure 81: Soil map of Antigonish County

Appendix B

2021 Field Assessment Photos

Figure 82: Gravel bars forming along the South River

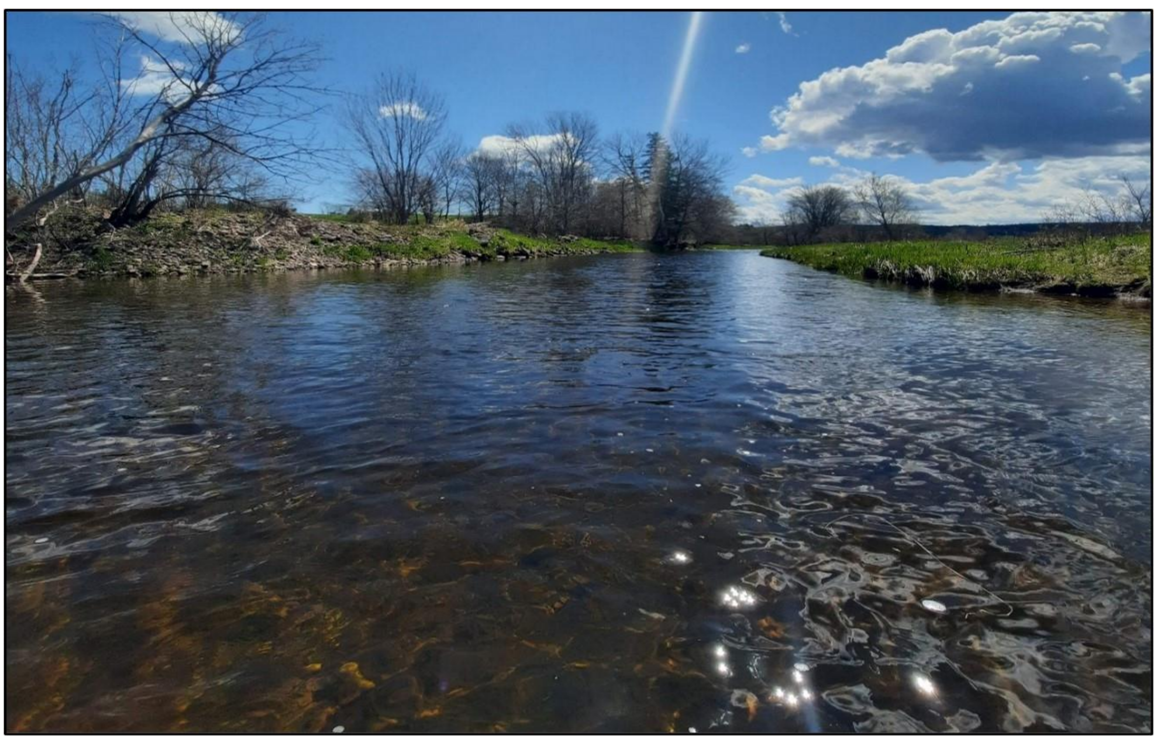

Figure 83: Long straight stretches along the South River with little riparian zone presence

Figure 84: Backwater areas are important habitat for juvenile salmon

Figure 85: Bedrock exposed (black patches under surface)

Figure 86: Tractor ford crossing the South River

Figure 87: Juvenile salmonoids in the South River

Figure 88: Erosion visible where Dunmore Road runs along the South River

Figure 89: Agriculture field lacking sufficient riparian zone

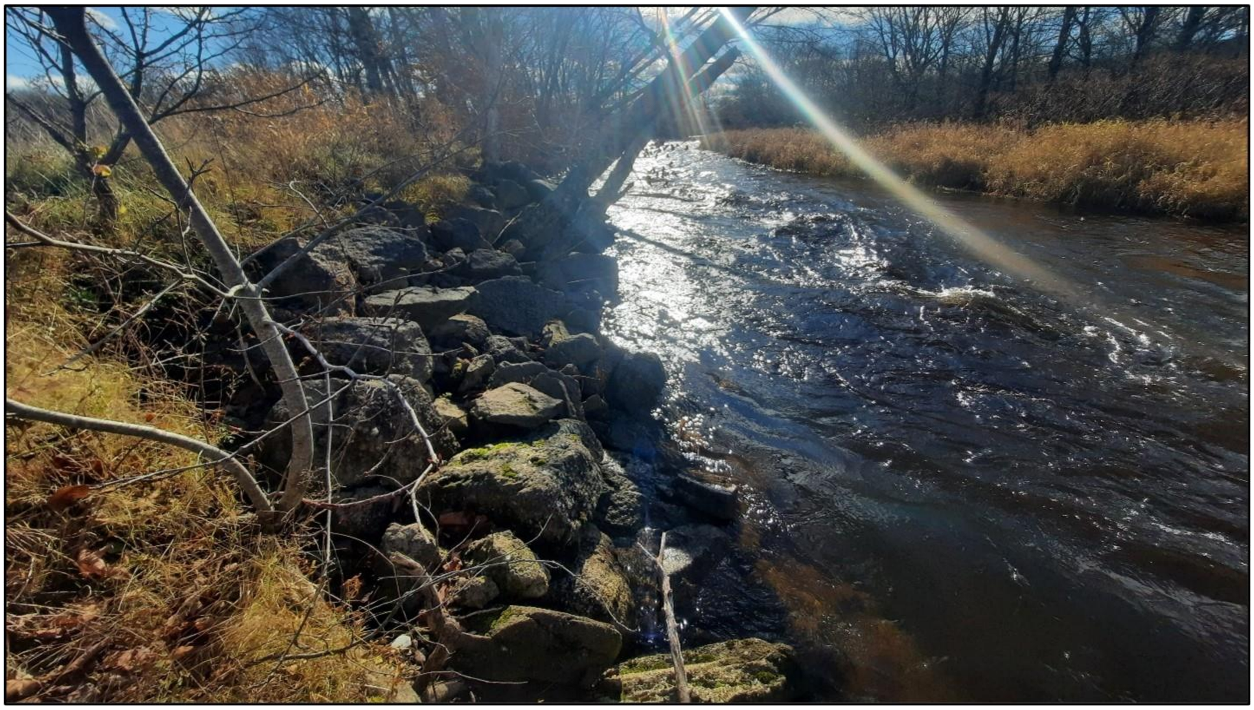

Figure 90: Old field stone installed by landowner along agriculture fields on the South River

Figure 91: Tributary to the South River less than 1m from the road with no riparian zone

Figure 92: Upper South River off Argyle Road with no defined channel

Appendix C

2021 Road Crossing Photos

Figure 93: Blacksmith Valley Road crossing over the South River

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Figure 95: Argyle Road culvert upstream view

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Appendix D

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