Fish Habitat Restoration Plan:

Southwest Mabou River Watershed

Submitted to the Atlantic Salmon Conservation Foundation

MacInnis Natural Resources
Services Inc.

11/22/18

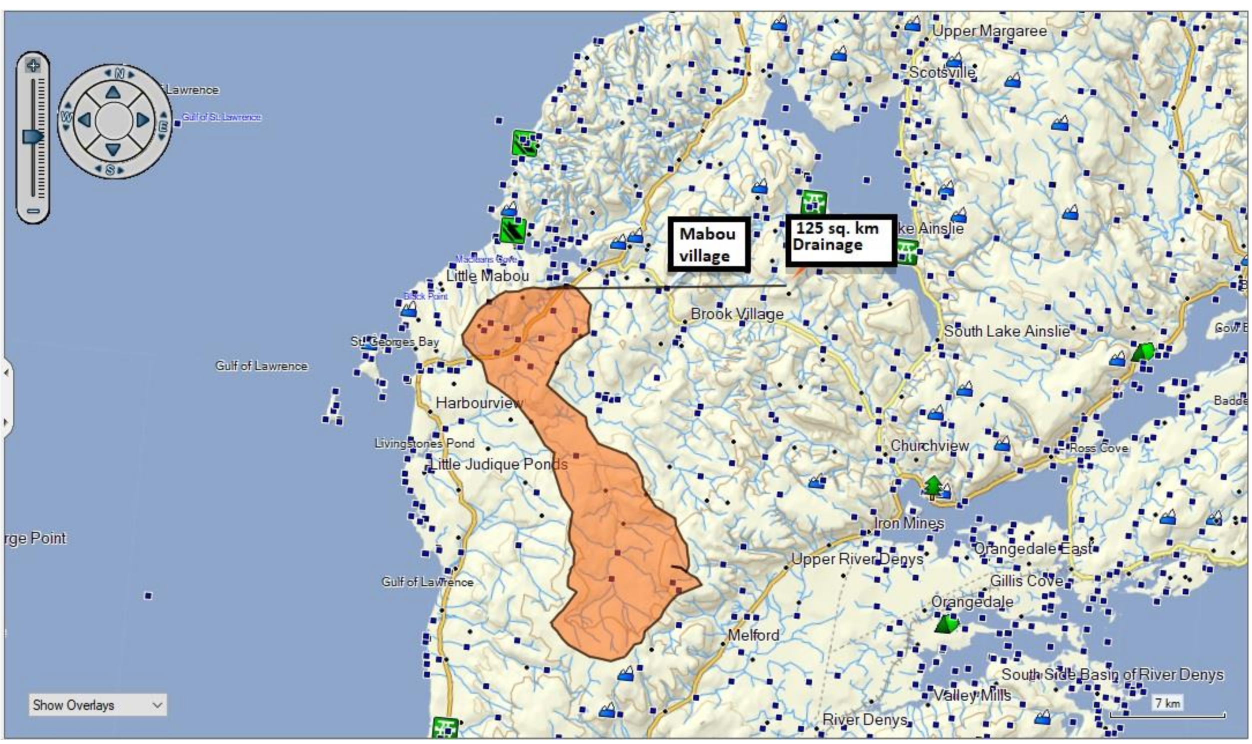
On behalf of the Inverness South
Anglers Association

Contents

Introduction

The Inverness South Anglers Association (ISAA) has been granted funding from the Atlantic Salmon Conservation Foundation (ASCF) to produce a stepwise plan for the restoration of Atlantic salmon (*Salmo salar)* habitat within the Southwest Mabou River watershed. This report follows the 2017 document *Southwest Mabou Watershed Restoration and Management Plan* which identified and assessed issues concerning habitat degradation and provided ISAA with guidance on how to improve the habitat productivity for Atlantic salmon.

This report focuses exclusively on the restoration of salmonid habitat within the Southwest Mabou watershed. It is clear from the 2017 report that much of the habitat within the SW Mabou watershed is degraded. The goal of this report is to provide ISAA with a clear and pragmatic strategy for completing restoration work and should enable ISAA to attract and obtain funding from a variety of agencies (e.g. government, non-profits and private charities). Watersheds contain a variety of stakeholders, working with these groups is paramount to accomplishing meaningful restoration actions. The Southwest Mabou watershed stretches over 125 square kilometers, intersecting agriculture and forestry land and contains a relatively high road density.



Background

The Southwest Mabou watershed, at 125 square kilometers, is the largest of three watersheds that empty into Mabou Harbour. The watershed was settled by Scottish immigrants in 1805, who established sheep and beef farms and cleared land for timber (MacDonald, 1952). Mabou Harbour was a known commercial salmon fishing destination as earlier as 1717 (Dunfield, 1985), supplying French troops stationed in Louisborg with a valuable source of protein. Prior to European settlement, the region was frequented by Indigenous fishermen (Dunfield, 1985). The Southwest Mabou watershed drains into the Gulf of St. Lawrence and is one of 115 Atlantic salmon rivers in the Gulf Region management area (Figure 2). The Southwest Mabou falls in Salmon Fishing Area (SFA) 18B.

The Inverness South Anglers Association [ISAA] has completed various habitat restoration projects targeted at improving Brook trout and Atlantic salmon (salmonids) habitat in their region over the last two decades. These projects have been completed in partnership between ISAA and the Nova Scotia Department of Environment, Nova Scotia Department of Inland Fisheries and Aquaculture, the Nova Scotia Salmon Association's (NSSA) Adopt-a-Stream program, the Unama'ki Institute of Natural Resources, Municipality of the county of Inverness, Wild Salmon Unlimited, the Nova Scotia Community College's Natural Resource Environment Technology program, the Atlantic Salmon Conservation Fund (ASCF) and the Department of Fisheries and Oceans Canada's (DFO) recreational fishery collaborative partnership program (RFCPP). Trout and salmon are pursued by recreational and Indigenous fishers and represent an important source of food and traditional importance for all stakeholders.

The Southwest Mabou River can be characterized as degraded salmonid habitat, which lacks spawning substrate, pool depth and large-woody debris. These conditions are the result of historical land use developments within the watershed and persistent impacts such as roads and agriculture. The harvesting of riparian zone forest in the past has led to increased runoff, the absence of large woody debris and the loss of overhead cover – critical for thermal regulation and protection from predatory birds. As a result of these historic developments, the Southwest Mabou river channel has become disconnected from the floodplain, over-widened and straightened – a condition referred to as an incised channel. As this process persists, the river channel will continue to exist in a state of disequilibrium and instability (Rosgen, 1994).

Habitat Assessment: A review

The channel habitat of the Southwest Mabou river was assessed by MacInnis Natural Resource Services Inc. in 2017. The following is a review of those findings coupled with a review of the channel morphological processes behind the current state of degradation.

Understanding the habitat conditions of a river channel requires an understanding of the natural processes that influence channel morphology. Rosgen (1994) provides an overview of these systems:

> The patterns of rivers are naturally developed to provide for the dissipation of the kinetic energy of moving water, and the transportation of sediment. The meander geometry and associated riffles and pools within a river system adjust in such a way that work expended on natural processes is minimized. Consequently, straightening stream channels ultimately leads to a state of disequilibrium or instability.

Increased channel width is predominant throughout the Southwest Mabou river and is the result of a cumulation of impacts and changes within the watershed during the last two centuries of human development. "Changes in the watershed that affect the quantity or timing of stream flows are activities such as vegetation removal, roads, soil compaction, diversions, urban development, and drainage alterations" (Rogen, 1994). Historically many activities have impacted the quantity and / or timing of stream flows and channel migration within the Southwest Mabou watershed. Presently several activities persist, limiting the potential recovery of the river. Agriculture and forestry for example have reduced the age and structure of vegetation within the watershed. Farmland management practices such as tile drainage and ditching are still commonly practiced. Historical aerial photography indicates that much of the upper portion of the Southwest Mabou watershed was cleared for farming at the turn of the last century.

Aerial surveys conducted in 2017 and 2018 using an unmanned aerial vehicle (UAV) coupled with ground truthing much of the watershed found that most of the main channel of the Southwest Mabou river (from MacLeod Settlement to the head of tide) is over-widened, incised and degraded. Much of the river bed has been degraded down to bedrock, which limits spawning and juvenile capacity and prevents the inter-change of streamflow from ground water systems. As a result of these conditions, the Southwest Mabou river is particularly vulnerable to increasing water temperatures during the summer months. Furthermore, the absence of large holding pools greatly reduces the chances of success for migrating Atlantic salmon. Halfyard and Rutherford (2016) found that without intermittent holding pools on the West River Sheet Harbour, adult salmon were less likely to migrate to the upper portions of the watershed. This is particularly concerning for the Atlantic salmon populations in the Southwest Mabou as the majority of suitable and productive spawning substrate is in the headwater portion of the river (MacLeod Settlement and up).

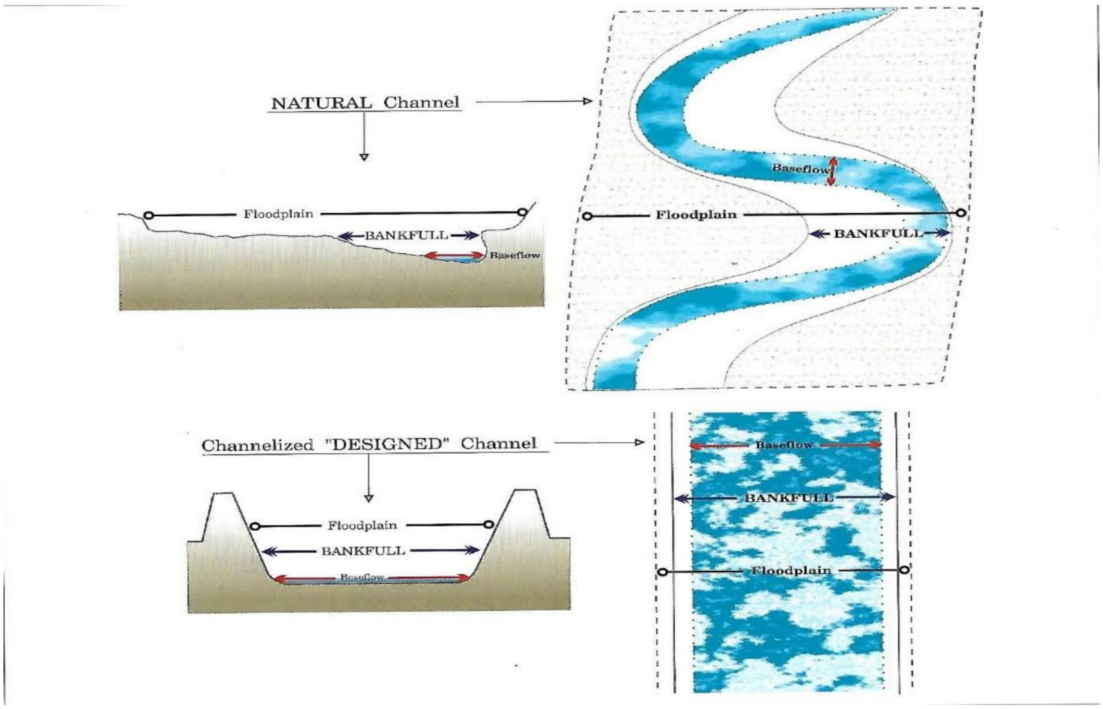


Figure 1: Comparison of degraded "designed" channel dimensions and patterns with a natural channel. (Rosgen 1993)

The incised channel that is predominant through the Southwest Mabou has resulted in severe bank erosion. As Figure 1 depicts, without access to the floodplain, high flow events are restricted to the channel, causing over-widening and a loss of pool depth. While erosion is a natural process for river systems, the absence of large woody debris and channel meander has limited the natural sorting function that would otherwise be found in the Southwest Mabou. Figure 2 provides an example of the extreme erosion that is found throughout the main channel. Figure 3 is an example of where a natural formation has benefitted the channel health. The beaver dam in this picture has promoted the settling of moving bed loads and is creating a well-defined gravel bar and meander. Restoration efforts should attempt to mimic this type of natural process. In areas where natural structures were absent (figure 4), channel braiding (i.e. split channels) were common.

Figure 2: Typical stream bank erosion on lower section of Southwest Mabou

Figure 3: Channel meandering re-establishing above beaver dam.

Figure 4: Severely over-widened and split channel.

The upper section of the Southwest Mabou (above MacLeod Settlement) contains more suitable and productive habitat than the lower reaches. However, this section still requires habitat restoration actions. MacLeod Brook, a cold-water tributary to the Southwest has limited fish passage to 90% of it's watershed. A triple culvert installed decades ago is breeched and deteriorating (Figure 5). Above the barrier culvert the remainder of MacLeod Brook has been impacted by historic land-clearing and more recent forestry practices. An unnamed tributary, roughly the same size as MacLeod Brook was recently impacted by riparian zone loss (Figure 6) and the ditching along several forestry roads were transporting fine sediments and silt (figure 7). Much of the land surrounding the upper section of the Southwest Mabou river is comprised of small cobble, gravel and fine sediment, making it particularly vulnerable to landscape changes (Figure 8). The removal of mature forest from much of the riparian zones on the unnamed tributary will likely limit the amount of large woody debris that will enter the stream channel.

Figure 5: Barrier culvert - lower MacLeod Brook

Figure 6: Riparian zone loss

Figure 7: Siltation from forestry road ditch

Figure 8: Mobile substrate

Restoration Plan

Overview of Restoration Plan – Four Key Actions

1) Restore the upper section: This involves the restoration of the upper reaches of the Southwest Mabou river, MacLeod Brook, the two unnamed tributaries. This work will be completed using the restoration crew, through the installation of digger logs and deflectors. There is approximately five field seasons worth of work to complete here. The upper section includes the entire watershed that lies upstream of the unnamed tributary and Southwest Mabou confluence. The cost to complete this work will vary depending on the number of employees ISAA hires and the effective of the crew. ISAA could estimate this cost based on typical season expenditures of labour incurred over the past few field seasons.
2) Restore the main branch of the Southwest Mabou river through the restoration of six sites, each containing a series of holding pools. This work will involve the use of heavy machinery, which will construct rock sills, groynes and deflectors. Sites will be chosen based on several variables, including distance from naturally occurring holding pools and site accessibility. The lower three kilometers of the Southwest Mabou river flows through agricultural land, it is recommended that where landowner permission is granted that areas with inadequate riparian zones should be planted with native tree species. The estimated cost to complete this portion of the project is $3.50 per square meter of restoration. This is based on recent experience restoring the West Branch St. Mary's River. Total project cost for this action is estimated to be $911,750.
3) Implement an extensive monitoring program. This involves water temperature monitoring throughout the entire watershed. Prior to restoration activities, Habitat Suitability Index surveys should be completed. This should take place on all restoration sites and several control sites should also be chosen. Monitoring should occur annually for at least 3 years.
4) Improve the natural functions of the watershed through stakeholder engagement. ISAA can accomplish by working with local farmers, forestry officials and municipal partners. Partnering with other organizations will also allow ISAA to leverage funding from government agencies.

Area	**Watershed Size**	**Channel Length Restored**	**Square meters of channel restored**	**Treatment Type**
Upper Section	52.5 sq. km	19 km	206,750 sq. m	Digger logs and deflectors
Main channel - Southwest Mabou	72.5 sq km	10 km	260,500 sq. m	Rock groynes, deflectors and sills. Tree planting were applicable.
Total	**125.5 sq km**	**29 km**	**477,250 sq. m**	**N/A**

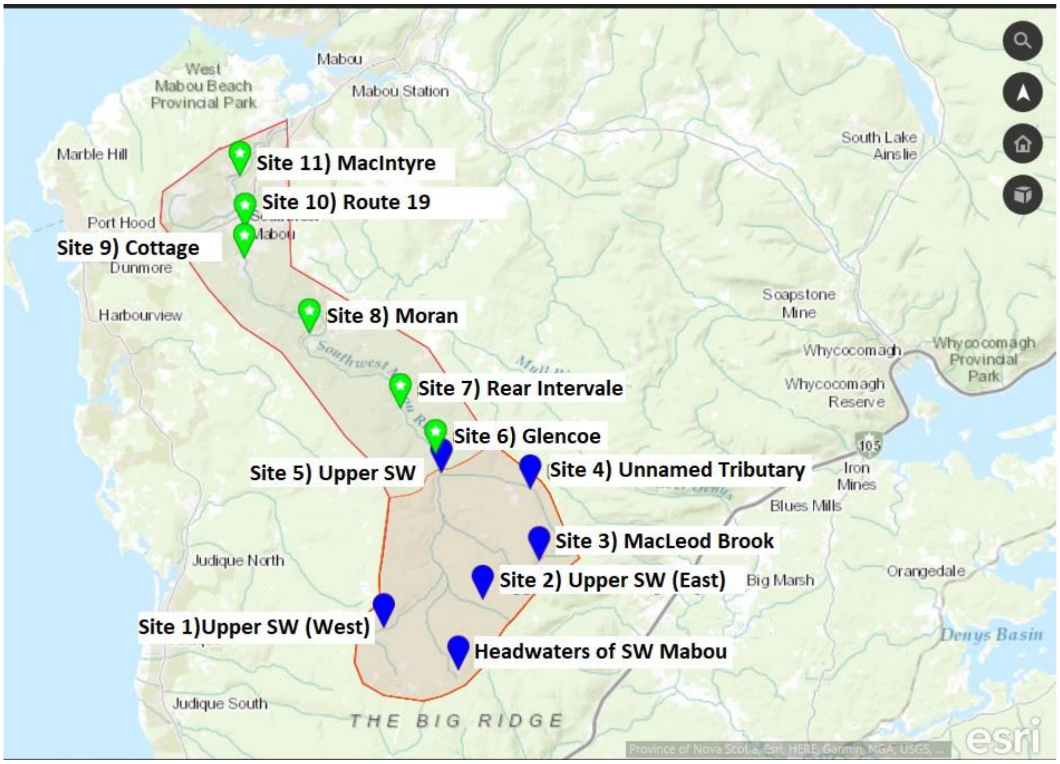


Figure 9: Total project area with labelled sites.

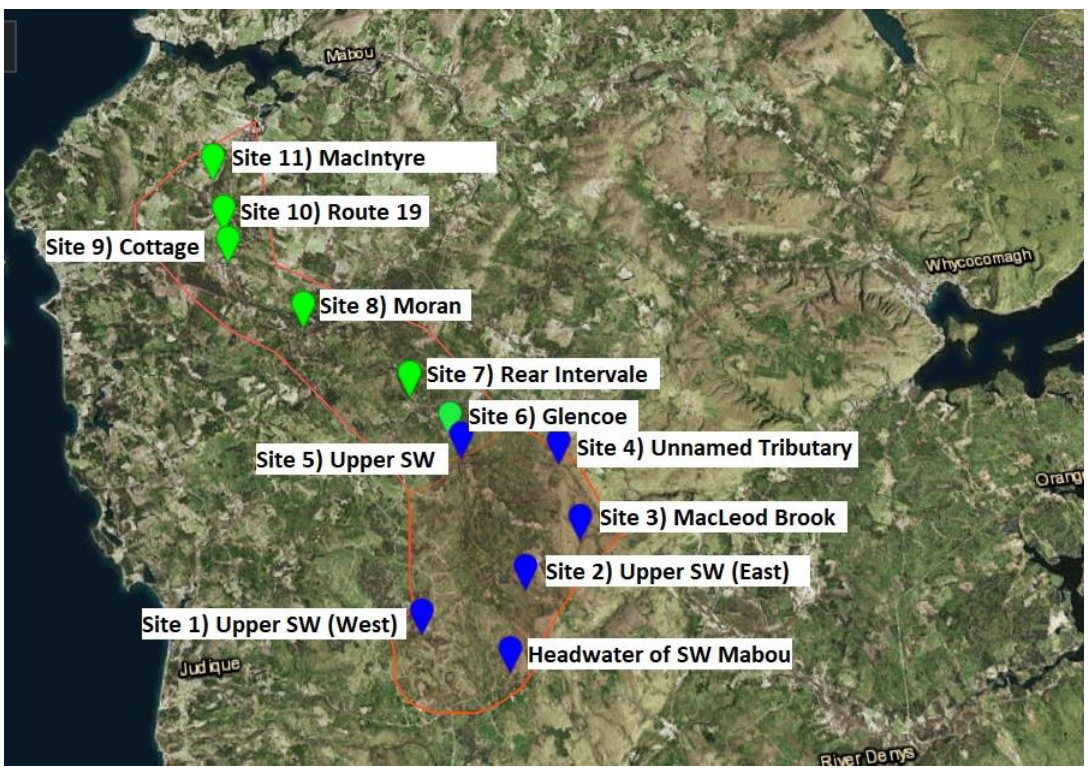


Figure 10: Satellite image of Southwest Mabou watershed with sites labelled.

Action #1: Restoring the upper Southwest Mabou and tributaries

For the purpose of this report, the upper section of the Southwest Mabou river will be defined as the area the drains into the Southwest Mabou from above the confluence with the unnamed tributary upstream to the headwaters. This section includes two tributaries (MacLeod Brook and Unnamed Tributary) as well as the three uppermost branches of the Southwest Mabou river. This section is divided into five sites and has a watershed area of 52 square kilometers. Substrate in this section is generally cobble, boulders and large gravel. Some sections are scoured to bedrock, but most are suitable for the installation of digger logs and deflectors.

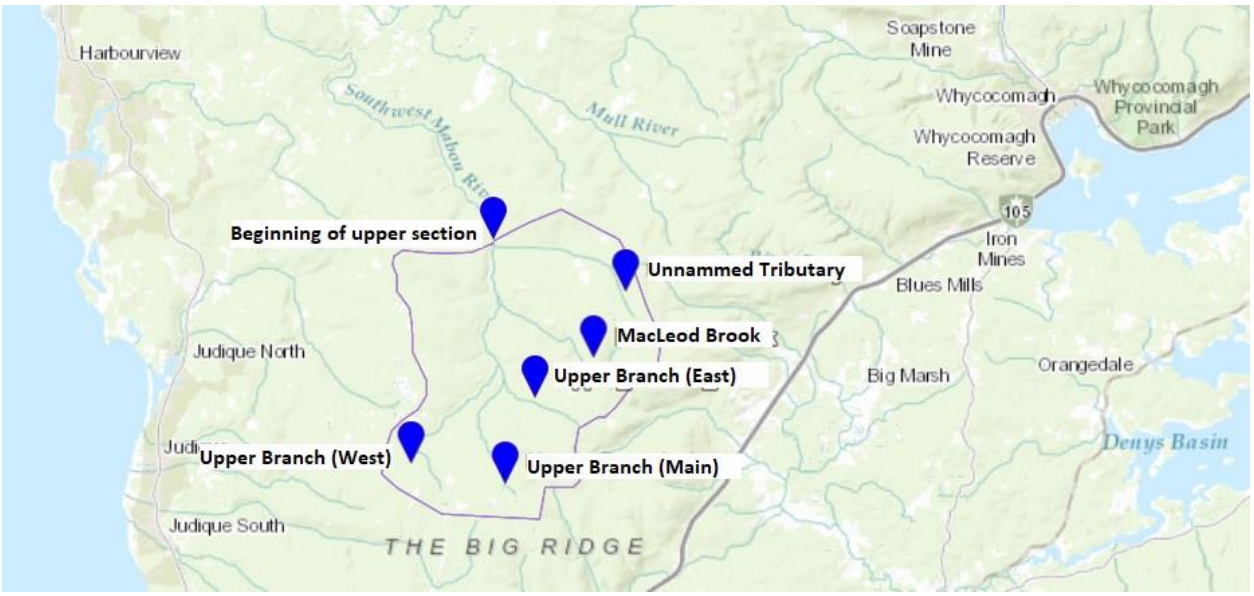


Figure 11: Map of the upper section. This section has a 52 square kilometer drainage.

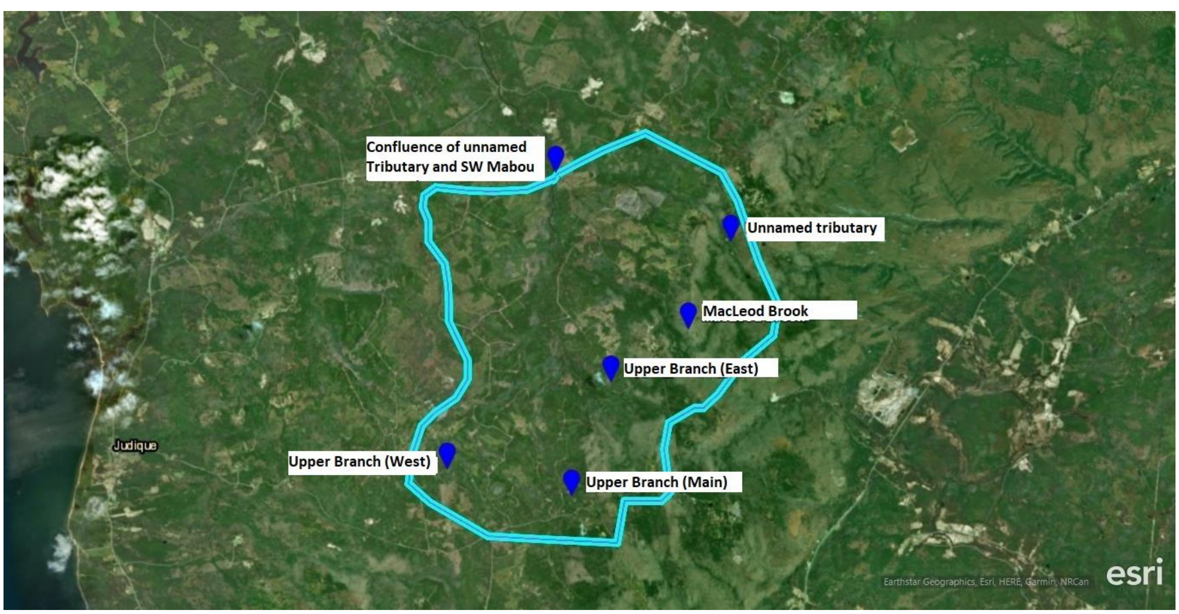


Figure 12: Satellite image of the upper watershed. The area is actively managed for forest products such as pulp and stud wood.

Overview of sites for Upper Section Restoration				
Site number and name	Site length	Average channel with	Sq. meters habitat	Treatment Type
1) Upper Southwest Mabou (Main channel)	5 kilometers	22 meters	110,000	Deflectors
2) Unnamed tributary	4.5 km	6.5 meters	29,250	Digger logs and deflectors
3) MacLeod Brook	4.5 km	7 meters	31,500	Digger logs and deflectors and fish passage remediation.
4) Upper Southwest (East)	3 km	8 meters	24,000	Deflectors
5) Upper Southwest (West)	2 km	6 meters	12,000	Digger logs and deflectors
Total	19 km	-	206,750 sq. meters	-

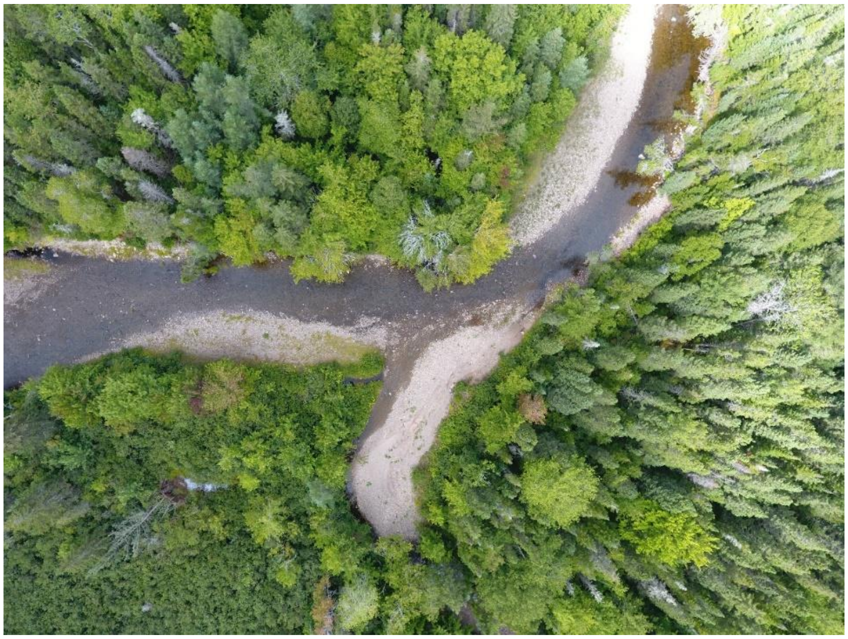


Figure 13: Confluence of unnamed tributary and SW Mabou

Site Specific Information for Watercourse Alteration Permit					
Site number and name	Downstream coordinates	Upstream coordinates	Substrate Type	Heavy equipment (Y /N)	Number of structures
1) Upper Southwest	61°20′48″W 45°52′1″N	61°21′6.9″W 45°53′37.7″N	Gravel, large cobble with some bedrock.	No	30
2) Unnamed Tributary	61°20′48″W 45°52′1″N	61°18′28.9″W 45°55′39.2″N	Gravel, fines and small cobble.	No	40
3) MacLeod Brook	61°21′16″W 45°55′8.5″N	61°17′46.5″W 45°54′23.1″N	Gravel, fines and small cobble.	No	40
4) Upper Southwest (East)	61°21′19.1″W 45°54′4″N	61°19′44.9″W 45°53′14.1″N	Gravel, small and large cobble with some boulders.	No	25
5) Upper Southwest (West)	61°21′19.1″W 45°54′4″N	61°22′51″W 45°52′14.6″N	Gravel, small and large couple and some bedrock.	No	20

Figure 14: An example of a properly installed digger log

Action #2: Restore the main channel of the Southwest Mabou River

Restore the main branch of the Southwest Mabou river through the restoration of six sites. Each site will be restored using heavy machinery and restoration techniques aimed at creating holding pools. Restoration techniques such as rock sills, groynes and deflectors should be constructed under the direct supervision of a trained and experience fish habitat consultant. Sites have been selected based on several variables, including distance from naturally occurring holding pools and site accessibility. Some sections of the Southwest Mabou river flow through active and abandoned agricultural land. Where land owner permission is granted, restoration can include riparian zone plantings of native floodplain tree species.

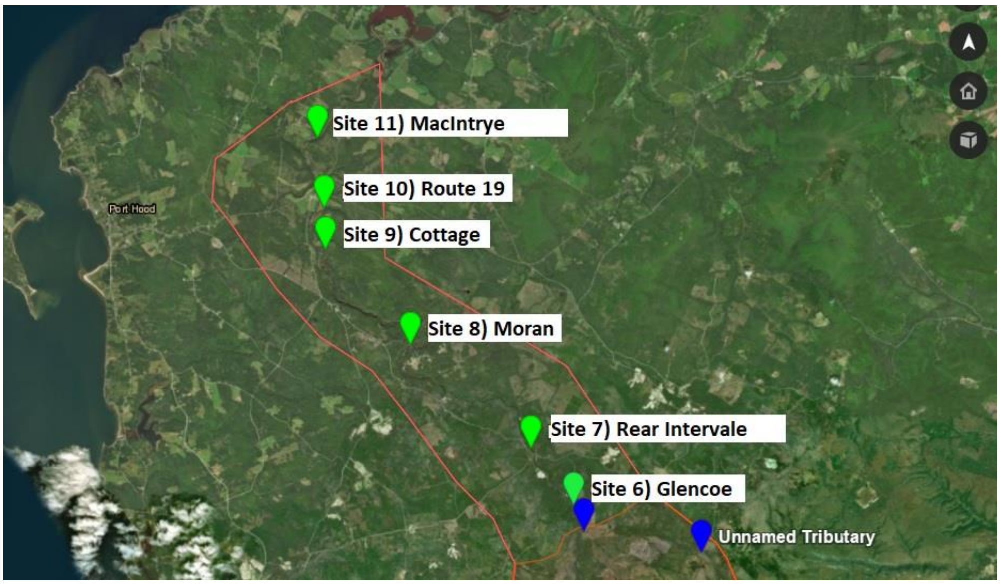


Figure 15: Satellite Image of main channel sites and watershed area.

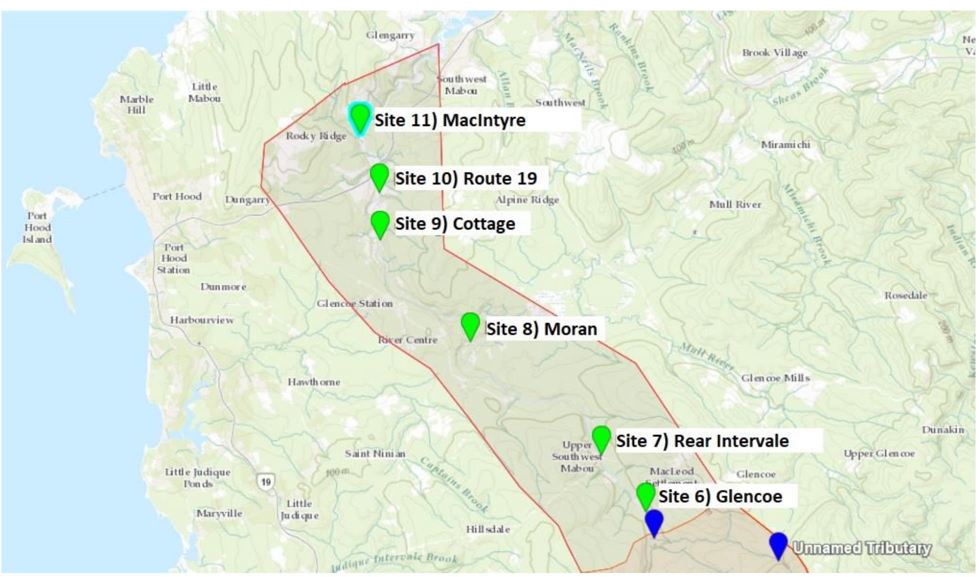


Figure 16: Topo map of Main Channel sites.

Overview of sites for main channel restoration				
Site number and name	**Site length**	**Average Channel Width**	**Square meters habitat restored**	**Treatment type**
6) Glencoe	500 meters	22 meters	11,000	Deflectors, rock groynes and sills.
7) Rear Intervale	1.5 km	25 meters	37, 500	Deflectors, rock groynes and sills.
8) Moran	2.5 km	25 meters	62,500	Deflectors, rock groynes and sills.
9) Cottage	1 km	25 meters	25,000	Deflectors, rock groynes and sills.
10) Route 19	1.5 km	27 meters	40,500	Deflectors, rock groynes and sills.
11) MacIntyre	1 km	30 meters	30,000	Bank treatment, deflectors, rock groynes and sills.
Total	**9 km**	**25 meters**	**206,500**	**N/A**

Much of the main channel has been degraded to bedrock and is classified as sediment starved. Therefore, the use of bank stabilization will be limited to the furthest downstream point (Site 11 – MacIntyre).

Site Specific Information for Watercourse Alteration Permit					
Site number and name	**Downstream coordinates**	**Upstream coordinates**	**Substrate Type**	**Heavy equipment (Y /N)**	**Number of structures**
6) Glencoe	61°21′27.6″W 45°56′26.4″N	61°21′24.4″W 45°56′11.5″N	Gravel bottom, with large and small cobble.	Yes	10
7) Rear Intervale	61°22′39.4″W 45°57′35.9″N	61°22′17.7″W 45°57′3.8″N	Gravel bottom, some cobble and bedrock.	Yes	15
8) Moran	61°24′45.7″W 45°59′0.2″N	61°24′50.2″W 45°58′26.4″N	Gravel bottom, some bedrock. Stream bed is highly mobile and forming mid-channel bar.	Yes	15
9) Cottage	61°27′6.2″W 46°00′36.1″N	61°27′3.3″W 46°00′24.7″N	Gravel, small cobble and some small boulders. Bank erosion is significant.	Yes	20
10) Route 19	61°27′5.6″W 46°01′23.1″N	61°27′9.7″W 46°00′59.8″N	Gravel, fines, some bedrock and small cobble.	Yes	20
11) MacIntyre	61°27′28.9″W 46°01′57.6″N	61°27′19.6″W 46°01′40.4″N	Gravel and fines. Channel is over-widened and shallow.	Yes	15

Site 6) Glencoe

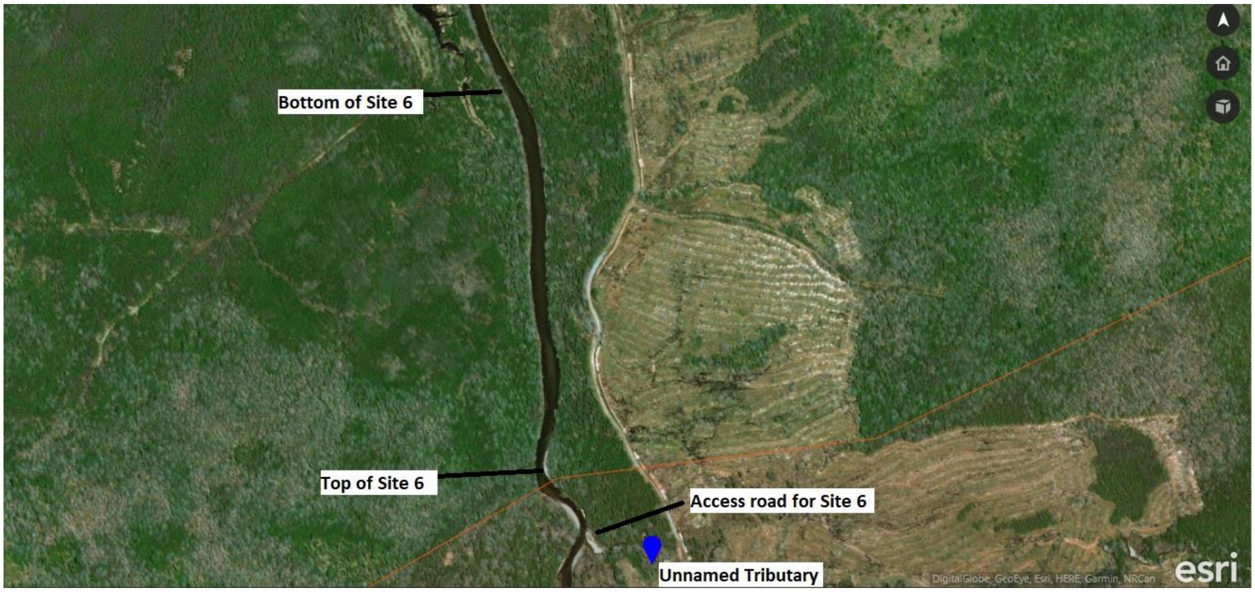


Figure 17: Satellite image of site 6. Note recent forest harvesting and the absence of a channel meander throughout the site.

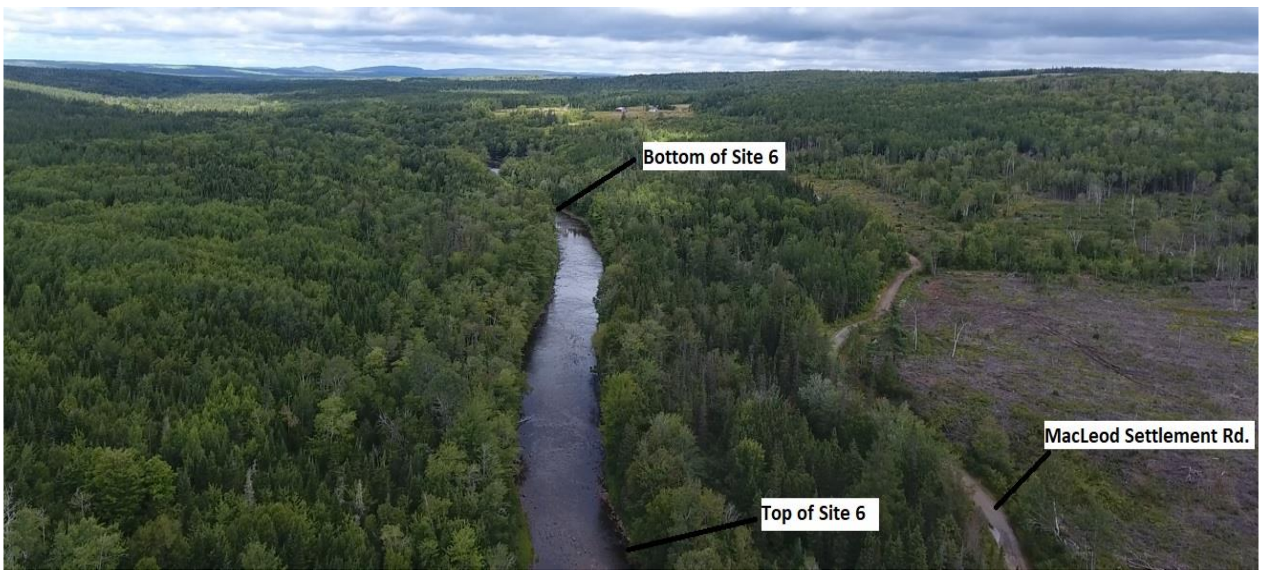


Figure 18: Drone photo of Site 6

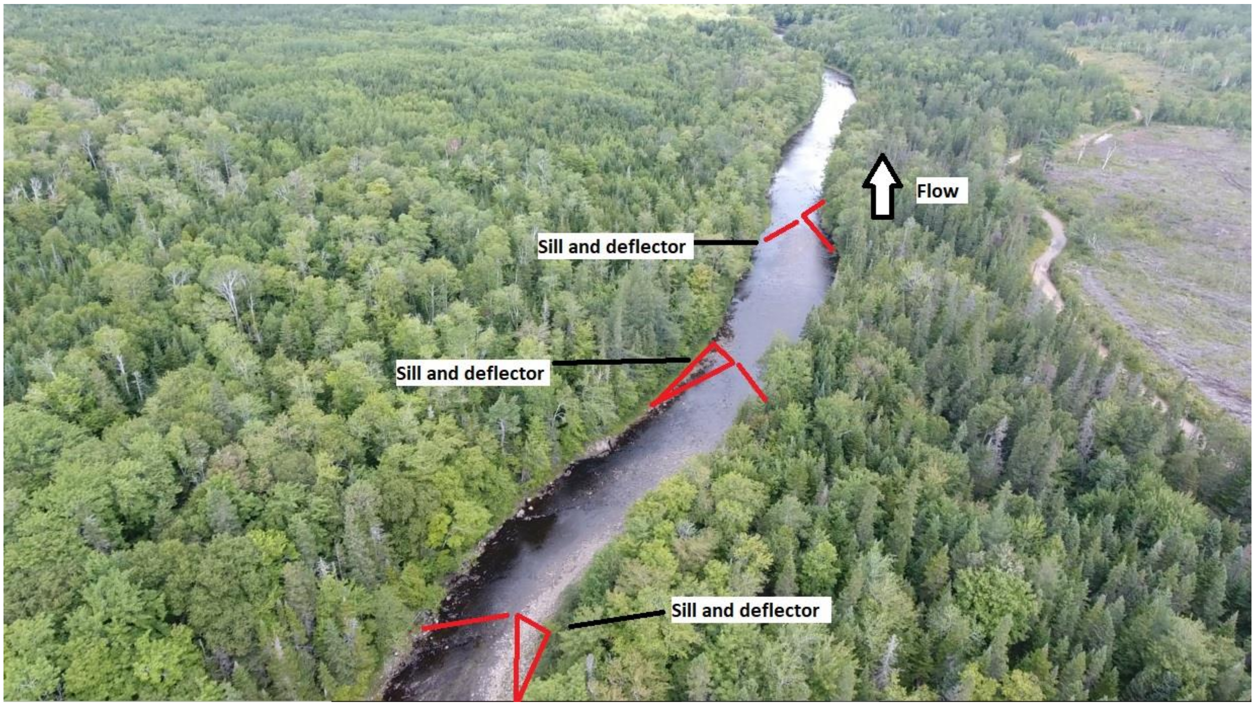


Figure 19: Conceptual drawing of proposed work for site 6

Figure 20: Glencoe section of Upper Southwest Mabou. The channel is over-widened and lacks a meander pattern.

Site 7) Rear Intervale

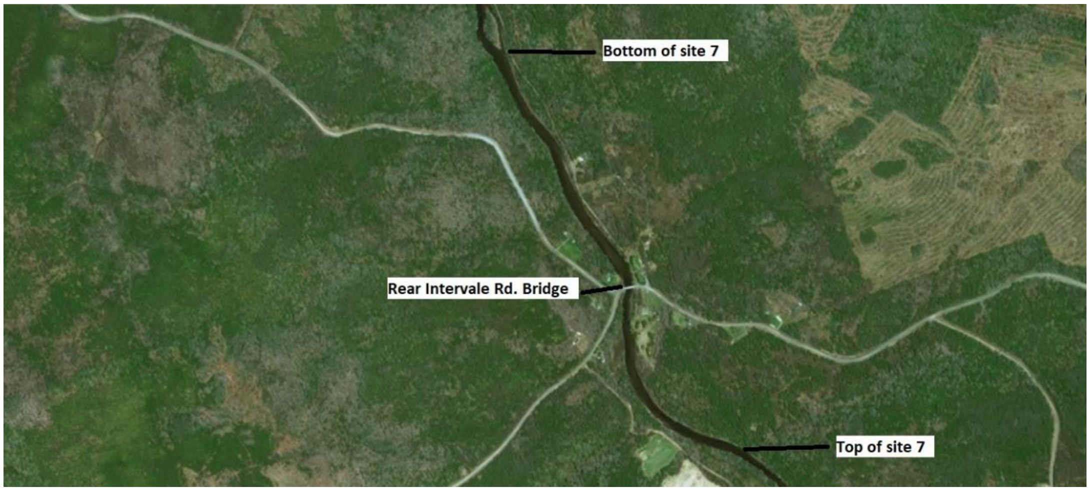


Figure 21: Site 7 Satellite image

Figure 22: Satellite image - top of site 7.

Figure 23: Bottom of site 7

Figure 24: Top of Site 7

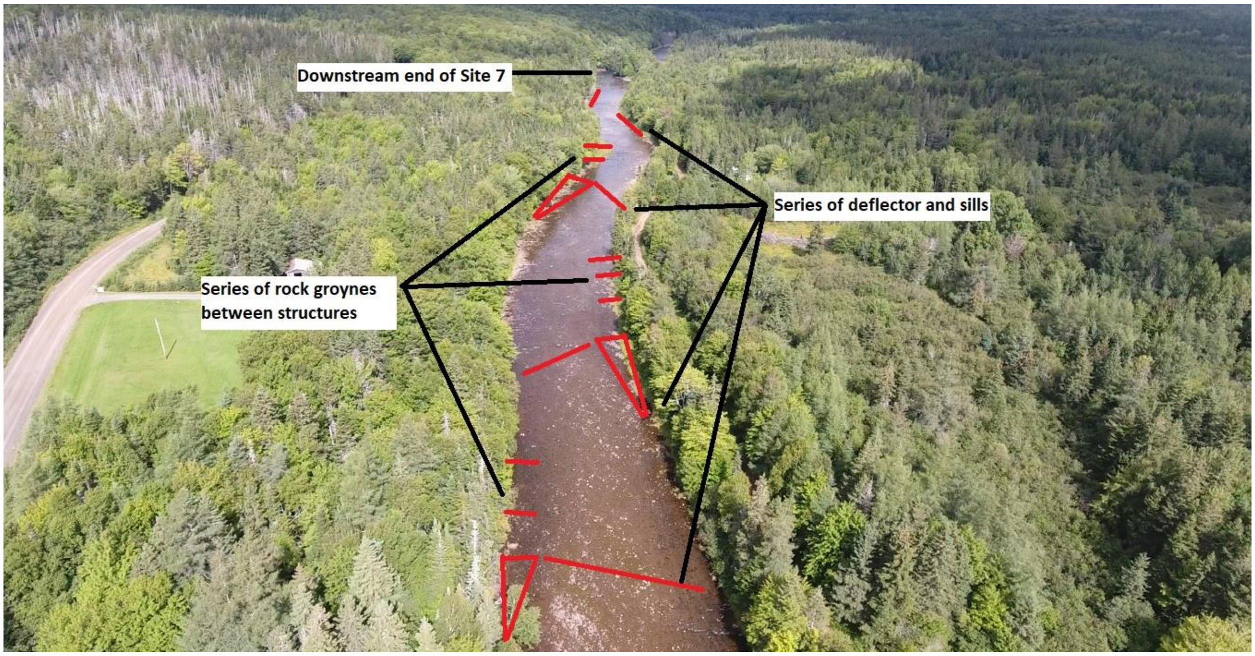
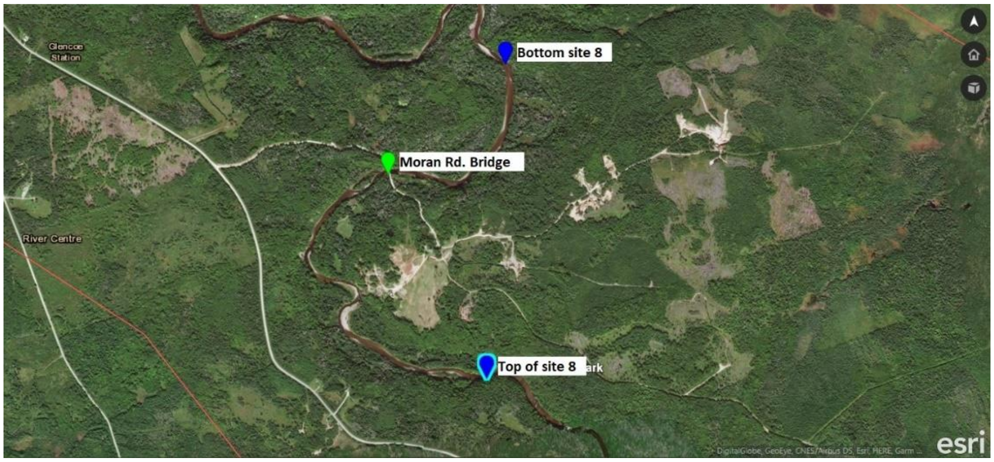


Figure 25: Bottom of site with conceptual structures marked.

Site 8) Moran



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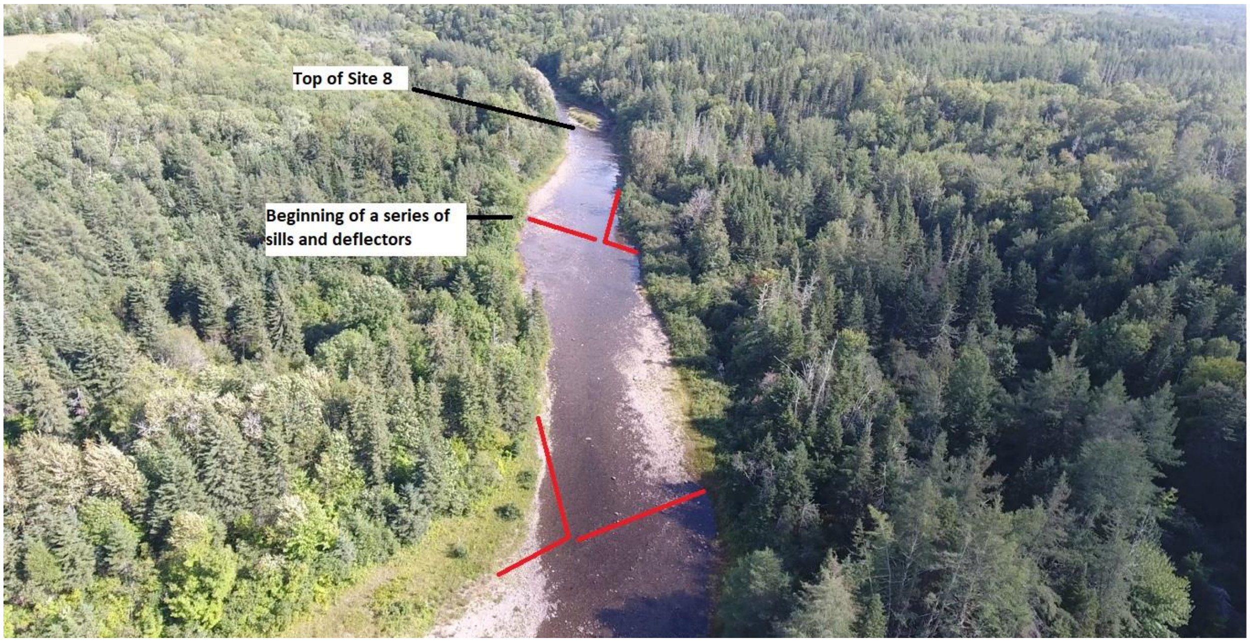
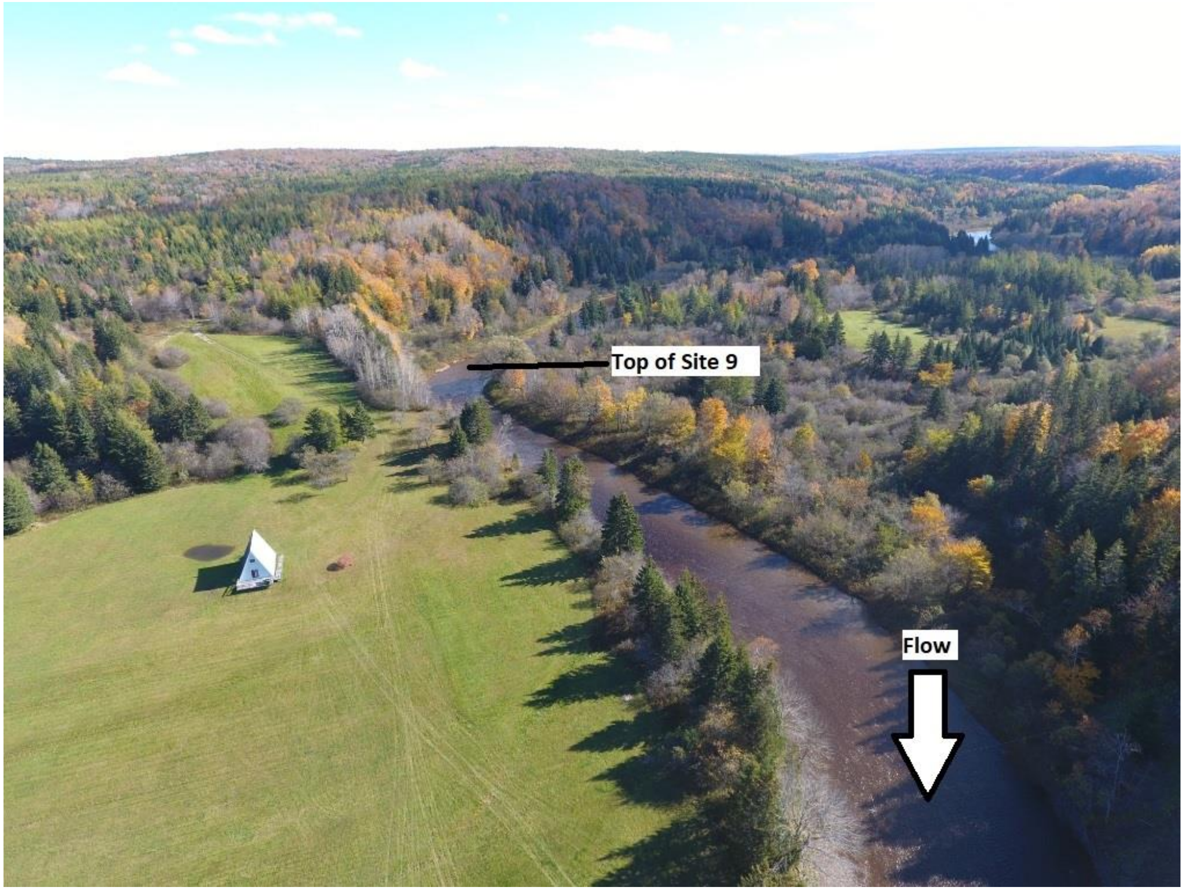


Figure 29: Site 8

Figure 30:

Site 9) Cottage

Figure 31: Site 9



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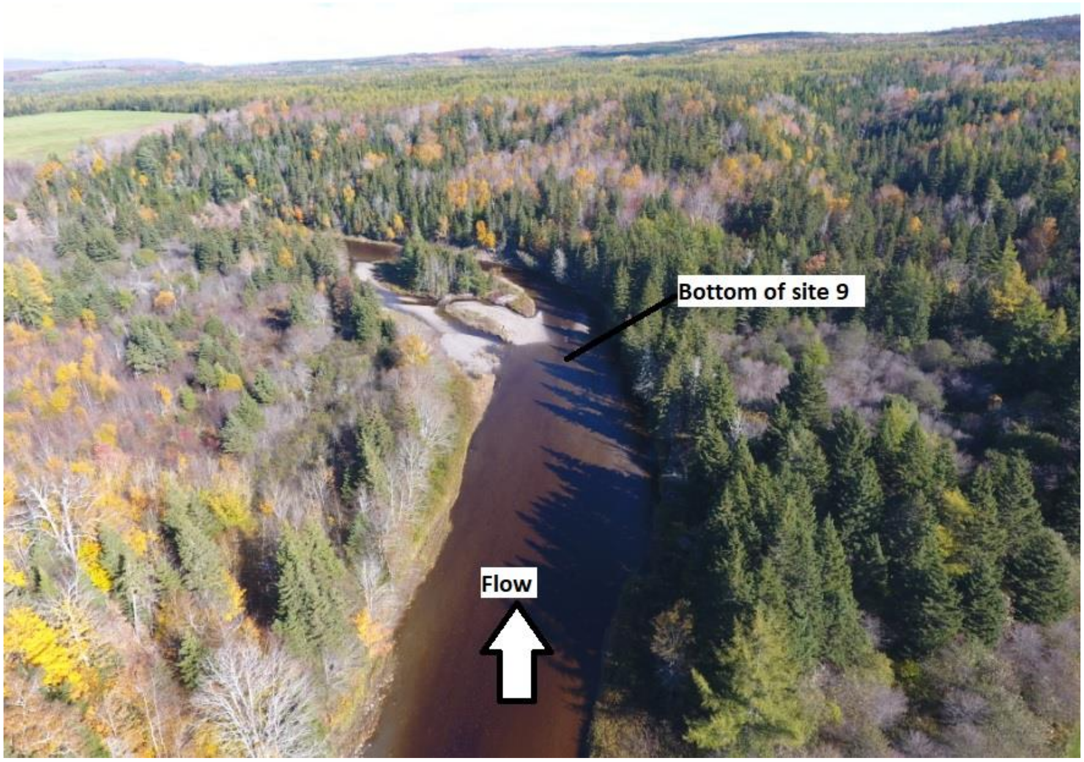

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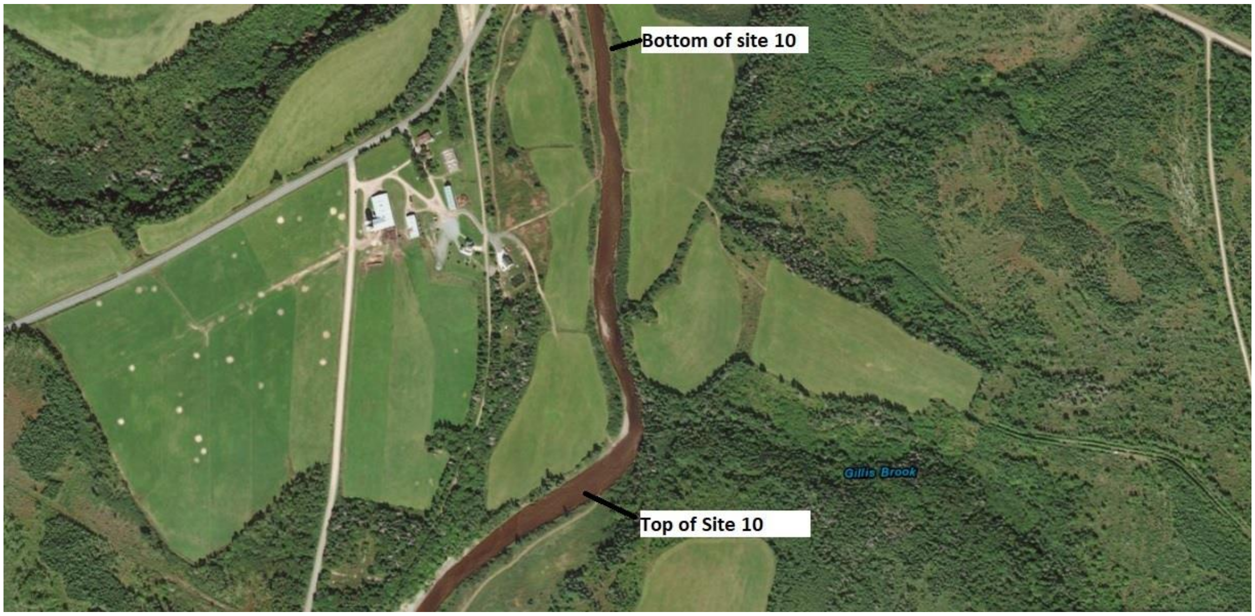
Figure 34:

Site 10) Route 19



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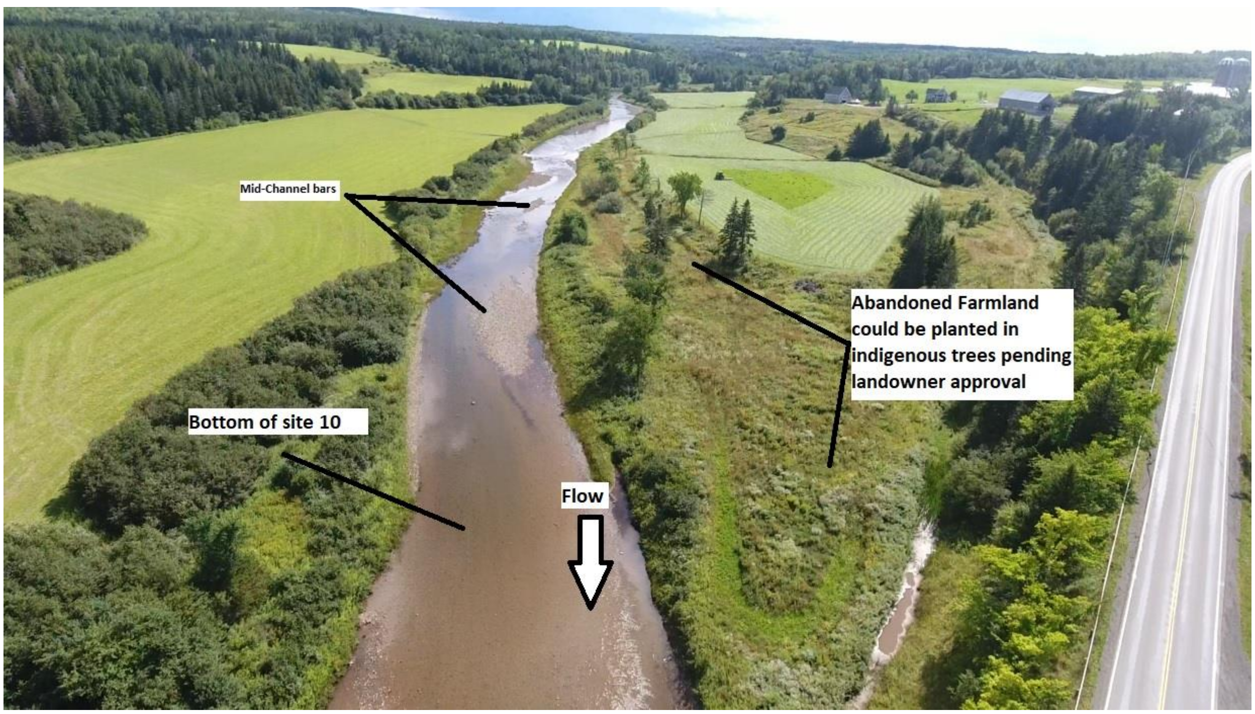

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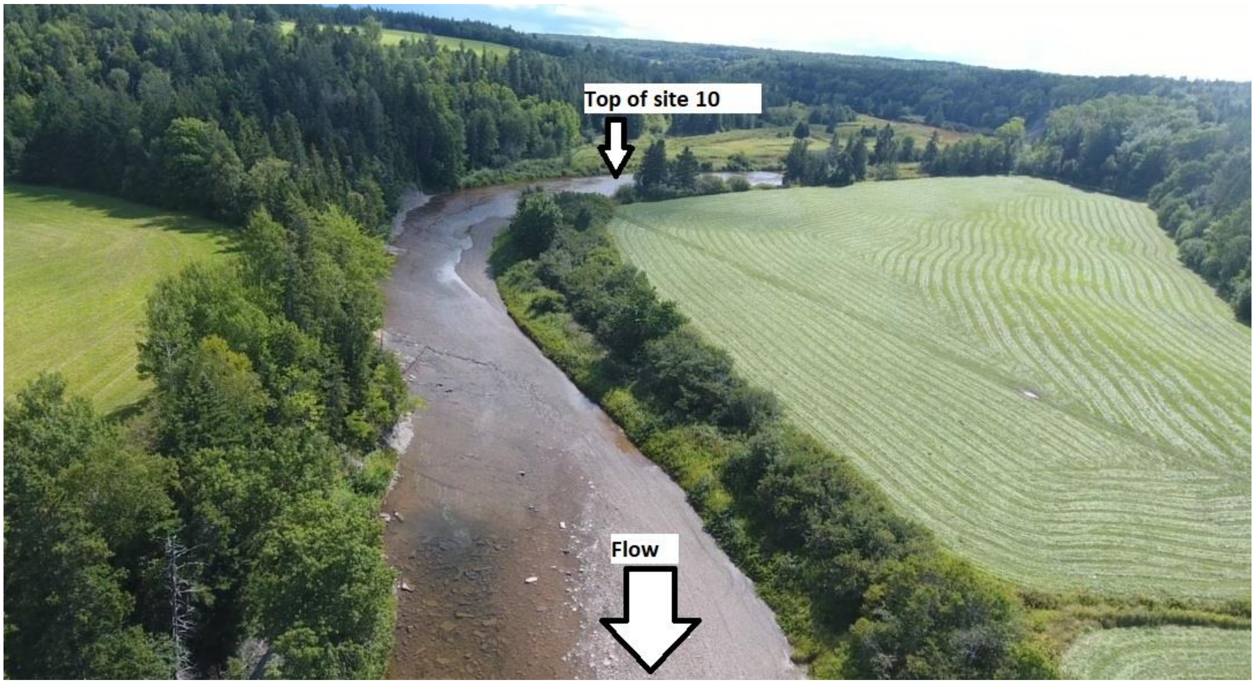

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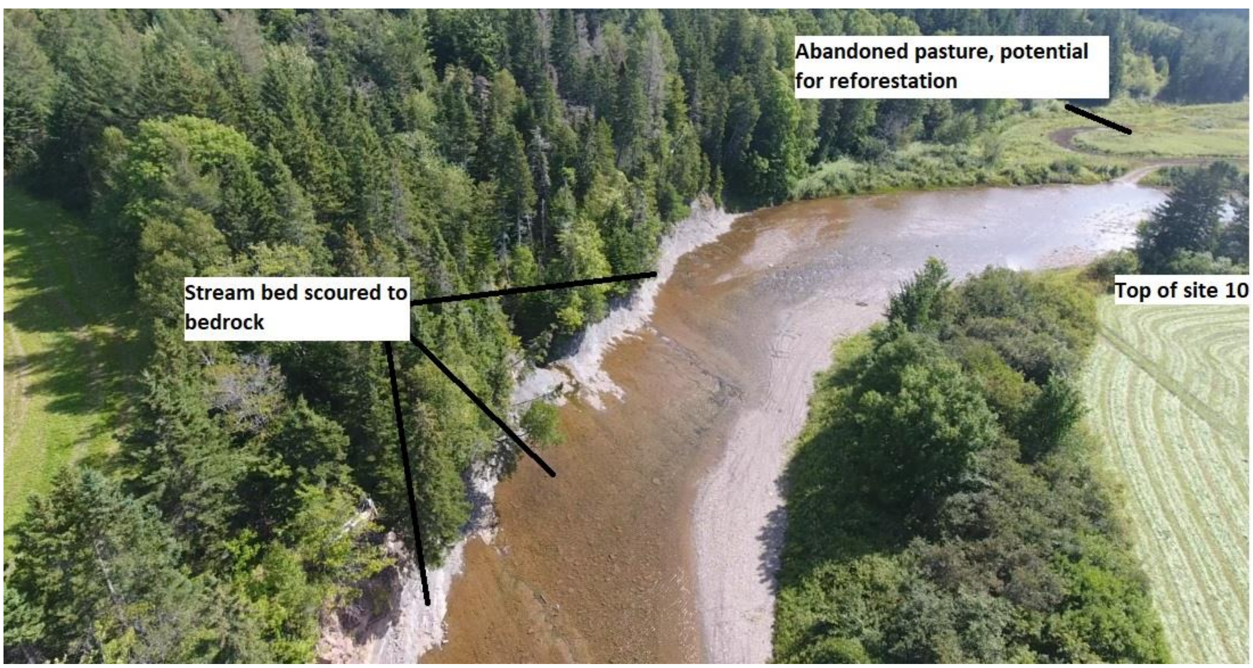

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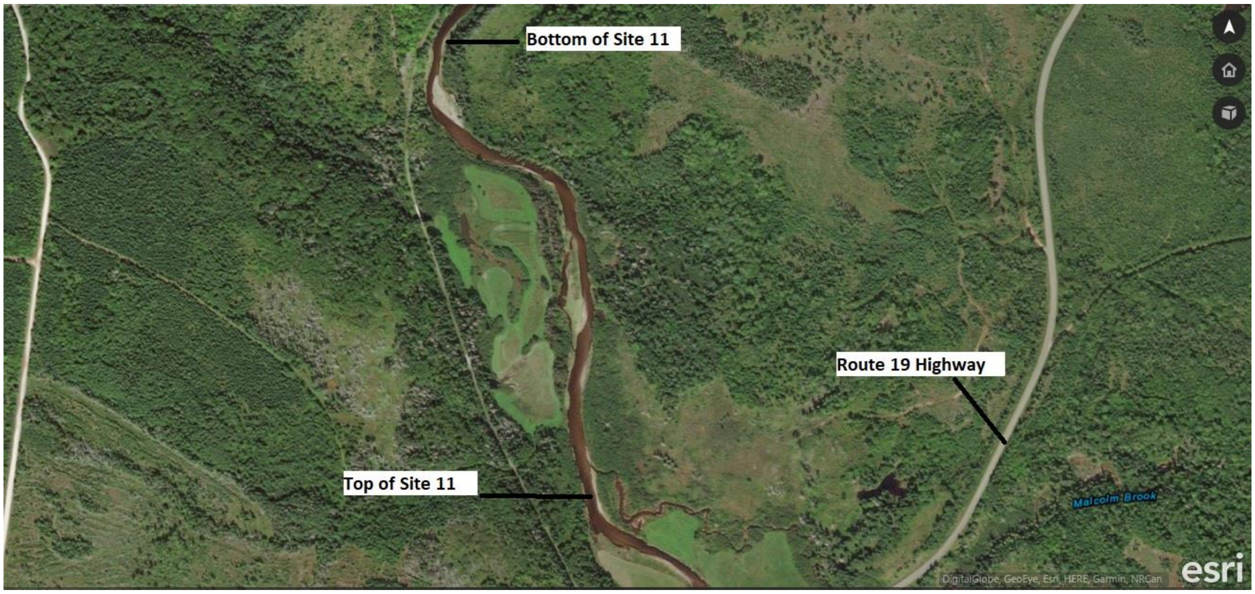
Site 11) MacIntyre



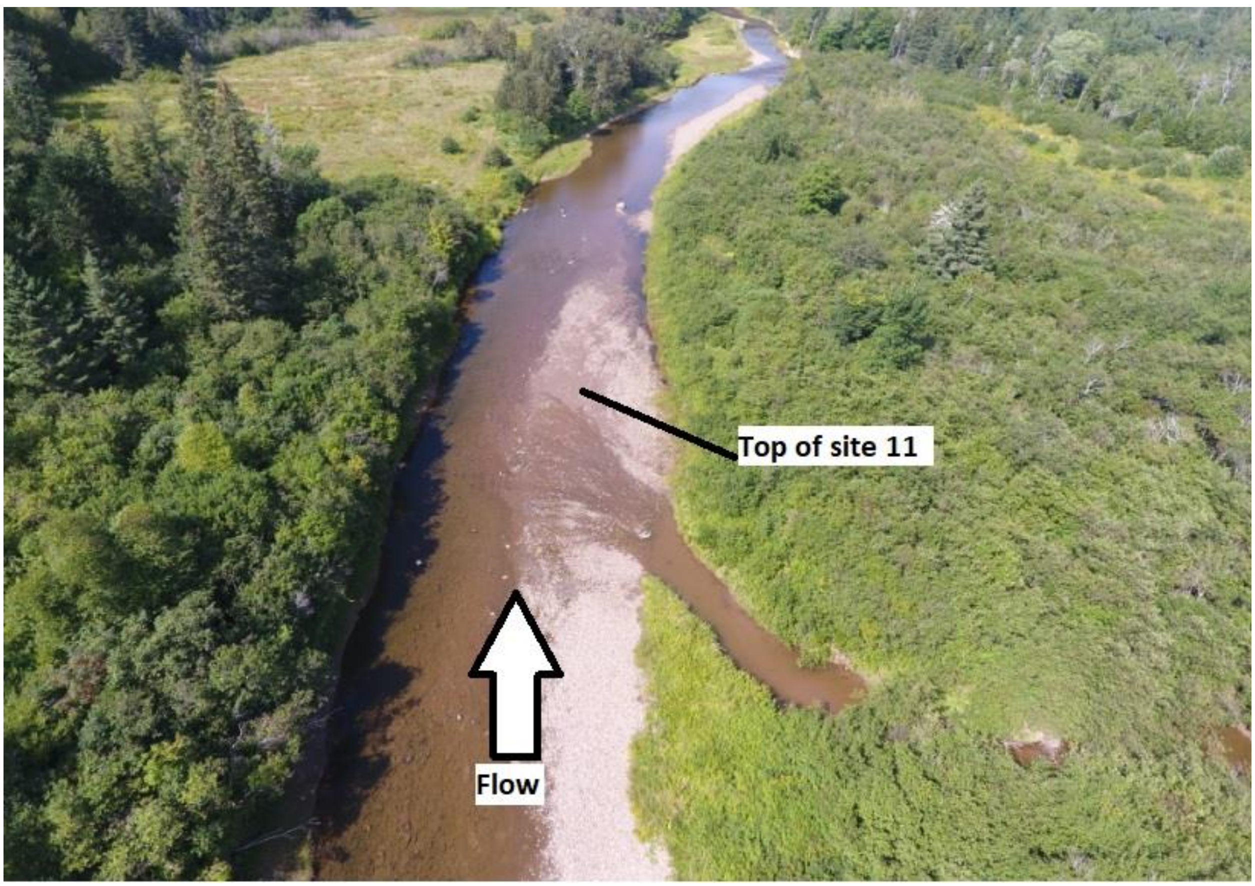


Figure 39:

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Appendix 1: River restoration techniques

Rock Sills

Rock sills support the riffle upstream of the structure and dig pools on the downstream side (DFO, 2006). They can also be constructed with deflectors and side sloping to narrow and deepen the river channel (MacInnis and Flynn, 2014). Rock sills are constructed at the head of a pool site and can be installed every six channel widths on alternating sides of the river. By alternating the direction of each successive sill, the structures can help re-establish proper meander patterns.

Deflectors

Deflectors are built much like a rock sill except the structure only cross a portion of the channel width. They serve to deflect water away from eroding banks and are often coupled with bank protection. Sediment often collects below deflectors and between groynes, helping to narrow the channel. Deflectors allow the restoration consultant to choose the direction that the river's energy will be directed.

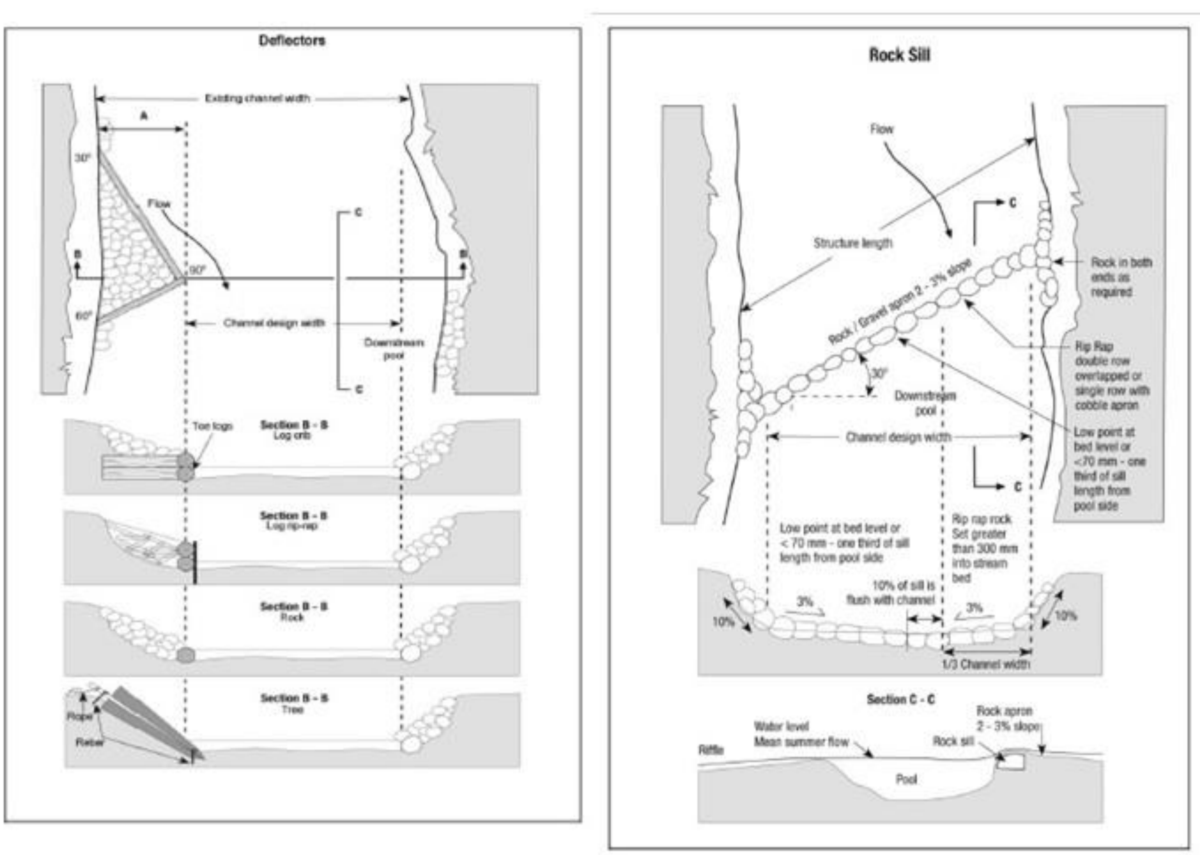

Figure 40: Illustration of deflectors and rock sills (source DFO, 2006)

Appendix 2: River Restoration Literature Review

River restoration is a "catchall term used to describe a wide range of management actions that are difficult to define" (Bennett et al., 2011). Multiple perceptions of what is meant by restoration reflects the wide range of stakeholder interests, scientific knowledge and biologic limitations encountered between various projects and river systems (Wohl et al., 2005). River restoration should improve a watershed's "capacity to provide clean water, consumable fish, wildlife habitat, and healthier coastal waters" (Palmer and Bernhardt, 2006). The term 'river restoration' however, has been erroneously used to describe any type of activity involved with the manipulation or containment of water channels (Shields et al., 2003).

River restoration is often focused on corridors that have been impaired or degraded by human activities (Bennett et al., 2011). River restoration is a commonly accepted practice which is viewed "by government agencies and various stakeholders as an essential complement to conservation and natural resource management" (Wohl et al., 2005). Stakeholders may include political entities, agencies that regulate commerce or environmental protection, commercial interests, non-governmental organizations, recreational users and individual riparian land owners (Jacobson and Berkley, 2011). In the United States 37,000 individual river restoration projects have been completed to date, with $1 billion (US) spent annually (Fishchenich, 2011).

The goal of most restoration projects is to return the degraded habitat to its dynamic equilibrium (Shields et al., 2003) or to a state of ecological sustainability (Wohl et al., 2005). "Restoring a channel to a state of dynamic equilibrium may not be a socially acceptable outcome if the resulting situation poses threats to riparian resources or infrastructure" (Shields et al., 2003). Wohl et al. (2005) believe that both technical and social constraints often "preclude full restoration of ecosystem structure and function". The successful implementation of river restoration projects is a significant task, as Rosgen (1994) points out "at no other time in the history of modern man have the cumulative impacts associated with the development along rivers had a greater impact on water resource values".

"Historically, decisions to implement river restoration were performed using ad hoc planning approaches" (Martin et al., 2016). These informal approaches typically focus on single, isolated sections of rivers (Wohl et al., 2005; Fischenich, 2011) and are often completed on a "piecemeal basis" (Wohl et al, 2005). Restoration projects were generally completed to maintain recreational utility (e.g. the continuance of a popular fishing pool) or to protect private property (Wohl, 2004). Scientific concern has been raised over the legitimacy of such projects, which are often chosen for reasons beyond ecological integrity (Martin et al., 2016). Wohl et al. (2005) therefore, define river restoration "as assisting the establishment of improved hydrologic, geomorphic, and ecological processes in a degraded watershed system and replacing lost, damaged, or compromised elements of the natural system".

Successful restoration projects are more likely to occur when planning incorporates a larger design that considers all the direct and indirect human influences on the chosen river system. The larger design that is most readily available and effective for restoration planning is the watershed boundary (Graf, 2001; McDonald et al., 2004; Wohl, 2004). "This reflects our view that successful restoration requires that key processes and linkages beyond the channel reach must also be considered" (Wohl et al., 2005). Pollock et al. (2014) see river restoration as an ecosystem process, that is reliant on the re-establishment of biological and geological relationships.

An important shift in the field of river restoration is the recognition and promotion of human, societal and cultural values and the inclusion of stakeholders in the governance process (Bennett et al., 2011; Jacobson and Berkley, 2011). Stakeholder involvement is a prerequisite to successful implementation of river restoration projects because of "the political realities of many natural resource management decisions" (Jacobson and Berkley, 2011). Stakeholders can aide in the planning of restoration projects and may also contribute specific and valuable information that may help understand past events (McDonald et al., 2004).

To advance the field of river restoration, Wohl et al. (2005) asserts that "major advances in the knowledge of river ecosystem processes are needed for application to river restoration projects". Palmer and Bernhardt (2006) believe a great deal of new research is needed to advance the field of river restoration. To achieve restoration objectives, Wohl et al. (2005) conclude that the scientific context of river restoration must be improved. This requires that practitioners develop an explicit knowledge of the complexities and uncertainties inherent in river ecosystems, and that theoretical frameworks to guide future projects continue to be developed (Wohl et al., 2005). All frameworks should include post-project monitoring and projects must proceed with an understanding of existing constraints (Wohl et al., 2005).