2014

# FINAL STEWARDSHIP PLANS

**Demoiselle Creek**

**Little River**

**Pollett River**

**North River**


Fort Folly Habitat Recovery

Petitcodiac Watershed Alliance

Petitcodiac Riverkeeper

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## INTRODUCTION

This document presents information assembled to enable planning of restoration activities within four watersheds: 1) Demoiselle Creek, a small watershed that drains directly into Shepody Bay, near the mouth of the Petitcodiac River estuary, and three tributaries of the Petitcodiac River system: 2) Little River, 3) Pollett River, and 4) North River. The location of these four watersheds in or near the Petitcodiac system, (just outside of Moncton New Brunswick) is presented below in Figure 1. Each watershed was assessed according to the four level approach laid out in the Department of Fisheries and Oceans document, “Ecological Restoration of Degraded Aquatic Habitats: A Watershed Approach” (DFO 2006). Under this process the first level of assessment is an examination of the land use history of the watershed. The second level of assessment looks at the current impacts. The third level of assessment considers the aquatic and riparian habitat, and the fourth level of assessment then brings this information together to develop an aquatic habitat rehabilitation plan that identifies priorities and opportunities for interventions within each watershed to advance the goal of habitat restoration.

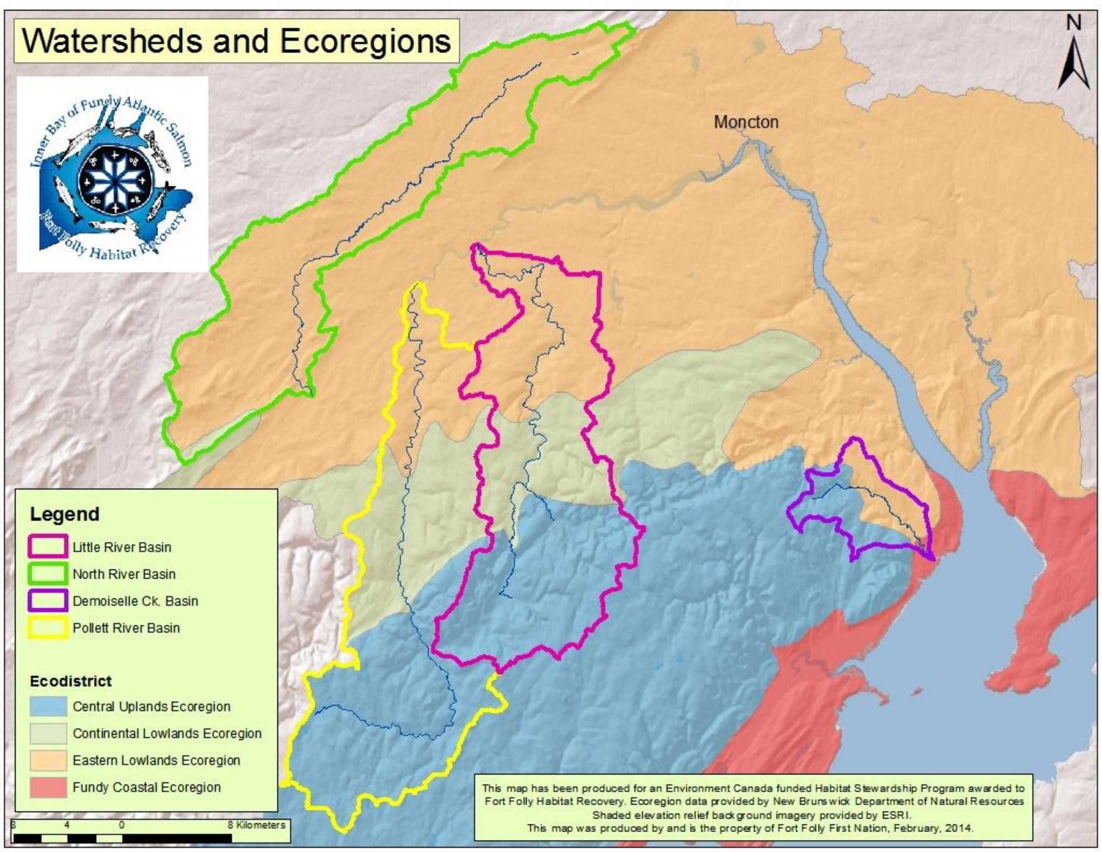


**Figure 1:** Location of examined watersheds within or near the Petitcodiac system

## DEMOISELLE CREEK

Demoiselle Creek is located within Albert County, approximately 40 km southeast of Moncton. It passes under Hwy 114 before emptying in to Shepody Bay. Albert Mines Road follows north along the creek (Figure 1-1). The Demoiselle Creek watershed is 46.00 km2. The basin drains areas of 3 ecoregions. Much of the headwaters drain Central Uplands Ecoregion (Department of Natural Resources 2007) the site of historic mining activity for albertite, gypsum and anhydrite. Other than forestry, blueberry production is the only other commercial activity current in this zone (Department of Natural Resources in 2014). The creek then passes through the Eastern Lowlands Ecoregion. This area is highly forested and is contains most of the settlement and light industry, and some of the agriculture for the watershed. Finally, Demoiselle creek enters the Fundy Coastal Ecoregion . This area is highly agricultural and contains large areas of fertile lands reclaimed by extensive dykes built by early French settlers. Where the creek enters Shepody Bay, there is an aboiteau, a one way hydro gate that allows fresh creek water to drain into the bay, but restricts the inflow of brackish water at high tide.

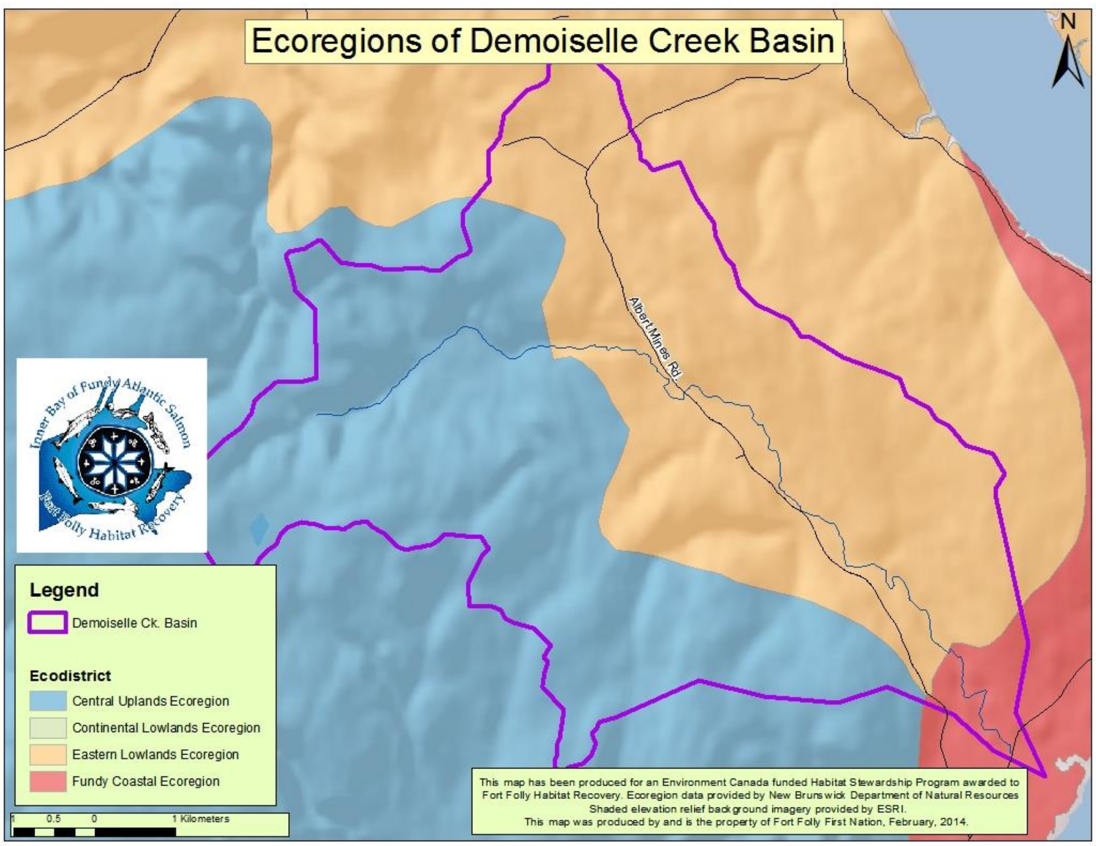


**Figure 1-1:** Demoiselle Creek watershed

Unfortunately, this also restricts migration of marine animals into the creek. Aboiteaus have been used since the dykes were built in the late 1600s. The current aboiteau is a modern concrete structure installed in the 1990s, but its design still restricts fish passage from the marine environment into the creek.

The name, Demoiselle, dates back to the time of Acadian settlement (Hamilton 1996). By 1749 it was applied to several features in the area, most notably Hopewell Cape, known then as “cap de Damoiselles” by the French (Ganong 1896), due to the famous Hopewell Rocks, located not far from the mouth of Demoiselle Creek . The rocks, often described as looking like flower pots by the English , were named a bit more romantically by the French, who thought that they looked like young ladies, i.e. Damoiselles (Rayburn 1970). The mouth of Demoiselle Creek, only 1.68 km away from the rocks as the crow flies, is the most significant inlet in the immediate area of the rocks (Natural Resources Canada 2010), which is likely why the name of the rocks became attached to it. In addition to its main stem, named tributaries of Demoiselle Creek include: Curryville Creek, McHenry Brook, and Wilson Brook.

## First Level Assessment – Land Use History of the Watershed

Understanding the historical land use in a watershed has the potential to help explain the underlying cause of issues present today. The following sections outline historical land use in the areas surrounding Demoiselle Creek in Albert County. Communities in the area include Albert Mines, Cape Station, Curryville , Harvey Bank, Hillsborough, and Lower Cape.

**Table 1-1:** Brief historical summary for communities along or near Demoiselle Creek

| Community | Settlement Type and Dates | Notes |
|---|---|---|
| Albert Mines<br>(Demoiselle Creek) | Settled: 1830<br>Mining and Farming | **1849** Albertite discovered<br>**1898** population 200, post office, 2 stores, 2 saw mills, 1 church, 1 Albertite mine |
| Cape Station<br>(Demoiselle Creek) | Settled: Not available<br>Farming | **1898** population 150, post office, 1 church<br>Railway station Salisbury – Albert Railway |
| Curryville<br>(Demoiselle Creek) | Settled: 1830 by Daniel Curry<br>Farming | **1898** population 250, post office, 1 saw mill, 1 church, flag station on Salisbury-Albert Railway |
| Harvey Bank<br>(Shepody River) | Settled: Not Available<br>Farming, Shipbuilding | **1898** population 190, post office, 1 store, 1 saw mill, 1 shipyard |
| Hillsborough<br>(Petitcodiac River) | Settled: 1765<br>Seaport, commercial centre | **1840** Name changed from German Village to Hillsborough<br>**1898** population 700, post office, 8 stores 2 hotels, 1 tannery, 1 carriage factory |
| Lower Cape<br>(Demoiselle Creek) | Settled: Not available<br>Farming | **1898** population 50, post office, 1 store<br>Railway station Salisbury – Albert Railway |

(Source: Provincial Archives of New Brunswick, 2015)

The Maritimes have had human inhabitants for the last 11,000 years (Wicken 2002), though for most of that time precise cultural identities are impossible to determine today. By the early 1600s, when Europeans arrived, much of the native population of coastal Atlantic Canada shared a common culture and language identifying themselves as the L'nuk, "the People", and recognized by Europeans as the Mi'kmaq. Traditionally, the Mi'kmaq lived in large villages along the coasts from April to November, and then dispersed during the winter, migrating inland to hunt moose and caribou. One such encampment was not far from the mouth of the Demoiselle, on the opposite bank of the Petitcodiac River estuary at Beaumont (Petitcodiac Heritage River Committee 2000) just 8.5 km away from the mouth of the Demoiselle, as the crow flies (Natural Resources Canada 2010). During this time physical impacts on the watershed were few compared to what was to follow.

In the 1630's the French began to make a serious effort to colonize Atlantic Canada, beginning to arrive in numbers significant enough to develop an enduring Acadian identity (Laxer 2006), at a fairly similar time frame to the English colonies further south. By 1676 the first Acadian settlers arrived at Beaubassin, near the current Nova Scotia Visitor's Centre along the Trans-Canada Highway at the New Brunswick border (Larracey 1985). Then, 34 years later in 1710, Acadians and Mi'kmaq in peninsular Nova Scotia fell under British control, which was subsequently formalized in 1713 under the treaty of Utrecht. In 1751 Fort Beausejour was built at the border to protect Acadian communities in what is now New Brunswick from attack by the British. By this time the Acadian population near the Fort had grown to 1,541 people, with an estimated additional 1,100 spread out at Shepody and along the Petitcodiac and Memramcook Rivers (Larracey 1985). The Acadians built dykes and tidal control structures turning marshland along the lower Petitcodiac estuary into pasture, and established their settlements nearby (Wright 1955).

There were two Acadian villages located near the Demoiselle. The first- Village des Blanchard, was established in 1698 (Ganong 1899) along the Petitcodiac near what today is Hillsborough (Dionne 1983), not far (5 to 10 km) overland from the headwaters of the Demoiselle (Natural Resources Canada 2010). The second- Chepodi (Ganong 1896), was about 10 kilometers overland from the mouth of the Demoiselle near what today is the community of Hopewell Hill, on the Shepody marsh (Albert County Museum 2015a; Natural Resources Canada 2010). The English name Shepody comes from the French Chepodi, most likely derived from the Mi'kmaq name "Es-ed'-a-bit" meaning "the bay that turns back on itself" (Ganong 1896; Hamilton 1996).

The Mi'kmaq sided with the French (Wicken 2002), participating in the defense of Fort Beausejour, as well as the short guerilla war which followed its capture (Grenier 2008). A battle was fought at Village des Blanchard (Hillsborough) in September 1755 when a combined force of Acadians and Mi'kmaq ambushed and defeated the British there (Petitcodiac Heritage River Committee 2000). But though they won that battle, the loss of Fort Beausejour earlier in June that year, meant the war had already been lost. There were several reasons that Mi'kmaq in New Brunswick allied themselves with the French. Prior to the arrival of the British, native communities had already established trade networks with the Acadians for steel tools, weapons and other European goods (Walls 2010). Another source of friction was that the Mi'kmaq had begun to adopt Catholicism from the French, while the British were Protestants, at a time when such differences added fuel to conflicts. Acadians also had had good relations with the Mi'kmaq in part because the lands Acadians occupied either complemented native use, as with fur traders, or were in areas that were marginal to native concerns as in the case of the Acadian farmers on the tidal flats (Mancke 2005). English settlers on the other hand tended to seize land the Mi'kmaq valued, to clear the forest for agriculture (Francis et al. 2010). After the arrival of the United Empire loyalists from the 13 colonies (late 1770's - 1780's), Mi'kmaq in what is now New Brunswick were moved off their lands and onto "reserves" (Walls 2010). This was done partially to provide land to incoming settlers, and partially to punish the Mi'kmaq for aligning themselves with the French.

### *Forestry Practices*

The ruggedness of coastal Albert County hindered early timber exploitation. The steep hills constrained road construction and limited the hauling that could be done by horse or oxen teams (Shoebottom 1999). Instead driving dams were required to ensure sufficient flow to move logs. During the early 1800s white pine was gradually culled from New Brunswick Forests to meet the demand for masts for the Royal Navy (Wynn, 1981). The White Pines Act of 1722 established the requirement of a royal license to fell white pines with a diameter exceeding 24 inches unless they were privately owned, and in 1729 Parliament reserved all such trees to the government except those already in private hands before 1690 (Purvis 1999). Since New Brunswick came under British control well after that time, this exception did not apply at all to its forests. During the American Revolution and the Napoleonic Wars from 80 to 90 percent of all masts supplied to the Royal Navy came from Canada, mostly New Brunswick (Williams 1992). The Napoleonic blockade of the Baltic forced England to expand New Brunswick's lumber production twentyfold, transforming an "undeveloped backwater" of 25,000 people to a bustling colony of 190,000 (Gordon 2014). Pines could still be found in 1850, but few of the magnificent trees the region was known for earlier in the century remained. Spruce was more abundant, but the largest had also been cut. Though there were not many extensive cutover tracts, by 1850 the character and composition of the forests in New Brunswick had been drastically modified over the course of just 50 years of harvesting.

The effects of this early economic activity were not limited to just the forests. By 1820 importation of food into New Brunswick was the rule rather than the exception, everything hinged on the timber trade, though there were warning signs of the danger of single source economy (DeMerchant, 1983). James Robb, professor of Natural Science at Kings College in Fredericton (now the University of New Brunswick), was appointed Secretary of the Provincial Board of Agriculture when it was established in 1858. He warned that timber harvesting was so lucrative that it distorted development, and that when the market in Europe declined, the farmer neglecting his homestead to work in the woods would be “surprised to find his fences down, his fields grown up with bushes, and both himself and his snug little clearing generally all gone bad”. It was not just agriculture that was falling short of its potential. In the years that shipbuilding boomed at Saint John and other towns along the coast, even the fishing industry was neglected as men were drawn to the forest to supply wood (DeMerchant, 1983).

The age of wooden ships was winding down however, causing a reduction in the scale of the demand for timber exports both as wood and manufactured into ships. By the end of the Crimean war in 1856, virtually all of the ships in the British Royal Navy had already been fitted with steam engines rendering masts irrelevant (Evans 2004), and the conversion to iron hulls began within a decade thereafter. In 1874 New Brunswick shipbuilding peaked (Shoebottom 2000). A year later Gaius Turner bought the shipyard at Harvey Bank, determined to compete by adapting to build larger ships that could yield greater profits (or losses), more like those being built further down the bay in St. Martins or Saint John, at a time when other builders at Alma, Hopewell, and Hillsborough still focused on the coastal trade. Turner controlled a significant supply of timber at a time when good ship’s timber was becoming scarce (Shoebottom 2000). He also adapted to changes in technology by investing in the Railway.

In 1877 when the Salisbury – Albert Railway arrived, it traveled from Hillsborough and Albert Mines, down the length of the Demoiselle Creek valley to its mouth, with plans for a branch to run along the Shepody marsh to a water terminus at Turner’s shipyard at Harvey Bank on the Shepody River (Chignecto Post, Thursday May 24th 1877). By the fall 1883 this was in place with the Province having paid for a bridge over the Shepody River, and Turner building a station, engine house and turntable at his wharf and shipyard. This expanded the supply of timber available to Turner by connecting his shipyard to the Intercolonial Railway, as well as more locally providing excellent access throughout the Demoiselle Creek watershed. In 1887, the Salisbury-Albert Railway reported carrying 8,913 tons of timber (The Maple Leaf Thursday January 12th 1888), some of which was likely destined for Turner’s shipyard. He put this supply to good use, building 18 large ships (averaging over 900 tons each) in 18 years, including the Annie E. Wright, the largest ship ever built in Albert County, and the 3rd largest ever built in New Brunswick (Shoebottom 2000). Despite such innovations however, the end of large scale wooden shipbuilding was inescapable. From the peak of New Brunswick production in 1874 of

40,000 tons when Turner began, to the time of his death in 1892 shipbuilding in the province had declined by 87% to about 5,000 tons.

### Agricultural Practices

With the exception of the marshes on the Shepody River, at the mouth of Demoiselle Creek, and the mouth of Weldon Creek at Hillsborough, coastal Albert County is quite rugged, which limited early development. The Acadians found however that these marshes offered excellent agricultural opportunities once dyked and drained (Shoebottom 2000). In addition to meeting their subsistence requirements, Acadian communities were able to produce surplus livestock and grain for trade with Louisbourg and New England (Wynn 1979). Fields of wheat, peas, oats, rye, barley, and hay covered as much as 13,000 to 20,000 acres of marshland in the upper Bay of Fundy, a portion of which were at Chepodi, and Village des Blanchard.

Many contemporary commentators were unimpressed with the initial “English” use of the marshlands compared to the Acadians (Wynn 1979). After the expulsion, many of these dykelands fell into disrepair, described at the time as being, mostly in meadow, providing pasturage for livestock, where they had borne vast quantities of wheat and other grains prior to 1755. However some of this was a consequence of economics, with reduced demand for surpluses and a lack of reliable markets, there was little incentive to expand production beyond local requirements. By the 1780s, things began to turn around as the loyalist influx created large urban markets in Halifax and Saint John, as well as for settlers in more remote rural districts that had to be supplied with provisions during their first few years on the land (Wynn 1979). While imported flour and grain offered stiff competition to local products, livestock, butter, and cheese from the upper Bay of Fundy began to find ready markets.

Agricultural practices were common in 1775 with the majority homes nearby in Hillsborough harvesting crops and keeping some sort of livestock (Wright 1955).) The bulk of early English settlements in the area sprung up around the dyked lands worked by Acadian settlers living near the upper limits of the Bay of Fundy and confluence of the Petitcodiac River. By 1860 the Harvey Agricultural Society reported the following being grown: wheat, oats, barley, buckwheat, peas, grass seed, hay, potatoes, turnips, cattle, horses, pork and poultry (DeMerchant, 1983). At the same time there were also reports of uplands being cleared for orchard production using grafted fruit trees.

Though agriculture and forestry had been in competition for labour during early English settlement, as the forestry industry declined, agriculture began to boom (DeMerchant, 1983). By 1850 25% of the land in Hopewell Parish had been developed for agriculture (Wynn 1981), which given the rough terrain would have been a good portion of the land suited to it. This included the Demoiselle described as follows in 1879, “The valley of Demoiselle has been described before, and I need hardly do other than allude to it as a fertile one, well settled and capable of producing good crops." (New Brunswick House of Assembly 1879). It was no exception; both Hopewell Parish and Harvey Parish were well regarded. The Chignecto Post in Sackville wrote in November 12, 1891 "Where these red lands adjoin the dyked marshes the most fertile and desirable farms are to be found. ... The marsh hay lands of this region are a great source of wealth to their owners, while the uplands are so rich as to raise magnificent crops with but little cultivation. There is no limit to the agricultural capabilities of Harvey and vicinities..."

### *Mining Practices*

The area surrounding Demoiselle Creek was home to a number of mines and quarries. Oil shale was located in Albert Mines (Canadian National Railways 1964). In 1847, Peter and John Duffy discovered Albertite, a mineral resembling asphaltium that yields oil and gas. Its discovery occurred as a result of a mill dam bursting on Frederick Brook after which the rushing water exposed the material (Jones et. al 1997; Clowes 2003). Abraham Gesner who had been the Provincial geologist of New Brunswick from 1838 to 1842 had already invented kerosene, by distilling it from coal (hence the alternate name "coal oil"), but the cost of extracting it that way proved to be too high. During his analysis of albertite Gesner found that it could be used to produce kerosene much less expensively than coal, and doing so quickly turned kerosene into a successful commercial product (Black 2008). Albertite was mined and shipped from New Brunswick to Boston where it was processed as one of the primary sources of kerosene by the Downer Kerosene Oil Company until 1861 when petroleum was discovered in Pennsylvania (Van Slyck 1879). The albertite deposit was mined-out after 230,000 tons were extracted over the course of 30 years. In 1859, the Caledonia Mining and Manufacturing Company was also active in Albert looking for bituminous shale and schist (Salter 1996).

Gypsum was mined at Albert Mines and transported via rail to Hillsborough (Jones et. al 1997). "The Wentworth Gypsum Company and the firm of J.B. King and Company, manufacturers of plaster, NY, visited the new plaster quarries owned by Mr. Dimock at Demoiselle Creek. A new wharf has been built at Gray's island, Hillsboro's, affording ample shipping facilities. A branch line from the Salisbury – Albert railway is now being built to the quarries." (The Albert Star, Hillsborough, NB, dated September 12, 1894). This rail link was a vital development, as during the winter months the Petitcodiac River would fill with ice, closing the seaport at Hillsborough, prior to that point making it impossible to ship out the valuable minerals mined in the area at that time of year (Albert County Museum 2015b).

One of the major long-term employers of the area was the Canadian Gypsum Company Ltd. In the 1930s, the company owned the mill and the deposits in Hillsborough (Jones et. al 1997). They extracted gypsum and anhydrite at Hillsborough for plaster, gypsum board and other gypsum product manufacturing (Canadian National Railways 1964). In 1981 the gypsum plant at Hillsborough was closed, at which point the rail line connecting it to Salisbury was no longer profitable, and Canadian National abandoned it the following year (New Brunswick Railway Museum 2015a).

Grindstone Island, housed a quarry for making grindstones, hence the name. (Jones et. al 1997). In the late 1700s they were used by merchants and traders as currency. Other local quarries in the area included; Caledonia Quarry (1865-1885), Curryville (1874-1885) and Caledonia Mountain for slate (Jones et. al 1997). A limestone quarry operated by a by a Mr. McHenry also produced agricultural lime in the Demoiselle Creek valley (Ells 1885)

## Second Level Assessment – Current Impacts

### *Forestry Practices*

The Demoiselle basin covers 46.00 km² (Figure 1-2), of which private woodlots cover 36.14 km² (78.57%), Crown forests cover 2.33 km² (5.01%), Industrial freehold forestry leases cover 4.43 km² (9.63%). Industrial freehold leases are exclusively held by JD Irving.

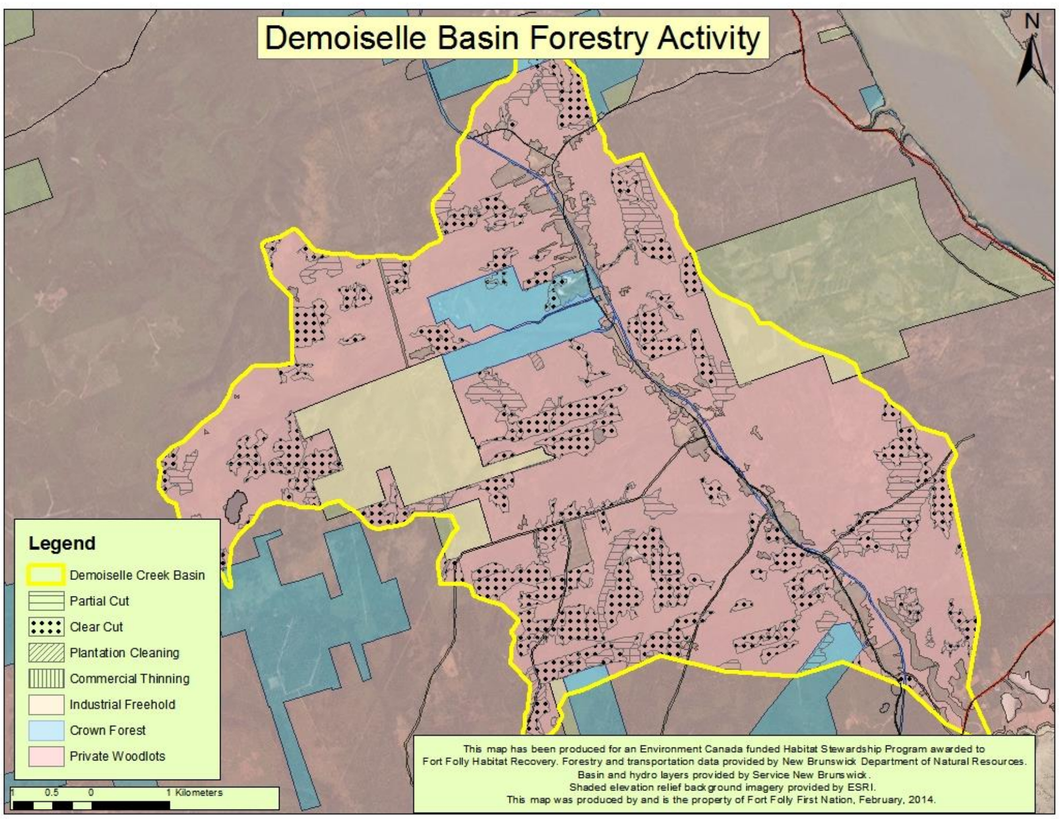


**Figure 1-2:** Forest Tenure and utilization within Demoiselle Creek watershed

## *Agricultural Practices*

Nonforest Land Use data obtained from the New Brunswick Department of Natural Resources (Figure 1-3) shows 5.3% of the watershed is used or purposes other than forestry. This activity mostly occurs along the Albert Mines Road which runs roughly parallel to Demoiselle Creek. Land use is classified as: Settlement (0.84 km² or 1.83% of the basin), Industry – In this case, small businesses such as machine shops and small garages (0.07 km² or 0.15% of basin), Crops & Grains – including hayfields ( 0.57km² or 1.24% of basin), Pasture (0.83 km² or 1.80% of basin), Blueberry production (0.15 km² or 0.33% of basin).

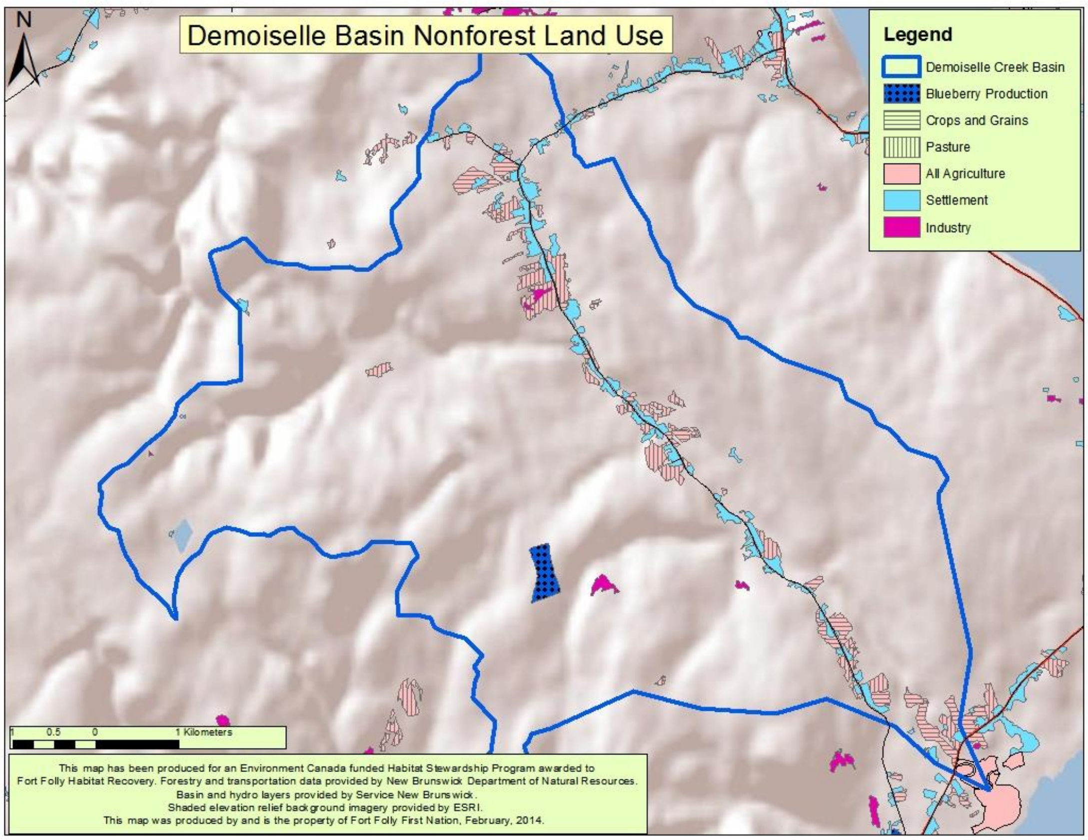


**Figure 1-3:** Agriculture and other non-forest usages of land in Demioselle Creek watershed

## *Urban Development*

A database was developed to house property boundary and landowner information. The property boundary information is incorporated in to a GIS layer for the Demoiselle Creek watershed. Additionally, an excel database, Property Boundary and Landowner Information 2012-2013, contains information from Service New Brunswick on owner or business names, location addresses, place names, and associated PIDs and PANs.

### *Transportation Development*

Discussions with New Brunswick's Department of Transportation identified four culverts (AJ10-13) over 3 feet in diameter that cross Demoiselle Creek (1-4). There may be culverts less than 3 ft in diameter within the watershed that are the responsibility of the DoT, however, records were not available for these. If a problem culvert is identified and there is a question of whom is responsible for it (private landowner versus the DoT), GPS coordinates should be taken and responsibility confirmed through further discussions with the DoT. Culvert inspection reports were provided by the DoT for the four aforementioned culverts. Selected information from these reports is provided below.

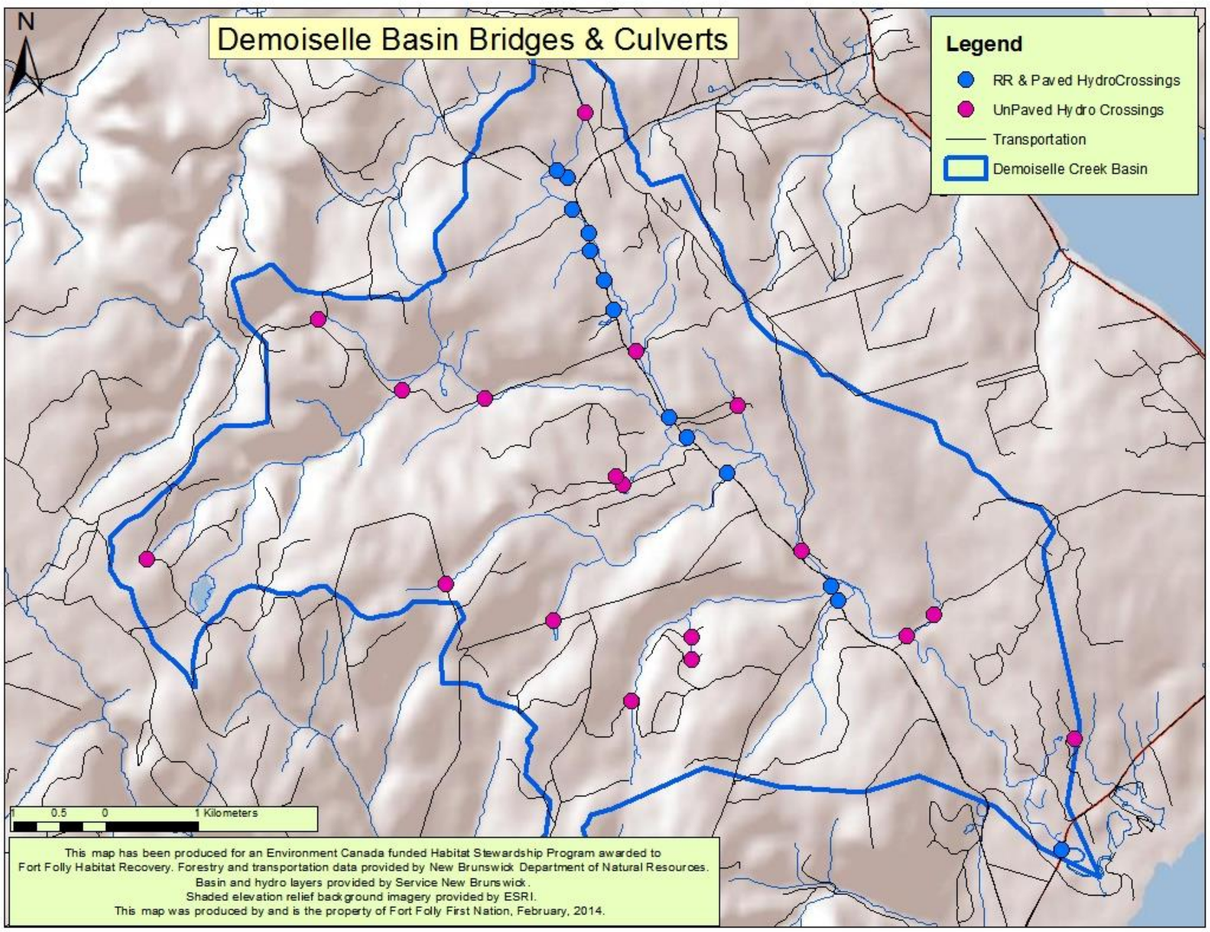


**Figure 1-4**: Locations of road / water crossings in the Demoiselle Creek watershed.

Culvert AJ10 (Figure 1-5) is located on Albert Mines Road and was last inspected on July 18, 2012. The overall structure condition is designated as FAIR. The following recommendations were made for this culvert:

- The vegetation on both sides of the road should be removed
- The debris and vegetation in the waterway and inside the pipe should be removed
- The gabions of rocks at both ends of the culvert should be replaced
- The wheel ruts, depressions, transversal cracks and pot holes should be repaired

Culvert AJ11 (Figure 1-6) is located on Albert Mines Road and was last inspected on July 18, 2012. The overall structure condition is designated as EXCELLENT. The following recommendations were made for this culvert:

- The vegetation on both sides of the road should be removed
- The debris and vegetation in the waterway should be removed
- The scouring hole at the downstream end of the culvert should be eliminated

**Figure 1-5:** Culvert AJ10.

**Figure 1-6:** Culvert AJ11.

Culvert AJ12 (Figure 1-7) is located on Albert Mines Road and was last inspected on July 18, 2012. The overall structure condition is designated as FAIR. The following recommendations were made for this culvert:

- The vegetation on both sides of the road should be removed
- The debris and vegetation in the waterway should be removed
- The wheel ruts, transversal cracks and cracks going in all directions should be repaired
- The scouring hole should be eliminated

Culvert AJ13 (Figure 1-8) is located on Albert Mines Road and was last inspected on July 18, 2012. The overall structure condition is designated as FAIR. The following recommendations were made for this culvert:

- The vegetation on both sides of the road should be removed
- The debris and vegetation in the waterway should be removed
- The scouring hole should be eliminated
- The wheel ruts, depression, transversal cracks and cracks going in all directions should be repaired
- The undermining at both ends should be stopped and repaired
- The erosion at the upstream end of the culvert should be stopped and repaired

**Figure 1-7:** Culvert AJ12.

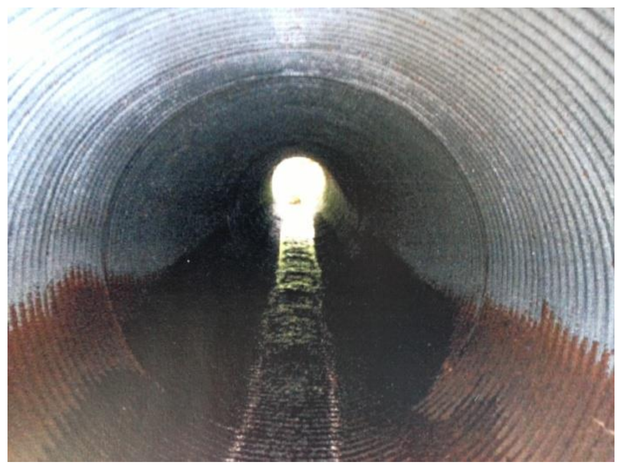

**Figure 1-8 :** Culvert AJ13.

There are also four bridges within the Demoiselle Creek watershed (D275, D270, D265, and D260). D260 is the bridge located on Hwy 114 and is the responsibility of the DoT. Bridges D265 and D270 located on Grub and Hawkes Roads, respectively, are located on public (not maintained) roads, which from our discussion with the DoT are not their responsibility. For the final bridge, D275, responsibility is difficult to discern based on the maps provided. If there are concerns with this bridge identified with this bridge, follow up will be necessary. Locations of these bridges and culverts have been incorporated in to a GIS layer.

### *Herbicide and Pesticide Use*

Based on general information provided by Service New Brunswick, two forestry operators (JD Irving as Forest Patrol and Natural Resources) may have conducted work in the Demoiselle Creek watershed. While intended blocks of land to be treated were identified by operators that does not necessarily mean that they were treated with herbicides. Products used in these industries may contain the active ingredient glyphosate. Glyphosate is found in several formulations under the trade names Arsenal (PCP 23713), Forza (PCP 26401), Vantage (PCP 26884), Vision (PCP 19899) and Vision Max (PCP 27736). The active ingredient triclopyr has also been used in the past as Release (PCP 22093).

In addition, two industrial operators (Asplundh and NB Power Transmission) may have conducted work with respect to an industrial right-of-way perspective (rail, transmission lines, etc.) in the Demoiselle Creek and North River watersheds. These companies may have used triclopyr as Garlon 4 (PCP 21053), Karmax (PCP 21252) and any of the aforementioned glyphosate products. Private growers must be individually certified (hold a valid pesticide applicator certificate) but do not report their usage. Likewise, vendors must report total sales but do not provide a breakdown relevant to individual purchasers. It is difficult to find information of individual grower or vendor pesticide or herbicide use.

### *Mining Practices*

Oil and Natural Gas lease rights within the Demoiselle Creek watershed are currently registered to Contact Exploration Inc. (Government of New Brunswick 2015). Contact Exploration In. merged with Donnycreek Energy in December 2014 to form Kicking Horse Energy Inc (Kicking Horse Energy 2015). There are both shale gas and oil resources within the lease, though the observed gas and the two existing oil fields are outside (north and east) of Demoiselle Creek. Given the historic hydrocarbon resources found within the watershed at Albert Mines, additional discoveries within the Demoiselle Creek watershed by the leaseholder would not be unprecedented. The former Provincial government made a clear commitment to promoting shale gas development in New Brunswick (Alward 2014). However, shortly after coming into office, the new government enacted a moratorium on expansion (Canadian Broadcasting Corporation 2014). If wells are eventually drilled within the Demoiselle Creek watershed, impacts will include freshwater extraction from streams, habitat destruction and sedimentation during road building, and the potential for wastewater spills contaminating surface waters.

## Third Level Assessment – Aquatic and Riparian Habitat Assessment

### *Wildlife*

Several species of wildlife that warrant specific attention are found or have been found in the Demoiselle Creek watershed: Atlantic salmon, American eels and Wood turtles. Atlantic salmon (*Salmo salar*) Inner Bay of Fundy (iBoF) populations were listed as endangered under the Species at Risk Act in 2003 (DFO 2010; SARA Registry 2013a). American eels (*Anguilla rostrata*) were designated as "Special Concern" by COSEWIC in 2006 (COSEWIC 2006). Their status was re-examined and raised to "Threatened" in May 2012 (COSEWIC 2014). This species is being considered for listing under the federal Species at Risk Act, but currently it has no status (SARA Registry 2013b). Wood turtles (*Glyptemys insculpta*) were designated as "Special Concern" by COSEWIC in 1996 which was raised to "Threatened" in 2007 (COSEWIC 2007; COSEWIC 2011). This species is listed as "threatened" under the Species at Risk Act (SARA Registry 2012). Guidelines for projects in areas with these species are in Appendix A.

The decline in numbers of iBoF salmon basin wide is a marked contrast to the abundance described by early settlers in the area (Dunfield 1991). Fort Folly Habitat Recovery has not encountered salmon in the course of its field work on the Demoiselle Creek. Similarly, DFO has no record of recreational catch or historic electrofishing data for it (Gibson et al. 2003). Demoiselle Creek has received captive reared fry as part of the Live Gene Bank program, and the habitat appears quite capable of supporting them as subsequent electrofishing in 2002 (only one site) by DFO turned up a high density of juvenile fish (Gibson et al. 2003) However, given the FFHR results, this did not lead to an enduring presence of salmon in the watershed, likely due to the poor rate of adult return to all iBoF rivers, compounded by the aboiteau at the mouth of Demoiselle Creek further decreasing the likelihood of adult return. Though the current aboiteau was installed in the 1990s, it is just the latest in a series of historic structures in place going back to Acadian settlement, which explains the lack of historic catch data for DFO as salmon have likely been excluded from Demoiselle Creek for quite some time, despite the evident quality of habitat upstream of the aboiteau. Similarly American eels have not been encountered by Fort Folly Habitat Recovery along the Demoiselle Creek, perhaps due in part to the limited amount of electrofishing done there (three sites in 2012), but more likely due to exclusion by the aboiteau at its mouth. Wood turtles have not been encountered by FFHR on Demoiselle Creek, though it lies well within their recognized range (Amato et al 2008), and so projects within the watershed should take into account the potential for their presence.

## *Rapid Geomorphic Assessment (RGA) and Rapid Stream Assessment (RSAT)*

The following is taken from the report prepared by Parish Geomorphic based upon the rapid geomorphic assessments (RGAs) and rapid site assessments (RSATs) Fort Folly Habitat Recovery conducted in 2012. Demoiselle Creek, which empties into Shepody Bay near Cape Station, was assessed northwest from Route 114 to a point upstream approximately 13 km. This section of creek was divided into two main reaches and 72 sub-reaches.

### *Geomorphic Background*

The RGA and RSAT data were used to determine the geomorphic condition and stability of the assessed sections of Demoiselle Creek. In order to interpret the geomorphic data, the watercourses are highlighted on their respective maps according to the sub-reach stability. A bar graph is also associated with each sub-reach and illustrates the dominant geomorphic process. The geomorphic processes identified included aggradation, degradation, channel widening, and planform adjustment.

**Aggradation**

Channel aggradation may occur when there has been a significant decrease in flows, a significant increase in sediment supply, or a significant decrease in slope due to irregular meander migrations. Depending on upstream processes and the boundary conditions of the reach, channel widening may occur in association with channel aggradation.

Indicators of aggradation include:

- Shallow pool depths
- Abundant sediment deposition on side bars and non-vegetated mid-channel bars, extensive sediment deposition at obstructions, channel constrictions, at the upstream end of tight meander bends, and in the overbank zone
- Most of the channel bed is exposed during typical low flow periods
- High frequency of debris jams
- Coarse gravels, cobbles, and boulders may be embedded with sand/silt and fine gravel
- Lateral migration of thalweg
- Soft, unconsolidated bed
- Mid-channel bars
- Deposition on point bars

**Degradation**

The process by which a stream's gradient becomes less steep, due to the erosion of sediment from the stream bed. Bed lowering can move in both an upstream direction (as a headcut or nick point) and/or downstream. This can occur from a rapid removal of streambed material due to an increase in discharge, water velocity, or a decrease in sediment supply.

Indicators of degradation are:

- Elevated tree roots
- Bank height increases as you move downstream
- Absence of depositional features such as bars
- Head cutting of the channel bed
- Cut face on bars
- Channel worn into undisturbed overburden/bedrock

**Widening**

When the stream becomes incapable of transporting its sediment load, sediments collect on the stream bed, forming mid-channel bars that concentrate flows into both banks, and lead to a wider channel. Streams that score poorly under channel aggradation may also score poorly for the channel widening parameter. Channels also become over-widened due to an increase in flows or to a decrease in sediment supply, which is not necessarily related to bed aggradation but may be seen in association with degradation. In these cases widening is the dominant process.

Indicators of widening include:

- Active undermining of bank vegetation on both sides of the channel; many unstable bank overhangs that have little vegetation holding soils together;
- Erosion on both right and left banks in riffle sections;
- Recently exposed tree roots;
- Fracture lines at the top of the bank that appear as cracks parallel to the river; evidence of landslides and mass failures;
- Deposition of mid-channel bars and shoals
- Urbanization and storm water outfalls leading to higher rate and duration of runoff and channel enlargement typically in smaller watersheds with a high percentage (>10%) of impervious surface (urban land use).

**Planform Adjustment**

Changes to the planform can be the result of a straightened channel imposed on the river through different channel management activities, or a channel response to other adjustment processes such as aggradation and widening. This migration process will start with degradation if the channel slope is increased or with aggradation if the slope is decreased.

Indicators of planform change are:

- Flood chutes, which are longitudinal depressions where the stream has straightened and cut a more direct route usually across the inside of a meander bend;
- Channel avulsions, where the stream has suddenly abandoned a previous channel alignment;
- Change or loss in bed form structure, sometimes resulting in a mix of plane bed and pool-riffle forms;
- Island formation and/or multiple thread channels;
- Additional large deposition and scour features in the channel length typically occupied by a single riffle/pool sequence (may result from the lateral extension of meander bends).
- Thalweg not lined up with planform. In meandering streams the thalweg typically travels from the outside of a meander bend to the outside of the next meander bend. During planform adjustments, the thalweg may not line up with this pattern.

***Watercourse Channel Stability***

A key piece of data obtained from the Rapid Geomorphic Assessment is stream geomorphic condition based on the degree of departure of the channel from its reference stream type, which is evaluated by the magnitude and combination of adjustments that are underway in the stream channel. With respect to stream equilibrium and natural variability, the degree of departure is captured by the following three terms:

**In Regime**: A stream reach in reference and good condition that is in dynamic equilibrium which may involve localized, insignificant to minimal change to its shape or location while maintaining the fluvial processes and functions of its watershed over time and within the range of natural variability.

**In Adjustment**: A stream reach in fair condition that has experienced major change in channel form and fluvial processes outside the expected range of natural variability; and may be poised for additional adjustment with future flooding or changes in watershed inputs that could change the stream type.

**Transitional or Stressed**: Refers to a stream experiencing extreme adjustment outside the expected range of natural variability for the reference stream type; likely exhibiting a new stream type; and is expected to continue to adjust, either evolving back to the historic reference stream type or to a new stream type consistent with watershed inputs and boundary conditions.

### *Geomorphic Assessment*

The assessed reaches on Demoiselle Creek extend 13 km upstream from Rte 114. This section of creek was divided into two main reaches that encompass 72 sub-reaches.

#### ***Upper Reach***

The upper reach of the assessed section of Demoiselle Creek begins at a point 3 km upstream of its western confluence with Underground Lake Road and continues east (downstream) approximately 5 km. This includes the sub-reaches DC 2-1 to DC 2-33. Sub-reaches in the upper reach are either in a state of transition or adjustment (Figure 1-9 and Figure 1-10). The dominant geomorphic processes include 10 sub-reaches that are aggrading, 15 sub-reaches that are degrading, 5 sub-reaches that are widening, and 3 sub-reaches that are experiencing planform adjustment. Moving downstream, the geomorphic processes generally alternate between degradation and aggradation as sediment migrates.

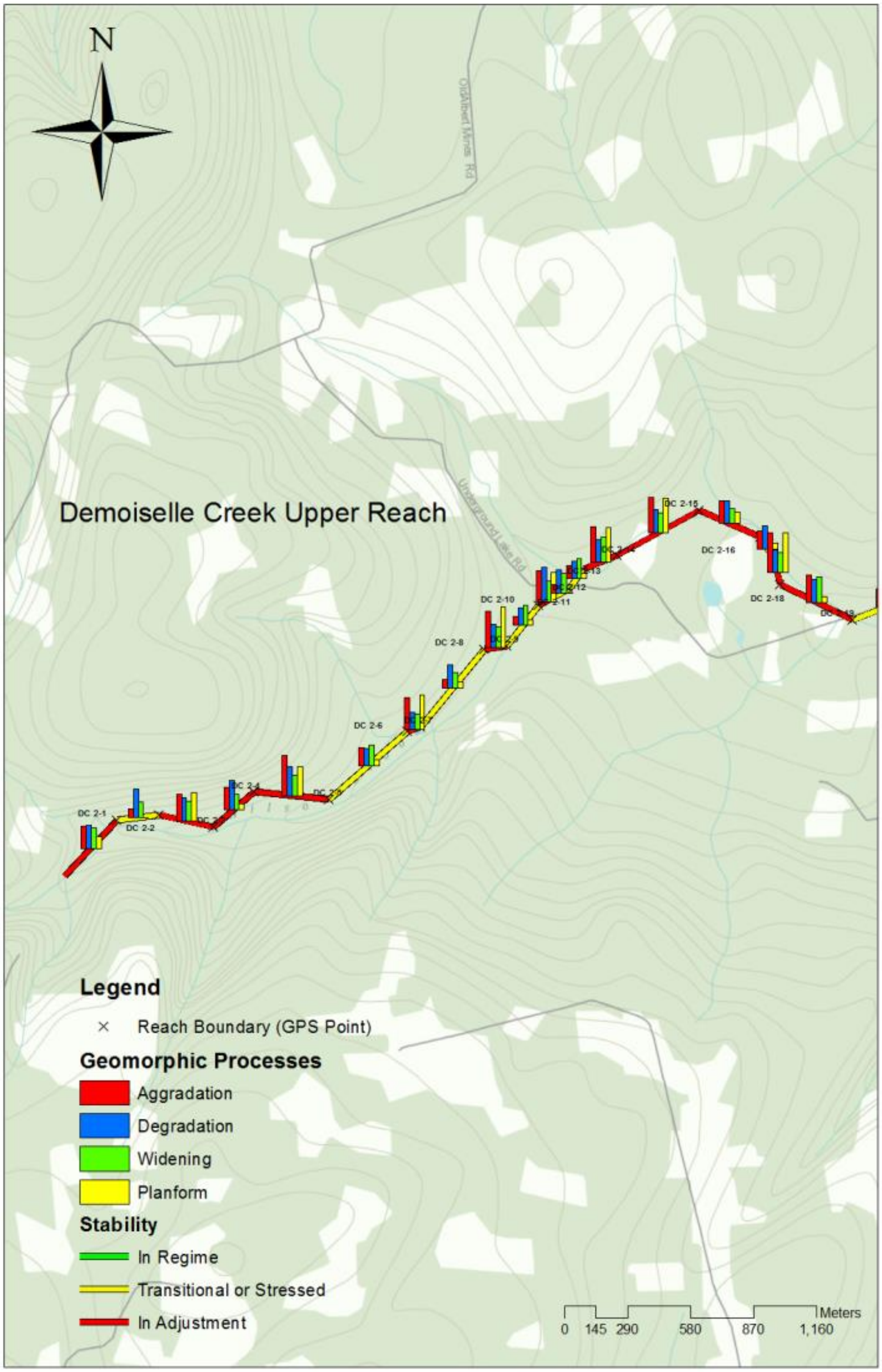


**Figure 1-9**: Demoiselle Creek, Sub-reaches DC 2-1 to DC 2-19.

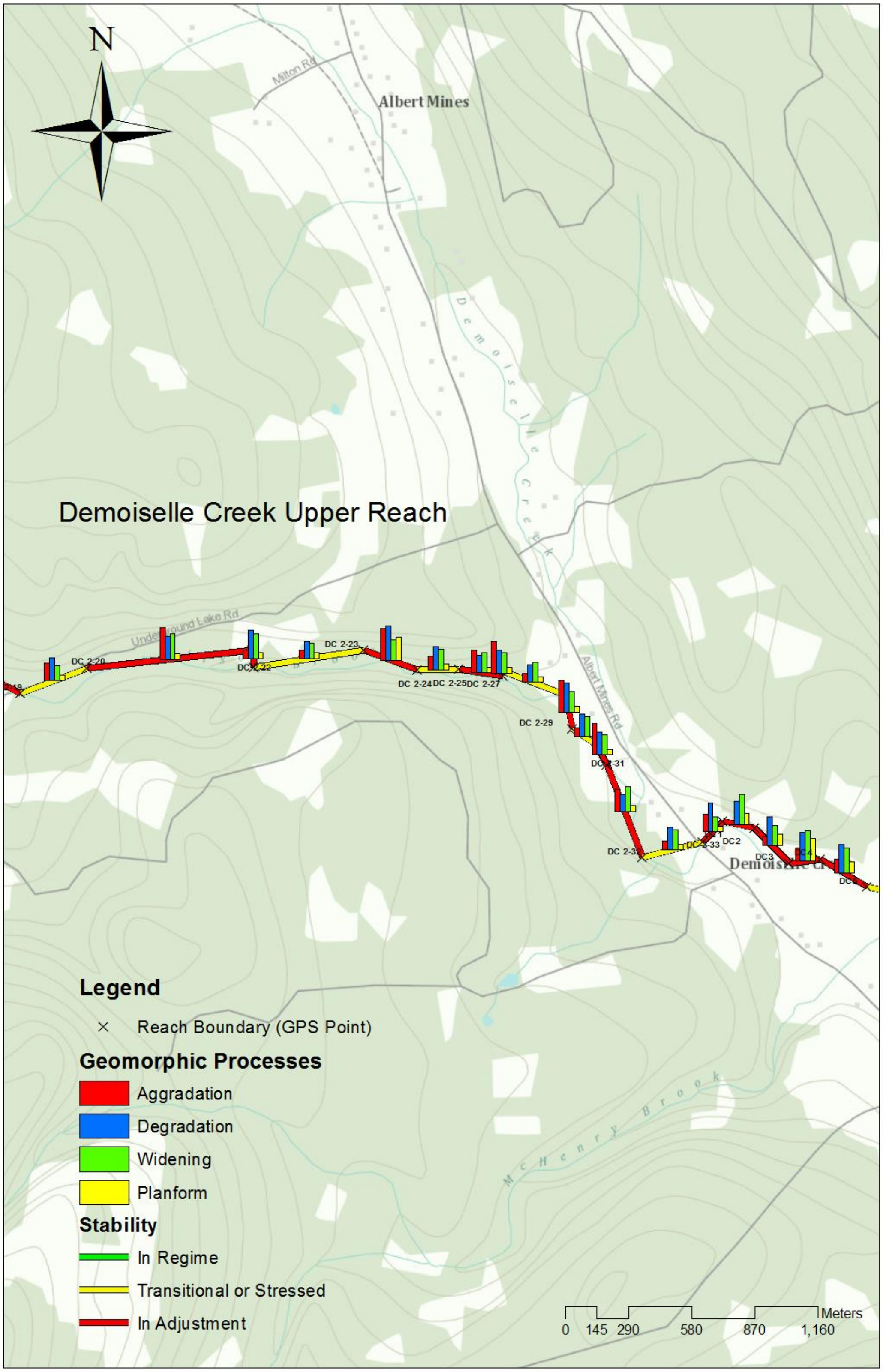


**Figure 1-10:** Demoiselle Creek, sub-reached DC2-20 to DC 2-33.

The upper reach of Demoiselle Creek shows evidence of planform adjustment, which is likely related to the channel widening process occurring along 5 sub-reaches (Figure 1-11). As the streambed widens, the channel can migrate laterally.

**Figure 1-11:** Channel widening on Demoiselle Creek.

***Lower Reach***

The lower reach of the assessed section of Demoiselle Creek begins just downstream of the confluence with the Albert Mines Road and runs southeast (downstream) approximately 8 km to Rte 114. This reach encompasses sub-reaches DC 1 – DC 39 (Figure 1-12 and Figure 1-13)

Sub-reaches in the lower section of Demoiselle Creek are primarily in a state of adjustment or transition, with only two sub-reaches in a stable state (DC 35 and DC 37). The dominant geomorphic processes include 18 sub-reaches that are aggrading, 17 sub-reaches that are degrading, and 8 sub-reaches that are widening. Similar to the upper section of the stream, the lower sub-reaches generally alternate between degradation and aggradation or widening. This occurs as the stream follows a cycle of taking sediment from one area and depositing it downstream.

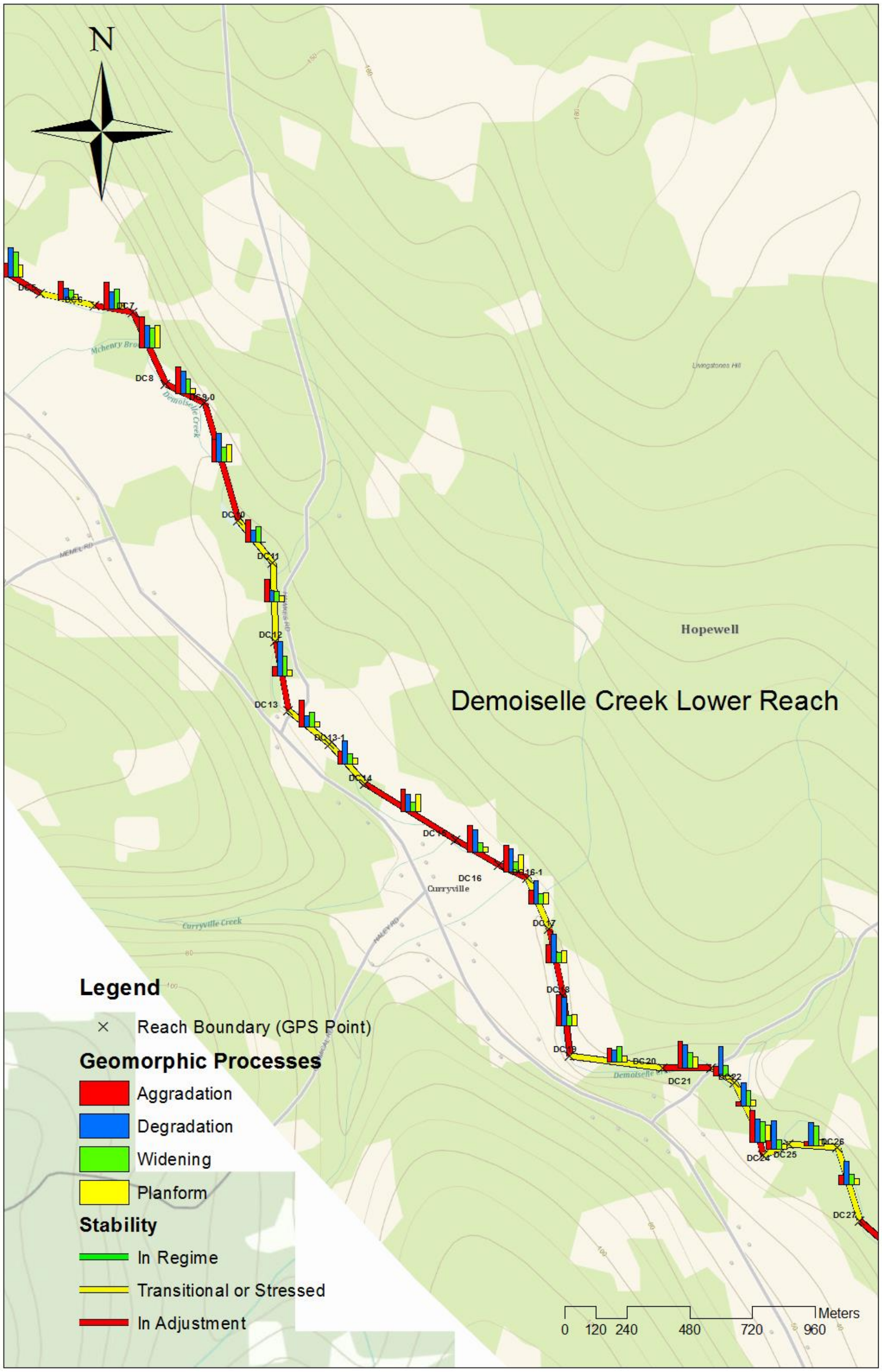


**Figure 1-12:** Demoiselle Creek, Sub-reaches DC 5 to DC 27.

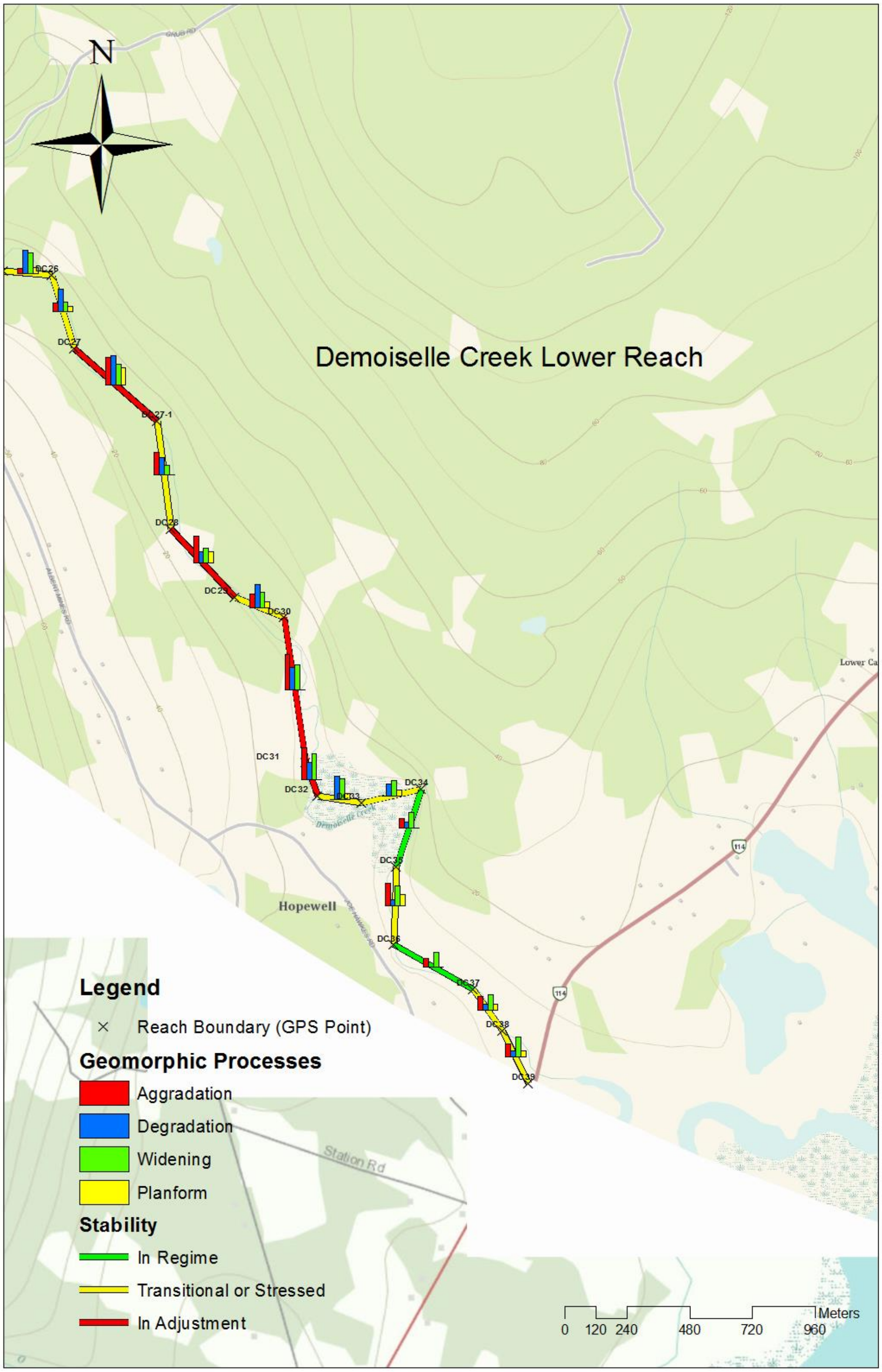


**Figure 1-13:** Demoiselle Creek, Sub-reaches DC 26 to DC 39.

The lower reach of the stream has a lower gradient than the upper reach and it flows through various farmlands. Erosion is occurring along stretches where the vegetation buffer has been removed and turned into farm fields. The result is increased sediment loads and channel widening, which shows that widening is the dominant geomorphic process in the lower portion of the lower reach. An example of erosion and channel widening as the stream flows through farmland is shown in Figure 1-14.

**Figure 1-14:** Degradation (bank erosion) and channel widening on Demoiselle Creek.

## Fourth Level Assessment – Aquatic Habitat Rehabilitation Plan

### *Summary of Issues Identified by Resource Users and Stakeholder Groups*

<u>The following issues were identified by stakeholders:</u>

- Proper functioning of the aboiteau; is it allowing for fish passage?
- We are following up with Agricultural New Brunswick for more information.
- An as yet unidentified culvert -We are hoping to identify its location at our next meeting.
- Debris in the creek (old plastic drums, car engines, car parts, etc.)
- Proper harvest buffers along streams
- General soil erosion prevention along the stream

### *Summary of Issues Identified from Geomorphic Assessments*

Restoration efforts in the upper reach should focus on understanding in greater detail the source and movement of sediment and then designs can be implemented to narrow the channel along reaches where there is widening. Narrowing and stabilizing the channel width typically creates deeper habitat that is favourable for species such as the Atlantic salmon and brook trout. Restoration possibilities in the lower reach should focus on establishing a vegetated riparian buffer at a minimum of 5 m where farm fields border Demoiselle Creek.

### *Summary of Issues Identified from Information on Current Impacts*

All of the culverts identified had some sort of debris or vegetation either upstream, within or downstream of the culvert that was impeding flow to some degree when they were evaluated by the DoT in the summer of 2012. General pesticide and/or herbicide concerns were described but without known individual users, this is difficult to touch upon at this point in time.

## Restoration Activities Undertaken

### *Targeted Artificial Debris Removal*

In 2013 debris was found and removed from three sites (Hawkes Road Bridge, Route 114 overpass, and Shepody Fish and Game access road) along Demoiselle Creek that had been first identified in 2010 (Figure 1-15). Not all of the material described in 2010 was found upon returning to these sites. It may have been subsequently cleaned up, shifted downstream by storm flow, or simply obscured by lush mid-July vegetation. Other debris sites noted during the geomorphic assessment conducted in 2012 were also investigated. Among these, debris was found at the Albert Mines Rd bridge site and the Wilson Brook headwaters near the "Underground Lake" Karst formations.

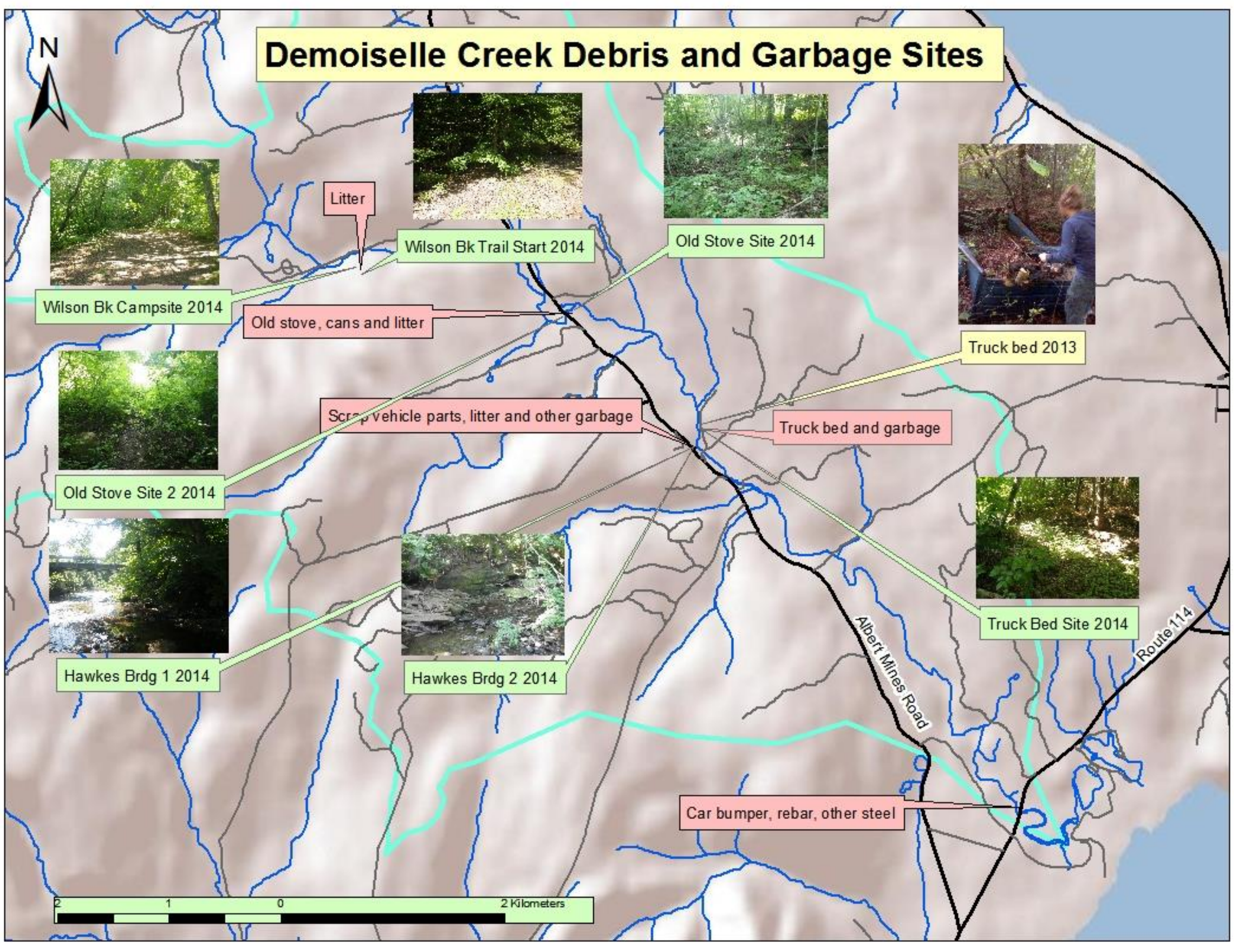


**Figure 1-15:** Debris removal in 2013, with monitoring in 2014 to determine if sites remained clean

**Project Timeline**

July 29, 2013 – Initial follow up survey of sites first identified in 2010 and 2012.

Sept 5-6, 2013 – Removed debris from all sites except Shepody Fish and Game access road. Debris collected & Aluminum beverage cans were donated to Sackville Boys and Girls Club

Sept 16, 2013 – Removed garbage from Shepody Fish and Game access road.

August 1, 2014 – Re-visited sites to confirm sites are still clean, and took photos in Figure 1-15.

**Table 1-2:** Debris clean up along Demoiselle Creek in 2013

| Date | Weight | | Notes |
|---|---|---|---|
| | Recyclable Scrap | Landfill | |
| September 5$^{th}$ & 6$^{th}$ | 287 kg | 130 kg | 5.5 kg scrap aluminum, 0.5 kg copper wire, 281 kg scrap metal |
| September 16$^{th}$ | 100 kg | 20 kg | Truck bed (scrap steel) |

## *Opportunities for Future Restoration Activities*

Two possible restoration activities are described below, bank stabilization and culvert replacement. We do not anticipate any negative effects to the target species or their respective habitats. All of the prospective activities would improve the quality of the aquatic habitat for American Eel, Atlantic salmon and wood turtle. Bank stabilization could provide shade, reduce siltation, and provide leaf little and food sources for instream insects (prey of all three target species). Culvert replacement could help restore passage in areas where it is currently blocked by faulty infrastructure. Restoring passage will be most beneficial to iBoF salmon as they are the least able of the three target species to navigate past barriers. American eels and wood turtles are both capable and known to cross barriers via terrestrial terrain to navigate around barriers.

### *Bank Stabilization*

Erosion is occurring along stretches where the vegetation buffer has been removed and turned into farm fields. The result is increased sediment loads and channel widening. Stakeholders and 2012 stream surveys both identified that sites without riparian buffer zones that were also experiencing erosion, were priorities for restoration. Selected sites may benefit from native tree and/or shrub planting to decrease soil erosion and maintain buffer/riparian zones along the creek. We will be working this season to identify landowners that would be interested in this option. Locations for possible bank stabilization activities are given in Table 1-3.

Table 1-3: Locations that could benefit from bank stabilization on Demoiselle Creek.

| PID | Location | Land Owner |
|---|---|---|
| 05080023 | Hawkes Road | Mr. and Mrs. Liptay |
| 05012018 | Hawkes Road | Mr. and Mrs. Liptay |
| 05036256 | 52 Joe Hawkes Rd. | Mr. Henwood |
| 05047428 | 48 Joe Hawkes Rd. | Ms. K. MacLeod |
| 00624619 | Hawkes Road | Mr. and Mrs. Parker |
| 05037114 | 28 Joe Hawkes Rd. | Mr. and Mrs. King |
| 05011226 | 20 Joe Hawkes Rd. | Ms. D. Douthwright |

Estimated Person Hours Required:

- One person, 1-3 weeks, to accumulate cuttings, seedlings, trees etc.
- One person, 3 days to plot out site and remove any debris
- Two people, 2 days to plant trees and/or shrubs

Equipment Required:

- One truck (FFHR), pruners, loppers, mulch (possible source is Westmorland Albert Ltd.), 2 rakes, 2 shovels, gloves.

Sources for Trees:

- Dogwood – Private property along Rte. 106
- Willow- Berry Mills at NB Power site
- Other possible trees could include:
    - Poplar – Macdonald Paving (Calhoun Quarry)
    - Balsam fir – Fort Folly First Nation Reserve
    - Red spruce – Fort Folly First Nation Reserve

Considerations and Permits:

- Native, flood-tolerant shrubs such as willow (*Salix*) or red osier dogwood (Cornus sericea) live stakes, or rooted alder (*Alnus rugosa*) shrubs have been identified as possible plants. These are typically planted with a spacing of 1m x 1m.

Considerations for shrubs:

- Plant one or two year old nursery seedlings in a trench. If a trench cannot be made, remove some sod where the shrub is to be planted.
- Plant in a zigzag row with a one-meter spacing to reduce weed competition (see
- Mulch laid on the soil aids greatly in keeping soils moist and reducing weed competition.
- Another method of establishing red-osier dogwood and willows is to plant fresh cuttings from established shrubs. If rooted plants are available, chances of survival will be improved.

Considerations for trees:

- Prepare the planting area by ploughing furrows 7.5 – 12.5 cm deep (3 – 5 in.), 1.8 m (6 ft) apart. Plant trees in the furrows. Furrow wetlands in the fall and plant the following spring. Lacking a plough, or where land is rocky or hilly, remove 1 square foot (one ninth of a square metre) of sod from each planting spot with a shovel and plant the tree in the centre. During planting, carry trees in a pail containing a few centimetres of water. Use damp moss or wet burlap for extra protection of trees in transit. Fence the planted area if grazing or trampling by livestock is a risk. The establishment and development of shrub and tree plantings can take place more rapidly with proper care.
- Plants lost to animal damage or winter kill off should be replaced.
- Plants may be fertilized to enhance their growth but this practice should only be done in combination with cultivation or mulching to reduce weed growth.

- Mulching with sawdust, straw or woodchips is often recommended to keep the soil moist and reduce competition from unwanted plants.

Permits:

- Watercourse and Wetland Alteration Provisional Permit
- Watercourse and Wetland Alteration Program (Fredericton – (506) 457-4850)
- Species at Risk Incidental Harm Permit
- Based on current surveys, there are no known locations of inner Bay of Fundy Atlantic salmon, American eel, or wood turtle within this watershed. However, as this habitat may be accessible to these animals, this permit may be necessary.

Any further development for this potential activity should continue to consult Bastien-Daigle et al. (1991) and the field manual for the community fisheries involvement program (Ontario Ministry of Natural Resources 1980).

### *Culvert Replacement*

Stakeholders identified that there was a faulty culvert on Demoiselle Creek, which could be impeded fish passage. However, resource users were unable to identify the site of the culvert at our last meeting. We will revisit this potential issue in the future. There was also debate as to whose responsibility the culvert was, the DoT or the landowner. Once located, we will contact the DoT to enquire whether it is their responsibility. If it is, the faulty culvert will be reported. If it is the responsibility of the landowner and it is something that the landowner would like to address then we can try to source the appropriate sized culvert and submit a permit to DFO and Environment Canada for the work.

Permits:

- Watercourse and Wetland Alteration Standard Permit
- Watercourse and Wetland Alteration Program (Fredericton – (506) 457-4850)
- DFO Authorization under Fisheries Act (Moncton office - (506) 851-7768)
- Species at Risk Incidental Harm Permit
- Based on current surveys, there are no known locations of either inner Bay of Fundy Atlantic salmon, American eel, or wood turtle within this watershed. However, as this habitat may be accessible to these animals, this permit may be necessary.
- Canadian Environmental Assessment Act may require CEAA review if machinery is going to be used in the watercourse.

## LITTLE RIVER

The Little River (also referred to as the Coverdale River), flows for its entirety in Albert County before emptying into the Petitcodiac River (which marks the boundary with Westmorland County). The Little River is, despite its name, the second largest tributary in the Petitcodiac watershed (after the Pollett River), draining a basin of 276 square kilometers. Its headwaters are at the base of Gowland Mountain in New Brunswick's Central Uplands Ecoregion (New Brunswick Department of Natural Resources 2007) a few kilometers southeast of Elgin (Figure 2-1). From there the river flows 51 km north through the communities of Parkindale in the Continental Lowlands Ecoregion, on through Colpitts Settlement in the Eastern Lowlands Ecoregion, ending finally at Salisbury where it joins the main stem of the Petitcodiac River near the head of tide.

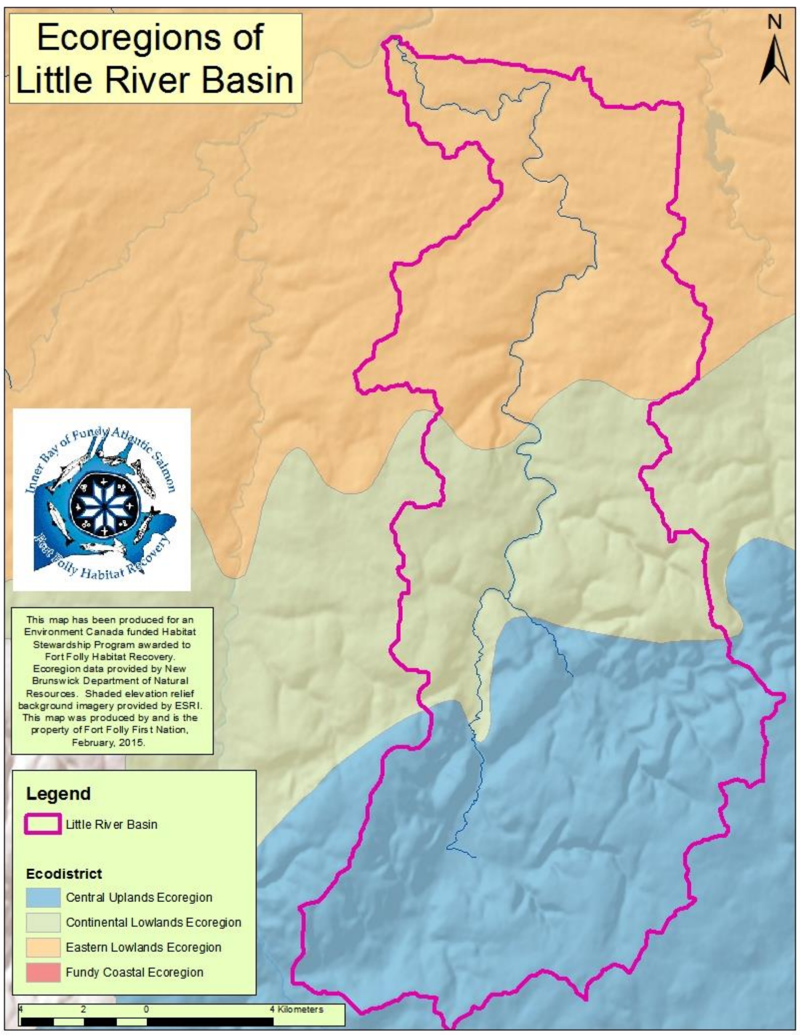


**Figure 2-1** Little River watershed

Along the way the Little River drops nearly 200 m in elevation between its headwaters and its mouth. In addition to its main stem, named tributaries of the Little River include: Bull Creek; East Branch Little River; Ferndale Brook; Hopper Brook; Leaman Brook; Mitton Brook; Pow Brook; Prosser Brook; Stiles Brook; and Upham Brook. The river usually runs clear, and often has a gravel bottom though in places bedrock is visible. During the spring freshet or after a storm it can become turbid for several days, before resuming its more normal condition.

The dominant land uses within the watershed are forestry and agriculture. Approximately 89% of the watershed is forested, 58% of which is small private woodlots, 41% is crown land, and 1% is industrial freehold forest land owned by J.D. Irving. Approximately 7% of the watershed has been cleared for agriculture, 75% of which is being used to grow row crops or grains, 12% pasture or hay, and 12% blueberries (Department of Natural Resources in 2014).

Government maps today label it as the Little River (Natural Resources Canada, 2010), though the Department of Fisheries and Oceans produced documents referring to it as the Coverdale River as recently as the mid-1980s (Ashfield et al 1984), and when speaking with the general public, both names are still frequently encountered. For much of its history since English settlement the river was known as the Coverdale River, from which Coverdale Parish took its name when it was split off from Hillsborough Parish in 1828 (Provincial Archives of New Brunswick 2015). The name, Little River, is not distinctive, and should not be confused with several other rivers in New Brunswick bearing the same name: one of which is a tributary of the upper Saint John River in northwestern New Brunswick near Grand Falls; another of which flows into Indian Lake before that drains into Grand Lake and eventually the Saint John River at Jemseg; and yet another which lies within the city limits of Saint John, and flows directly into Saint John Harbour. The situation has improved somewhat however, as Ganong (1896) noted the name “Little River”, in use for 7 other rivers within the Province, though not this one, which he referred to as the Coverdale River.

The name Coverdale remains part of the modern landscape in the nearby localities of Upper Coverdale, Coverdale, and Middle Coverdale spread out along the main stem of the Petitcodiac towards Riverview, as well as Lower Coverdale, downstream between Riverview and Hillsborough. Riverview itself is the result of the amalgamation in 1974 of several communities including Coverdale (Hamilton 1996). Ganong (1896) noted usage of the name Coverdale in reference to the river on a land grant dating from 1788, though he indicated that the origin was unknown to him. Interestingly he also pointed out that an 1889 Postal map referred to it as the Scadouck River by mistake, an error which was also repeated 6 years later in the Electoral Atlas of the Dominion of Canada 1895 (Library and Archives Canada 2015). This usage presumably should have been applied to the nearby Scadouc River, which flows into the Northumberland Strait at Shediac. Baillie’s (1832) An Account of the Province of New Brunswick… with advice for emigrants; Perley's (1857) Handbook of Information for Immigrants to New Brunswick; Walling's (1862) Topographical Map of Westmoreland and Albert Counties; and the Roe Brothers 1878 Atlas of the Maritime Provinces (Dawson 2005), all confirm Ganong's (1896) statement that Coverdale was the official name in use for the Little River at that time. That said, there still appears to have been some ambiguity and dual name usage even then, as in 1889 a complaint was registered with the Provincial Legislature over the state of the John Mitton Bridge, described as "crossing the Little River a few miles from Salisbury Station, in Coverdale Parish, Albert County" (New Brunswick House of Assembly 1890).

Two theories exist about where the name Coverdale itself came from (Kanner and Geldart 1984). One is that it was a tribute to Myles Coverdale, a British Bishop in 16th century England who produced the first translation of the Bible from Latin to English. The other suggests that it comes from the first English settlers at the mouth of the river, Joshua Geldart and his nephew John who arrived in May 1774, both of who were born in Coverham in the Dale of Cover in Yorkshire (also near where Myles Coverdale was born, and from which he took his name). Given Ganong's (1896) observation that the name Coverdale had been applied to the river as early as 1788, just 14 years after the arrival of the Geldarts, their use of the name in reference to their home in Yorkshire seems the simpler and more persuasive of the two theories. In either case though, it is clear that the name arrived with early English settlers and was contemporary with the arrival of the Geldarts.

Colpitts Settlement was itself known as Little River from 1857 to 1903 (Provincial Archives of New Brunswick, 2015), which is how it was listed by the Electoral Atlas of the Dominion of Canada (1895). In 1904 the community changed its name to Colpitts Settlement in recognition of the Colpitts family, the first English settlers at that location along the river (Provincial Archives of New Brunswick, 2015), and who's descendants subsequently accounted for much of the early population at that location (Walling 1862). John Colpitts arrived from England as a teenager with his father (Robert Colpitts, who settled along the Petitcodiac near Salisbury in 1783). In 1786, John moved off the main stem, up along a tributary (then called the Coverdale River) to develop his own homestead at Little River (Moncton Daily Times, Thursday August 26th 1920; Provincial Archives of New Brunswick, 2015). This may explain the origin of the name Little River for the river itself today, taken from the prior English name for that settlement along its banks. That name is also still in use, now referring to a smaller community further upstream between Colpitts Settlement and Parkindale (Natural Resources Canada, 2010).

## First Level Assessment – Land Use History of the watershed

An understanding of the historical land use within a watershed provides context that helps explain the causes of issues affecting the watershed today. The following sections outline the historical land use both within the Little River watershed, and in the surrounding communities in both Westmorland County and Albert County. Within the Little River watershed this includes the communities of Colpitts Settlement, Parkindale, and Pleasant Vale; and outside the watershed, the community of Salisbury at the river's confluence with the Petitcodiac; and Elgin (on the Pollett River) as the centre serving the upper reaches of the Little River (Table 2-1).

**Table 2-1:** Brief historical background summary for communities along or near the Little River

| Community | Settlement Type and Dates | Notes |
|---|---|---|
| Colpitts Settlement<br>*(Little River)* | Settled c.1786 by Colpitts family<br>Farming | **1898** population 250, post office, store, 2 grist mills, church<br>**1904** name changed from Little River to Colpitts Settlement |
| Elgin<br>*(Pollett River)* | Settled c.1811 by Geldart family<br>Farming and lumbering | **1871** population 250<br>**1876** connected to the Intercolonial Railway at Petitcodiac by completion of branch line, The Elgin, Petitcodiac, & Havelock Railway<br>**1898** post office, railway station, 6 stores, 3 hotels, 2 churches sawmill, grist mill, tannery, carriage shop, and cheese factory, |
| Parkindale<br>*(Little River)* | Settled c.1817 by Parkin family<br>Lumbering | **1898** population 150, post office, store, sawmill, church |
| Pleasant Vale<br>*(Little River)* | Settled c.1831<br>Farming | **1898** population 190, post office, sawmill, grist mill, furniture factory, church |
| Prosser Brook<br>*(Little River)* | Farming | **1898** population 150, post office, sawmill, store, and a church |
| Salisbury<br>*(Petitcodiac River)* | Settled c.1774<br>Farming and lumbering | **1898** population 400, railway station, post office, 6 stores, 2 hotels, carriage factory, 3 churches |

(Source: Provincial Archives of New Brunswick, 2015)

The Maritimes have had human inhabitants for the last 11,000 years (Wicken 2002), though for most of that time precise cultural identities are impossible to determine today. By the early 1600s, when Europeans arrived, much of the native population of coastal Atlantic Canada shared a common culture and language identifying themselves as the L'nuk, "the People", and recognized by Europeans as the Mi'kmaq. Traditionally, the Mi'kmaq lived in large villages along the coasts from April to November, and then dispersed during the winter, migrating inland to hunt moose and caribou. During this time physical impacts on the watershed were few compared to what was to follow.

Ganong's (1905) map of known First Nations villages and campsites includes a Mi'Kmaq site at Salisbury located along the north bank of main stem of the Petitcodiac, near the head of tide between the mouths of Little River and the Pollett River. A native leaving Beaumont (where there was another camp in the lower Petitcodiac estuary) could ride the 13 km per hour tidal bore upstream to Salisbury, greatly facilitating such travel (Petitcodiac Heritage River Committee 2000). The importance of the Salisbury encampment was due to its location both at the head of tide and near the ends of a pair of portage routes leading to the Saint John River system. The more highly traveled of the two routes crossed from the main stem of the Petitcodiac River to the Canaan River (Ganong 1914) near what is now the Village of Petitcodiac, as doing so provided the best access to the upper St. John and on to the St. Lawrence (Petitcodiac Heritage River Committee 2000). The other route crossed from a tributary of the Petitcodiac, the Anagance River, to the Kennebecasis River (and from there to the lower portion of the Saint John River system). In fact the name Anagance comes from Maliseet "Oo-ne- guncé" meaning portage (Ganong 1896), presumably a reference to the link provided by that tributary.

In the 1630's the French began to make a serious effort to colonize Atlantic Canada, beginning to arrive in numbers significant enough to develop an enduring Acadian identity (Laxer 2006), at a fairly similar time frame to the English colonies further south. By 1676 the first Acadian settlers arrived at Beaubassin, near the current Nova Scotia Visitor's Centre along the Trans-Canada Highway at the New Brunswick border (Larracey 1985). Then, 34 years later in 1710, Acadians and Mi'kmaq in peninsular Nova Scotia fell under British control, which was subsequently formalized in 1713 under the treaty of Utrecht. In 1751 Fort Beausejour was built at the border to protect Acadian communities in what is now New Brunswick from attack by the British. By this time the Acadian population near the Fort had grown to 1,541 people, with an estimated additional 1,100 spread out at Shepody and along the Petitcodiac and Memramcook Rivers (Larracey 1985). The Acadians built dykes and tidal control structures turning marshland along the lower Petitcodiac estuary into pasture, and established their settlements nearby (Wright 1955). Their physical impacts on the Little River, what for them was a remote hinterland, were limited.

Ganong (1899) notes that like First Nations, the French made use of the Kennebecasis-Petitcodiac portage along the Anagance in order to maintain communication between Fort Beausejour and Acadian settlements on the lower St. John. However the French route between the Canaan and the Petitcodiac to access the upper St. John was slightly different than the one favoured by First Nations, reportedly crossing overland to the Canaan from the North River, rather than the main stem of the Petitcodiac (Raymond 1891). From there messengers from Fort Beausejour, and the Fortress of Louisbourg passed up along the St John to reach Quebec.

After the fall of Fort Beausejour in 1755, the British attempted to expel the Acadians, to open up land for English settlers. There is a record of an Acadian settlement, Village Victuare, located nearby in Salisbury, close to the Mi'kmaq encampment (Ganong 1930). It was documented in 1758 by British Major George Scott as he was forcefully removing Acadian families from the upper Petitcodiac (Scott 1758). The village appears to have been composed of approximately 10 homesteads, settled in about 1751, and was reportedly the largest Acadian village along the Petitcodiac upstream of Beausoleil Village, modern day Allison (Ganong 1930).

Arsenault (2004) suggests that a settlement named Village des Babineau existed at the mouth of the "Coverdale" (Little) River near Salisbury. That is a surprisingly specific and questionable location given that Ganong (1899) using a map from 1754, puts Village des Babineau downstream, in what is now Riverview, at a location that prior to amalgamation in 1974 was called Coverdale (Provincial Archives of New Brunswick, 2015). Surette et al. (1981) confirm this, indicating the Village des Babineau was an alternate name for a community named Fourche-à-crapaud, located at the mouth of Turtle Creek (Provincial Archives of New Brunswick, 2015), an area later known as Coverdale. Presumably Arsenault (2004) confused Turtle Creek and the later English community of Coverdale with the Coverdale (i.e. Little) River. Though Village des Babineau was reportedly destroyed by Scott in 1758 (Ganong 1905), it does not appear on his map at either location (Scott 1758).

Ganong (1930) suggests that it is likely that in the wake of the expulsion, Acadians briefly occupied locations such as Fourche-à-crapaud at Turtle Creek, and on the Coverdale and Pollett Rivers in order to be near the head of tide and thus above the reach of English Ships. Major Scott apparently found the tidal bore on the Petitcodiac problematic during his raids in 1758, nearly losing two ships on one occasion (Pincombe and Larracey 1990).

The Mi’kmaq sided with the French (Wicken 2002), participating in the defense of Fort Beausejour, as well as the short guerilla war which followed its capture (Grenier 2008). There were several reasons that Mi’kmaq in New Brunswick did so. Prior to the arrival of the British, native communities had already established trade networks with the Acadians for steel tools, weapons and other European goods (Walls 2010). Another source of friction was that the Mi’kmaq had begun to adopt Catholicism from the French, while the British were Protestants, at a time when such differences added fuel to conflicts. Acadians also had had good relations with the Mi’kmaq in part because the lands Acadians occupied either complemented native use, as with fur traders, or were in areas that were marginal to native concerns as in the case of the Acadian farmers on the tidal flats (Mancke 2005). English settlers on the other hand tended to seize land the Mi’kmaq valued, to clear the forest for agriculture (Francis et al. 2010).

The dates that various communities listed in Table 2-1 were first settled (where available) indicate how movement by English colonists into the upper reaches of the Petitcodiac River system above the head of tide occurred first along the more easily accessible main stem, and occurred progressively later the further into the upper reaches one goes. Many of the early dates coincide with the arrival of United Empire loyalists from the 13 colonies (late 1770's - 1780's). After the arrival of the Loyalists, Mi'kmaq in what is now New Brunswick were moved off their lands and onto "reserves" (Walls 2010). This was done partially to provide land to incoming settlers, and partially to punish the Mi'kmaq for aligning themselves with the French. Subsequent generations of English settler families and those that arrived after them then pushed further up the Petitcodiac and into its more remote tributaries such as the Little River, and the Pollett River (Wright 1945). An early example would be the previously mentioned homestead John Colpitts established in 1786 at Little River (later becoming Colpitts Settlement in 1904), after leaving the farm his father established near Salisbury a few years previously.

### *Forestry Practices*

The relative inaccessibility of the Petitcodiac stood in contrast to the Saint John River, as the comparative lack of long easily navigable tributaries within the Petitcodiac system discouraged commercial logging activities until the mid-1800s (Department of Natural Resources 2007). The ruggedness of the region hindered timber exploitation, requiring driving dams to ensure sufficient water-flow to move logs, and limited the amount of hauling that horse and oxen teams could do (Shoebottom 1999). So, instead early settlers cleared the land to allow for agriculture, locally consuming cordwood for fuel, and lumber to build their homesteads, while generating only limited income by selecting marketable timber to send downriver to be sold for shipbuilding or export. As time progressed the latter gradually became a more significant aspect of the local economy. Timber harvest in the Petitcodiac timber district as a whole grew from 260 tons in 1818 to 3,137 tons by 1836 (Wynn 1981), though this paled in comparison cutting in other more accessible portions of the province such as in numerous timber districts along the Saint John and Miramichi Rivers where harvests taking place at the same time were in some cases an order of magnitude greater.

During the early 1800s white pine was gradually culled from New Brunswick Forests to meet the demand for masts for the Royal Navy (Wynn, 1981). The White Pines Act of 1722 established the requirement of a royal license to fell white pines with a diameter exceeding 24 inches unless they were privately owned, and in 1729 Parliament reserved all such trees to the government except those already in private hands before 1690 (Purvis 1999). Since New Brunswick came under British control well after that time, this exception did not apply at all to its forests. During the American Revolution and the Napoleonic Wars from 80 to 90 percent of all masts supplied to the Royal Navy came from Canada, mostly New Brunswick (Williams 1992).

The Napoleonic blockade of the Baltic forced England to expand New Brunswick's lumber production twentyfold, transforming an "undeveloped backwater" of 25,000 people to a bustling colony of 190,000 (Gordon 2014). Pines could still be found in 1850, but few of the magnificent trees the region was known for earlier in the century remained. Spruce was more abundant, but the largest had also been cut. Though there were not many extensive cutover tracts, by 1850 the character and composition of the forests in New Brunswick had been drastically modified over the course of just 50 years of harvesting.

The effects of this early economic activity were not limited to just the forests. By 1820 importation of food into New Brunswick was the rule rather than the exception, everything hinged on the timber trade, though there were warning signs of the danger of single source economy (DeMerchant, 1983). James Robb, professor of Natural Science at Kings College in Fredericton (now the University of New Brunswick), was appointed Secretary of the Provincial Board of Agriculture when it was established in 1858. He warned that timber harvesting was so lucrative that it distorted development, and that when the market in Europe declined, the farmer neglecting his homestead to work in the woods would be "surprised to find his fences down, his fields grown up with bushes, and both himself and his snug little clearing generally all gone bad". It was not just agriculture that was falling short of its potential. In the years that shipbuilding boomed at St. John and other towns along the coast, even the fishing industry was neglected as men were drawn to the forest to supply wood (DeMerchant, 1983).

Unlike the Pollett River, which Elson (1962) describes as having had several large dams to power sawmills, McLeod (1973) reports that the Coverdale (Little) River had no major obstructions and that salmon were able to use the lower 40 km of the river extensively between the early 1800s to the 1970s, such that the Coverdale actually produced a majority of salmon smolts in the Petitcodiac system during that time. It is somewhat of a challenge to reconcile this description with the 3 sawmills and 3 grist mills present on the Little River by 1898 in Table 2-1 (Provincial Archives of New Brunswick, 2015), since presumably those were all water powered. It may be that the situation on the Little River was simply better relative to the Pollett, which after all had a major mill dam just 16 km above the mouth of the river at Forest Glen that reportedly for much of that time had no functioning fishway and so blocked passage beyond it (Elson 1962). This situation was exacerbated in 1910 when the Sanatorium Dam was put in 6 km below Forest Glen- just 10 km above the mouth of the Pollett River. In contrast fishways on dams on the Coverdale were described as being in good order in 1876, and though there were declines in catches of salmon that year, these were blamed upon recent increases in milling and "mill rubbish" (sawdust etc.) fouling the water (Commissioner of Fisheries 1877). This confirms that sawmills on the river were powered by dams (as one would expect), but is consistent with McLeod's (1973) conclusion that the dams on the Little River did not block fish passage. Mill wastes were a problem because, other than burning, dumping into the river was the most common form of disposal of sawdust, bark, and other waste (Department of Fisheries 1890). Such material covered river bottoms, sometimes smothering spawning sites.

By 1877 the railway branch line, The Salisbury - Albert Railway opened, connecting the lower portion of the Little River watershed to the Intercolonial Railway (Chignecto Post Thursday May 24th 1877). Its main focus was serving points beyond the watershed however, running only a short distance up the Coverdale, (no further upstream than near to Colpitts Settlement ). A time table notes a stop there at a point referred to as "Coverdale" located 4 miles from Salisbury Station (The Maple Leaf, Thursday February 18th 1885). This suggests it is the modern community of Synton, which is the correct distance down the line and right on the river (hence the name Coverdale). From there the railway headed east, crossing Turtle Creek and nearly paralleling the Petitcodiac on to Hillsborough, with much of the area described as "unsettled country". From there it traveled south on to Albert Mines, the mouth of the Demoiselle and the Shepody River on the Bay of Fundy, ending at that time at Riverside. Ten years later, during the whole of 1887, it carried to market 2,334 cords of firewood, and 8,913 tons of timber (The Maple Leaf Thursday January 12th 1888). While some of this material may have originated within the Little River watershed, much of it probably just passed through going either direction from points further along the line.

Judging by the roads present in 1878 (Dawson 2005), the headwaters at the southern end of the watershed were more remote and less populated than the area between what is now Colpitts Settlement and Salisbury. These upper reaches were not served by the Salisbury – Albert Railway, but did have access to the Elgin, Petitcodiac, & Havelock Railway which came up the adjacent Pollett River watershed, and ended a short distance away at Elgin. As a consequence the road network of the time tied communities in the Coverdale headwaters more closely to Elgin than to Coverdale Station, which was quite a distance downstream (Dawson 2005), and explains why they were part of Elgin Parish instead of Coverdale parish. The Chignecto Post in Sackville wrote of the Elgin, Petitcodiac, & Havelock Railway opening on September 14th 1876, "Within a few months over 350 cars of lumber (which could not have otherwise profitably been put in the market) have been hauled over the railway. The estimated shipments of lumber per year is about six million. Besides this there is ship timber from the virgin forests of Elgin, bark, sleepers, cordwood, country produce, local and passenger traffic." It goes on, "There is said to be enough timber in her (referring to the Elgin region) hills to keep the shipyards in Saint John busy for a century." How "virgin" the forests may have been is an interesting question given a population at that time (Table 2-1) of over 250 people in Elgin, plus hundreds elsewhere in the Pollett River watershed and surrounding communities on the Little River who had been there, in some cases for much of the previous 50 years. Such things are relative however, given that, as noted previously, other more easily accessible portions of the Province, had experienced more intensive harvesting. Eleven months later The Daily Times of

Moncton noted on August 15th 1877 that “during the year a great quantity of ship timber has been got out at Elgin for consumption in Saint John.”

At that point the age of wooden ships was winding down however, causing a reduction in the scale of the demand for timber exports both as wood and manufactured into ships. By the end of the Crimean war in 1856, virtually all of the ships in the British Royal Navy had already been fitted with steam engines rendering masts irrelevant (Evans 2004), and the conversion to iron hulls began within a decade thereafter.

A non-timber forest product that was commercially significant at the time was maple sugar.  In the 1840s the Colpitts family was already producing marketable surpluses, gathering enough sap to produce 6,200 pounds of maple sugar (Albert County Museum 2015c). By 1851 the annual output from Elgin Parish (which included all of the forested upper reaches of the Little River where sugar maple is common) was approximately 80,000 pounds (Fellows 1980).

### *Agricultural Practices*

As noted in the timber section, before crops could be planted settlers were faced with cutting and clearing the forest.  Stumps were often left a few years to rot, and crops were sown amongst them (DeMerchant, 1983).  In Perley’s (1857) Handbook of Information for Emigrants to New Brunswick, he suggests that “No emigrant should undertake to clear land and make a farm, unless he has the means of supporting his family for 12 months.” However, it was not just a matter of the financial resources of individuals. Since in the early 1800’s the province as a whole was not self-sufficient agriculturally, it is unlikely the communities along the Little River were either.  Given the initial logistical challenges of transporting food to remote homesteads, it is doubtful that importation of food was as practical as in urban centres. More likely for the early English settlers, subsistence agriculture was supplemented with food available from the forest and river.  Even as late as 1876 fishing regulators noted that farmers devoted a significant portion of their time to fishing salmon, with most of the entire catch being used for home consumption (Commissioner of Fisheries 1877). This pattern had been established previously on the Petitcodiac River.  In 1783 while Robert Colpitts first crop at his farm near Salisbury was ripening, his family’s main source of food was salmon (Moncton Daily Times, Thursday August 26th 1920).  In fact as early as 1852, concerns were being expressed about noticeable declines in the once abundant salmon population on the Petitcodiac (Elson 1962). At first this was presumed to be a consequence of overfishing, though by the 1870s it was recognized to be a result of issues with fish passage at dams nearby on the Pollett.

Baillie (1832) indicated that a “tolerably good” road went up the Coverdale River.  However he went on to qualify that by noting that “generally speaking it is not fit for carriages”, which suggests that foot, horse, and perhaps limited cart traffic may have been the norm.  Thus it is reasonable to conclude that the arrival of the Salisbury – Albert railroad in 1877 reduced many of the logistical constraints on bringing supplies into the lower end of the Little River watershed, and moving surpluses out to trade. Freight traffic of food along this line in 1887 amounted to 384.9 tons of flour, 190.9 tons of grain, and 873 head of livestock (The Maple Leaf Thursday January 12th 1888). However, as was mentioned earlier in the forestry section, much of that would have been in transit through the watershed, originating from points beyond such as Hillsborough or communities at or near the Fundy coast, and so does not actually provide much of an indication one way or the other of the productivity of the watershed. Also, unlike the forest products (which, given the abundance of forests locally, would likely have been a one-way flow out to market), a portion of the total agricultural freight carried may have been inbound for local consumption rather than an outbound surplus being sold elsewhere. Comparison of the roads in 1878 (Dawson 2005) serving the area from what later became Colpitts Settlement on downstream to Salisbury, to those in the rest of the watershed upstream of that point, suggests that the bulk of agricultural activity occurred in the lower valley, as is still the case today (Department of Natural Resources in 2014).

Nearby, marketable surpluses of food were being produced on the Pollett River with reports of potatoes being sent via the Elgin, Petitcodiac, & Havelock Railway to as far away as Boston in 1887 (Moncton Daily Times, Monday October 1887), and cattle to Saint John the following year (The Maple Leaf, Albert NB, Thursday October 18th 1888). Similarly from along the Fundy coast the Salisbury – Albert Railway was carrying hay from Riverside to Halifax, and cattle from Harvey to Saint John (The Maple Leaf, Thursday January 12th 1888). So communities in the Little River watershed were likely tied into such economic activity and (particularly in the case of those in the upper reaches of the river) if they were not contributing to these agricultural surpluses, then they likely served as local markets for the consumption of them.

Dawson (2005) shows that by 1878 the road network within the Little River watershed looked quite recognizable to the modern eye, with roads of some kind present along many of the routes that are significant enough to be paved today, though obviously these wouldn't have been developed to that extent then. In 1893 the lack of good roads was still described as one of the greatest constraints on agriculture (The Daily Times, Saturday April 23rd, 1893). Next door on the Pollett River, upstream of Elgin, there were actually many more roads in place by 1878 than remain in the area today (Dawson 2005; Natural Resources Canada 2010). Between the First and Second World Wars most of the scattered farms that had been established on the Pollett above Elgin were abandoned and allowed to revert back to forest (Elson 1962), as many people left the area during that time to search for more arable land out west (Department of Natural Resources 2007; Degraaf et al. 2007). In contrast, the headwaters of the Little River in 1878 had fewer roads (Dawson 2005), suggesting that these areas were not nearly as settled and developed. So while no doubt this region also lost population during that time for the same reasons as the Pollett, the effect was less pronounced.

In May 1911 the portion of the Salisbury – Albert Railway south from Hillsborough to Albert was in financial distress and was temporarily closed down, leaving the line operating only from Salisbury to Hillsborough (Sackville Tribune, Thursday July 13th 1911). It was eventually purchased by the Dominion of Canada and operated by the Intercolonial Railway (New Brunswick Railway Museum 2015a). The Section of track from Albert to Salisbury continued to operate although with only one train per week up to 1946, though the section from Hillsborough to Salisbury still had daily trains during this period. Meanwhile the Elgin, Petitcodiac, & Havelock Railway was not profitable either, and went bankrupt in 1890. It was sold to the government in 1918 and operated by the Intercolonial Railway (New Brunswick Railway Museum 2015a) until that was taken over by Canadian National in 1919 (Marsh 1999).

### *Mining Practices*

There are records of mineral exploration and discovery in the watershed, but little evidence of significant subsequent development of these resources. Coal was noted along the Coverdale River (Johnston 1850; Monro 1855), but not much was said about its properties or location, other than an indication that the deposits were not thought to be large. In 1864 L. W. Bailey, a Professor of Chemistry and Natural History at the University of New Brunswick reported that "thin pieces of gold of considerable size" were found in an unnamed (perhaps not surprisingly) stream that is a branch of the Coverdale River, near Elgin Corner (Bailey 1864). The same year, in another document Bailey also describes bituminous shale in the upper reaches of Prosser Brook that he concludes is likely a local extension of the deposit from which Albertite was being extracted at Albert Mines (Bailey 1865). So there was an awareness of mineral resources in the watershed, but their extraction was not economically viable.

## Second Level Assessment- Current Impacts

### *Forestry Practices*

Forest tenure within the Little River watershed today is a mixture of private woodlots, industrial freehold, and crown land, which are subject to varying levels of management in terms of harvesting planting and thinning (Figure 2-2). Forests cover 89% of the watershed (Department of Natural Resources in 2014). Unlike the Pollett (the next watershed over to the west) where the proportion of private woodlots increases along a gradient from the headwaters downstream towards its mouth, on the Little River private woodlots are common throughout. Private woodlots account for 58% of the forested area of the watershed, dominating the west, and making up much of the eastern half. Crown forests make up most of the rest at 41% of the forested area, primarily in the eastern half of the watershed. Industrial freehold forest lands account for about 1% of the forested area of the watershed, scattered throughout.

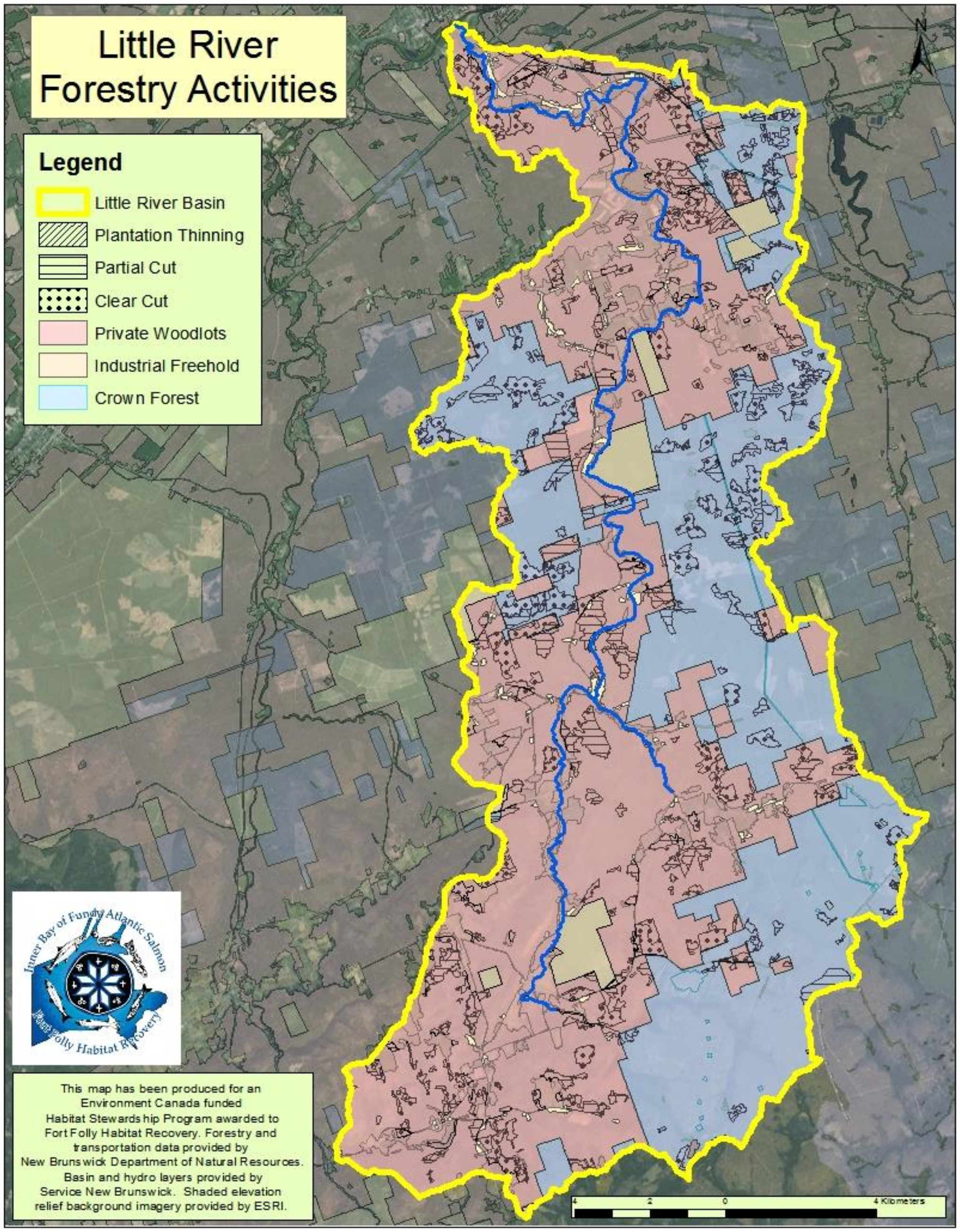


**Figure 2-2:** Forest Tenure and utilization within the Little River watershed

Maple syrup production remains a significant activity in the area. In addition to small scale private production there is a large commercial operation, Briggs Maples, tapping over 12,000 sugar maple trees in Albert County on both private and crown land near Fundy National Park (Briggs Maples 2015), with distribution through both Sobeys and CO-OP Atlantic.

### *Agricultural Practices*

Agriculture is the dominant non-forest land use within the Little River watershed (Figure 2-3). There are two major farms in the watershed (one of which is a dairy farm), as well as numerous hobby farms (Petitcodiac Watershed Alliance 2010). The dairy farm allows its cattle unrestricted

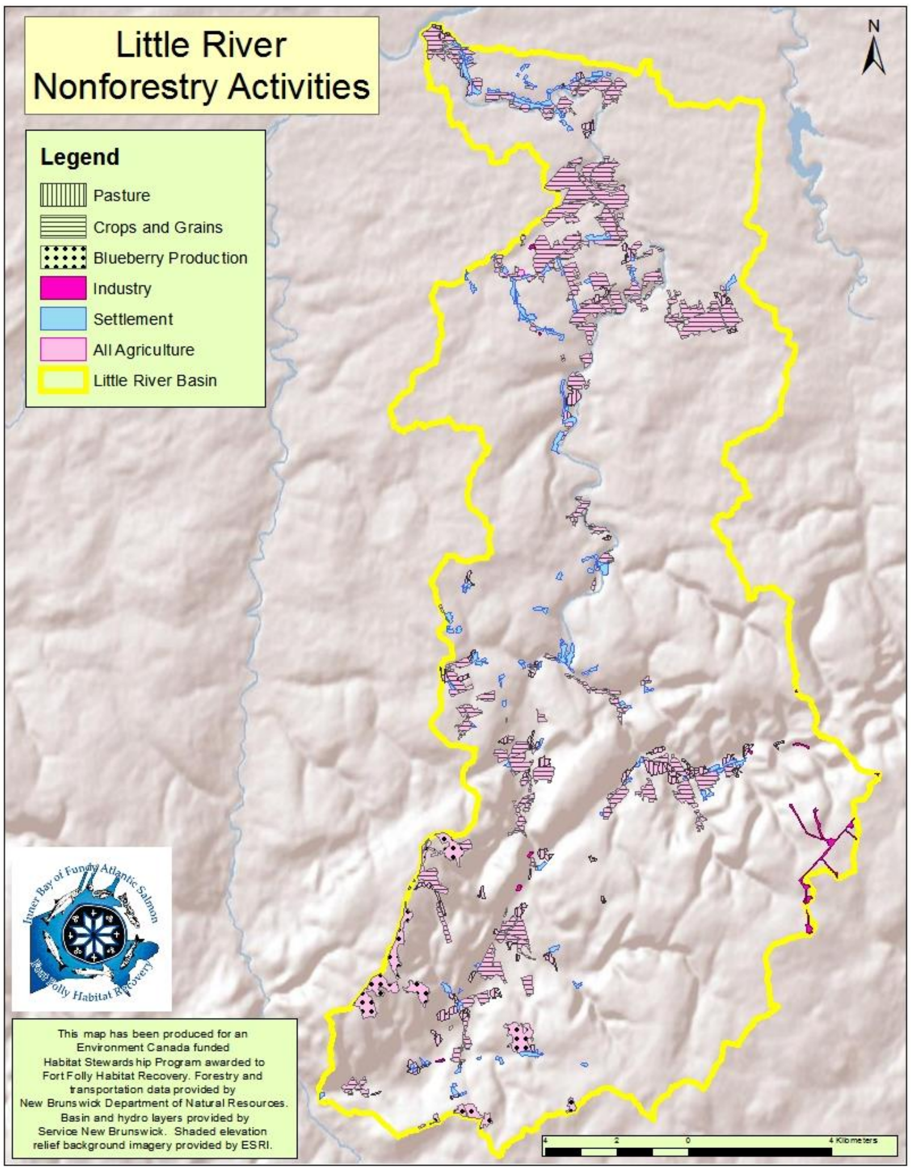


**Figure 2-3:** Agriculture and other non-forest usages of land in the Little River watershed

access to the river with predictable consequences (Figure 2-10). Row crops and grains predominate across the watershed, representing about 75% of the agricultural activity (Department of Natural Resources 2014). The rest is divided nearly evenly between blueberry fields 12 % and pastureland 13%. The blueberry fields are concentrated at higher elevation in the remote upper reaches of the watershed, while pastureland, row crops and grains are distributed throughout at lower elevations along the valley floor, with the latter particularly concentrated within about a 2 km radius near and below Colpitts Settlement.

### *Transportation Development*

A GIS layer of the road network (paved and unpaved) within the Little River watershed was overlaid on the river and its tributaries, to yield Figure 2-4. There are 52 unpaved crossings

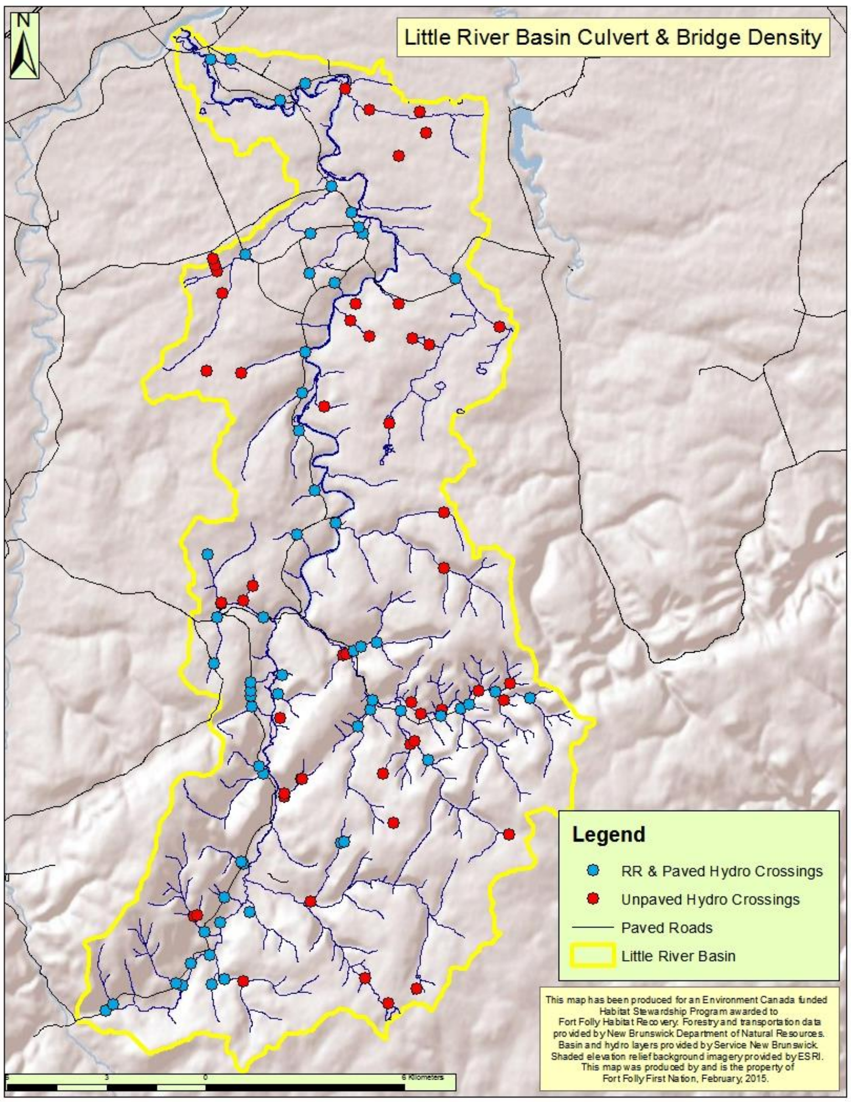


**Figure 2-4**: Locations of road / water crossings in the Little River watershed.

and 63 paved crossings. For the most part the unpaved crossings are likely to be in the form of culverts, though there could be the occasional bridge as well. A partial survey of these crossings on the Little River was conducted in 2014, yielding Figure 2-5. This work was being done along with a survey of water crossings nearby on the Pollett River, which were the primary focus of the 2014 season (Petitcodiac Watershed Alliance 2015).

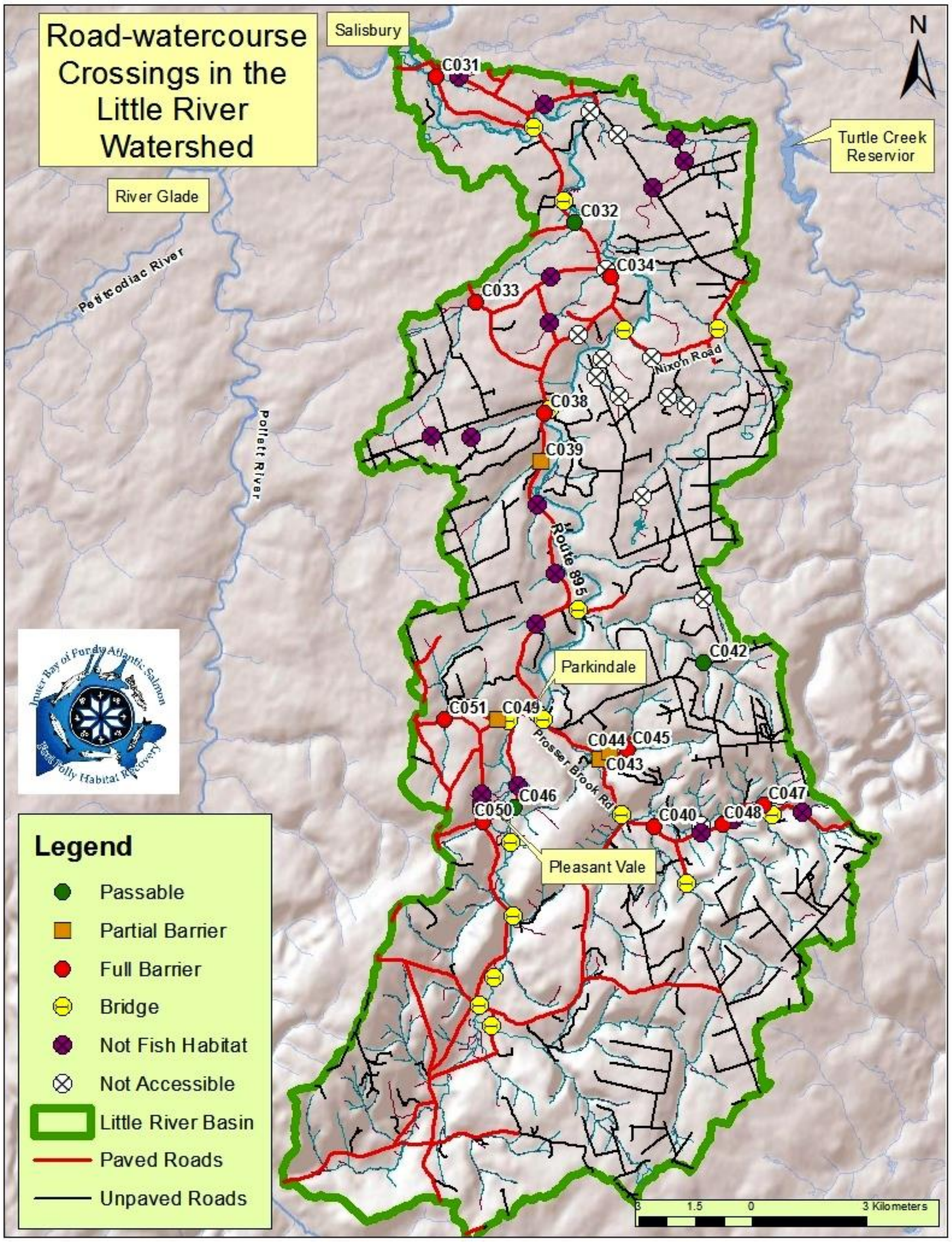


**Figure 2-5:** Water crossings visited during 2014 culvert survey

Of the 115 crossings in the Little River watershed identified in Figure 2-5, there was an attempt in 2014 to locate 59 of them (51% of the total), primarily in the lower reaches of the watershed. Some (11) of these were not found (19% of those searched for), possibly due to limited access caused by equipment constraints (lack of ATV), or because of issues with accuracy of the road layer of GIS data. These were listed as “Not Accessible”.

The 48 crossings that were located (81% of those searched for), were then assessed following a protocol developed by CARP, the Clean Annapolis River Project (2013). Of these: 16 were deemed not to be fish habitat; 15 were bridges; 3 were passable culverts; 4 were culverts that were determined to be partial barriers; and 10 were culverts that were determined to be full barriers to fish passage.

One of those deemed a full barrier to fish passage, culvert C051, was remediated through construction of a vortex rock weir below it to increase the height of the existing plunge pool (Petitcodiac Watershed Alliance 2015). This culvert is located where Route 895 crosses Mitton Brook just west of Parkindale near the divide between the Little River watershed and the Pollett (Figure 2-5). Doing so opened up approximately 2.5 km of upstream habitat to brook trout and other species. Further discussion of this action, as well potential for other remediation projects will be discussed in the Fourth Level of Assessment Aquatic Habitat Rehabilitation Plan, under the heading Opportunities for Future Restoration Activities.

While the New Brunswick Department of Transportation (DoT) is responsible for bridges and culverts on the public paved roads, they are not responsible for the vast majority of culverts on unpaved roads which are likely to be on either private woodlots, industrial freehold, or crown land. If a problem culvert is identified and there is a question of who is responsible (private landowner versus DoT), using GPS coordinates responsibility will be confirmed through further discussions with the Department of Transportation.

Rail service on the section of track from Albert to Hillsborough was closed in 1955 (New Brunswick Railway Museum 2015a). The Salisbury to Hillsborough portion of the line remained profitable until 1981 when the gypsum plant in Hillsborough closed. Shortly thereafter, in 1982, Canadian National abandoned the line. As with service to Albert, rail service from Petitcodiac to Elgin was ended in 1955, and the line abandoned.

In 1968, 22 kilometers downstream of the Little River, along the main stem of the Petitcodiac, the Moncton to Riverview Causeway was built instead of a bridge, in order to accommodate vehicular traffic between the two cities. The fishway built into it proved to be ineffective. The causeway gates created a barrier to fish passage with significant consequences for native fish species in the river, and led to the decline in the populations of species such as alewife, blueback herring, rainbow smelt, and sea-run brook trout. Some species disappeared altogether from the upland reaches of the Petitcodiac (such as the Little), including Atlantic tomcod, American shad, and striped bass (Locke, et al. 2003). Atlantic salmon only remained present in the river as a consequence of ongoing stocking efforts (AMEC 2005)

In April 2010 the Moncton to Riverview Causeway gates were opened as part of the Petitcodiac River restoration project. Five years of monitoring from 2010 to 2014 following the restoration of fish passage (Redfield 2015) found American shad, striped bass, and Atlantic tomcod returning to the river. Of these, the latter two have shown sustained and progressive increases in numbers over the years, while invasive non-native smallmouth bass have declined. Consequently it is clear from these results that the fish community of the Petitcodiac has the capacity to recover, given the right conditions, and appears to be on its way to doing so.

### *Herbicide and Pesticide Use*

Based on general information provided by Service New Brunswick, two forestry operators (JD Irving as Forest Patrol and Natural Resources) may have conducted work in the Little River watershed. While intended blocks of land to be treated were identified by operators that does not necessarily mean that they were treated with herbicides. Products used in these industries may contain the active ingredient glyphosate. Glyphosate is found in several formulations under the trade names Arsenal (PCP 23713), Forza (PCP 26401), Vantage (PCP 26884), Vision (PCP 19899) and Vision Max (PCP 27736). The active ingredient triclopyr has also been used in the past as Release (PCP 22093).

In addition, two industrial operators (Asplundh and NB Power Transmission) may have conducted work with respect to an industrial right-of way perspective (transmission lines) in the Little River watershed. These companies may have used tricoplyr as Garlon 4 (PCP 21053), Karmax (PCP 21252) and any of the aforementioned glyphosate products.

Private growers must be individually certified (hold a valid pesticide applicator certificate) but do not report their usage. Likewise, vendors must report total sales but do not provide a breakdown relevant to individual purchasers. It is difficult to find information of individual grower or vendor pesticide or herbicide use.

### *Mining Practices*

Oil and Natural Gas lease rights within the Little River watershed are currently registered to both Corridor Resources Inc. and Petroworth Resources Inc. (Government of New Brunswick 2015). Unlike the Pollett, where most of the watershed has been leased out exclusively to Corridor Resources (which has already drilled several wells), only a small portion of the Little River around Parkindale and Prosser Brook are subject to leases, held primarily by Petroworth. Considering that this is the area that was noted for bituminous shale by Bailey (1865), interest today in hydrocarbons in that portion of the watershed is not surprising. In July 2013 Petroworth Resources Inc. changed its name to First Sahara Energy Inc. (Marketwired.com 2013). Then in December 2014 First Sahara Energy Inc. changed its name again to M Pharmaceutical Inc. and announced its intention to pursue interests in pharmaceuticals and biomedical devices (Marketwired.com 2014). As a consequence it is unclear how serious this company is about developing its lease, though apparently less so than Corridor Resources.

### *Urban Development*

Large areas of privately owned land along the Little River have been developed into homes or cottages, leaving little or no buffer in the riparian zone in order to obtain clear views of the river (Petitcodiac Watershed Alliance 2010). Such properties are also a potential source of sewage contamination as rural septic systems are not always properly maintained. Several sites were noted where homeowners had pipes discharging directly into the river.

### *Other*

A portion of the Kent Hills Wind farm lies in the southeastern corner of the Little River Watershed (Figure 2-3), noticeable as the road network linking the turbine pads forms a web of industrial land use lines. Kent Hills was the first wind facility developed in New Brunswick, constructed in two phases in 2008 and 2010 (TansAlta 2015). Turbines installed during both Phase I and Phase II lie within the Little River watershed on leased crown land near Prosser Brook (TransAlta 2009; Natural Forces Technologies 2015). Altogether the entire project consists of 50 3 MW Vestas V-90 turbines and is the largest windfarm in the province, with a total capacity of 150 MW (The Maritimes Energy Association 2015). NB Power has a 25 year agreement to purchase the energy produced from TransAlta (83% interest) and their local partner Natural Forces Technologies Inc. (17% interest), which is estimated to be enough to power approximately 26,000 New Brunswick homes (NB Power 2015).

## Third Level Assessment – Aquatic and Riparian Habitat Assessment

### *Wildlife*

Several species of wildlife that warrant specific attention occur in the Little River watershed: Atlantic salmon, American eels, and wood turtles. Of these, the locations of documented encounters with salmon and eels are presented in (Figure 2-6). Due to their small home range, encounters with wood turtles are considered to be sensitive information, and so are being withheld here. Atlantic salmon (*Salmo salar*) Inner Bay of Fundy (iBoF) populations were listed as endangered under the Species at Risk Act in 2003 (DFO, 2010; SARA Registry, 2013a), and the species is considered to be extirpated from the Petitcodiac River system, except for those introduced in stocking programs (AMEC, 2005).

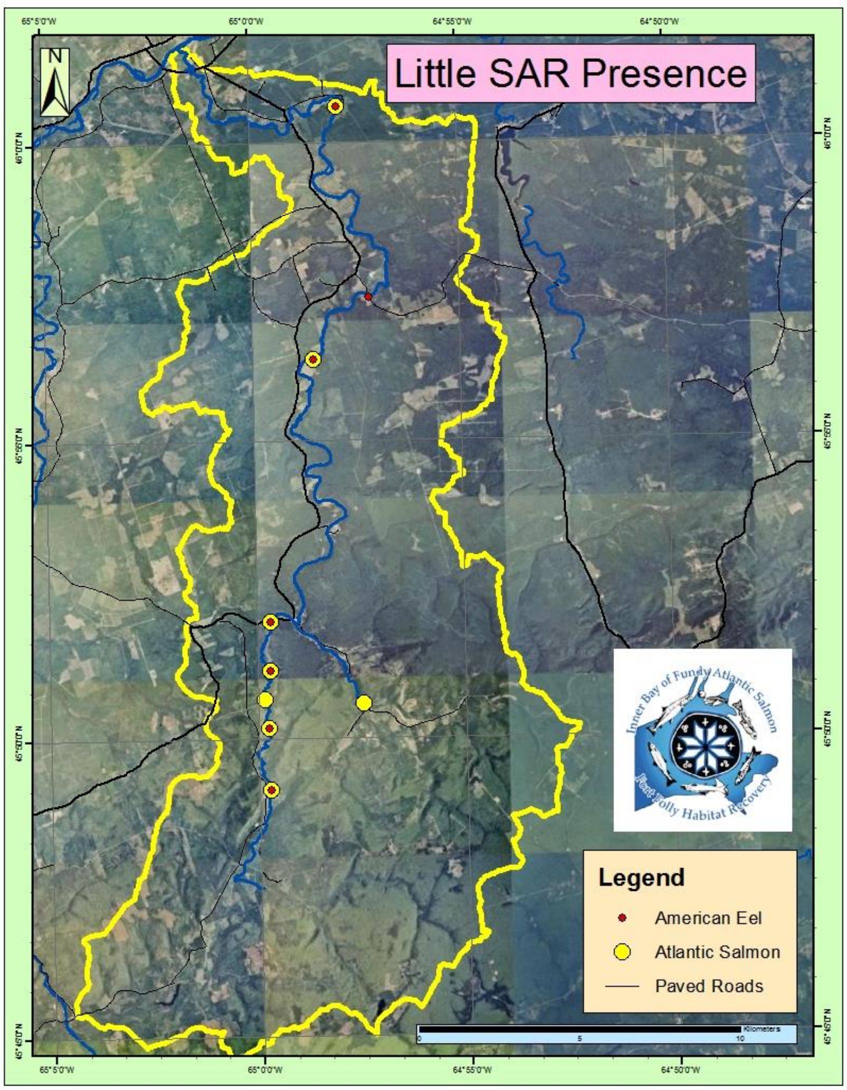


**Figure 2-6:** Locations of Atlantic salmon and American eels within the Little River watershed.

American eels (*Anguilla rostrata*) were designated as “Special Concern” by COSEWIC in 2006 (COSEWIC, 2006). Their status was re-examined and raised to “Threatened” in May 2012 (COSEWIC, 2014). This species is being considered for listing under the federal Species at Risk Act, but currently it has no status (SARA Registry, 2013b). Wood turtles (*Glyptemys insculpta*) were designated as “Special Concern” by COSEWIC in 1996 which was raised to “Threatened” in 2007 (COSEWIC 2007; COSEWIC 2011). This species is listed as “threatened” under the Species at Risk Act (SARA Registry, 2012). Guidelines for projects in areas with these species are in Appendix A.

The decline in numbers of iBoF salmon is a marked contrast to the abundance described by early settlers, particularly given McLeod’s (1973) conclusion that the Coverdale (Little) River produced the majority of the smolts in the Petitcodiac system from the early 1800s up to the 1970s. Though numbers of this species had been decreasing for some time (Elson 1962) construction of the Moncton to Riverview causeway in 1968 eliminated fish passage for adult salmon and smolts altogether and essentially (but for ongoing intervention) extirpated the species from a river system that represented 20% of the iBoF population (Locke, et al. 2003).

Adult iBoF Atlantic Salmon deemed surplus from the Mactaquac Live Gene Bank were released at two locations on the Little River during the fall of each of 2012, 2013, and 2014, timed to encourage spawning. Of these releases the most significant in terms of numbers of fish and proportion of females was the 2012 release. Redd surveys following the releases in 2012 indicated that spawning took place. Electrofishing in 2013 at six sites along the river (Figure 2-6) detected 72 young of the year coming out of those redds. Most were still fry sized, though at least five had reached 5 parr size their first summer, probably due in part to lack of competition. In 2014 three additional electrofishing sites were added increasing the number sampled to nine, at which were found a total of 3 salmon fry and 46 parr. Finding fewer fry in 2014 was not surprising given the smaller number of ripe females released in the fall of 2013. The increase in proportion of parr meanwhile likely reflects the additional time the cohort spawned by the 2012 release had had to grow. No salmon were caught at one of the new sites, which is why only eight points with salmon appear in Figure 2-6. In May and June of 2015 smolts produced on the Little River as a result of the 2012 adult release will be migrating out to sea. Due to lack of a good site for the smolt wheel on the Little River, it will remain in use on the Pollett River, and instead fyke nets will be used trap and quantify smolts on the Little River. These will also be injected with PIT tags and retained for sea cage rearing with the eventual goal of returning them to the river as adults in the fall of 2016.

American eels were encountered at six sites while electrofishing (Figure 2-6). Since eels were not the target of the electrofishing effort (which was sampling salmon) their presence or absence was not specifically quantified or at these locations. However, they were present more often than not. In the decades that the causeway gates were closed on the Petitcodiac, eels had more success than salmon did navigating the fishway and accessing the upper reaches of the river, such as the Little. In fact they were deemed to be one of the dominant species in the headpond (Locke et al. 2000), and the most abundant resident species upstream of it (Flanagan 2001). Being catadromous, the eel population was less vulnerable as they are not as dependent upon accessing any given river. Their spawning takes place in the Sargasso Sea, so young eels already arrive at and reside in different rivers than those in which their parents had lived (COSEWIC, 2006). This allowed for a steady stream of incoming eels, despite the causeway.

Wood turtles were searched for through a series of targeted surveys conducted by the Petitcodiac Watershed Alliance along the Little River in 2014. Simultaneously Geomorphic Assessments were being performed within the watershed by a Fort Folly Habitat Recovery crew, during which wood turtles were actively searched for. A total of 3 wood turtles were found on the Little River, one of which was deceased.

### *Water Quality*

Water quality on the Little River was monitored by the Petitcodiac Watershed Alliance as part of their habitat assessment project in 2010 (Petitcodiac Watershed Alliance 2010). They maintain a fixed monitoring site downstream of the Route 112 bridge over the Little River, just outside of Salisbury, As a single site within the watershed there is a limited amount that can be concluded from it, however being located near the mouth, it provides useful insight to the watershed upstream. The fact this location has been monitored since 2005 with results available on their website (Petitcodiac Watershed Alliance 2015) also provides time depth.

**Table 2-2** . Water Quality on the Little River in 2010 (Petitcodiac Watershed Alliance 2010)

| Monthly at Site | Dissolved Oxygen | Conductivity | Temperature °C | pH |
|---|---|---|---|---|
| May | 9.86 mg/L | 59.3 µS | 10.2 °C | 7.1 |
| June | 9.11 mg/L | 60.1 µS | 13.5 °C | 7.1 |
| July | 8.14 mg/L | 63.0 µS | 20.4 °C | 7.7 |
| August | 8.38 mg/L | 85.9 µS | 20.7 °C | 7.1 |
| September | 10.10 mg/L | 79.6 µS | 11.1 °C | 7.1 |
| October | 11.72 mg/L | 56.0 µS | 10.7 °C | 7.0 |
| Average | 9.55 mg/L | 67.31 µS | 14.4 °C | 7.2 |

## *Rapid Geomorphic Assessment (RGA) and Rapid Stream Assessment (RSAT)*

The following is taken from the report prepared by Parish Geomorphic based upon the rapid geomorphic assessments (RGAs) and rapid site assessments (RSATs) Fort Folly Habitat Recovery conducted in 2012.

### *Geomorphic Analysis*

Data collected from the Rapid Geomorphic Assessment (RGA) and Rapid Stream Assessment Technique (RSAT) were used to evaluate the geomorphic condition and stability of the assessed reaches of the Little River. In order to interpret the geomorphic data, the included maps of the watercourse are highlighted according to reach stability and dominant geomorphic processes.

**Rapid Stream Assessment Technique (RSAT) – Methodology**

The RSAT provides a qualitative assessment of the overall health and functions of a reach in order to provide a quick assessment of stream conditions and the identification of restoration needs on a watershed scale. This system integrates visual estimates of channel conditions and numerical scoring of stream parameters using six categories:

- Channel Stability
- Erosion and Deposition
- Instream Habitat
- Water Quality
- Riparian Conditions
- Biological Indicators

Once a parameter has been assigned a score, all scores are totaled to produce an overall channel health rating that is based on a 50 point scoring system, divided into three classes:

<20 Low
20-35 Moderate
>35 High

**Rapid Stream Assessment Technique (RSAT) – Results**

Figure 2-7 outlines the RSAT classes of the reaches assessed in the Little River Watershed. The vast majority of reaches were scored in the ‘Moderate’ class range (88%). 11% of the assessed reaches scored a RSAT class within the ‘High’ class range indicating the system is in excellent condition. Channel reaches classified as ‘High’ were predominantly located on the Prosser Brook system (PB1 – PB13), upstream of the confluence with the Little River (Figure 2-8). These reaches are characterized by well vegetated banks with excellent riparian conditions. The substrate is composed primarily of cobbles and gravels, with some sand in pools. Exposed bedrock was noted in the upper portions of the system as well. On the other hand, a single reach (LR-83) received an RSAT score within the 'Low' RSAT class range suggesting the site exhibits poor channel conditions. This reach was located in the lower portion of the Little River system where the channel enters active cattle pasture with trees removed from the banks (Figure 2-9). The trampling of soil and grazing of vegetation along the top of banks minimizes the stability of the channel banks leading to excess erosion and sediment discharge (Figure 2-10). In addition, the excessive organic input from cattle likely contributes to poor water quality, minimizing the suitability for aquatic species. Lack of vegetation along the banks further reduces available habitat for aquatic species and contributes to increased water temperature levels. The quality of the riparian conditions and the surrounding land-use appear to have severally impacted this reach which is expected to remain in poor condition unless improvements are made.

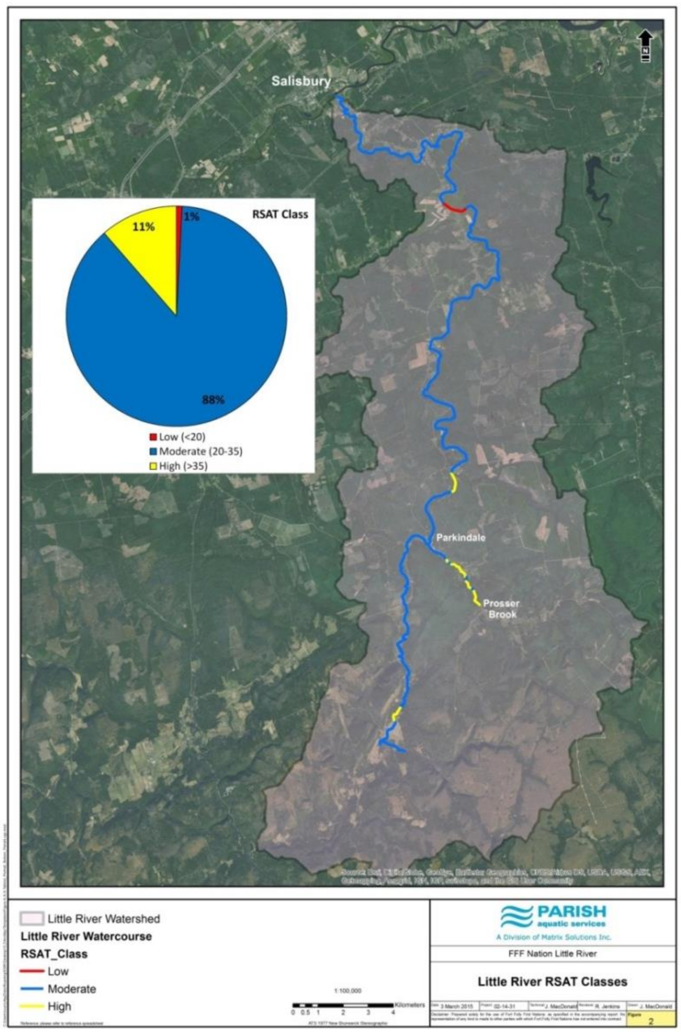


**Figure 2-7**: RSAT classes along the Little River

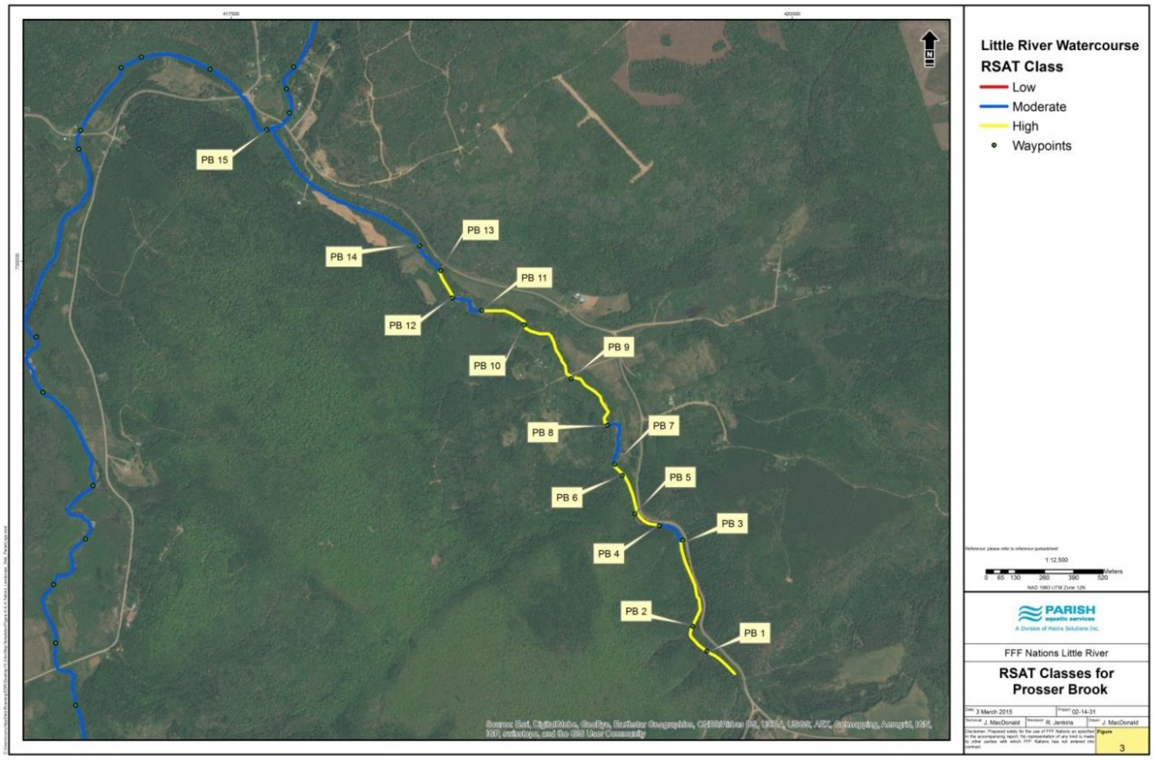


**Figure 2-8:** RSAT Classes for Prosser Brook

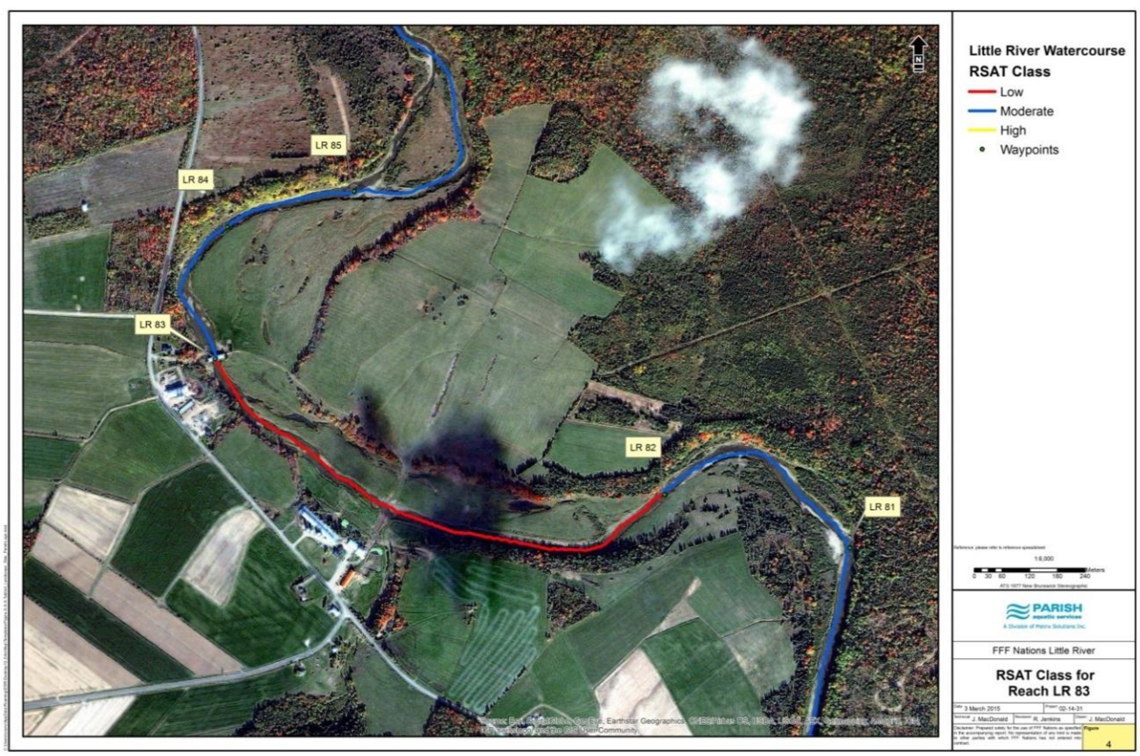


**Figure 2-9:** RSAT Class for Reach LR 83

**Figure 2-10:** Photo of active cattle pasture along floodplain of LR 83

### *Rapid Geomorphic Assessments (RGAs) – Methodology*

The RGA is used to quantify channel stability based on the presence and (or) absence of key indicators of channel adjustment (Parish Geomorphic Ltd. 2003) with respect to four categories: 1) Aggradation, 2) Degradation, 3) Channel Widening, and 4) Planimetric Form Adjustment. Each indicator has been described in detail below.

**Aggradation**

Channel aggradation may occur when the sediment load to a river increases (due to natural processes or human activities) and it lacks the capacity to carry it. Piles of sediment in the river can re-direct flows against the banks, leading to erosion and channel widening.

<u>Typical indicators used to identify aggradation include:</u>

- Shallow pool depths.
- Abundant sediment deposition on point bars.
- Extensive sediment deposition around obstructions, channel constrictions, at upstream ends of tight meander bends, and in the overbank zone.
- Most of the channel bed is exposed during typical low flow periods.

- High frequency of debris jams.
- Coarse gravels, cobbles, and boulders may be embedded with sand/silt and fine gravel.
- Soft, unconsolidated bed.
- Mid-channel and lateral bars.

**Degradation**

Degradation occurs as the river cuts deeper into the land and decreases its gradient. This can occur from a rapid removal of streambed material due to an increase in discharge, water velocity, or a decrease in sediment supply. Bed lowering can move in both an upstream (as a headcut or nick point) and/or downstream direction. Indicators of degradation include:

- Elevated tree roots.
- Bank height increases as you move downstream.
- Absence of depositional features such as bars.
- Head cutting of the channel bed.
- Cut face on bar forms.
- Channel worn into undisturbed overburden/bedrock.

**Widening**

Widening typically follows or occurs in conjunction with aggradation or degradation. With aggradation, banks collapse when flows are forced on the outside, and the river starts to widen. Wide, shallow watercourses have a lower capacity to transport sediment and flows continue to concentrate towards the banks. Widening can also be seen with degradation, as it occurs with an increase in flows or decrease in sediment supply. Widening ultimately occurs because the stream bottom materials eventually become more resistant to erosion (harder to move) by the flowing waters than the materials in the stream banks.

<u>Indicators of widening include:</u>

- Active undermining of bank vegetation on both sides of the channel, and many unstable bank overhangs that have little vegetation holding soils together.
- Erosion on both right and left banks in riffle sections.
- Recently exposed tree roots.
- Fracture lines at the top of banks that appear as cracks parallel to the river, which is evidence of landslides and mass failures.
- Deposition on mid-channel bars and shoals.
- Urbanization and storm water outfalls leading to higher rate and duration of runoff and channel enlargement typically in small watersheds with >10% impervious surface.

**Planform Adjustment**

These are the changes that can be seen from the air when looking down at the river. The river's pattern has changed. This can happen because of channel management activities (such as straightening the bends of the river with heavy equipment). Planform changes also occur during floods. When there is no streambank vegetation with roots to hold soil in place, rivers cut new channels in the weak part of the bank during high water. Planform adjustments typically are responses to aggradation, degradation, or widening geomorphic phases.

Indicators include:

- Flood chutes, which are longitudinal depressions where the stream has straightened and cut a more direct route usually across the inside of a meander bend.
- Channel avulsions, where the stream has suddenly abandoned a previous channel.
- Change or loss in bed form, sometimes resulting in a mix of plane bed and pool-riffle forms.
- Island formation and/or multiple channels.
- Additional large deposition and scour features in the channel length typically occupied by a single riffle/pool sequence (may result from the lateral extension of meanders).
- Thalweg not lined up with planform. In meandering streams, the thalweg typically travels from the outside of a meander bend to the outside of the next meander bend.
- During planform adjustments, the thalweg may not line up with this pattern.

Upon completion of the field inspection, indicators are tallied for each category to produce an overall reach stability index. The index classified the channel in one of three stability classes:

**Table 2-3:** RGA reach stability index classification

| Factor Value | Classification | Interpretation |
|---|---|---|
| ≤0.20 | In Regime or Stable (Least Sensitive) | The channel morphology is within a range of variance for streams of similar hydrographic characteristics – evidence of instability is isolated or associated with normal river meander propagation processes. |
| 0.21-0.40 | Transitional or Stressed (Moderately Sensitive) | Channel morphology is within the range of variance for streams of similar hydrographic characteristics but the evidence of instability is frequent. |
| ≥0.41 | In Adjustment (Most Sensitive) | Channel morphology is not within the range of variance and evidence of instability is wide spread. |

## *Rapid Geomorphic Assessments (RGAs) – Results*

The results of the RGA surveys indicate the majority of reaches are in a 'Transitional or Stressed' state (65%). These reaches exhibit frequent evidence of instability and are moderately sensitive to altered sediment and flow regimes which will lead to instability. The remaining 35% of the reaches were identified as 'In Adjustment' while no sites were found to be 'In Regime' (0%). This indicates widespread instability throughout these reaches outside of a natural rate of change.

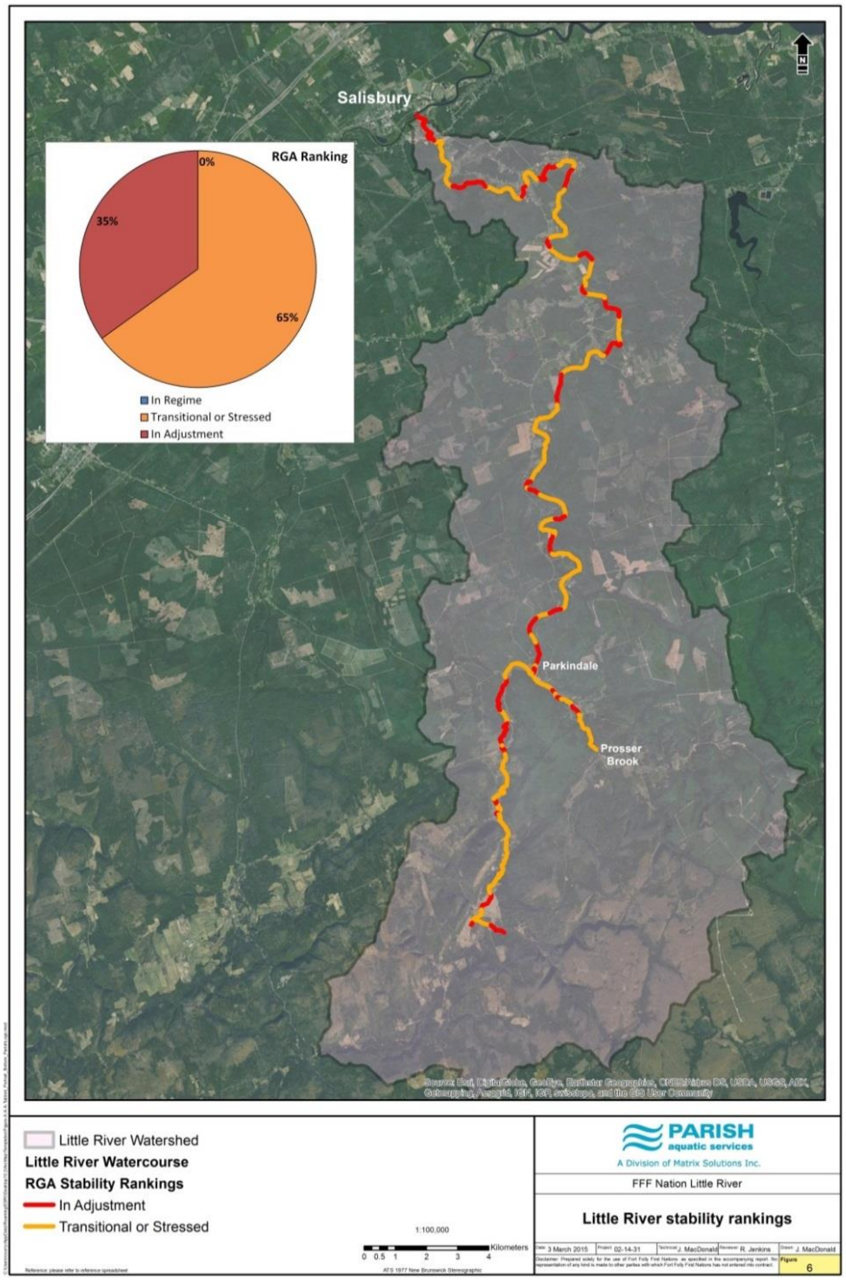


**Figure 2-11:** Little River RGA stability rankings

Aggradation was identified as the most common primary geomorphic process (54%), with degradation being the second most common primary process (34%) within the Little River watershed. Widening was also observed as a primary geomorphic process (12%), with no

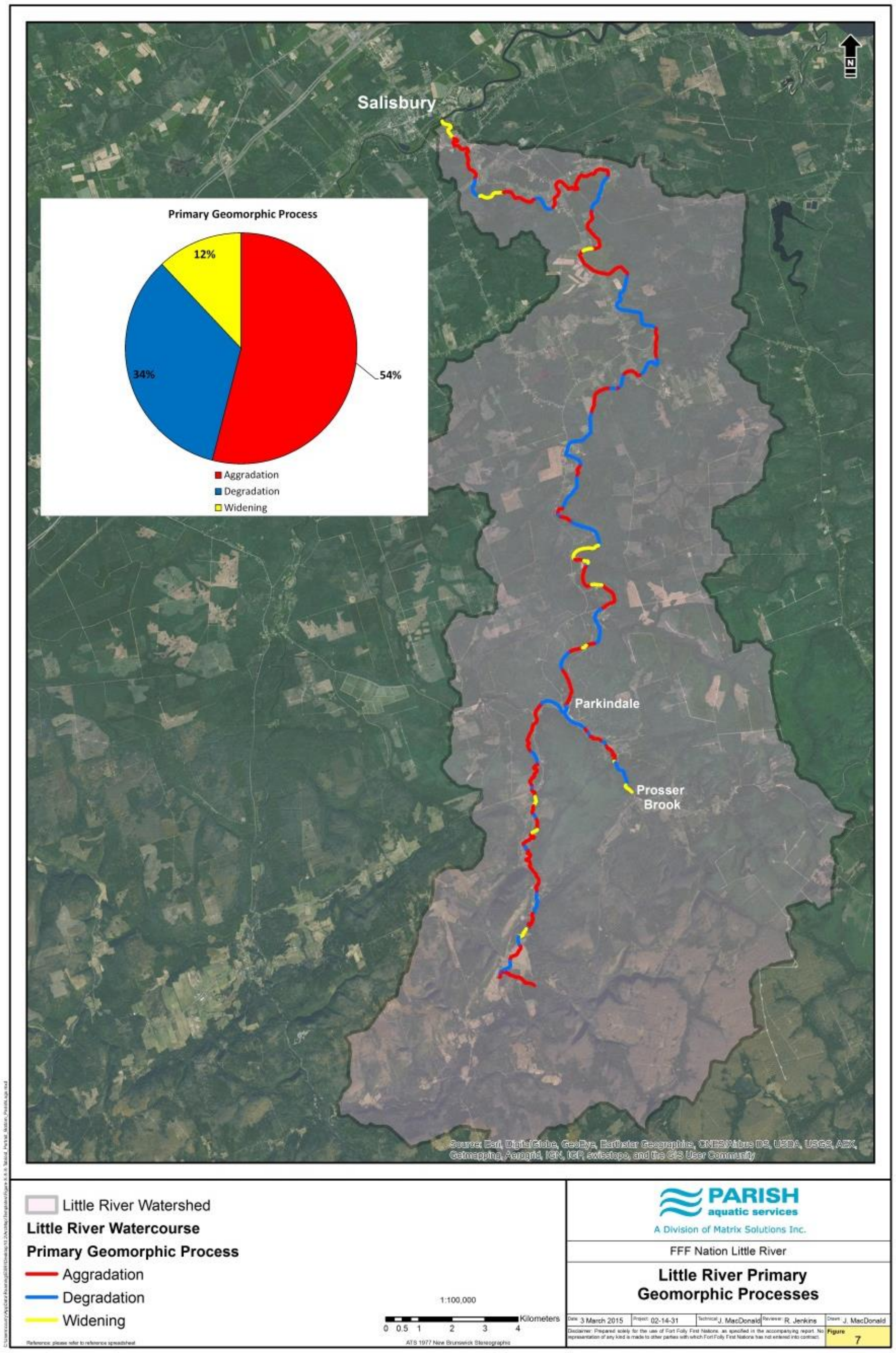


Figure 2-12: Little River primary geomorphic processes

reaches experiencing planform adjustment (Figure 2-12). Channel aggradation appears to occur in the upper and lower portions of the assessed reaches of the watershed whereas degradation is concentrated more centrally.

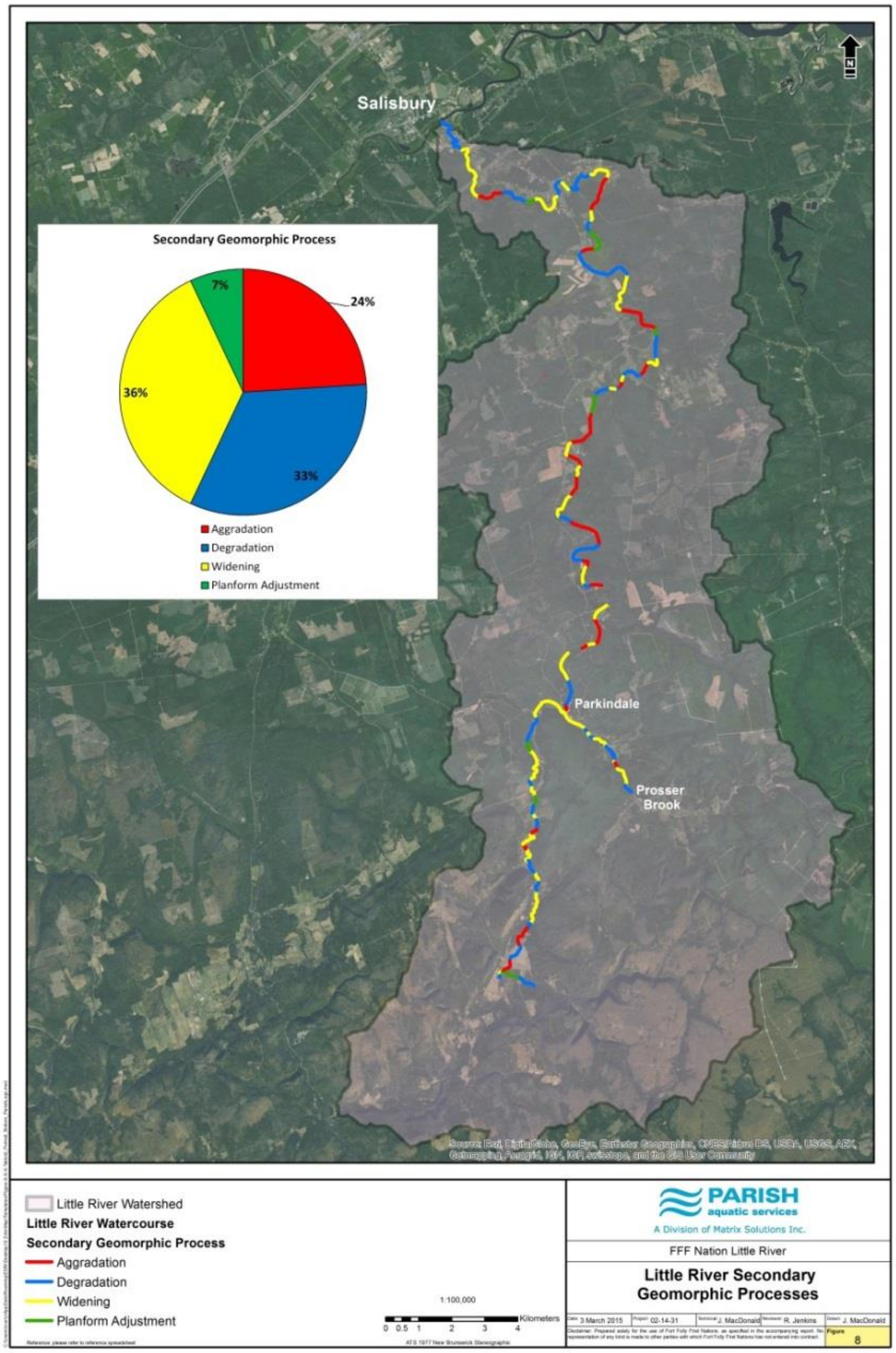


**Figure 2-13:** Little River secondary geomorphic processes

Channel aggradation may occur when there has been a significant decrease in flow, a significant increase in sediment supply, or a significant decrease in slope due to irregular meander migrations. In the lower reaches of the Little River, aggradation is likely a result of increased sediment supply provided by erosion from bank widening and degraded bed material observed towards the middle portion of the assessed reaches. The aggradation observed in the upper reaches may be related to a natural process such as a cyclical high in the hydrology of the watershed or a response to land-use changes. Additional information is necessary to assess the source of sediment in the upper reaches.

Secondary geomorphic processes exhibited greater variability than the primary process of aggradation. Widening (36%) and degradation (33%) represented the most prominent secondary processes throughout the assessed reaches of the watershed. Aggradation was also found to comprise 24% of the assessed reaches, while 7% of the sites experienced planform adjustment as the secondary geomorphic processes. The secondary process of channel widening is expected within the Little River system as this geomorphic process is often seen in conjunction with the primary process of aggradation. When the stream becomes incapable of transporting its sediment load, sediments collect on the stream bed, forming mid-channel bars that concentrate flows into both banks, and lead to a wider channel. Channels also become over-widened due to an increase in flows.

## Fourth Level Assessment - Aquatic Habitat Rehabilitation Plan

### *Summary of Issues Identified from Geomorphic Assessments*

Results from the RGA and RSAT assessments conducted on Little River indicate that the majority of the reaches were determined to be in a transitional/stressed state while the remaining reaches were classified as in adjustment. In general, the results indicate a watershed responding to change with aggradation as the primary geomorphic process and widening as the secondary process. Therefore, restoration efforts should focus on narrowing of the channel to promote scour of the riverbed.

In general, reaches with excessive sediment accumulation may be restored via in-channel structures including rock vanes, upstream-V log weirs, double tree deflectors, and brush mattresses. These structures are designed to concentrate flows, promote scour pools, and narrow the channel. By narrowing the channel, the stream will regain the capacity to transport sediment as flow velocity will increase. This will encourage the channel to return to a state of dynamic equilibrium whereby sediment accumulation and deposition are in balance with flow discharge. A detailed site survey including longitudinal and cross-sectional profiles, pebble counts and riparian topography is necessary to appropriately identify a restoration strategy for a site.

At the watershed scale, best management practices should be promoted to improve stability of the Little River. Although agricultural land-use constitutes a low proportion of the watershed, much of the existing agricultural land is concentrated along the riparian corridor. Many of the assessed reaches of the Little River were identified as in adjustment and lack adequate riparian conditions due to surrounding agricultural land-use. Shrub and tree planting will provide greater stability and habitat along banks that currently lack cover and will reduce sediment input. This will minimize aggradation experienced in the lower reaches of the Little River. Furthermore, active cattle pasture along the channel should be restricted from access to the river to promote vegetation growth along the riparian corridor and to improve water quality. Any opportunities to reforest the riparian corridor will lower water temperatures, reduce sediment input and runoff, minimize non-point source pollution and improve channel stability.

### *Summary of Issues Identified from Information on Current Impacts*

The 2014 culvert survey noted 4 culverts that were partial barriers and 10 that were full barriers to fish passage (Figure 2-5). One of the latter, C051 has already been modified through construction of a vortex rock weir, as described below. Plans should be developed to address the remaining 13 culverts where issues are known to exist.

### *Restoration Activities Undertaken*

Culvert C051 located where Route 895 intersects Mitton Brook (Figure 2-5) was found to be a full barrier to fish passage during the 2014 culvert survey. It was identified as a candidate for construction of a rock weir below the outflow. Culverts that are not properly designed can create a drop, or change in elevation, between the culvert outflow and the stream flowing through it. Culvert C051 has a downstream slope of 3.79% and an outflow drop of 19 cm, potentially blocking approximately 2.5 km of upstream habitat for brook trout and other species. Large changes in elevations between the outflow drop and stream can prevent fish from jumping into the culvert and migrating upstream.

To reduce this barrier, a vortex rock weir design was selected to increase the height of the existing plunge pool. By installing this type of structure water levels are raised in the plunge pool and the barrier outflow drop is effectively eliminated. The size and volume of the rock weir is based upon the stream and culvert characteristics and can be calculated using data collected from the culvert assessment.

The apex or low flow notch (located at the center of the weir where water can flow during times of lower volume) has the lowest point of elevation and points upstream. The wings of the weirs were built at a 30° angle from the base of the weir (Figure 2-14).

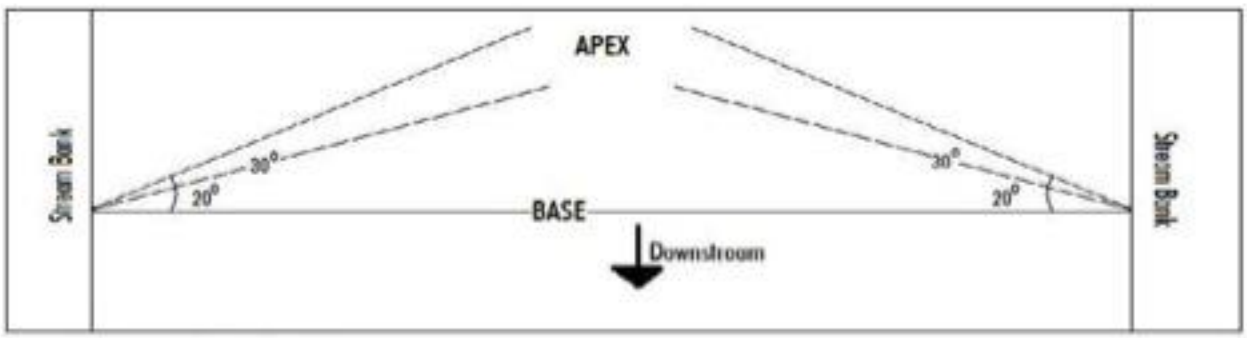


**Figure 2-14:** Vortex Rock Weir Design (CARP 2013)

Gradual reduction of the outflow drop was visible during rock weir construction. Comparison of before and after outflow drop photos below show that the outflow drop was successfully reduced.

**Figure 2-15**: Outflow photos of culvert C051 before and after construction of a vortex rock weir downstream.

Over time, the watercourse will naturally deposit material within the rock weir and fortify the structure. Stream-crossing structures should be inspected and maintained on a regular basis, especially following high water flow season and large rainfall events. Installing this rock weir allowed fish access to approximately 2.5 km in length and 6.03 km² of upstream habitat.

## Opportunities for Future Restoration Activities

### Culverts and fish passage

There are 67 water crossings in the Little River watershed that have been identified in the GIS layer that have not yet been assessed. Due to equipment constraints, (need for ATV) 11 of these were not located either because they were deemed inaccessible, or in some cases they may not have been found because they do not exist, possibly identified in error due to errors in the road and water layers of the GIS. There was not an attempt in 2014 to locate the other 56. So completion of the survey (with an ATV) would be useful in order to fine tune the list and properly rank priorities. The state of watercourse buffers along such tributaries ought to be assessed by the same crew at the same time.

In 2014 the work done with culverts on the Little River found 4 that were partial barriers and 10 that were full barriers to fish passage. Of these, 1 of the full barrier culverts has already been addressed (Figure 2-15) through the work described above. The remaining 13 should be ranked in order prioritize them (by factors such as complexity of repair (due to either technical or landowner issues), upstream habitat made accessible, etc.). Then starting with those where action is most practical & beneficial they should be modified as needed to improve passage.

### Streambank stabilization and sediment control

David and Marilyn Mitton have expressed a desire for help with stream bank stabilization in order to protect part of the pasture of their cattle farm, in the community of Meadow on the Little River, downstream of its confluence of the East Branch Little River, Figure 2-16.

**Figure 2-16:** Mitton Farm's unstable bank

As a source of sediment fairly high up in the system, work at this site has the potential to provide benefits for quite some distance downstream. The Rapid Stream Assessment Technique (RSAT) rating for overall health and functioning in the river at this location was moderate. The Rapid Geomorphic Assessment (RGA) result for this section was Transitional or Stressed, with Degradation being the primary geomorphic process, and Aggradation being the secondary geomorphic process.

Work at this site will be undertaken in a three phase process. The first (planning) phase in 2015 to 2016 involves further site specific assessment to layout and design a prescriptive plan of how to address the issues occurring there, and the preparation for implementation of that plan (getting permits, finding equipment & operators (if required), lining up planting stock etc.). Then during 2016 to 2017 the second (project) phase itself will be carried out in terms of earth moving, tree planting etc. as determined during the first phase. Finally in 2017 to 2018 will be the third (post construction) phase, involving survey, monitoring and maintenance (such as weed control if needed) of the site. This last phase should also provide opportunities for outreach at the site as neighbouring landowners see what has been done, and imagine how similar projects might benefit their properties.

### *In stream work*

Once such landowner engagement has begun, then additional, ambitious in-stream projects such as brush matting, upstream-V log weirs, and double tree deflectors (depending upon the needs of any given site) may become practical. This will help address the recommendation coming out of the RGA that restoration efforts should focus on narrowing of the channel to promote scour of the riverbed. When it is time to develop and implement such projects, Melanson et al. (2006) note that interventions must be properly designed by trained individuals spending several days doing a proper layout. Structures not sited properly are unlikely to produce the desired improvements to habitat, instead becoming buried, washed out, or creating worse problems than were present prior to installation. The presence of threatened and endangered species (salmon, eels, and wood turtles) in the watershed also means that such projects must be planned and implemented with awareness of the vulnerabilities of these species. Fort Folly Habitat Recovery has developed project checklists (Appendix A) based on species biology to provide guidelines to help avoid or minimize the risk of negative impacts.

## POLLETT RIVER

The Pollett River flows from Albert County into Westmorland County. It is the largest tributary in the Petitcodiac River watershed, with a basin that covers 314 square kilometers. Its headwaters surround Mechanic Lake near Fundy National Park in New Brunswick's Central Uplands Ecoregion (New Brunswick Department of Natural Resources 2007). From there, the 57 kilometer long river passes through Elgin in the Continental Lowlands Ecoregion and on to its mouth along the Petitcodiac, near Salisbury in the Eastern Lowlands Ecoregion, a short distance above the head of tide. From its top to the confluence with the Petitcodiac, the Pollett drops approximately 335 metres in elevation.

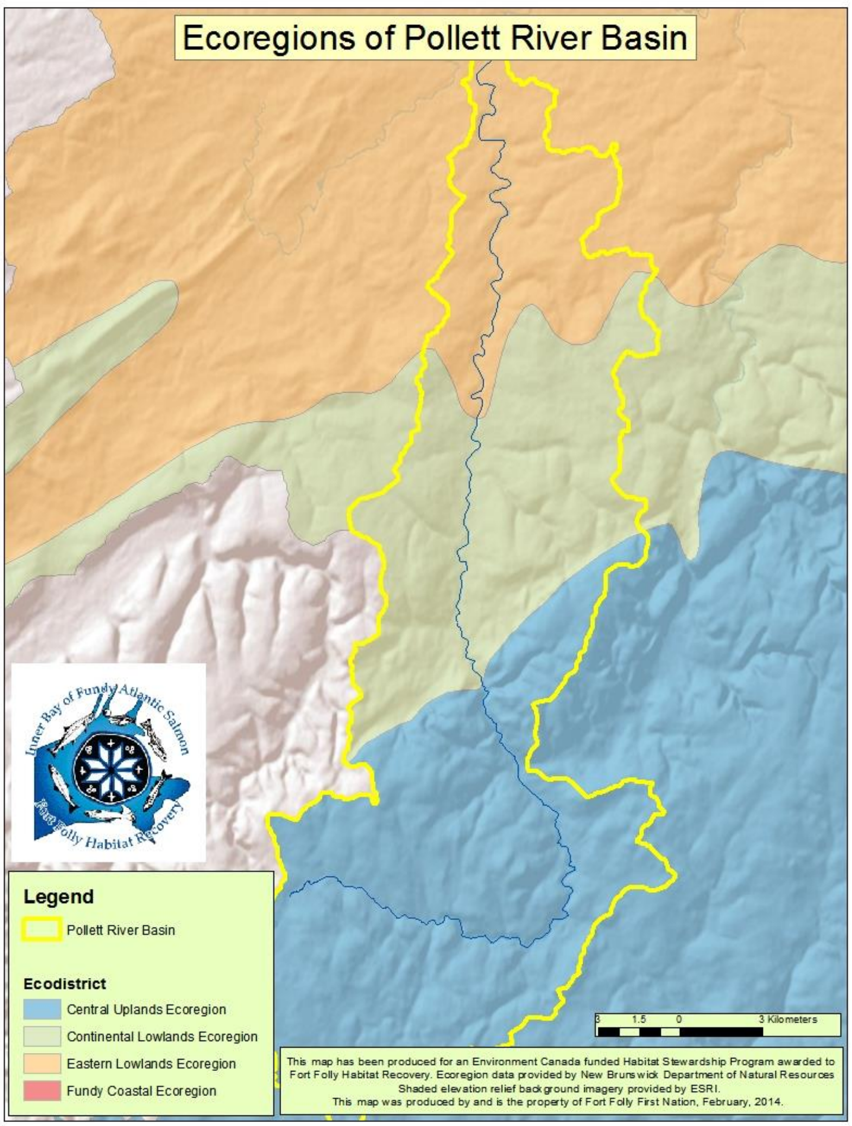


**Figure 3-1:** Pollett River watershed

In addition to its main stem, named tributaries of the Pollett River include: Barchard Brook; Bustin Brook; Campbell Brook; Colpitts Brook; Dry Brook; Grassy Lake Brook; Gibson Brook; Haslam Brook; Kelley Brook; Lee Brook; Mapleton Brook; McMain Brook; Mechanic Lake Brook; Miller Brook; Pinnacle Brook; Popple Intervale Brook; Shaffer Brook; Steeves Brook; and Webster Brook. The river usually runs clear, and often has a gravel bottom though in places bedrock is visible. During the spring freshet or after a storm it can become turbid for several days, before resuming its more normal condition. Rises of up to 1 metre can occur in the spring and fall, and surges of 2 to 3 metres have occurred in as little as 12 hours (Elson 1962).

In its upper reaches the Pollett flows through a steep valley covered with mixed conifer and deciduous forest and is separated from the lower reaches by a deep gorge over a kilometer long. Gordon Falls (Figure 2) located near the midpoint along the gorge, drops 4.5 to 6 meters depending upon the level of flow in the river. Below the gorge from Elgin to its mouth the river is fairly consistent, with a gradient of about 3 meters per kilometer. It forms a series of shallow pools that alternate with long gentle rapids, flowing through stretches of forest broken up occasionally by scattered farmland and camps, that become increasingly frequent the closer to the mouth one gets.

**Figure 3-2:** Gordon Falls upstream of Elgin

The dominant land uses are forestry and agriculture. Approximately 90% of the watershed is forested, 48.3% of which is on small private woodlots, 26% is on crown land, and 25.6% is industrial freehold forest land owned by J.D. Irving. Though there is some fragmentation, 22% of the forest is considered mature (University of New Brunswick 2014). Approximately 5 % of the watershed has been cleared for agriculture, 59% of which is being used to grow row crops or grains, 22% pasture or hay, and 18% blueberries.

## First Level Assessment – Land Use History of the watershed

An understanding of the historical land use within a watershed provides context that helps explain the causes of issues affecting the watershed today. The following sections outline the historical land use both within the Pollett River watershed, and in the surrounding communities in both Westmorland County and Albert County. Within the Pollett watershed this includes the communities of Elgin, Pollett River (or Forest Glen), and Kay Settlement. Neighboring communities outside the watershed include: the village of Petitcodiac to the west; the village of Salisbury downstream a short distance below the confluence of the Pollett and the Petitcodiac River; and the communities of Colpitts Settlement, and Parkindale to the east.

**Table 3-1:** Brief historical background summary for communities along or near the Pollett River

| **Community** | **Settlement Type and Dates** | **Notes** |
|---|---|---|
| Colpitts Settlement<br>*(Little River)* | Settled c.1786 by Colpitts family<br>Farming | **1898** population 250, post office, store, 2 grist mills, church |
| Elgin<br>*(Pollett River)* | Settled c.1811 by Geldart family<br>Farming and lumbering | **1871** population 250<br>**1876** connected to the Intercolonial Railway at Petitcodiac by completion of branch line, The Elgin, Petitcodiac, & Havelock Railway<br>**1898** post office, railway station, 6 stores, 3 hotels, 2 churches sawmill, grist mill, tannery, carriage shop, and cheese factory, |
| Kay Settlement<br>*(Pollett River)* | Settled c. 1803 by Kay family<br>Farming | **1898** population 25, post office, church |
| Parkindale<br>*(Little River)* | Settled c.1817 by Parkin family<br>Lumbering | 1898 population 150, post office, store, sawmill, church |
| Petitcodiac<br>*(Petitcodiac River)* | Settled c 1786 by Blakeney family<br>Farming and lumbering | **1898** population 700, Station on Intercolonial Railway, central depot for The Elgin, Petitcodiac, & Havelock Railway, post office, 6 stores, 2 hotels, tannery, sawmill, carriage factory, 4 churches |
| Pollett River / Forest Glen<br>*(Pollett River)* | Farming and lumbering | **1898** population 125, post office, store, sawmill, and hall |
| Salisbury<br>*(Petitcodiac River)* | Settled c.1774<br>Farming and lumbering | **1898** population 400, railway station, post office, 6 stores, 2 hotels, carriage factory, 3 churches |

(Source: Provincial Archives of New Brunswick, 2014)

The Maritimes have had human inhabitants for the last 11,000 years (Wicken 2002), though for most of that time precise cultural identities are impossible to determine today. By the early 1600's, when Europeans arrived, much of the native population of coastal Atlantic Canada shared a common culture and language identifying themselves as the L'nuk, "the People", and recognized by Europeans as the Mi'kmaq. Traditionally, the Mi'kmaq lived in large villages along the coasts from April to November, and then dispersed during the winter, migrating inland to hunt moose and caribou. During this time physical impacts on the watershed were few compared to what was to follow.

The Mi'kmaq name for the Pollett River was Manoosaak' (Provincial Archives of New Brunswick, 2014), The English name for the river is reportedly a reference to Peter Paulet, a Mi'kmaq elder who lived near the mouth of the river (Hamilton, 1996), whose name suggests some Acadian cultural influence. Presumably he was a member of the historical Mi'kmaq community that existed on the north side of the Petitcodiac River between the mouths of the Little & Pollett Rivers. Ganong's (1905) map of known First Nations villages and campsites includes this site at Salisbury located along the north bank of main stem of the Petitcodiac, near the head of tide between the mouths of Little River and the Pollett River. A native leaving Beaumont (where there was another camp in the lower Petitcodiac estuary) could ride the 13 km per hour tidal bore upstream to Salisbury, greatly facilitating such travel (Petitcodiac Heritage River Committee 2000). The importance of the Salisbury encampment was due to its location both at the head of tide and near the ends of a pair of portage routes leading to the Saint John River system. The more highly traveled of the two routes crossed from the main stem of the Petitcodiac River to the Canaan River (Ganong 1914) near what is now the Village of Petitcodiac, as doing so provided the best access to the upper St. John and on to the St. Lawrence (Petitcodiac Heritage River Committee 2000). The other route crossed from a tributary of the Petitcodiac, the Anagance River, to the Kennebecasis River (and from there to the lower portion of the Saint John River system). In fact the name Anagance comes from Maliseet "Oo-ne- guncé" meaning portage (Ganong 1896), presumably a reference to the link provided by that tributary.

In the 1630's the French began to make a serious effort to colonize Atlantic Canada, beginning to arrive in numbers significant enough to develop an enduring Acadian identity (Laxer 2006), at a fairly similar timeframe to the English colonies further south. By 1676 the first Acadian settlers arrived at Beaubassin, near the current Nova Scotia Visitor's Centre along the Trans-Canada Highway at the New Brunswick border (Larracey 1985). Then, 34 years later in 1710, Acadians and Mi'kmaq in peninsular Nova Scotia fell under British control, which was subsequently formalized in 1713 under the treaty of Utrecht. In 1751 Fort Beausejour was built at the border to protect Acadian communities in what is now New Brunswick from attack by the British. By this time the Acadian population near the Fort had grown to 1,541 people, with an estimated additional 1,100 spread out at Shepody and along the Petitcodiac and Memramcook Rivers (Larracey 1985). The Acadians built dykes and tidal control structures turning marshland along the lower Petitcodiac estuary into pasture, and established their settlements nearby (Wright 1955). Their physical impacts on the Pollett River, what for them was a remote hinterland, were limited.

Ganong (1899) notes that like First Nations, the French made use of the Kennebecasis-Petitcodiac portage along the Anagance in order to maintain communication between Fort Beausejour and Acadian settlements on the lower St. John. However the French route between the Canaan and the Petitcodiac to access the upper St. John was slightly different than the one favoured by First Nations, reportedly crossing overland to the Canaan from the North River, rather than the main stem of the Petitcodiac (Raymond 1891). From there messengers from Fort Beausejour, and the Fortress of Louisbourg passed up along the St John to reach Quebec.

After the fall of Fort Beausejour in 1755, the British attempted to expel the Acadians, to open up land for English settlers. There is a record of an Acadian settlement, Village Victuare, located nearby in Salisbury, close to the Mi'kmaq encampment there (Ganong 1930). It was documented in 1758 by British Major George Scott as he was forcefully removing Acadian families from the upper Petitcodiac (Scott 1758). The village appears to have been composed of approximately 10 homesteads, settled in about 1751, and was reportedly the largest Acadian village along the Petitcodiac upstream of Beausoleil Village, modern day Allison. Ganong (1930) suggests that it is likely that in the wake of the expulsion, Acadians briefly occupied locations such as Fourche-à-crapaud at the mouth of Turtle Creek, and on the Coverdale (Little), and Pollett Rivers in order to be near the head of tide and thus above the reach of English Ships. Major Scott apparently found the tidal bore on the Petitcodiac problematic during his raids in 1758, nearly losing two ships on one occasion (Pincombe and Larracey 1990).

The Mi'kmaq sided with the French (Wicken 2002), participating in the defense of Fort Beausejour, as well as the short guerilla war which followed its capture (Grenier 2008). There were several reasons that Mi'kmaq in New Brunswick did so. Prior to the arrival of the British, native communities had already established trade networks with the Acadians for steel tools, weapons and other European goods (Walls 2010). Another source of friction was that the Mi'kmaq had begun to adopt Catholicism from the French, while the British were Protestants, at a time when such differences added fuel to conflicts. Acadians also had had good relations with the Mi'kmaq in part because the lands Acadians occupied either complemented native use, as with fur traders, or were in areas that were marginal to native concerns as in the case of the Acadian farmers on the tidal flats (Mancke 2005). English settlers on the other hand tended to seize land the Mi'kmaq valued, to clear the forest for agriculture (Francis et al. 2010).

The dates that various communities listed in Table 3-1 were first settled (where available) indicate how movement by English colonists into the upper reaches of the Petitcodiac River above the head of tide occurred first along the more easily accessible main stem. Many of the early dates coincide with the arrival of United Empire loyalists from the 13 colonies (late 1770's - 1780's). After the arrival of the Loyalists, Mi'kmaq in what is now New Brunswick were moved off their lands and onto "reserves" (Walls 2010). This was done partially to provide land to incoming settlers, and partially to punish the Mi'kmaq for aligning themselves with the French.

Subsequent generations of English settler families and those that arrived after them then pushed further up the Petitcodiac and into its more remote tributaries such as the Little River, and the Pollett River (Wright 1945). An early example would be John Colpitts, the eldest son of Robert Colpitts who had settled near Salisbury in 1783. John Colpitts arrived from England as a teenager with his father, and had already moved on to develop his own homestead just a few years later, founding Colpitts Settlement on the Little River (Moncton Daily Times, Thursday August 26th 1920).

### *Forestry Practices*

In 1811, when the first homesteaders (the Geldarts) arrived near what became Elgin, the area was described as unbroken wilderness, having no roads and extremely dense forest (St John Daily Telegraph October 14th, 1870). Such early settlers cleared the land to allow for agriculture, locally consuming cordwood for fuel, and lumber to build their homesteads, while generating income by selecting marketable timber to send downriver to be sold for shipbuilding or export. The latter became a significant aspect of the local economy. Timber harvest in the Petitcodiac timber district as a whole grew from 260 tons in 1818 to 3,137 tons by 1836 (Wynn 1981), though this paled in comparison cutting in other more accessible portions of the province such as in numerous timber districts along the Saint John and Miramichi Rivers where harvests taking place at the same time were in some cases an order of magnitude greater.

On the Pollett six or seven dams on streams and on the river itself would be simultaneously opened during the spring freshet to cause of surge of water that could carry logs cut over the winter to mills downstream (Jones et. al 1997), a practice which reportedly continued to supply the mill at Forest Glen (the community of Pollett River) up to 1947. During the early 1800s white pine was gradually culled from New Brunswick Forests to meet the demand for masts for the Royal Navy (Wynn, 1981). The White Pines Act of 1722 established the requirement of a royal license to fell white pines with a diameter exceeding 24 inches unless they were privately owned, and in 1729 Parliament reserved all such trees to the government except those already in private hands before 1690 (Purvis 1999). Since New Brunswick came under British control well after that time, this exception did not apply at all to its forests. During the American Revolution and the Napoleonic Wars from 80 to 90 percent of all masts supplied to the Royal Navy came from Canada, mostly New Brunswick (Williams 1992). The Napoleonic blockade of the Baltic forced England to expand New Brunswick's lumber production twentyfold, transforming an "undeveloped backwater" of 25,000 people to a bustling colony of 190,000 (Gordon 2014). Pines could still be found in 1850, but few of the magnificent trees the region was known for earlier in the century remained. Spruce was more abundant, but the largest had also been cut. Though there were not many extensive cutover tracts, by 1850 the character and composition of the forests in New Brunswick had been drastically modified over the course of just 50 years of harvesting.

The effects of this early economic activity were not limited to just the forests. By 1820 importation of food into New Brunswick was the rule rather than the exception, everything hinged on the timber trade, though there were warning signs of the danger of single source economy (DeMerchant, 1983). James Robb, professor of Natural Science at Kings College in Fredericton (now the University of New Brunswick), was appointed Secretary of the Provincial Board of Agriculture when it was established in 1858. He warned that timber harvesting was so lucrative that it distorted development, and that when the market in Europe declined, the farmer neglecting his homestead to work in the woods would be “surprised to find his fences down, his fields grown up with bushes, and both himself and his snug little clearing generally all gone bad”. It was not just agriculture that was falling short of its potential. In the years that shipbuilding boomed at St. John and other towns along the coast, even the fishing industry was neglected as men were drawn to the forest to supply wood (DeMerchant, 1983).

Elson (1962) reports that there were several dams on the Pollett during this time to provide power to sawmills. He notes that one at the community of Pollett River/Forest Glen (Table 3-1) 16 kilometers above the mouth of the river, functioned for at least 150 years, which if accurate would be almost the entire period from early settlement up to his time of writing. Reportedly during much of that time it had no fishway and prevented Salmon from passing upstream. Beyond that dam another sawmill dam was located near Elgin (Table 3-1), 28 kilometers above the mouth of the river and less than a kilometer below Gordon Falls. Arguably with regards to salmon, the presence of that dam was rendered somewhat moot by the one below it. Aside from restricting passage, mill wastes were also a problem because at the time, other than burning, dumping into the river was one of the most common forms of disposal of sawdust, bark, and other waste (Department of Fisheries 1890). Such material sometimes covered river bottoms, smothering spawning sites. Despite the Pollett draining a larger watershed and being a longer river than the Little River, it is thought that following English settlement from the early 1800s to the 1970s, the Little River contributed more salmon smolts to the Petitcodiac than the Pollett did, due to the extent of human impacts on the Pollett (MacLeod 1973).

By 1876 the completion of the railway branch line, The Elgin, Petitcodiac, & Havelock Railway connected the Pollett watershed to Intercolonial Railway, eliminating transportation as a constraint on timber harvesting. According to Dawson (2005) it entered the watershed following what is today Route 905 (which already existed then as a road) heading east from Petitcodiac until arriving at the Pollett at Forest Glen (another name for the community of Pollett River), near where Sanatorium Rd now meets the 905. From there it continued upstream, alongside the precursor of the modern 905 to Elgin.

The Chignecto Post in Sackville wrote of the railway opening on September 14th 1876, "Within a few months over 350 cars of lumber (which could not have otherwise profitably been put in the market) have been hauled over the railway. The estimated shipments of lumber per year is about six million. Besides this there is ship timber from the virgin forests of Elgin, bark, sleepers, cordwood, country produce, local and passenger traffic." It goes on, "There is said to be enough timber in her (referring to the Elgin region) hills to keep the shipyards in Saint John busy for a century." How "virgin" the forests may have been is an interesting question given a population at that time (Table 3-1) of over 250 people in Elgin, plus hundreds elsewhere in the watershed and surrounding communities who had been there, in some cases for much of the previous 50 years. Such things are relative however, given that, as noted previously, other more easily accessible portions of the Province, had experienced more intensive harvesting. Eleven months later The Daily Times of Moncton noted on August 15th 1877 that "during the year a great quantity of ship timber has been got out at Elgin for consumption in Saint John."

At that point the age of wooden ships was beginning to wind down however, causing a reduction in the scale of the demand for timber exports both as wood and manufactured into ships. By the end of the Crimean war in 1856, virtually all of the ships in the British Royal Navy were already fitted with steam engines, rendering masts irrelevant (Evans 2004), and the conversion to iron hulls began within a decade thereafter.

A non-timber forest product that was commercially significant at the time was maple sugar. In the 1840s the Colpitts family was already producing marketable surpluses, gathering enough sap to produce 6200 pounds of maple sugar (Albert County Museum 2015). By 1851 the annual output of maple sugar from Elgin Parish (which also included all of the forested upper reaches of the Little River, immediately to the east of the Pollett) was approximately 80,000 pounds (Fellows 1980).

### *Agricultural Practices*

As noted in the timber section, before crops could be planted settlers were faced with cutting and clearing the forest. Stumps were often left a few years to rot, and crops were sown amongst them (DeMerchant, 1983). In Perley's (1857) Handbook of Information for Emigrants to New Brunswick, he suggests that "No emigrant should undertake to clear land and make a farm, unless he has the means of supporting his family for 12 months." However, it was not just a matter of the financial resources of individuals. Since in the early 1800's the province as a whole was not self-sufficient agriculturally, it is unlikely the communities along the Pollett River were either. However, given the logistical challenges of transporting food to remote homesteads, it is doubtful that importation of food was as practical as in urban centres. More likely for the early settlers, subsistence agriculture was supplemented with food available from the forest and river. In fact, Elson (1962) notes that the abundant supply of Salmon on the Pollett River was reported to have been one of the attractions for early settlers. This pattern had already been established a generation previously on the Petitcodiac River. In 1783 while Robert Colpitts first crop at his farm just downstream of the mouth of the Pollett was ripening, his family's main source of food was salmon (Moncton Daily Times, Thursday August 26th 1920).

By 1850 over 25% of the land in coastal Parishes such as Hopewell, Dorchester, and Westmoreland had been cleared for agriculture, and Sackville Parish had 16,000 of its 100,000 acres fit for cultivation. Of the eight remaining Parishes in Westmorland and Albert Counties, Elgin Parish was the only one at that time with less than 5,000 acres of cleared land (Wynn 1981). What is more, in only both Elgin and Salisbury Parishes was the population density less than 5 people per square mile. The quality of the land was not the issue however. The Chignecto Post in Sackville on Thursday September 14th 1876 described Elgin as, "one of those richly dowered places to whose prospective growth no one need set a limit. The climate, owing perhaps to being shut by her hills from the turbulent Bay of Fundy – is delightful. Its reputation as a fruit growing district will someday rival the Valley of Annapolis." Hyperbole perhaps, as things didn't turn out that way, but the upper Pollett valley did become and has remained agriculturally productive.

By 1871 the census results for Elgin Parish indicated that approximately 84% of the adults reporting an occupation, said that they were either farmers or farm laborers (Kanner, 1994). In 1876 with the arrival of The Elgin, Petitcodiac, & Havelock Railway branch line, sale of cash crops in distant markets became a more viable option, with reports of potatoes being sent as far away as Boston in 1887 (Moncton Daily Times, Monday October 1887), and cattle to Saint John the following year (The Maple Leaf, Albert NB, Thursday October 18th 1888). Such ventures indicate that agriculture had reached the point where it was producing marketable surpluses.

Dawson (2005) shows that in 1878 the road network within the watershed looked quite recognizable to the modern eye, with roads of some kind already present along most of the routes that are significant enough to be paved today, though obviously these wouldn't have been developed to that extent then. Still, given that in 1811 the watershed was described as roadless, this represented major change during the intervening 67 years.

The sawmill dam at Elgin may also have supplied power to the grist mill (Table 3-1). As a means of grinding grains into flour this would have provided the community the ability to process food being grown locally to facilitate either consumption or storage, and added value to it as a cash crop to be transported to distant markets.

It was fortunate for settlers that agricultural productivity and transportation had improved since the ability of the growing population to supplement their diets with food from the river was diminishing. As early as 1852, concerns were being expressed about noticeable declines in the once abundant salmon population on the Petitcodiac. At the time it was presumed then to be a consequence of overfishing (Elson 1962). But by the 1870's the lack of fishways on the dams on the Pollett was acknowledged to be part of the problem.

Though productive, commercial agriculture did not change the Pollett valley in the ways that early enthusiasts had hoped. Between the First and Second World Wars most of the scattered farms above Gordon Falls were abandoned and allowed to revert back to forest (Elson 1962). Dawson (2005) shows that in 1878 the density of roads in that area was quite high (compared to today), some of which probably served those farms. The Elgin, Petitcodiac, & Havelock Railway was never very profitable, and went bankrupt in 1890. It was sold to the government in 1918 and operated by the Intercolonial Railway until that later became part of Canadian National (New Brunswick Railway Museum 2014). Service ended in 1955 when the branch line from Petitcodiac to Elgin was shut down.

### *Mining Practices*

A short lived lime burning operation provided agricultural lime for the use of local farmers. It was extracted from a now abandoned limestone quarry west of the community of Pollett River (Goudge 1934).

### *Other*

In 1910 an earth and concrete dam was built just 10 kilometers above the mouth of the river as part of the Jordan Memorial Sanatorium. This institution was established along the Pollett River at a community called The Glades, near Kay settlement, as part of a Provincial effort to treat tuberculosis (Elson 1962). The fish passage built with the dam was destroyed in the mid 1930's, and the dam became a barrier to fish passage until 1950 when a new fishway was built. This dam has since been removed as have all of the other dams along the Pollett.

## Second Level Assessment- Current Impacts

### *Forestry Practices*

Forest tenure within the Pollett River watershed today is a mixture of private woodlots, industrial freehold, and crown land, which are subject to varying levels of management in terms of harvesting planting and thinning. As Figures 3-3 and 3-4 show (according to data provided by the Department of Natural Resources in 2014), there is a difference in the proportions in of these categories of land ownership and usage between the upper and the lower portions of the river . The upper portion of the river (Figure 3-3) is 33% private woodlots, 37% industrial freehold, and 22% crown land, with the remainder in other uses, primarily agriculture 6%. The lower portion of the watershed (Figure3-4) has a greater proportion of private woodlots (likely with associated focus on parallel recreational values) and less industrial freehold land. Ownership in the lower end of the river is approximately 58% private woodlots, 11% industrial freehold and 25% crown land, with agriculture again the bulk of the remainder at 4%. These differences reflect the level of access and population between the two portions of the river, which, as is often the case, becomes increasingly remote and less populated the higher up in the watershed one goes.

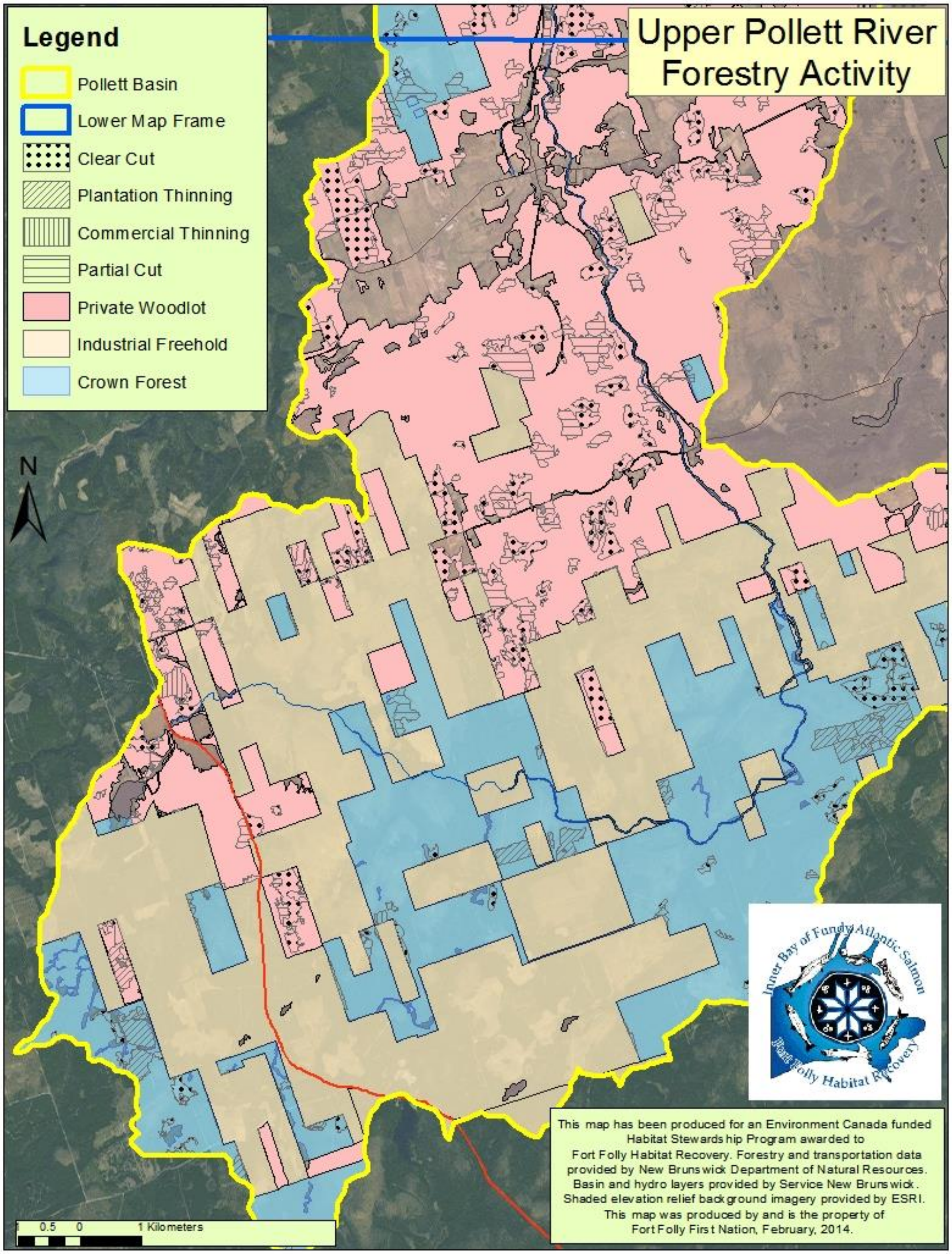


**Figure 3-3:** Forest tenure and management in the upper Pollett River

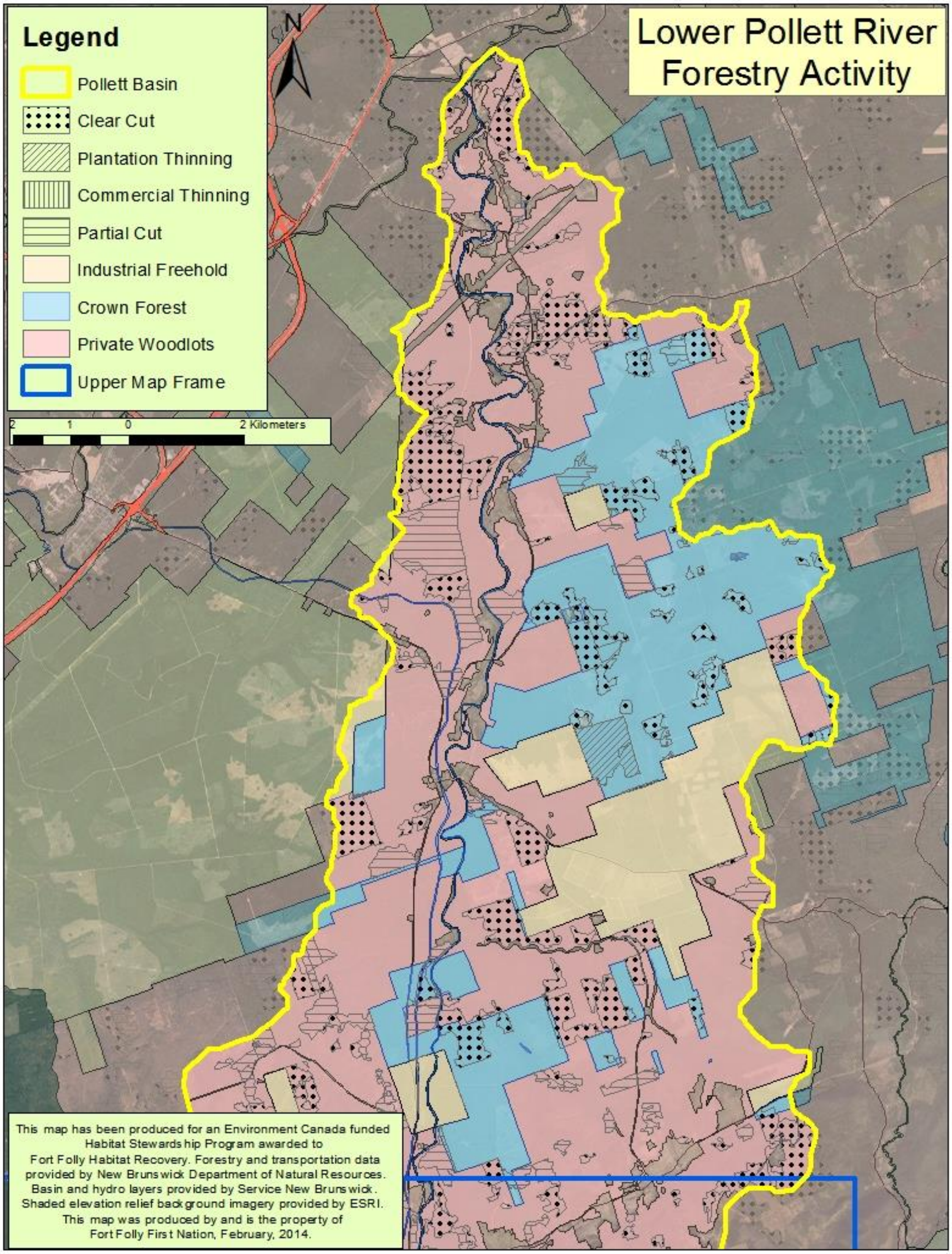


**Figure 3-4:** Forest tenure and management in the lower Pollett River

Maple syrup production remains a significant activity in the area. In addition to small scale private production there is a large commercial operation, Briggs Maples, tapping over 12,000 sugar maple trees in Albert County on both private and crown land near Fundy National Park (Briggs Maples 2015), with distribution in super markets through both Sobeys and CO-OP Atlantic.

### *Agricultural Practices*

Agriculture is the dominant non-forest land use within the Pollett River watershed There are four working dairy farms in the watershed, and numerous hobby farms (Petitcodiac Watershed Alliance 2009), such that the watershed as a whole can be described as (aside from its 90% forest cover) 3% row crops and grains, 1.1% pastureland, and 1% blueberry fields. The uppermost reaches of the watershed are restricted to scattered blueberry fields. Just a little further downstream is the town of Elgin, still fairly high up within the watershed. None-the-less, well over half of the cultivated land (primarily crops and grains) found in the Pollett River valley lays several kilometers immediately east or west of the Elgin town site (Figure 3-5).

As one continues downstream below Elgin, agriculture largely disappears for about 14 km until one nears the community of Pollett River, where the 905 is met by Parkindale Rd in the south and Sanatorium Rd further downstream to the north (Figure 3-6). Here, immediately along the river is some pasture land, and to a lesser extent crops and grains. Below the point where Sanatorium Rd crosses onto the east side of the river, production begins to transition into primarily crops and grains. There are numerous scattered small fields along a narrow corridor between the Pollett River and Sanatorium Rd, mostly within about a kilometer of the river. This pattern continues even as the road network becomes more complex down near the confluence of the river with the Petitcodiac near Salisbury, increasing in density the closer one gets to the Pollett’s mouth.

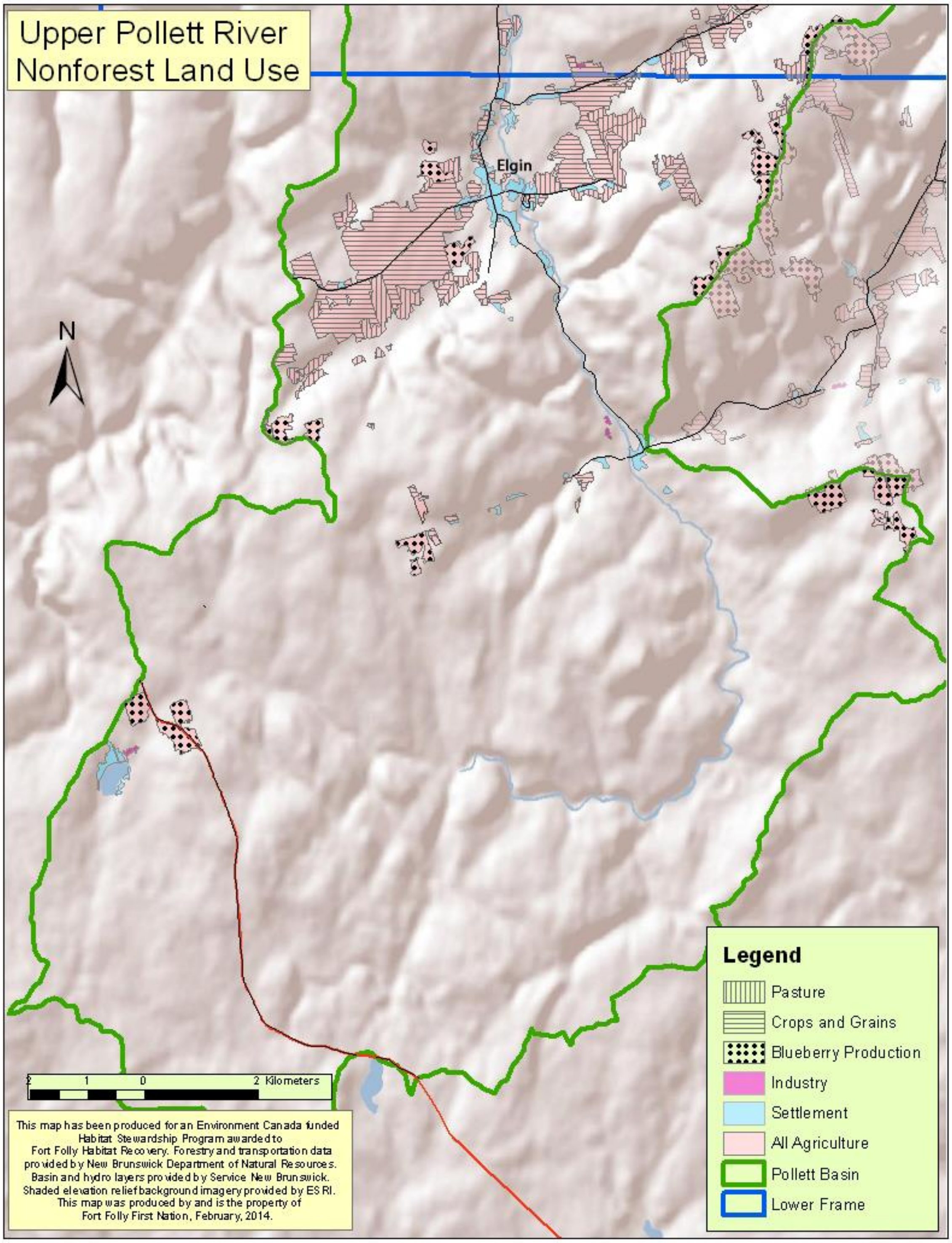


**Figure 3-5:** Non-forest land use in the upper Pollett River

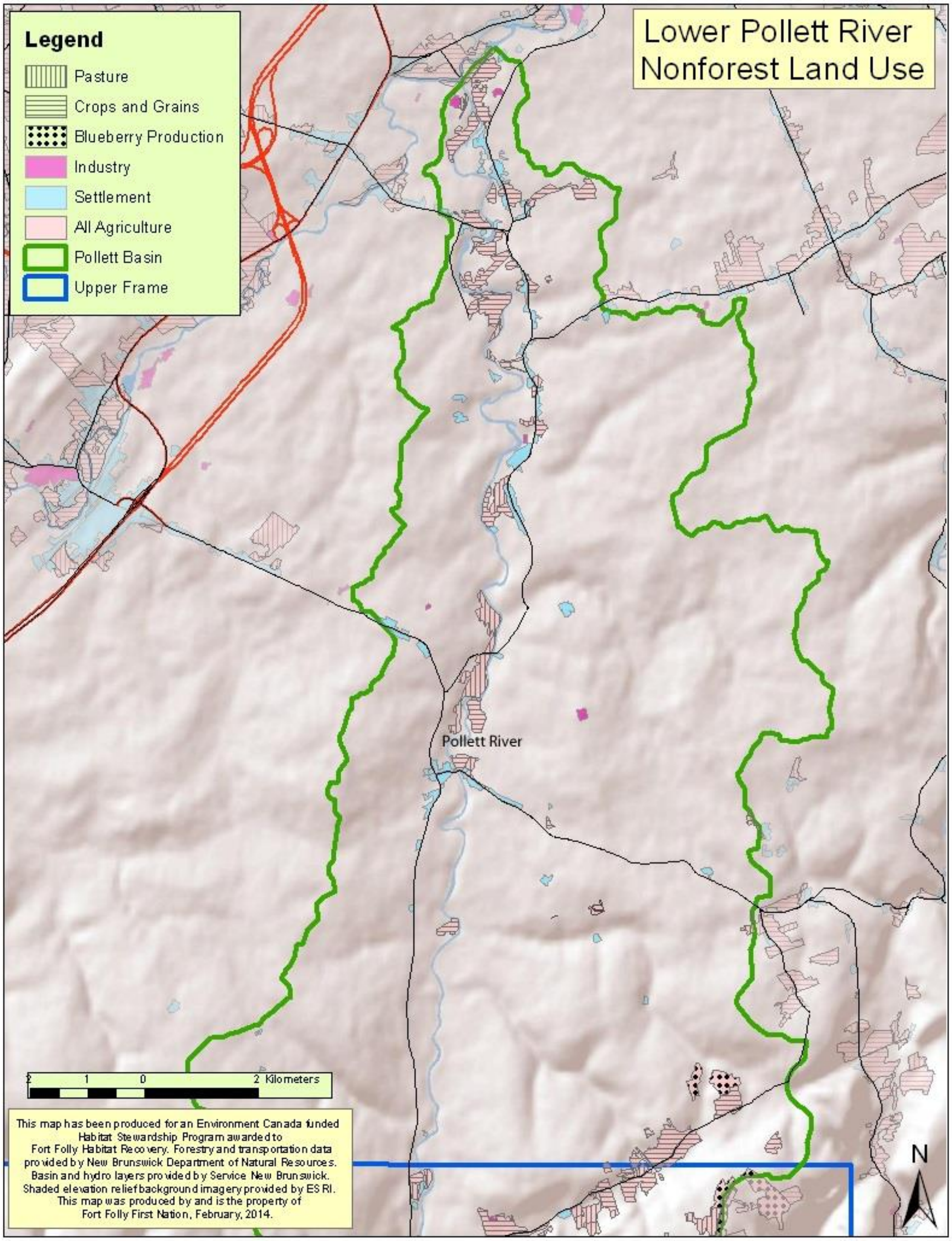


**Figure 3-6:** Non-forest land use in the lower Pollett River

### *Transportation Development*

A GIS layer of the road network (paved and unpaved) within the Pollett watershed was overlaid on the river and its tributaries, to yield Figures 3-7 for the upper basin and 3-8 for the lower portion of the basin. Numerous unpaved crossings are present on both figures, 69 in the upper, and 38 in the lower. In both cases they outnumber the paved crossings, though the proportions are quite different. The 69 unpaved crossings on the upper Pollett make up to 76% of all

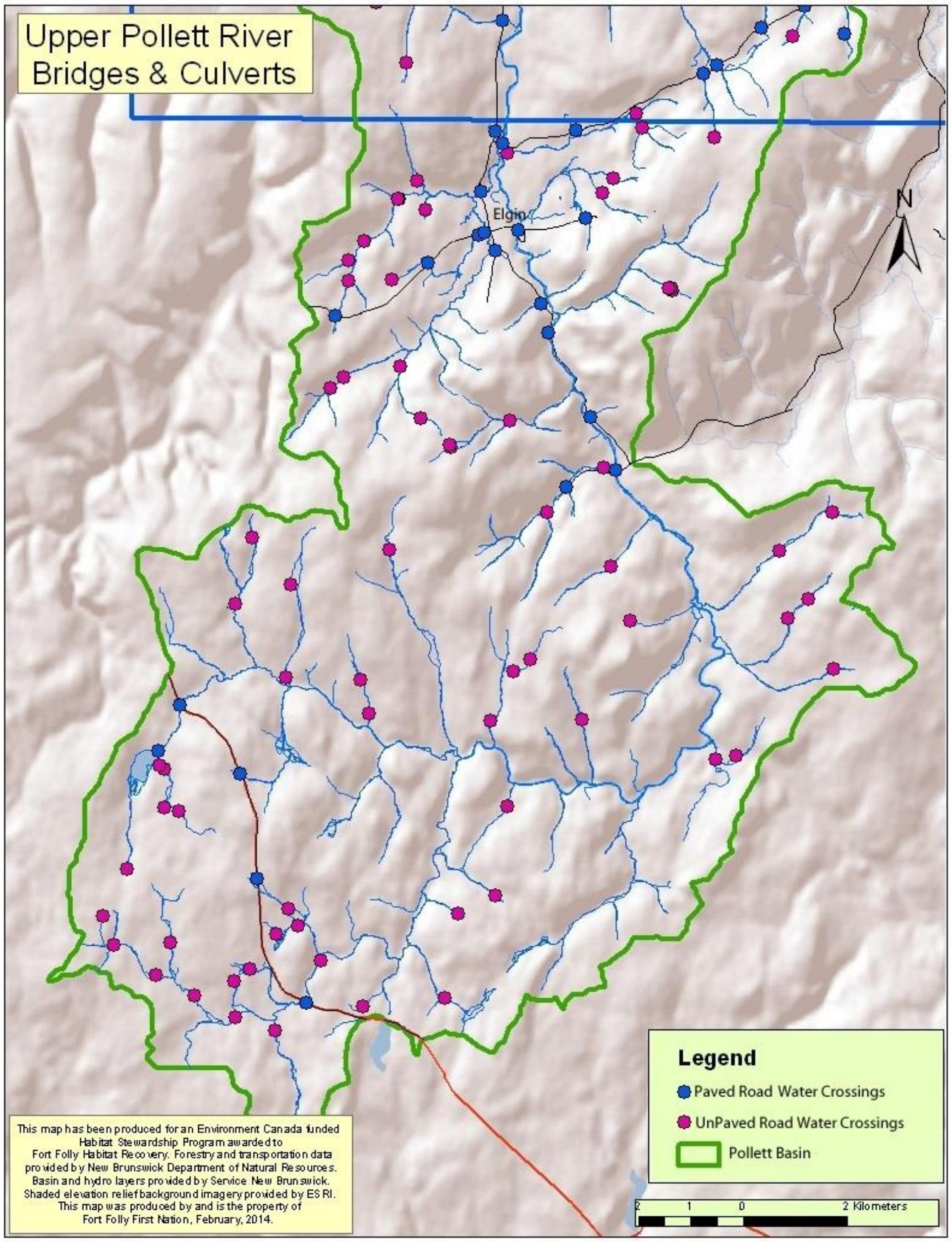


**Figure 3-7:** Water Crossings on the upper Pollett River

crossings in the more remote upper half of the watershed, while the 38 on the lower Pollett are only 58% of the total in that portion of the basin. For the most part these are likely to be in the form of culverts, though there could be the occasional bridge as well. There are fewer places where paved roads cross the river, 22 in the upper Pollett (24% of total), and 27 crossings along the lower Pollett (42% of total). Those along the main stem of the river are known to be

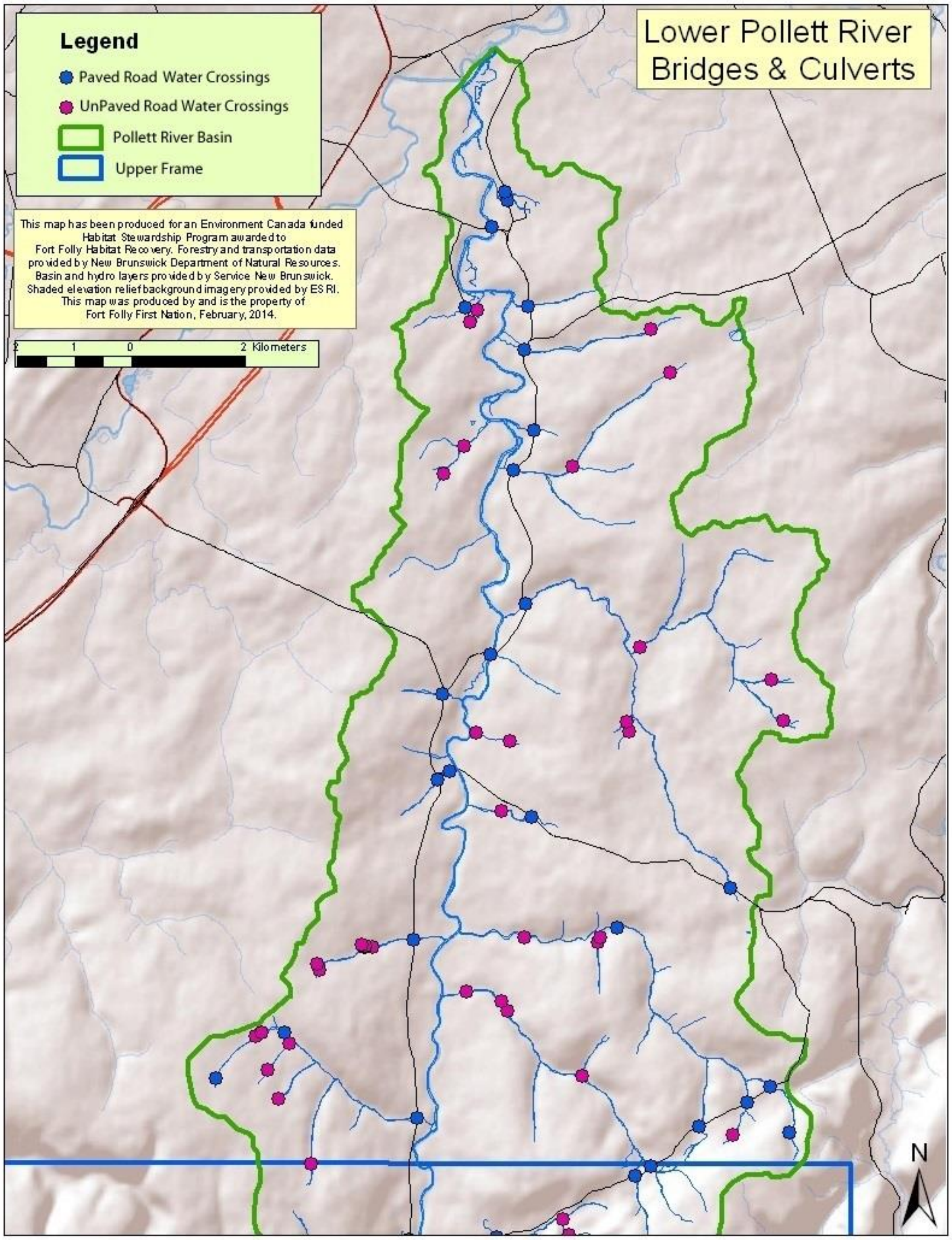


**Figure 3-8:** Water Crossings on the lower Pollett River

bridges, but it is likely that the majority of the smaller paved crossings are culverts. A survey was conducted in 2014 (Petitcodiac Watershed Alliance 2015), yielding Figure 3-9.

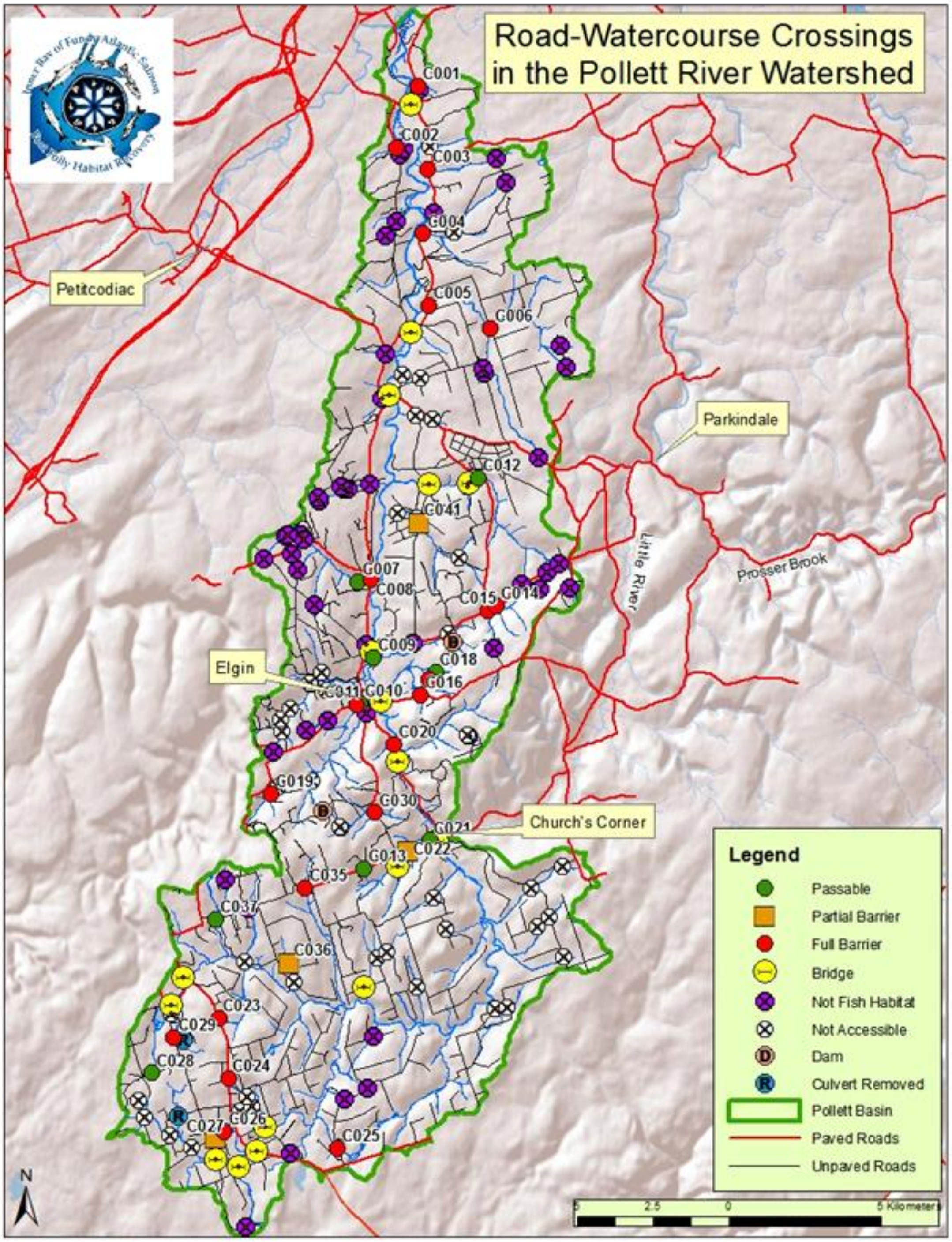


**Figure 3-9:** Water crossings visited during 2014 culvert survey

Of the 156 crossings in the Pollett River watershed identified in Figure 3-7 and Figure 3-8, there was an attempt in 2014 to locate 131 of them, shown on Figure 3-9 (84% of the total), primarily in the lower reaches of the watershed. Some (37) of these were not found (28% of those searched for), possibly due to limited access caused by equipment constraints (lack of ATV), or because of issues with accuracy of the road layer of GIS data. These were listed as "Not Accessible".

The 94 crossings that were located (72% of those searched for), were then assessed following a protocol developed by CARP, the Clean Annapolis River Project (2013). Of these: 41 were deemed not to be fish habitat; 2 had been removed; 16 were bridges; 8 were passable culverts; 4 were culverts that were determined to be partial barriers; 21 were culverts that were determined to be full barriers to fish passage; and 2 were dams.

During the course of the survey, debris removal was conducted at 4 culverts to improve fish passage (Petitcodiac Watershed Alliance 2015). Two of these: C022 (where Churchill Road crosses Shaffer Brook); and C041 (where a JD Irving logging road crosses Popple Intervale Brook) ranked as partial barriers due to debris. The other two: C012 (where Kaye Road crosses Colpitts Brook); and C021 (where Church Hill Road crosses Shaffer Brook several kilometers downstream of C022) were determined to be passible, but clearing debris ensured that passage remained possible. Further discussion of these actions, as well potential for other remediation projects will be discussed in the Fourth Level of Assessment Aquatic Habitat Rehabilitation Plan, under the heading Possible Restoration Activities.

While the New Brunswick Department of Transportation (DoT) is responsible for bridges and culverts on the public paved roads, they are not responsible for the vast majority of those on the unpaved roads which are likely to be on either private woodlots, industrial freehold, or crown land. If a problem culvert is identified and there is a question of who is responsible (private landowner versus DoT), GPS coordinates should be taken and responsibility confirmed through further discussions with the DoT.

Rail service to Elgin from Petitcodiac was discontinued and the line was abandoned by Canadian National in 1955 (New Brunswick Railway Museum 2014). Subsequently the New Brunswick All Terrain Vehicle Federation entered into a signed agreement with the Department of Natural Resources to allow development of an ATV trail along this line (New Brunswick All Terrain Vehicle Federation 2006).

In 1968, 28 kilometers downstream of the Pollett along the Petitcodiac, the Moncton to Riverview Causeway was built instead of a bridge, in order to accommodate vehicular traffic between the two cities. The fishway built into it proved to be ineffective. The causeway gates created a barrier to fish passage with significant consequences for native fish species in the river, and led to the decline in the populations of species such as alewife, blueback herring, rainbow smelt, and sea-run brook trout. Some species disappeared altogether from the upland reaches of the Petitcodiac (such as the Pollett), including Atlantic tomcod, American shad, and striped bass (Locke, et al. 2003). Atlantic salmon only remained present in the river as a consequence of ongoing stocking efforts (AMEC 2005)

In April 2010 the Moncton to Riverview Causeway gates were opened as part of the Petitcodiac River restoration project. Four years of monitoring from 2010 to 2013 following the restoration of fish passage (Redfield 2015) found American shad, striped bass, and Atlantic tomcod returning to the river. Of these, the latter two have shown sustained and progressive increases in numbers over the years, while invasive non-native smallmouth bass have declined. Consequently it is clear from these results that the fish community of the Petitcodiac has the capacity to recover, given the right conditions, and appears to be on its way to doing so.

### *Herbicide and Pesticide Use*

Based on general information provided by Service New Brunswick, two forestry operators (JD Irving as Forest Patrol and Natural Resources) may have conducted work in the Pollett River watershed. While intended blocks of land to be treated were identified by operators that does not necessarily mean that they were treated with herbicides. Products used in these industries may contain the active ingredient glyphosate. Glyphosate is found in several formulations under the trade names Arsenal (PCP 23713), Forza (PCP 26401), Vantage (PCP 26884), Vision (PCP 19899) and Vision Max (PCP 27736). The active ingredient triclopyr has also been used in the past as Release (PCP 22093).

In addition, two industrial operators (Asplundh and NB Power Transmission) may have conducted work with respect to an industrial right-of way perspective (transmission lines) in the Pollett River watershed. These companies may have used tricoplyr as Garlon 4 (PCP 21053), Karmax (PCP 21252) and any of the aforementioned glyphosate products.

Private growers must be individually certified (hold a valid pesticide applicator certificate) but do not report their usage. Likewise, vendors must report total sales but do not provide a breakdown relevant to individual purchasers. It is difficult to find information of individual grower or vendor pesticide or herbicide use.

### *Mining Practices*

Several fracked shale gas wells already exist within the Pollett watershed (Petitcodiac Watershed Alliance 2009), with rights for further fracking and gas extraction held by Corridor Resources Inc. (Government of New Brunswick 2015). The former Provincial government made a clear commitment to promoting shale gas development in New Brunswick (Alward 2014).

However, shortly after coming into office, the new government enacted a moratorium on expansion (Canadian Broadcasting Corporation 2014). If additional wells are eventually added, impacts will include freshwater extraction from streams, habitat destruction and sedimentation during road building, and the potential for wastewater spills contaminating surface waters.

A granite quarry began operations in the Pollett watershed in 2009 (Petitcodiac Watershed Alliance 2009). The buffer between the main stem of the river and the quarry is adequate, however Gibson Brook, a tributary of the Pollett passes near the quarry and as the operation expands there is potential for the quarry to become a sediment source through deforestation, road building, and release of water due to ongoing drainage of the site.

### *Urban Development*

Though there is no large urban centre within the watershed, along some of the more populated sections of the river, large portions of private woodlots have been subdivided and sold as building lots for recreational properties such as camps (Petitcodiac Watershed Alliance 2009). In addition to the damage to the riparian buffer that results from adding new access roads, camp construction and clearing for lawns and views of the river, there is significant potential for sewage contamination if septic systems are poorly maintained.

A database was developed to house property boundary and landowner information. The property boundary information is incorporated in to a GIS layer for the Pollett River watershed. Additionally, an excel database, Property Boundary and Landowner Information 2012-2013, contains information from Service New Brunswick on owner or business names, location addresses, place names, and associated PIDs and PANs.

## Third Level Assessment – Aquatic and Riparian Habitat Assessment

### *Wildlife*

Several species of wildlife that warrant specific attention occur in Pollett watershed: Atlantic salmon, American eels, and wood turtles. Of these, the locations of documented encounters with salmon and eels are presented in (Figure 3-10). Due to their smaller home range, encounters with wood turtles are considered to be sensitive information, and so are being withheld here. Atlantic salmon (*Salmo salar*) Inner Bay of Fundy (iBoF) populations were listed as endangered under the Species at Risk Act in 2003 (DFO, 2010; SARA Registry, 2013a), and the species is considered to be extirpated from the Petitcodiac River system, except for those introduced in stocking programs (AMEC, 2005).

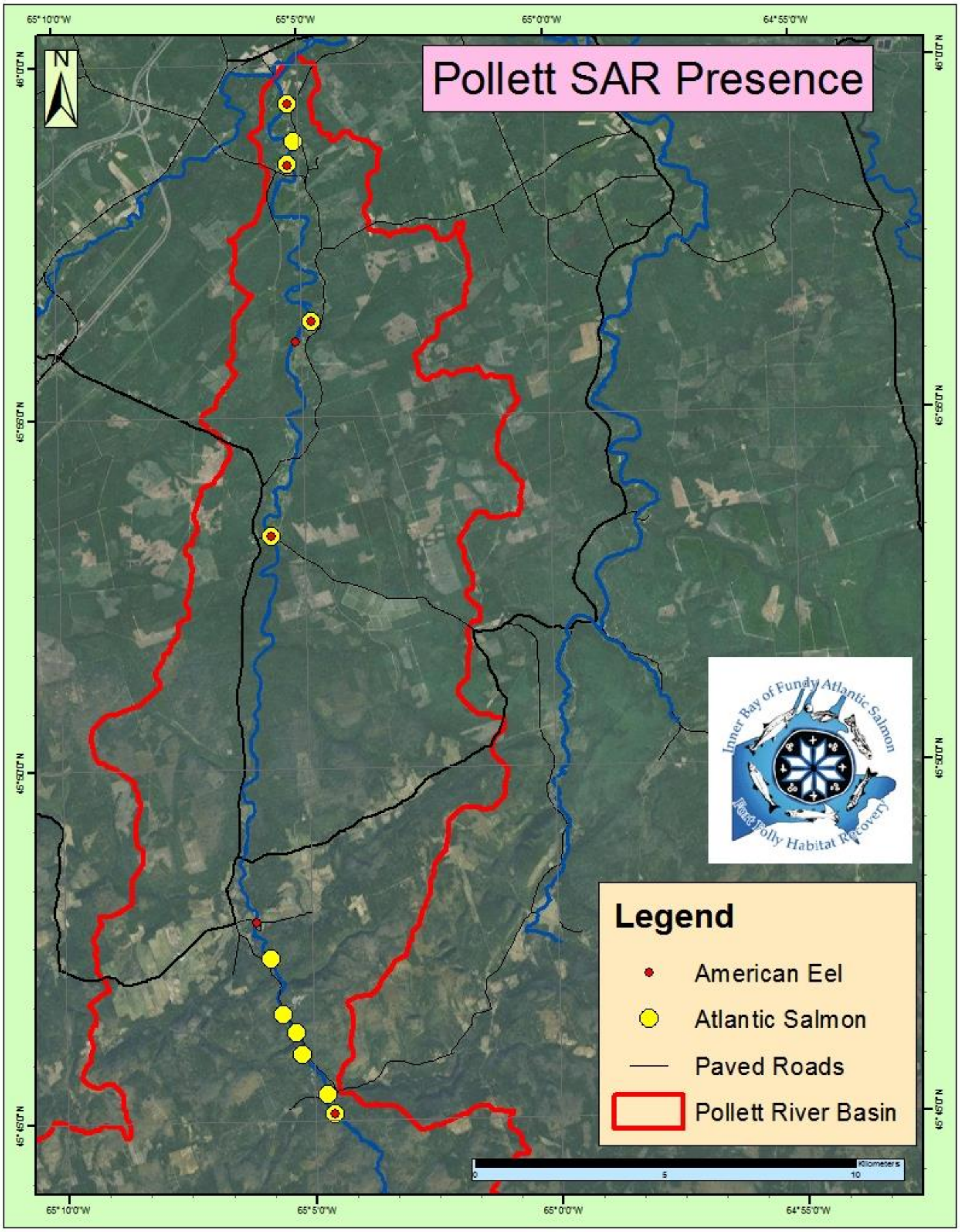


**Figure 3-10:** Locations of Atlantic salmon and American eels within the Pollett River watershed.

American eels (*Anguilla rostrata*) were designated as “Special Concern” by COSEWIC in 2006 (COSEWIC, 2006). Their status was re-examined and raised to “Threatened” in May 2012 (COSEWIC, 2014). This species is being considered for listing under the federal Species at Risk Act, but currently it has no status (SARA Registry, 2013b). Wood turtles (*Glyptemys insculpta*) were designated as “Special Concern” by COSEWIC in 1996 which was raised to “Threatened” in 2007 (COSEWIC 2007; COSEWIC 2011). This species is listed as “threatened” under the Species at Risk Act (SARA Registry, 2012). Guidelines for projects in areas with these species are in Appendix A.

The decline in numbers of iBoF salmon is a marked contrast to the abundance described by early settlers. Though numbers of this species had been decreasing for some time (Elson 1962) construction of the Moncton to Riverview causeway in 1968 eliminated fish passage for adult salmon and smolts and effectively (but for ongoing intervention) extirpated the species from a river system that represented 20% of the total iBoF population (Locke, et al. 2003).

The survival and development of fry released along the Pollett in 2009, 2011 and 2012 were monitored by annual electrofishing at the release sites, and operation of a Rotary Screw Trap (RST) or “smolt wheel” near the mouth of the river during the smolt runs in 2011, 2012, 2013, and 2014 ; with plans for additional work in 2015. Release sites (Figure 3-10) included locations upstream of Gordon Falls, where quality habitat exists, even though there is some question if salmon would be unable to access it naturally. The decision was made to use that portion of the river as well since such areas could provide nursery habitat for juveniles (who then migrate out as smolts), despite them possibly being unable to return that far upstream as adults. Electrofishing in 2013 captured 28 salmon parr on the Pollett. The RST was operated 7 days per week that year, from April 30th to June 25th (except for 5 days lost to high water), and caught 172 smolts. In 2014 only 6 parr were found by electrofishing, which was not surprising as the last release of salmon fry was in 2012. This decline was consistent with lack of natural salmon spawning in the river. The RST was operated 7 days per week in 2014, from May 8th to June 9th (except for 1 day due to low water), There were 351 smolts caught during their downstream migration either in the RST or nearby fyke nets.

American eels were encountered at numerous sites while electrofishing, and in the RST. The RST data has catch, length and weight available; however since eels were not the target of the electrofishing effort (which was sampling salmon) their presence or absence was not specifically quantified or documented at these locations. However, a reasonable interpretation of the observations is that at most sites they were present more often than not.

In the decades that the causeway gates were closed downstream on the Petitcodiac, eels had more success than salmon did navigating the fishway and accessing the upper reaches of the river, such as the Pollett. Aside from that, being catadromous, instead of anadromous like salmon, made the eel population less vulnerable as they are not as dependent upon accessing any given river. Their spawning takes place in the Sargasso Sea, and so young eels already arrive at and reside in different rivers than those in which their parents had lived (COSEWIC, 2006). This allowed for a steady stream of incoming eels, despite the causeway.

The Petitcodiac Watershed Alliance reported observing a wood turtle on a tributary stream while conducting field work in 2009 (Petitcodiac Watershed Alliance 2009). Wood turtles were seen also while Fort Folly Habitat Recovery crews were doing smolt monitoring most years; electrofishing in 2012; and while conducting geomorphic assessments in 2013. Wood turtles were searched for through a series of targeted surveys conducted by the Petitcodiac Watershed Alliance along the Pollett River in 2014. Wood turtles are terrestrial turtles that require forest cover, clean water courses, and access to gravel or sand for nesting.

### *Water Quality*

Water quality on the Pollett was assessed by the Petitcodiac Watershed Alliance as part of their habitat assessment project in 2009 (Petitcodiac Watershed Alliance 2009). During the months of July, August and September they measured Dissolved Oxygen (DO), Conductivity (CON), pH, and Temperature (TEMP) at numerous locations within the watershed. They also maintained a fixed monitoring site near the mouth of the river, a short distance downstream of the site used in subsequent years for the Rotary Screw Trap during the smolt run. Both the basin wide results and those for this monitoring site are presented in Table 3-2.

**Table 3-2:** Water Quality on the Pollett River in 2009 (Petitcodiac Watershed Alliance 2009)

| Basin wide | Dissolved Oxygen | Conductivity | Temperature °C | pH |
|---|---|---|---|---|
| July, Aug., Sept. | 10 mg/L Average | 39.1 µS Average | 11.2 to 21.4 °C | 7 to 7.5 |
| Monthly at Site | Dissolved Oxygen | Conductivity | Temperature °C | pH |
| May | 12.07 mg/L | 43.9 µS | 12.3 °C | 6.5 |
| June | 9.33 mg/L | 51.3 µS | 15.2 °C | 7.0 |
| July | 9.54 mg/L | 45.0 µS | 20.6 °C | 7.0 |
| August | 10.26 mg/L | 56.7 µS | 24.0 °C | 7.5 |
| September | 10.58 mg/L | 55.6 µS | 13.5 °C | 7.0 |
| October | 12.23 mg/L | 32.1 µS | 5.2 °C | 6.5 |
| Average | 10.7 mg/L | 47.4 µS | 15.1 °C | 6.9 |

Across the basin, Dissolved Oxygen readings were taken at 45 different sites and averaged 10 mg/L, which is well within the desired range of 7 to 11 mg/L for streams with cold water fish such as salmon. Conductivity was measured at 50 different locations during this period, and ranged from a low of 27.8 to a high of 55.3 µS, increasing along a gradient from low values high in the watershed to higher values lower in the watershed. Temperature readings were taken 48 times, the lowest being 11.2 °C taken one morning in September and the highest being 21.4 °C in the afternoon of a hot day in July. It is worth noting that the fixed monitoring station got up to 24 °C on day in August. Values for pH were measured 50 times, with little variance. With the exception of the high August temperature recorded at the fixed site, water quality on the river appears to be reasonably good and not a limiting factor for fish.

### *Rapid Geomorphic Assessment (RGA) and Rapid Stream Assessment (RSAT)*

The following is taken from the report prepared by Parish Geomorphic based on the Rapid Geomorphic Assessment (RGA) and Rapid Stream Assessment (RSAT) data collected by Fort Folly Habitat Recovery on the Pollett River, New Brunswick during the summer of 2013. Figure 3-11 depicts the three main assessed reaches divided by their respective sub-reach ranges. The total length of watercourse assessed was approximately 57 kilometres (km); the entire Pollett River system drains an area of approximately 314 square kilometres ($km^2$).

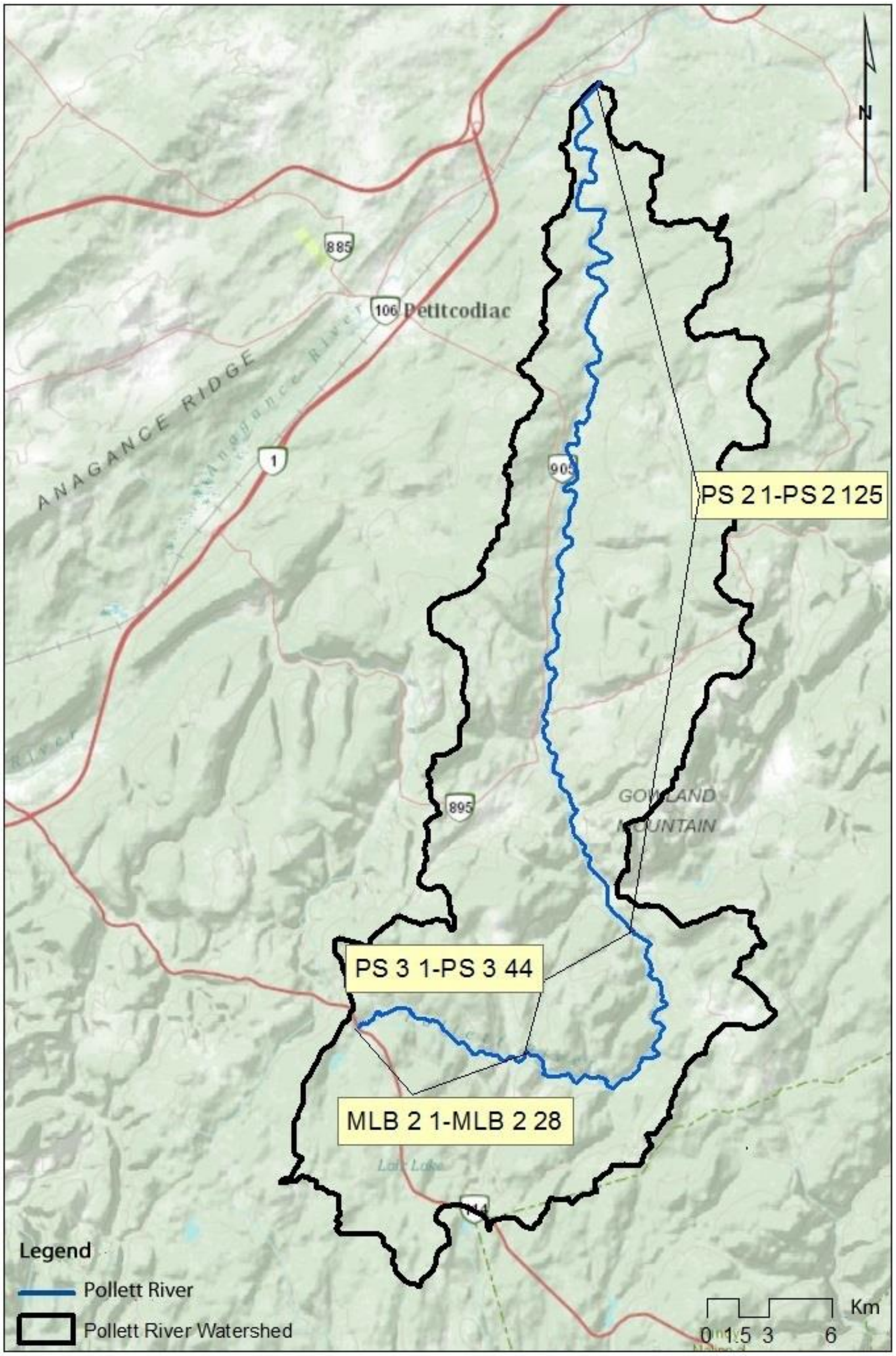


**Figure 3-11:** Pollett River watershed and assessed reaches

### *Geomorphic Background*

The RGA and RSAT data were used to determine the geomorphic condition and stability of the assessed sections of the Pollett River. In order to interpret the geomorphic data, the watercourse is highlighted according to sub-reach stability and dominant geomorphic processes. The geomorphic processes identified were aggradation, degradation, channel widening, and planform adjustment.

**Aggradation**

Channel aggradation may occur when the sediment load to a river increases (due to natural processes or human activities) and it lacks the capacity to carry it. Piles of sediment in the river can re-direct flows against the banks, leading to erosion and channel widening.

<u>Some indicators of aggradation include:</u>

- Shallow pool depths
- Abundant sediment deposition on point bars
- Extensive sediment deposition around obstructions, channel constrictions, at upstream ends of tight meander bends, and in the overbank zone
- Most of the channel bed is exposed during typical low flow periods
- High frequency of debris jams
- Coarse gravels, cobbles, and boulders may be embedded with sand/silt and fine gravel
- Soft, unconsolidated bed
- Mid-channel and lateral bars

**Degradation**

Degradation occurs as the river cuts deeper into the land and decreases its gradient. This can occur from a rapid removal of streambed material due to an increase in discharge, water velocity, or a decrease in sediment supply. Bed lowering can move in both an upstream (as a headcut or nick point) and/or downstream direction.

Indicators of degradation include:

- Elevated tree roots
- Bank height increases as you move downstream
- Absence of depositional features such as bars
- Head cutting of the channel bed
- Cut face on bar forms
- Channel worn into undisturbed overburden/bedrock

**Widening**

Widening typically follows or occurs in conjunction with aggradation or degradation. With aggradation, banks collapse when flows are forced on the outside, and the river starts to widen. Wide, shallow watercourses have a lower capacity to transport sediment and flows continue to concentrate towards the banks. Widening can also be seen with degradation, as it occurs with an increase in flows or decrease in sediment supply. Widening ultimately occurs because the stream bottom materials eventually become more resistant to erosion(harder to move) by the flowing waters than the materials in the stream banks.

Indicators of widening include:

- Active undermining of bank vegetation on both sides of the channel, and many unstable bank overhangs that have little vegetation holding soils together
- Erosion on both right and left banks in riffle sections
- Recently exposed tree roots
- Fracture lines at the top of banks that appear as cracks parallel to the river, which is
- evidence of landslides and mass failures
- Deposition on mid-channel bars and shoals
- Urbanization and storm water outfalls leading to higher rate and duration of runoff and channel enlargement typically in smaller watershed with a high percentage (>10%) of impervious surface (urban land use).

**Planform Adjustment**

These are the changes that can be seen from the air when looking down at the river. The river's pattern has changed. This can happen because of channel management activities (such as straightening the bends of the river with heavy equipment). Planform changes also occur during floods. When there is no streambank vegetation with roots to hold soil in place, rivers cut new channels in the weak part of the bank during high water. Planform adjustments typically are responses to aggradation, degradation, or widening geomorphic phases.

Indicators of planform change include:

- Flood chutes, which are longitudinal depressions where the stream has straightened and cut a more direct route usually across the inside of a meander bend
- Channel avulsions, where the stream has suddenly abandoned a previous channel alignment
- Change or loss in bed form structure, sometimes resulting in a mix of plane bed and pool-riffle forms
- Island formation and/or multiple channels
- Additional large deposition and scour features in the channel length typically occupied by a single riffle/pool sequence (may result from the lateral extension of meander bends)
- Thalweg not lined up with planform. In meandering streams, the thalweg typically travels from the outside of a meander bend to the outside of the next meander bend.
- During planform adjustments, the thalweg may not line up with this pattern.

***Watercourse Channel Stability***

The stream geomorphic condition is a key piece of data obtained from the Rapid Geomorphic Assessment. This is based on the degree of departure of the channel from its reference stream type and is evaluated by the magnitude and combination of adjustments underway in the stream channel. Upon completion of the field inspection, indicators were tallied by category and used to calculate an overall reach stability index. There are three stability classes that refer to a relative sensitivity to altered sediment and flow regimes:

**In Regime:** The channel morphology is within a range of variance for streams of similar hydrographic characteristics – evidence of instability is isolated or associated with normal river meander propagation processes (considered stable or least sensitive).

**Transitional or Stressed:** Channel morphology is within the range of variance for streams of similar hydrographic characteristics but the evidence of instability is frequent (considered moderately sensitive).

**In Adjustment:** Channel morphology is not within the range of variance and evidence of instability is wide spread (considered most sensitive).

The RSAT provides a more qualitative assessment of the overall health and functions of a reach in order to provide a quick assessment of stream conditions and the identification of restoration needs on a watershed scale. This system integrates visual estimates of channel conditions and numerical scoring of stream parameters using six categories:

- Channel Stability
- Erosion and Deposition
- Instream Habitat
- Water Quality
- Riparian Conditions
- Biological Indicators

Once a condition has been assigned a score, these scores are totalled to produce an overall rating that is based on a 50 point scoring system, divided into three classes:

<20 Low
20-35 Moderate
>35 High

The majority of RSAT classes determined on the Pollett River were in the moderate range with some in a High class of RSAT stability. Figure 3-12 outlines RSAT classes of the Pollett River.

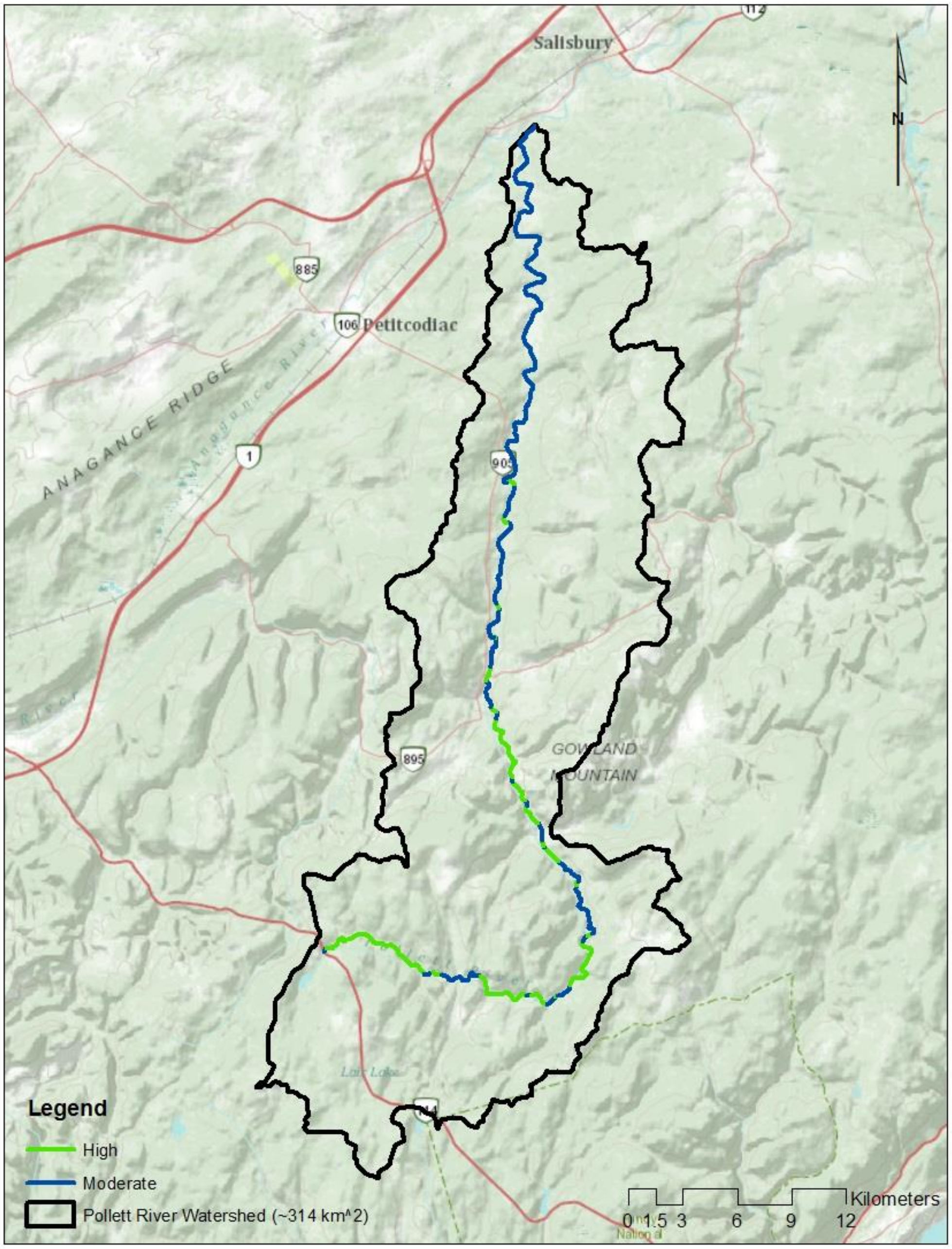


**Figure 3-12:** Pollett River RSAT classes

### *Geomorphic Assessment*

The Pollett River was divided into 3 main reaches made up of a total of 197 sub-reaches. The assessment of the Pollett River started at Rte 114 where it crosses Mechanic Lake Brook and ended at the confluence with the Petitcodiac River. The majority of sub-reaches were in a transitional or stressed state (57%), 21% of the sub-reaches were classified as in adjustment and 22% were identified as in regime (Figure 3-13). The stable (in regime) sub-reaches could be utilized as reference reaches; channel cross sections and thalweg profiles could be obtained for comparisons with the less stable sub-reaches. Reference reaches could also be used to provide

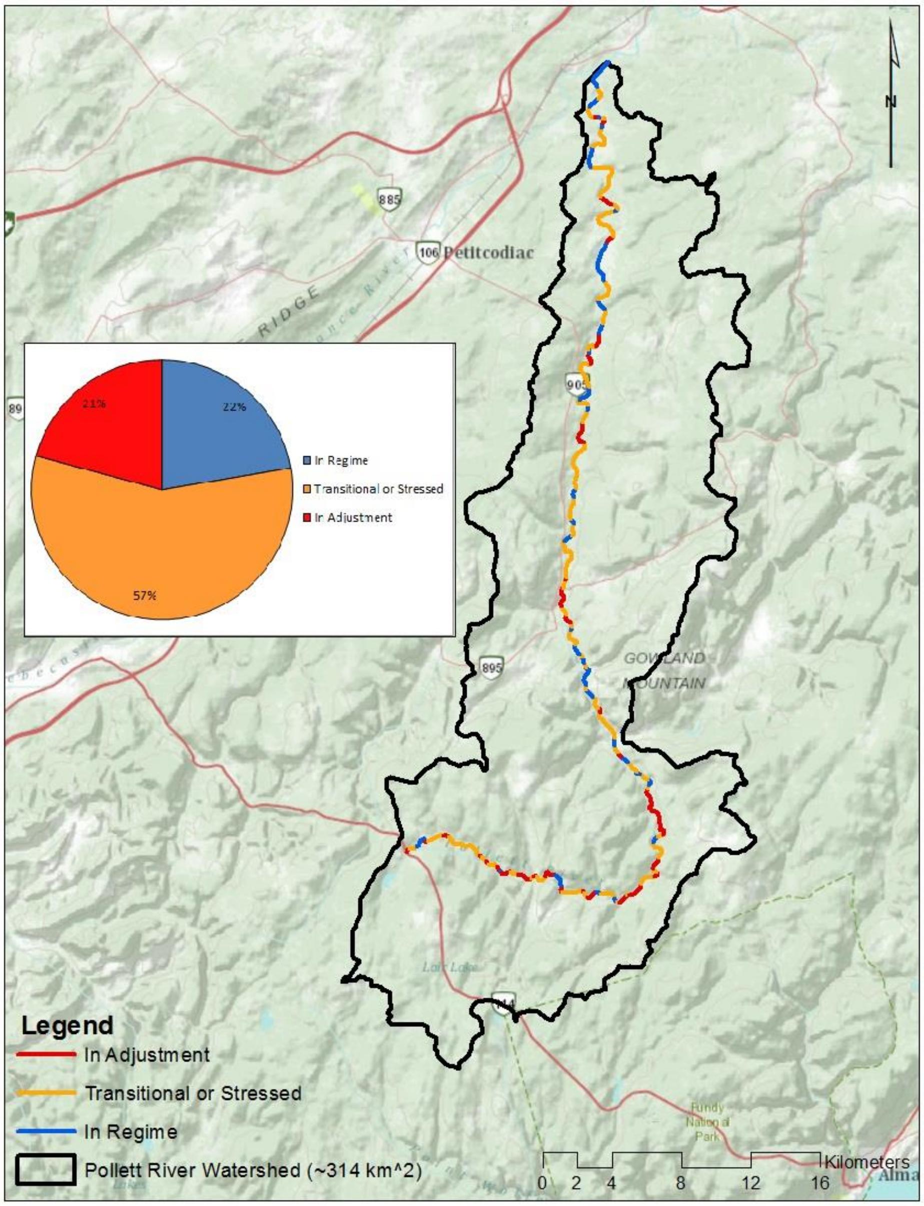


**Figure 3-13**. Pollett River stability rankings

baseline data where cross sections and thalweg could be measured on a recurring basis to allow for identification of changes to the watercourse over time and provide insight into changes that may occur elsewhere in the system.

Aggradation was identified as the most common primary geomorphic process, with degradation being the second most common primary process. Widening and planform adjustment were relatively uncommon as primary geomorphic processes (Figure 3-14).

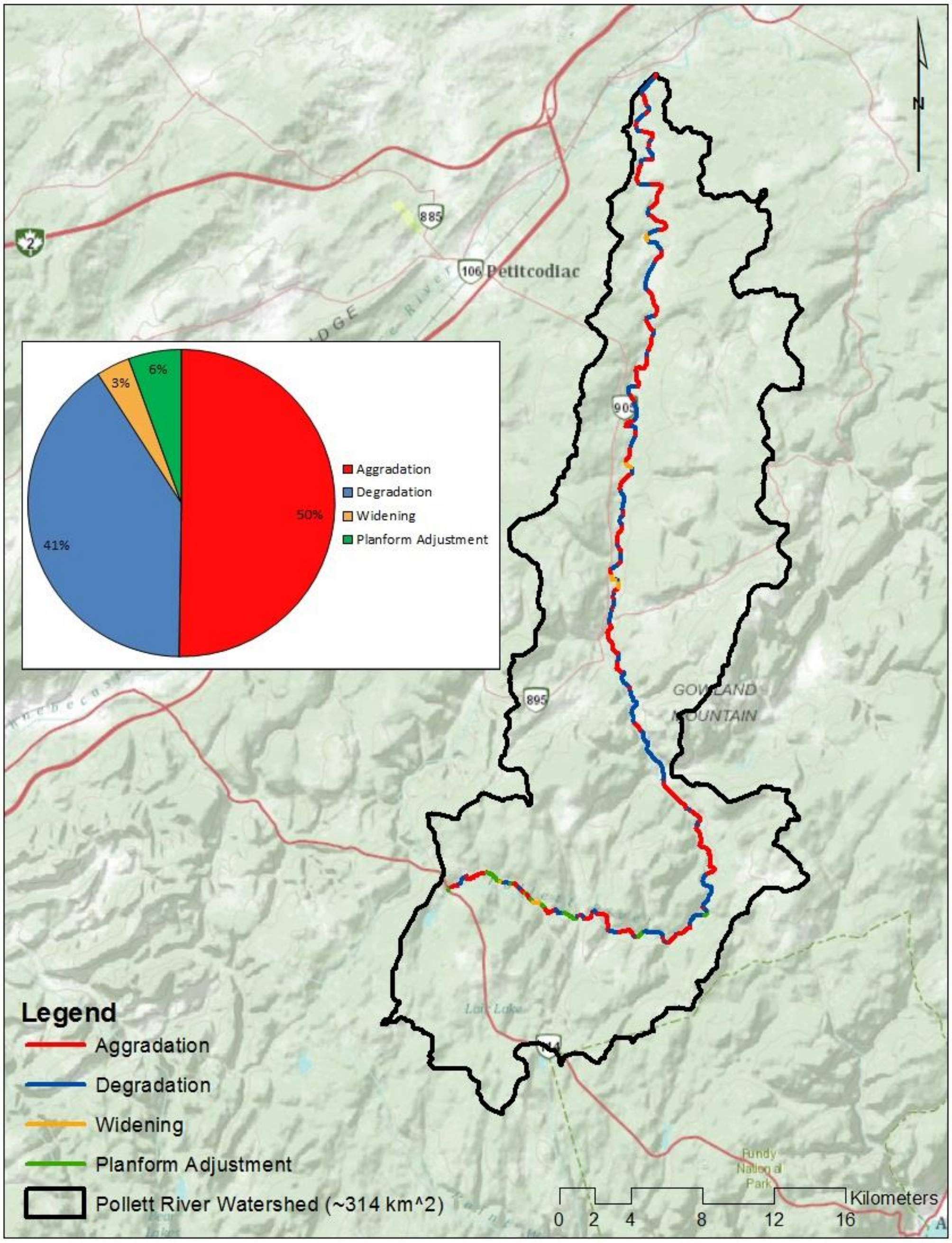


**Figure 3-14:** Pollett River primary geomorphic processes

Secondary geomorphic processes were more varied, with degradation and aggradation being identified as the most and second most common processes respectively. Widening and planform adjustment also made up a significant portion of secondary processes (Figure 3-15).

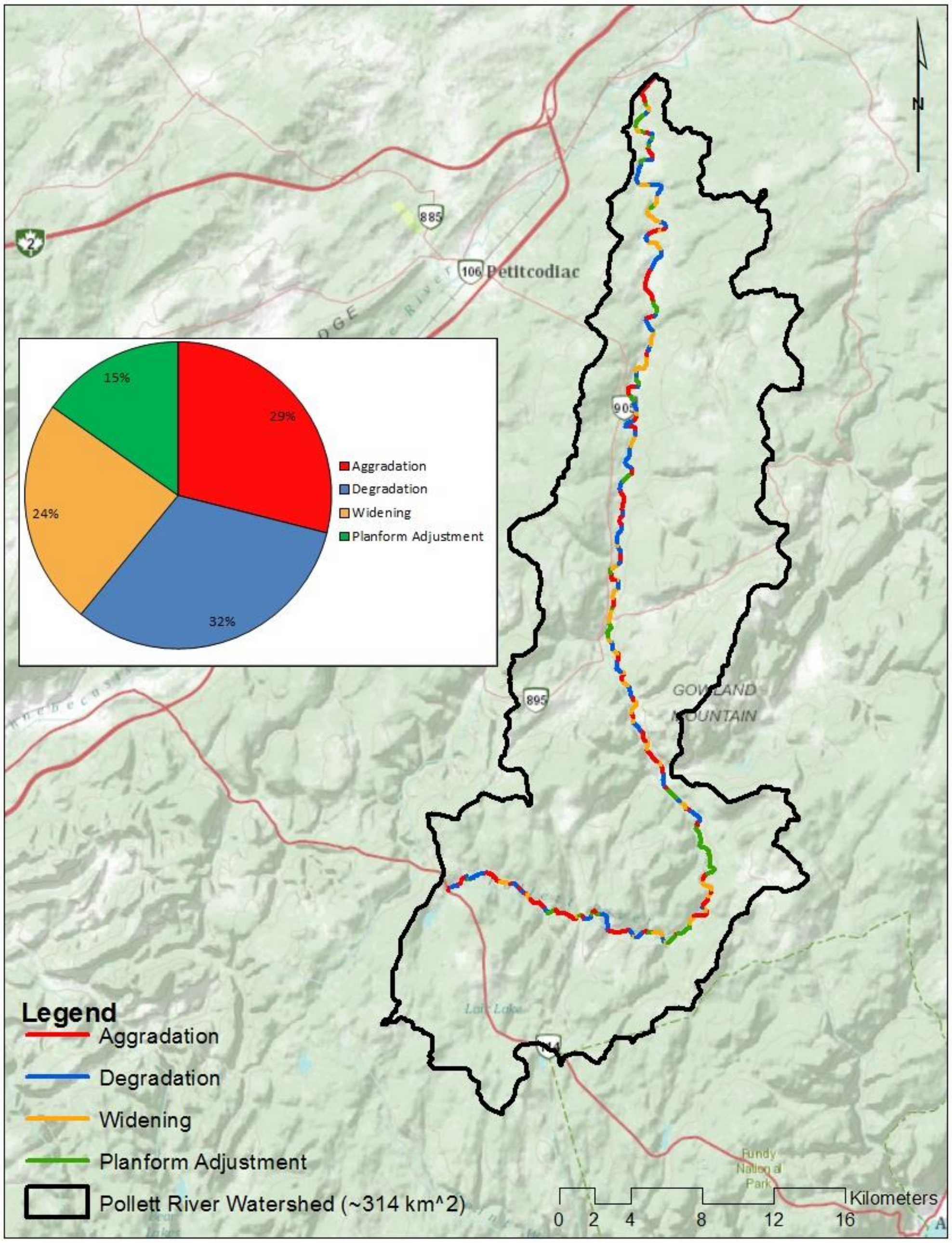


**Figure 3-15:** Pollett River secondary geomorphic processes

## *Assessment Results by Reach*

The following sections provide a more detailed look into the assessed sub-reaches. For the ease of data presentation, the three assessed reaches are presented in six sections. The first and second reaches (starting upstream moving downstream) are presented in their own in sections, while the third (lower) reach of the Pollett River is presented in 4 parts. In addition to providing discussion on the dominant geomorphic processes in each section, data analysis focuses on sub-reaches classified as in-adjustment. While this provides a more focused discussion, the importance of identifying and addressing problems in other sub-reaches experiencing instability (i.e. sub-reaches in a transitional or stressed state) should not be overlooked.

**Reach 1: Rt 114 to where Mechanic Lake Brook joins the Pollett (Sub-reaches MLB 2 1 to 2 28)**

The assessment of the upper reach started at Rte 114 where it crosses Mechanic Lake Brook and ended at the confluence with the Pollett River. This included approximately 7 km of stream that was divided into 28 sub-reaches. This section of river is experiencing a wide range of stability classes. Transitional or stressed was the most common condition. Sub-reaches MLB 2 1, MLB 2 5, MLB 2 8, MLB 2 17, MLB 2 19, MLB 2 21, MLB 2 23, MLB 2 25, and MLB 2 27 were in a state of adjustment; MLB 2 3, MLB 2 4, and MLB 2 22 were classified as in regime (Figure 3-16).

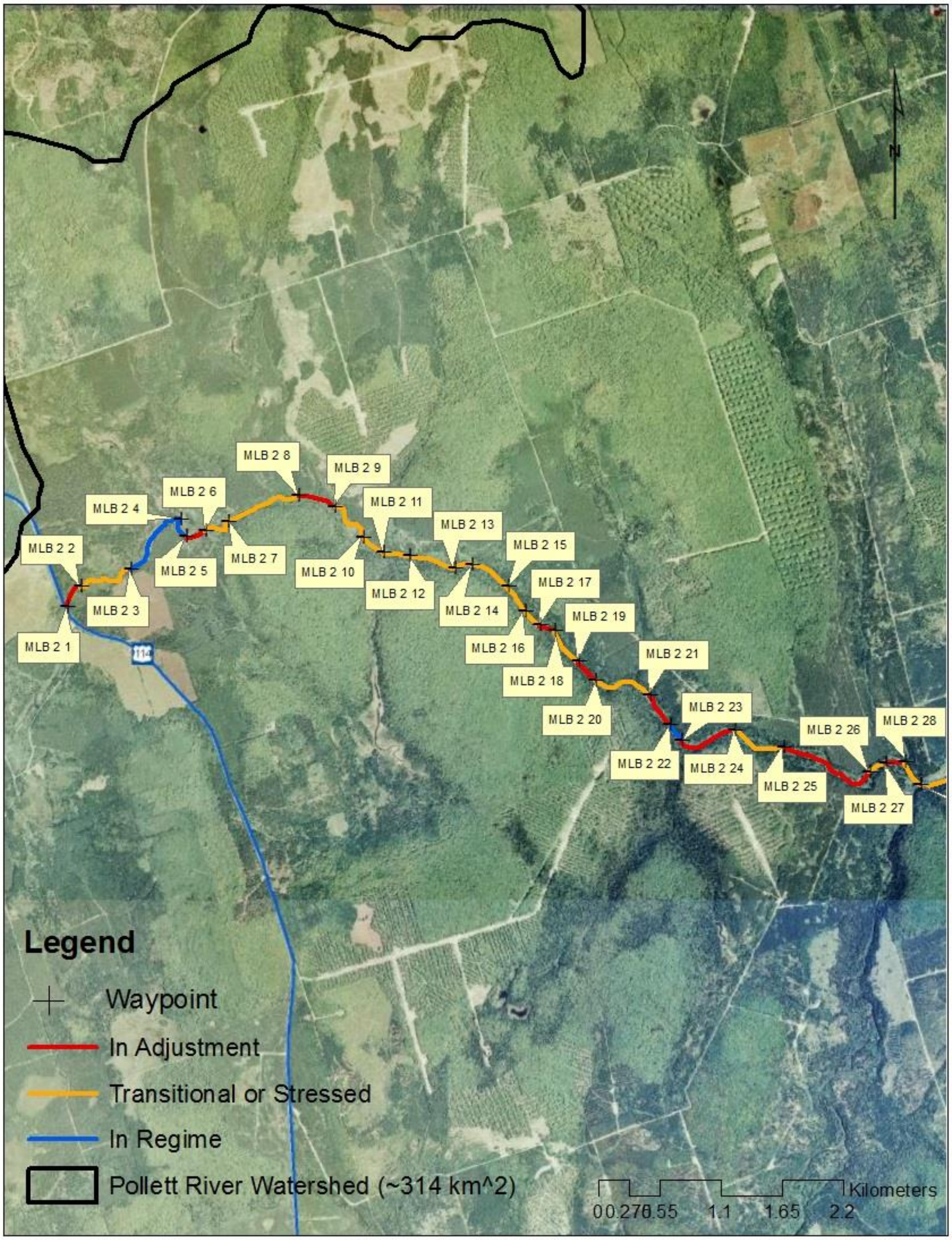


**Figure 3-16:** Stability rankings for Reach 1 (sub-reaches MLB 2 1 to MLB 2 28)

The dominant primary geomorphic process for the sub-reaches MBL 2 1 – MBL 2 28 was aggradation followed by planform adjustment (Figure 3-17). The dominant primary geomorphic process associated with the unstable (in adjustment) sub-reaches was planform adjustment followed by aggradation.

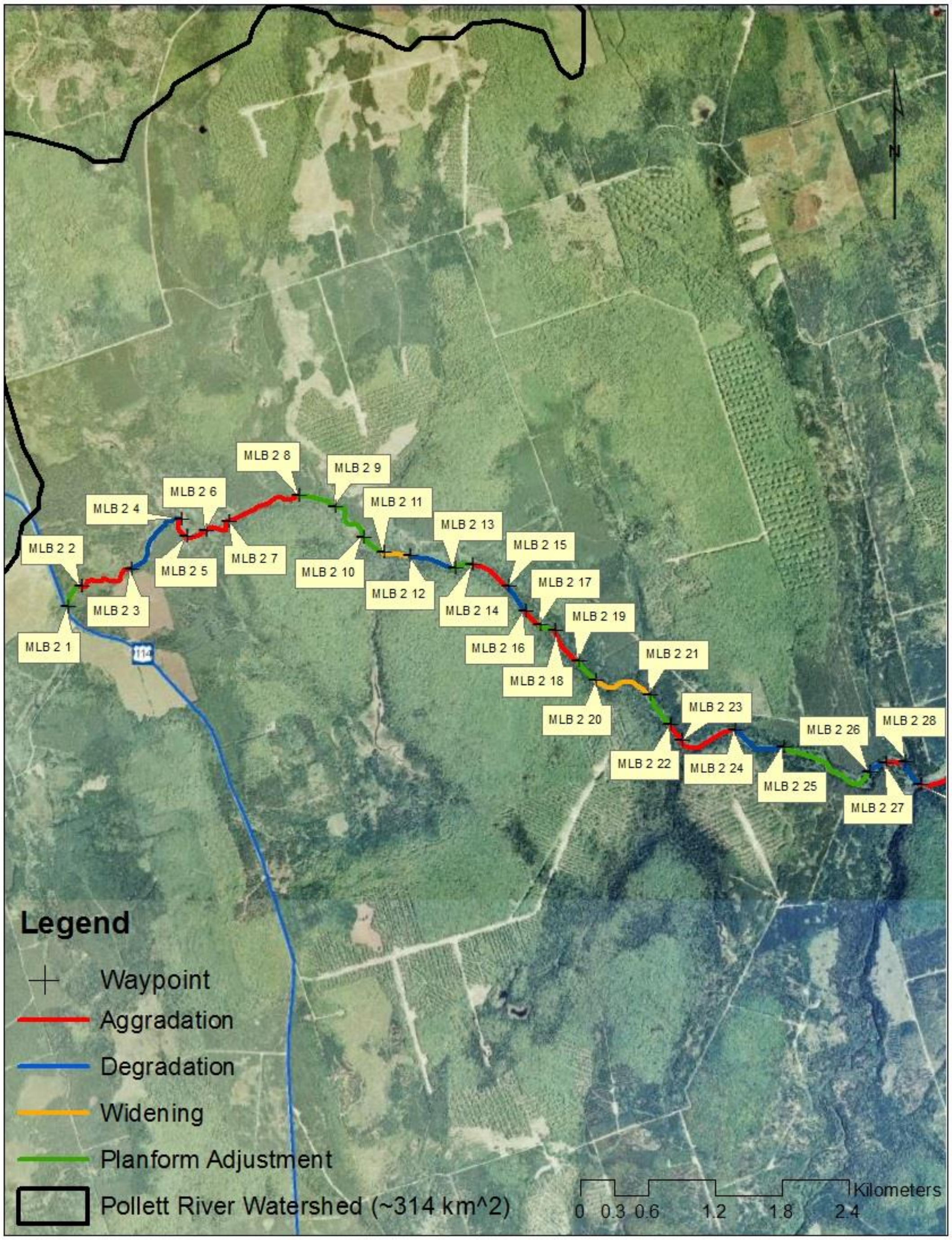


**Figure 3-17:** Primary geomorphic processes for Reach 1 (sub-reaches MLB 2 1 to MLB 2 28)

Secondary processes for sub-reaches MLB 2 1 to MLB 2 28 are outlined in (Figure 3-18), with aggradation being identified as the most common secondary process. A pattern in the data was noted where aggradation and planform adjustment appeared in conjunction with each other in the unstable reaches. Where one appeared as the primary process, the other was always the secondary process. This suggests that the unstable sites are in a state of adjustment due to an increase in bedload materials, bringing on a subsequent change in channel planform.

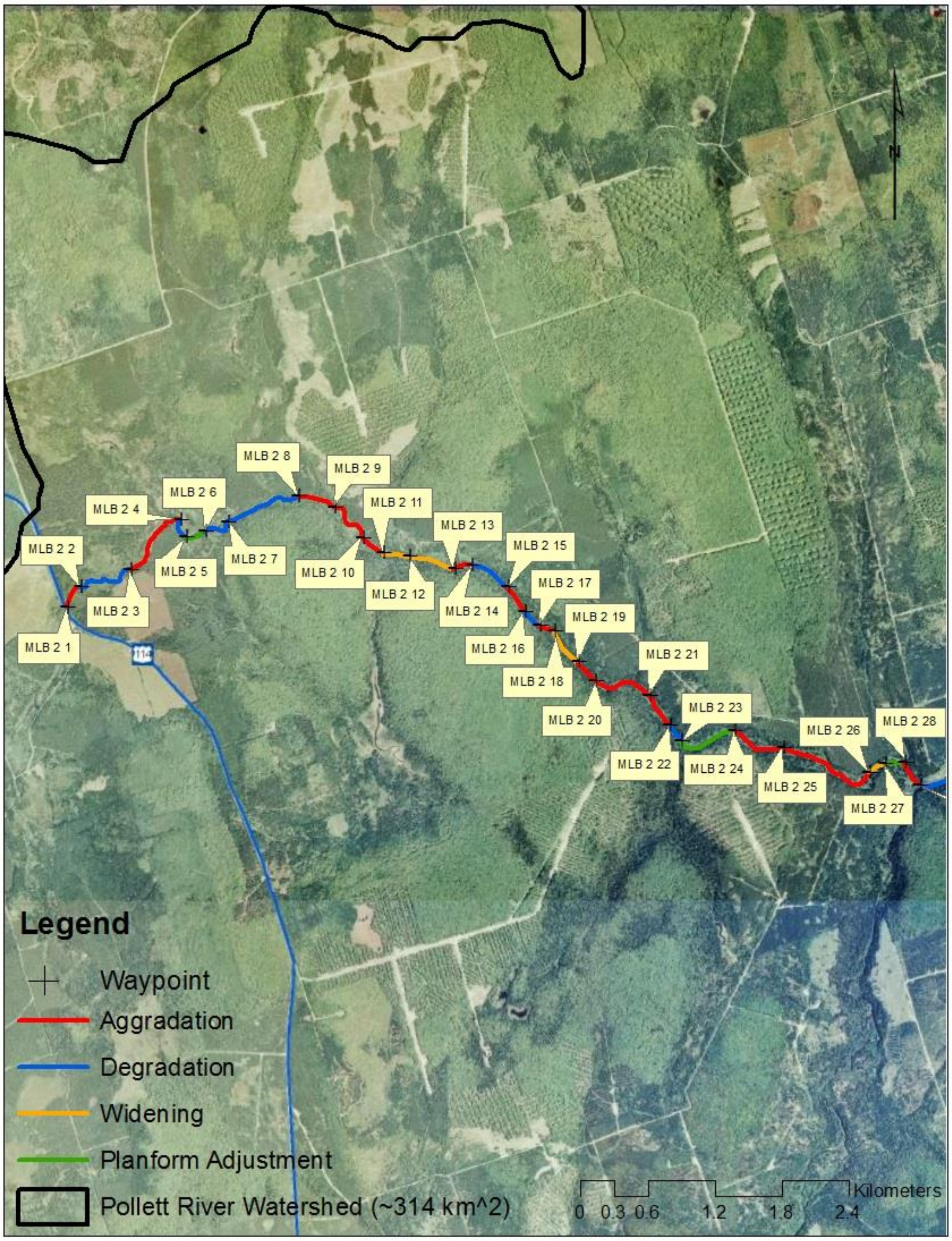


**Figure 3-18:** Secondary geomorphic processes for Reach 1 (sub-reaches MLB 2 1 to MLB 2 28)

Identification and control of the sediment sources in this reach should precede any instream restoration efforts. Otherwise, the excessive amount of sediments in the system could end up burying installed structures. Possible sources of sediment could be from eroding banks or mobile bed materials, poorly vegetated upslope areas, poorly constructed roads, poorly managed timber harvest and agricultural areas etc. Once sediment sources have been identified, some possible restoration options include: re-establishment of vegetation via changing land use practises, seeding, planting, or slope regrading if banks are severely eroded.

It has been noted that a large amount of crown timberland and woodland as well as private woodlots exist in the surrounding watershed (GeoNB mapping service). It is important that harvesting activities adhere to existing legislation so that buffer zones maintain their function. The lack of good buffer or riparian zones adjacent to watercourses could lead to increased runoff and larger peak flows. More intense flows have more erosive energy and thus greater potential to carry more sediment. Another potential anthropogenic source of sediment would be at poorly installed stream crossings. Improperly sized or misaligned woods road culverts can lead to erosion of road berms or even road washouts in extreme cases. It would be prudent to ensure that buffer zones and stream crossings on the assessed length of stream and its associated tributaries are in good condition.

As evidenced by photographs, the area contains a number of beaver dams (Figure 3-19 provides an example). These could be a potential natural source of sediment. Large amounts of sediment can become mobile and move through the system as sediment accumulated upstream of beaver dams becomes free when the dam is breached.

**Figure 3-19:** Beaver dam along Reach 1 at sub-reach MLB 2 19

### Reach 2: Start of Pollett to Churchs Corner (Sub-reaches PS 3 1 to PS 3 44 & PS 2 1 to PS 2 5)

This section of sub-reaches carries on from the previous sub-reaches on Mechanic Lake Brook, starting at the confluence of the Pollett River and Mechanic Lake Brook and ending just upstream of Church Hill Road. This includes approximately 13.7 km of river that is divided into 49 sub-reaches. These sub-reaches make up a large bend in the river, where the flow path changes from a westward direction to a primarily northward direction. Once again, transitional or stressed was the most common condition with 24 sub-reaches and 16 sub-reaches were in a state of adjustment. This section of sub-reaches, when compared to the other sections of river presented, had the highest percentage of sub-reaches in adjustment, making this section of river a particular concern due to its high instability. 8 of the 49 sub-reaches outlined here were classified as in regime (Figure 3-20).

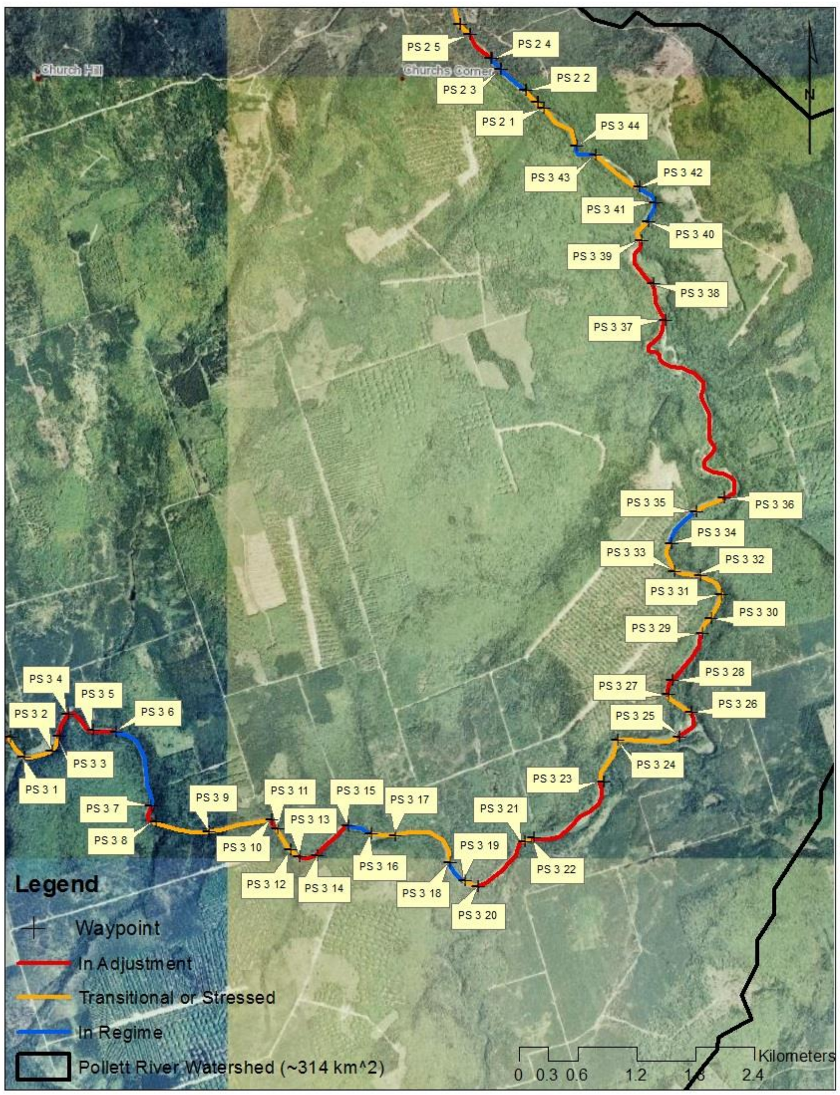


**Figure 3-20:** Stability rankings for Reach 2 (sub-reaches PS 3 1 to PS 3 44 & PS 2 1 to PS 2 5)

The dominant primary geomorphic process for these sub-reaches was aggradation followed by degradation (Figure 3-21). Widening was never observed as the primary geomorphic process and planform adjustment was identified as the primary process in 2 sub-reaches. The primary geomorphic process most associated with the unstable (in adjustment) sub-reaches, by far, was aggradation; degradation and planform adjustment each were the primary geomorphic process for two unstable sub-reaches. A pattern in the data was noted where sub-reaches with aggradation and degradation identified as primary geomorphic processes often occurred in sequence with each other. This could be a result of materials eroding from degraded portions of channel and depositing further downstream in areas with lower sediment carrying capacity.

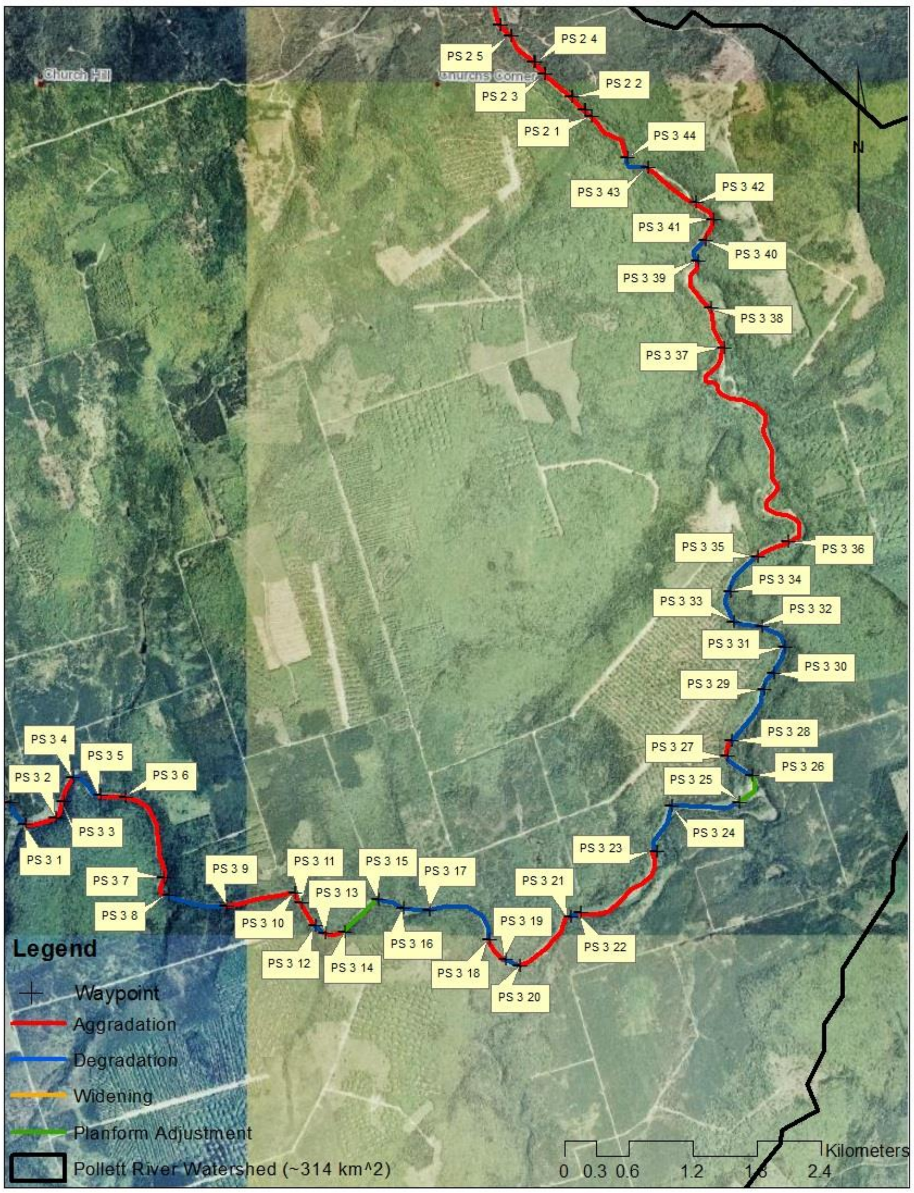


**Figure 3-21:** Primary geomorphic processes for Reach 2 (sub-reaches PS 3 1 to PS 3 44 & PS 2 1 to PS 2 5)

Degradation was identified as the most common secondary process; with the other geomorphic processes each also being identified as secondary processes in some sub-reaches (Figure 3-22).

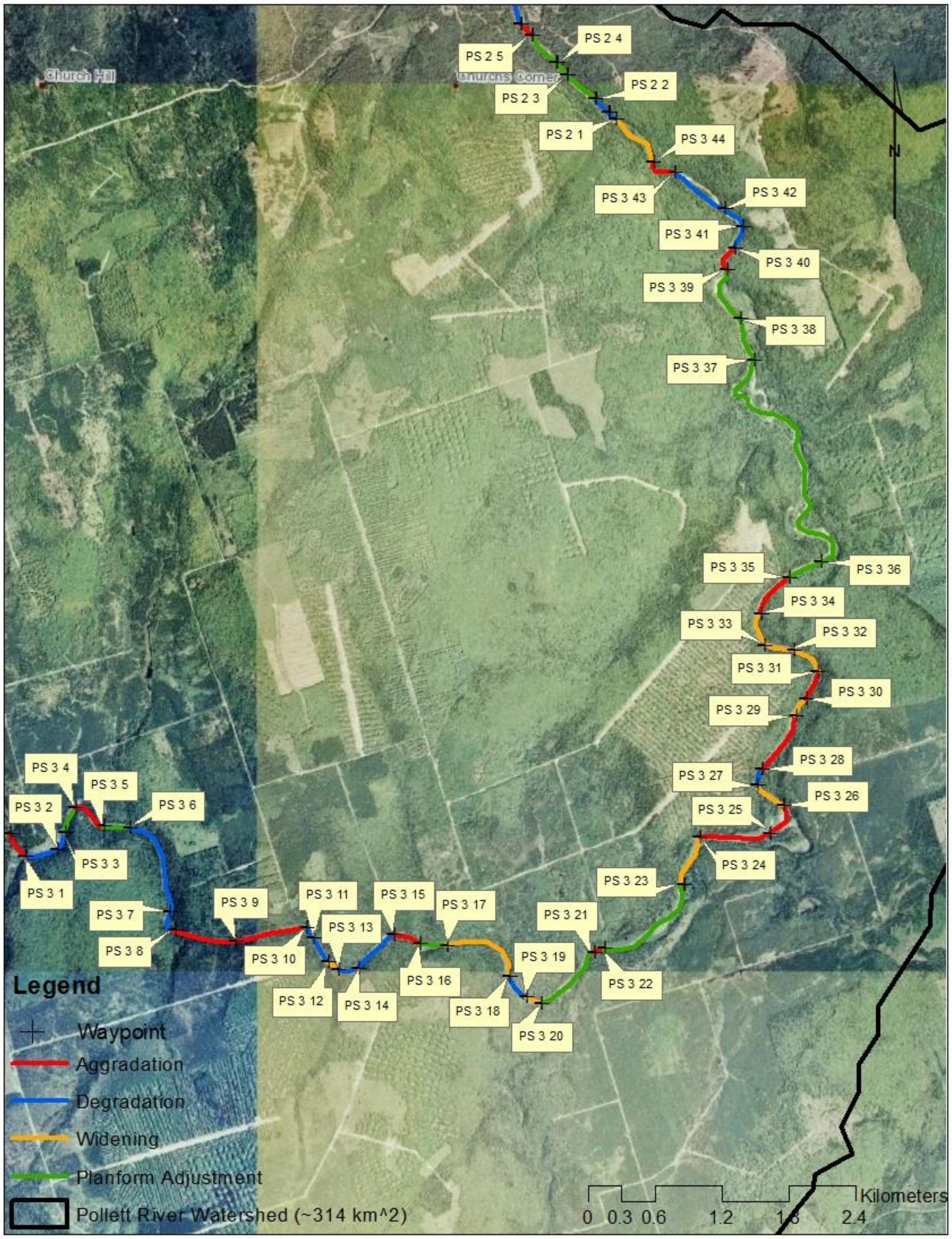


**Figure 3-22:** Secondary geomorphic processes for Reach 2 (sub-reaches PS 3 1 to PS 3 44 & PS 2 1 to PS 2 5)

As with the previous reach, identification and control of the sediment sources in this reach should be the first step towards any restoration efforts. The presence of crown timberland and woodland as well as private woodlots in the surrounding watershed, like the upstream reach, remains prevalent in this section as well. Once again, ensuring that buffer zones and stream crossings on the assessed length of stream and its associated tributaries are in good condition would be beneficial. The occurrence of exposed bedrock and large areas of deposition was also noted in photographs taken in this section of the Pollett River (see Figure 3-23 and Figure 3-24).

**Figure 3-23:** Exposed bedrock on left bank in Reach 2 (sub-reach PS 3 10)

**Figure 3-24:** Large depositional feature in Reach 2  (sub-reach PS 3 36)

**Reach 3 Part 1: Churchs Corner to below Elgin near Rt 895 (Sub-reaches PS 2 6 to PS 2 38)**

This section of sub-reaches starts at Church Hill Road and ends approximately 400 metres upstream of where route 895 crosses over the river, just north of Elgin. This includes approximately 8.8 km of river that is divided into 33 sub-reaches. The underlying geology changes in this section (Figure 3-25), which corresponds to a series of rapids and waterfalls that make up a large portion of this reach (Figure 3-26 and Figure 3-27). The waterfalls can be thought of as large headcuts caused by knickpoints in the less resistant sedimentary bedrock.

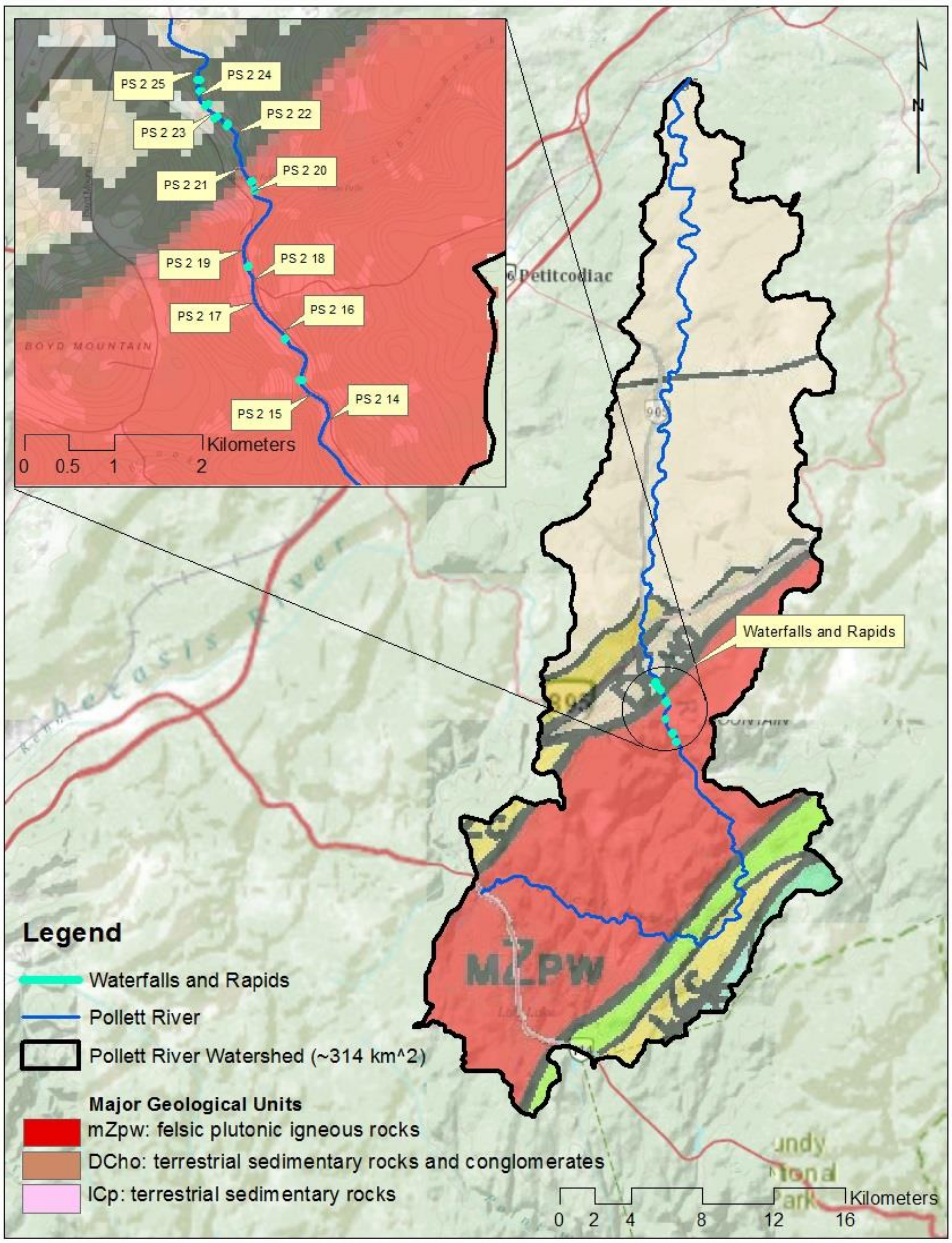


**Figure 3-25:** Major geological units, waterfalls and rapids in the Pollett River watershed

**Figure 3-26:** Rapids in Reach 2: sub-reach PS 2 14 (left); and sub-reach PS 2 17 (right)

**Figure 3-27:** Rapids and waterfalls in Reach 2: sub-reach PS 2 21 (bottom right);  sub-reach PS 2 23 (top right ); and sub-reach PS 2 24 (left)

The majority of sub-reaches (19 of 33) in this section were in a transitional or stressed state. There were fewer sub-reaches in adjustment (6), and more sub-reaches in regime (8) compared to the upper sections (Figure 3-28).

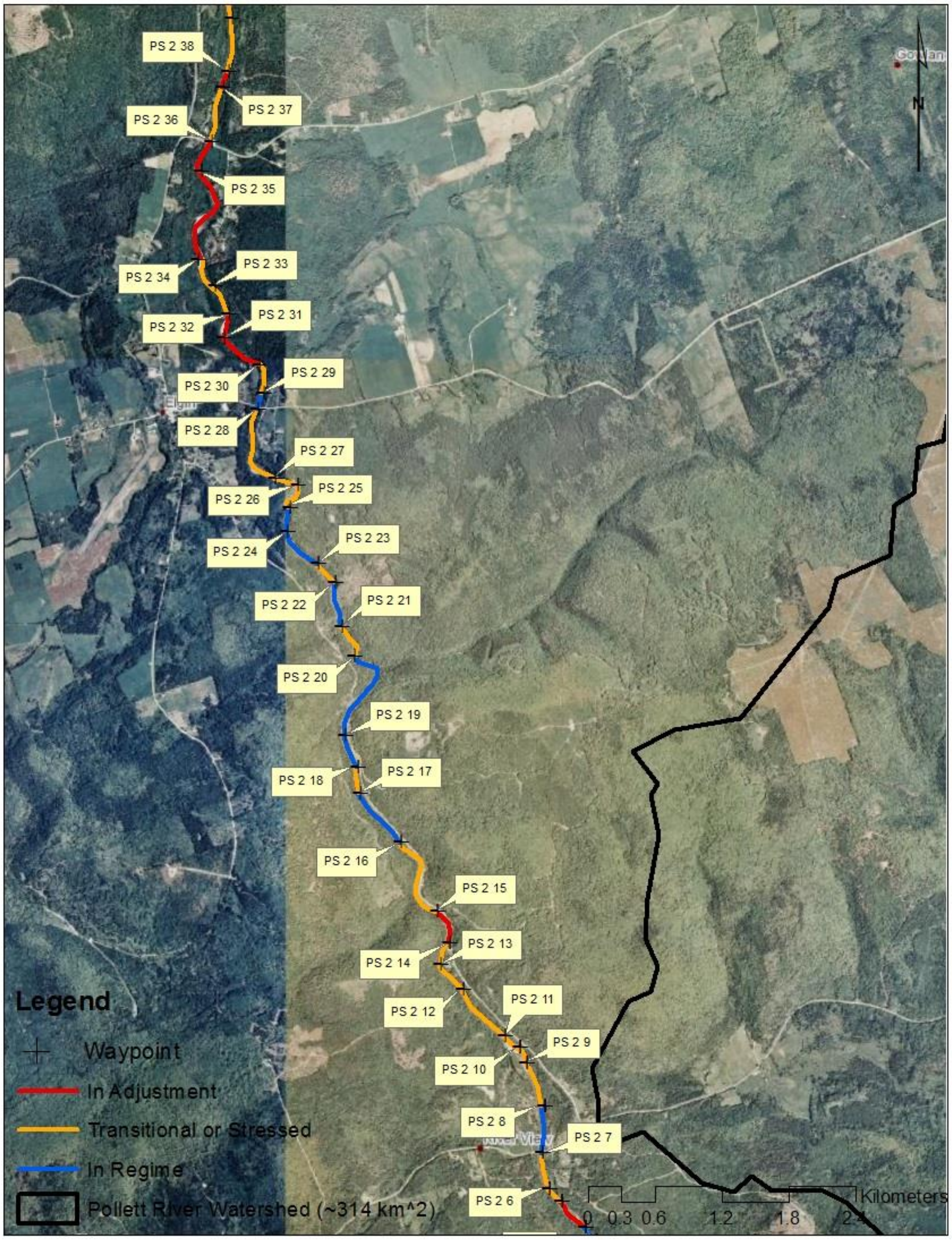


**Figure 3-28:** Stability rankings for Reach 3 part 1 (sub-reaches PS 2 6 to PS 2 38)

The dominant primary geomorphic process for these sub-reaches was degradation followed by aggradation (Figure 3-29). Widening and planform adjustment were never observed as primary geomorphic processes. The primary geomorphic process often associated with the unstable (in adjustment) sub-reaches, again, was aggradation; degradation was the primary geomorphic process for 3 unstable sub-reaches. The pattern where sub-reaches with aggradation and degradation identified as primary geomorphic processes occurred in sequence with each other was again noted.

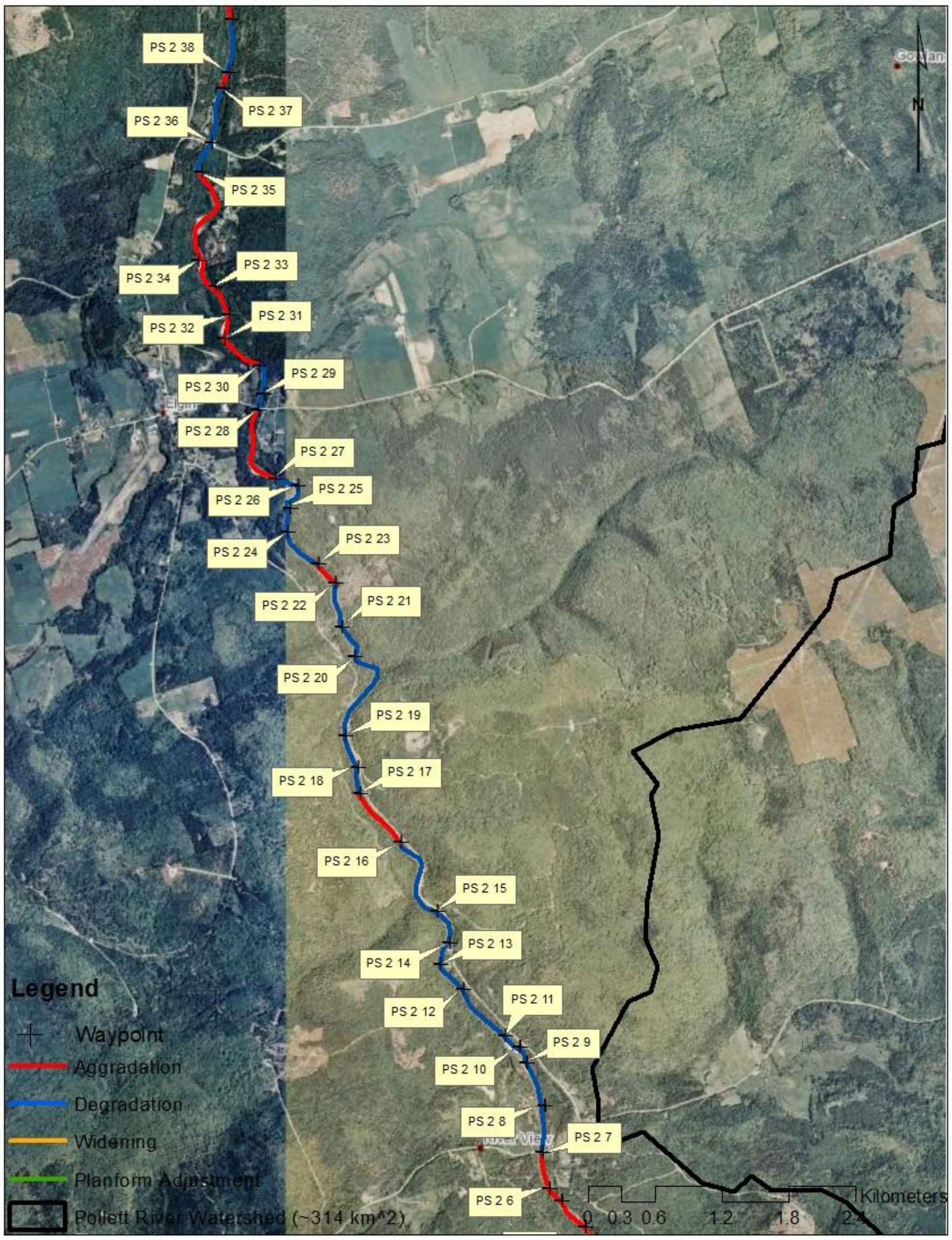


**Figure 3-29:** Primary geomorphic processes for Reach 3 part 1 (sub-reaches PS 2 6 to PS 2 38)

Widening was identified as the most common secondary process; with aggradation, degradation, and planform adjustment also being identified as secondary processes in some of the sub-reaches (Figure 3-30).

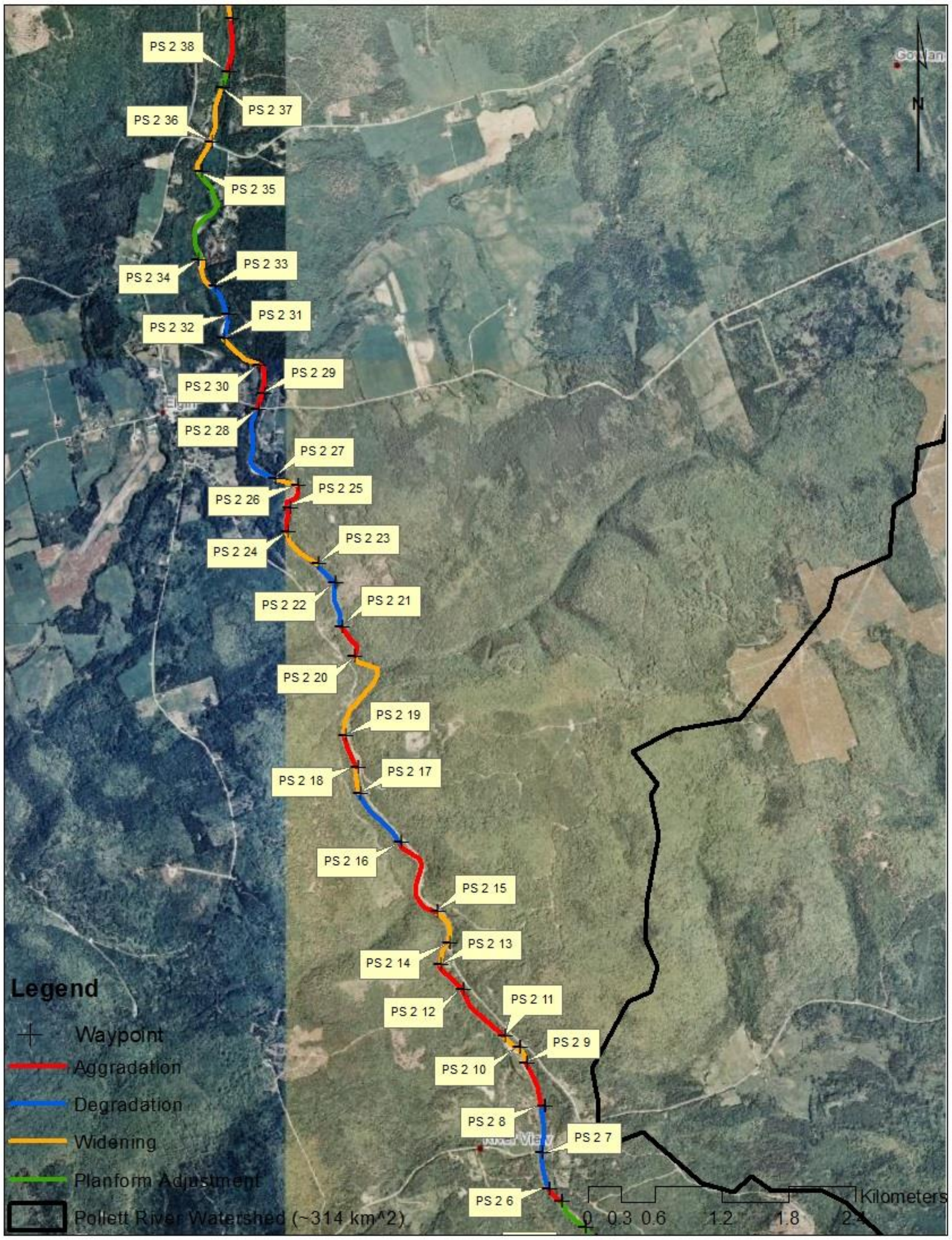


**Figure 3-30:** Secondary geomorphic processes for Reach 3 part 1 (sub-reaches PS 2 6 to PS 2 38)

Any restoration efforts attempted in the upper sub-reaches of this section should take consideration the very shallow depth to bedrock, where the bedrock often makes up the channel bed and/or banks. In this case, anchoring in-stream or bank stabilization structures will be more difficult compared to areas with a well-established soil layer. Common restoration techniques applied to degraded streams include: raising the stream bed and/or lowering the floodplain to provide floodplain access and allow for energy dissipation in high flows (cut and fill areas from the floodplain and channel bed should be designed to ensure proper stream dimensions); and using grade control structures to prevent knickpoint/headcut migration, and stabilize the stream grade (grade control structures can also be designed to provide access to the floodplain).

Another consideration is the presence of aggradation causing instability in the first subreach and immediately upstream of the first sub-reach. This would have to be addressed prior to commencing any in stream works downstream; otherwise the effectiveness of the work could be compromised if the sediments in the upstream sections migrate downstream.

The lower sub-reaches of this section, downstream of the waterfalls, are mostly experiencing instability due to an increase in the bedload (refer to Figure 3-31 and Figure 3-32 for examples). Restoration efforts should focus on locating the source of the sediment and implementing strategies discussed in section on Reach 1 (sub-reaches MLB 2 1 to MLB 2 28). The presence of farmland, croplands and pastures as well as woodlots and residences adjacent to the river was noted in the area surrounding the aggraded reaches (GeoNB mapping service and Landuse datasets). Figure 3-33 outlines the aggraded areas on aerial maps with landuse. Ensuring proper buffer zones in this section of river as well as in adjoining tributaries using previously discussed techniques would help fulfill the requirement of identification and control of the sediment sources.

**Figure 3-31:** Aggradation in Reach 3 (sub-reach 3 31)

**Figure 3-32:** Aggradation in Reach 3 (subreach PS 3 34)

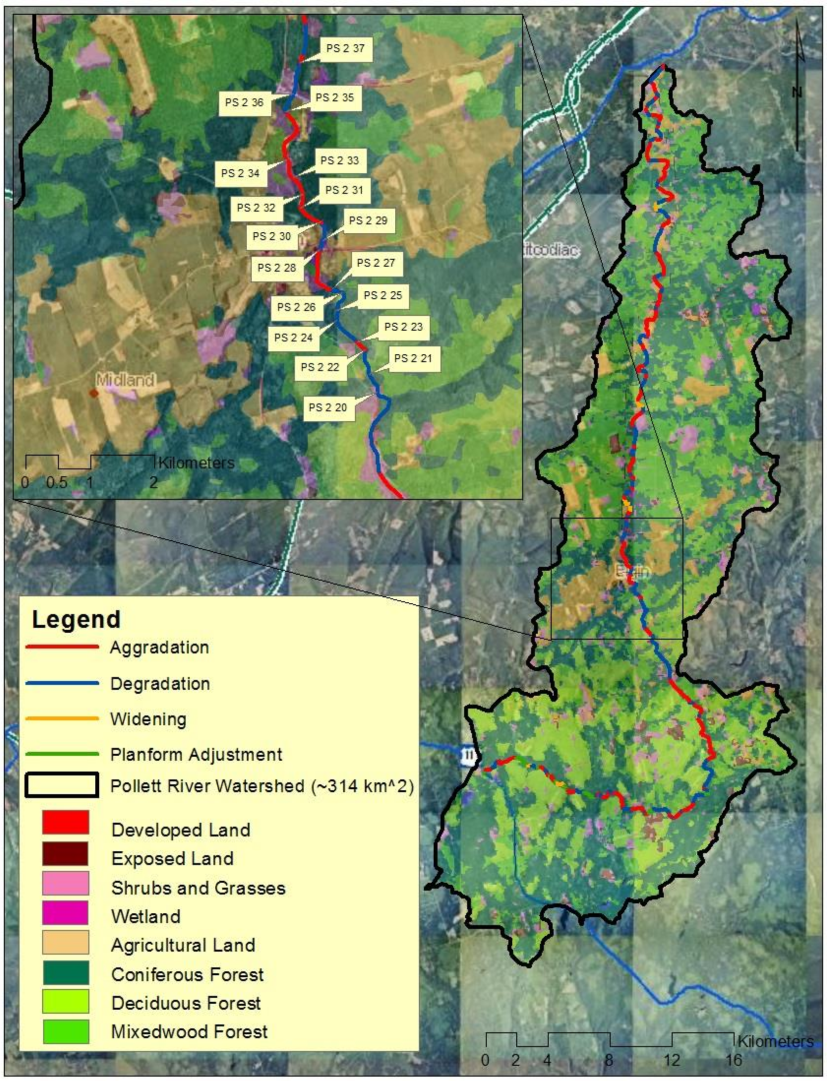


**Figure 3-33:** Land use and primary geomorphic processes for Reach 3 sub-reaches PS2 20 to PS 2 37

**Reach 3, Part 2: Below Elgin near Rt 895 to Parkindale Bridge(Sub-reaches PS 2 39 to PS 2 67)**
This section of sub-reaches starts north of Elgin and ends approximately 400 metres upstream of the Parkindale Road Bridge near the community of Pollett River. This includes approximately 8.7 km of river that was divided into 29 sub-reaches. This section of river is experiencing all ranges of stability and is relatively more stable compared to sections upstream. Transitional or stressed was the most common condition. Sub-reaches PS 2 59, PS 2 60, and PS 2 61 were in a state of adjustment; PS 2 46, PS 2 49, PS 2 53, PS 2 63, PS 2 66, and PS 2 67 were classified as in regime (Figure 3-34).

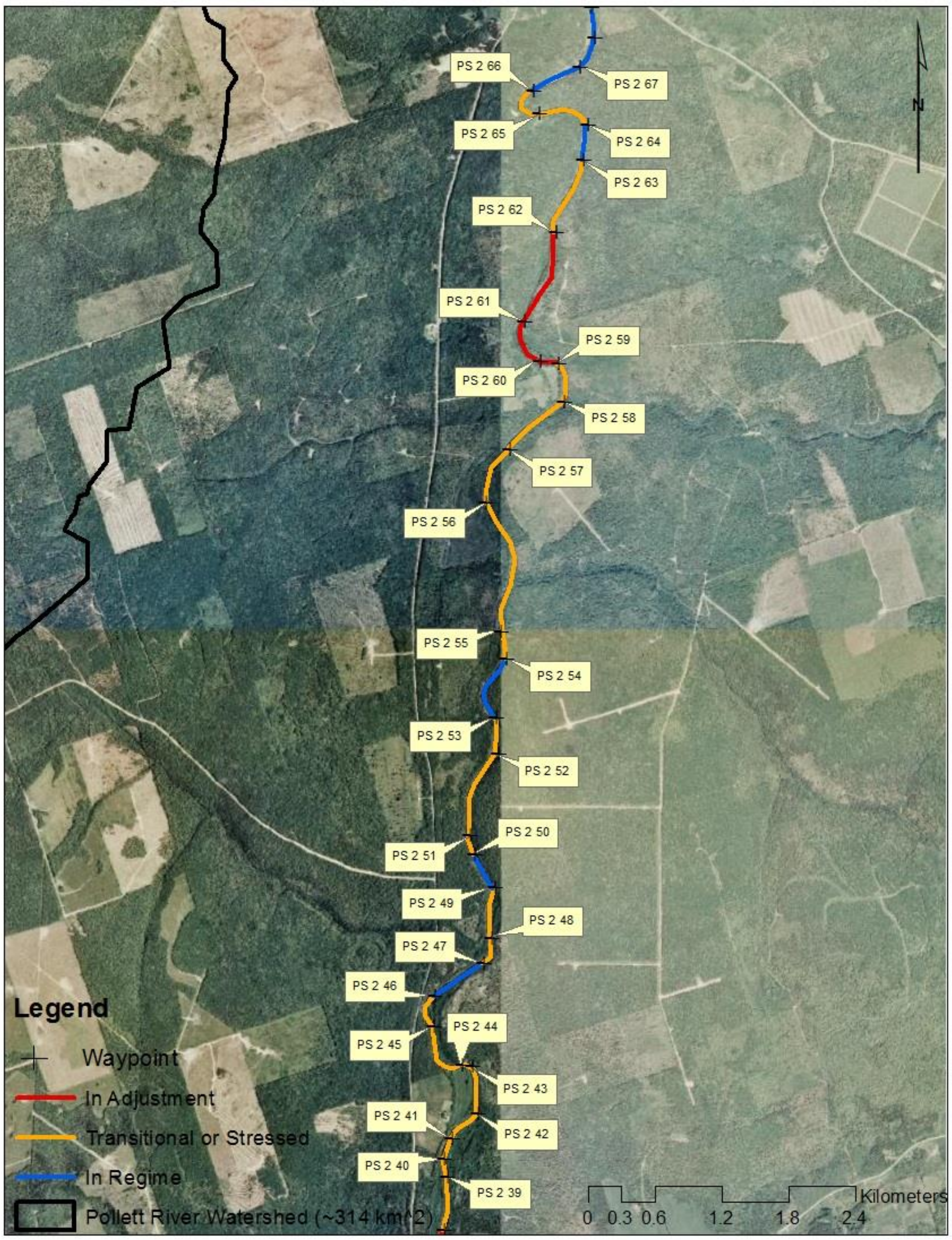


**Figure 3-34:** Stability rankings for Reach 3 part 2 (sub-reaches PS 2 39 to PS 2 67)

The dominant primary geomorphic process for these sub-reaches was aggradation followed by degradation (Figure 3-35). Widening was the primary geomorphic process for 4 sub-reaches and planform adjustment was never observed as the primary geomorphic process in these sub-reaches. A common primary geomorphic process associated with the most unstable sub-reaches was widening; aggradation was the primary geomorphic process for 1 sub-reach in adjustment. Sub-reaches with aggradation and degradation identified as primary geomorphic processes occurred in sequence with each other once again. Intermittent sections of widening as a primary process, especially in unstable subreaches, occurred between aggraded and degraded sub-reaches.

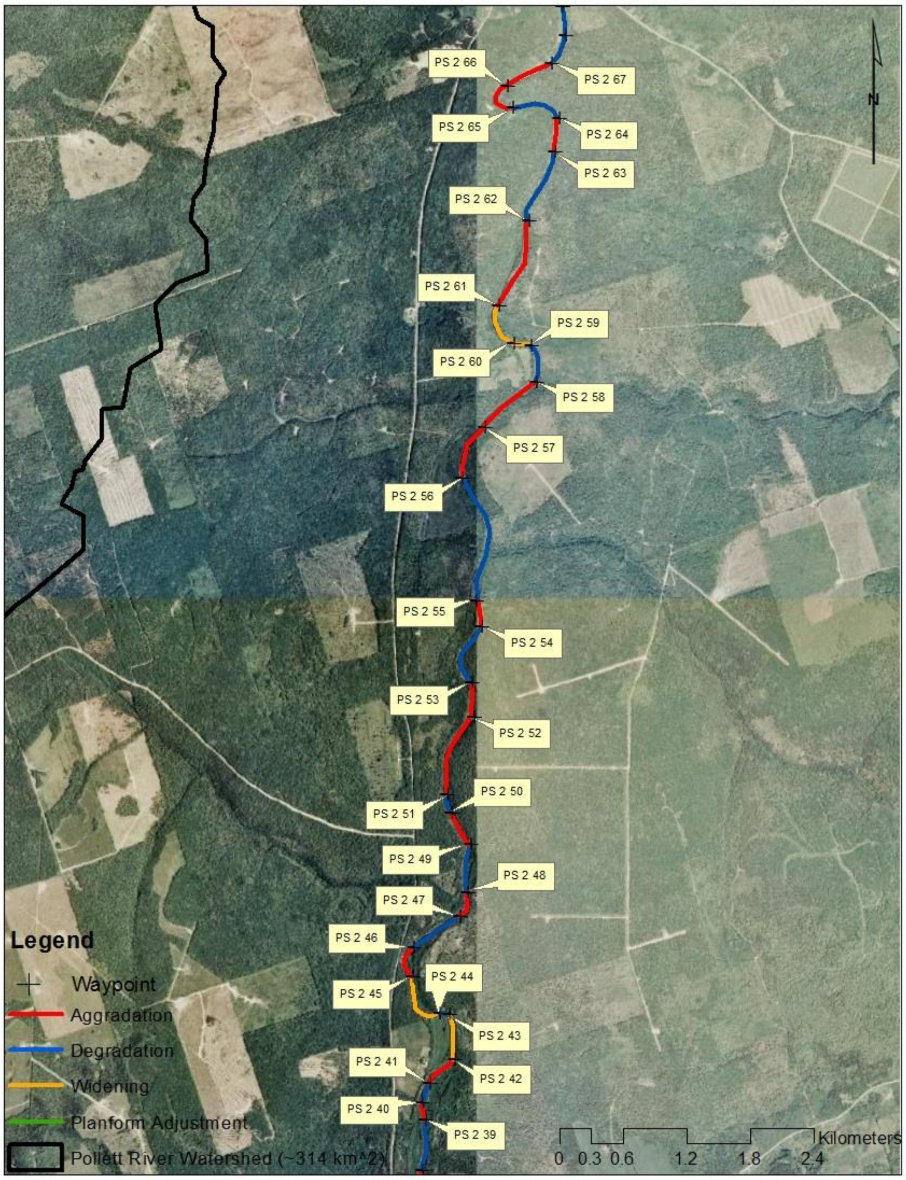


**Figure 3-35:** Primary geomorphic processes for Reach 3 part 2 (sub-reaches PS 39 to PS 2 67)

Degradation was the most common secondary process; with the other geomorphic processes also being identified as secondary processes in some sub-reaches (Figure 3-36).

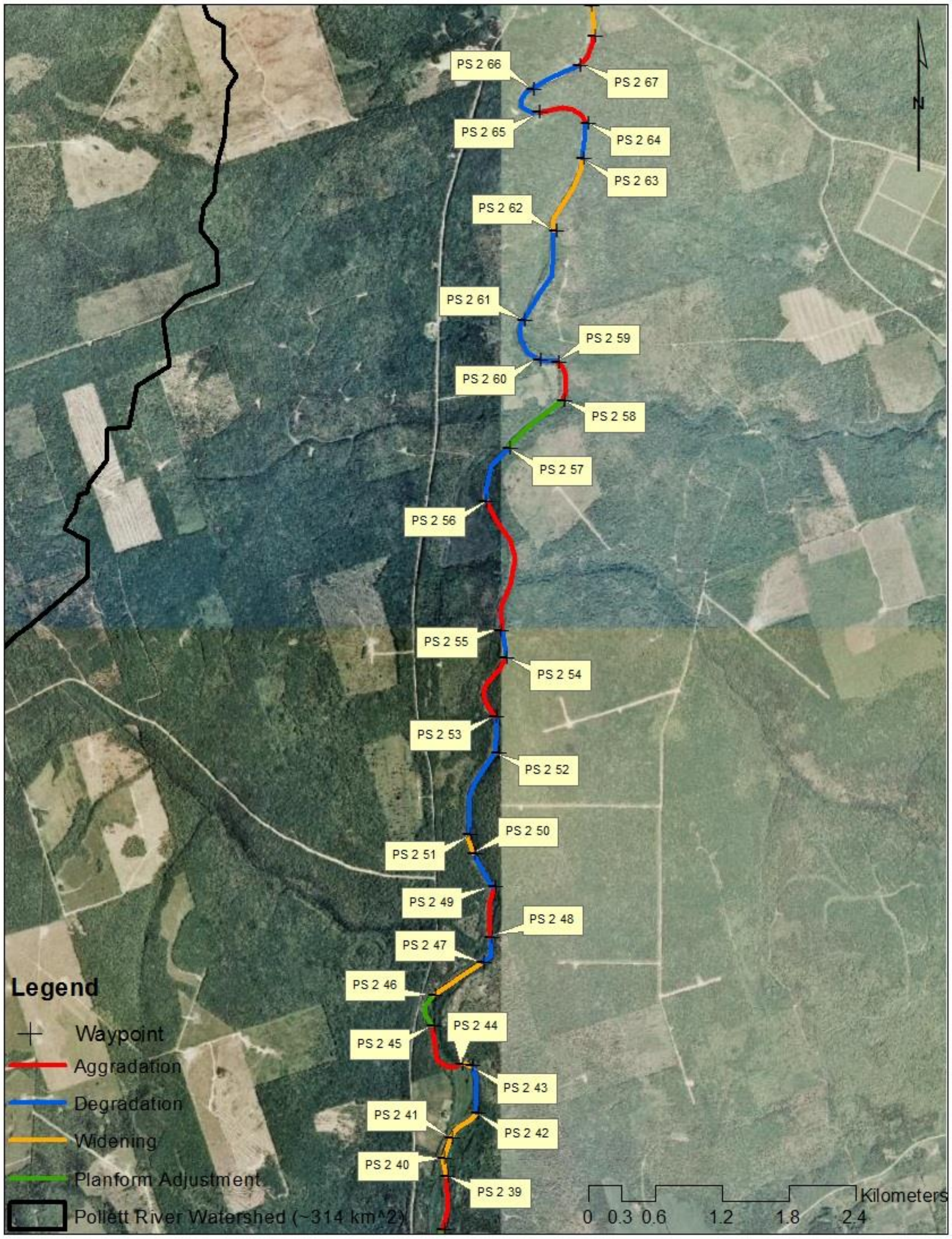


**Figure 3-36:** Secondary geomorphic processes for Reach 3 part 2 (sub-reaches PS 2 39 to PS 2 67)

The prevalence of degrading sub-reaches, as a primary and secondary geomorphic process, was partially evidenced by a significant amount of exposed bedrock in these sub-sections (see examples in Figure 3-37).

**Figure 3-37:** Exposed sedimentary bedrock in Reach 3 part 2: sub-reaches PS 2 54 (left); and PS 2 58 (right)

Unstable sub-reaches should be handled appropriately as outlined in previous sections, whether by mitigating erosive forces with stabilization of the grade and/or providing floodplain access for degrading sections or identifying and controlling sediment sources for aggrading reaches. Channel restoration in widening sub-reaches should be designed to narrow the channel by accumulating sediments towards the banks. Any in-stream structures designed for improving stream habitats should also be designed to assist in narrowing channel width and not create scour along banks, particularly where the channel is also experiencing degradation.

**Reach 3, Part 3: Above Parkindale Bridge to The Glades (Sub-reaches PS 2 68 to PS 2 95)**

This section of sub-reaches starts near the community of Pollett River at ends just downstream of The Glades. This includes approximately 10 km of river that was divided into 29 sub-reaches. Transitional or stressed was the most common geomorphic condition. 4 sub-reaches were in a state of adjustment; 8 sub-reaches were classified as in regime (Figure 3-38).

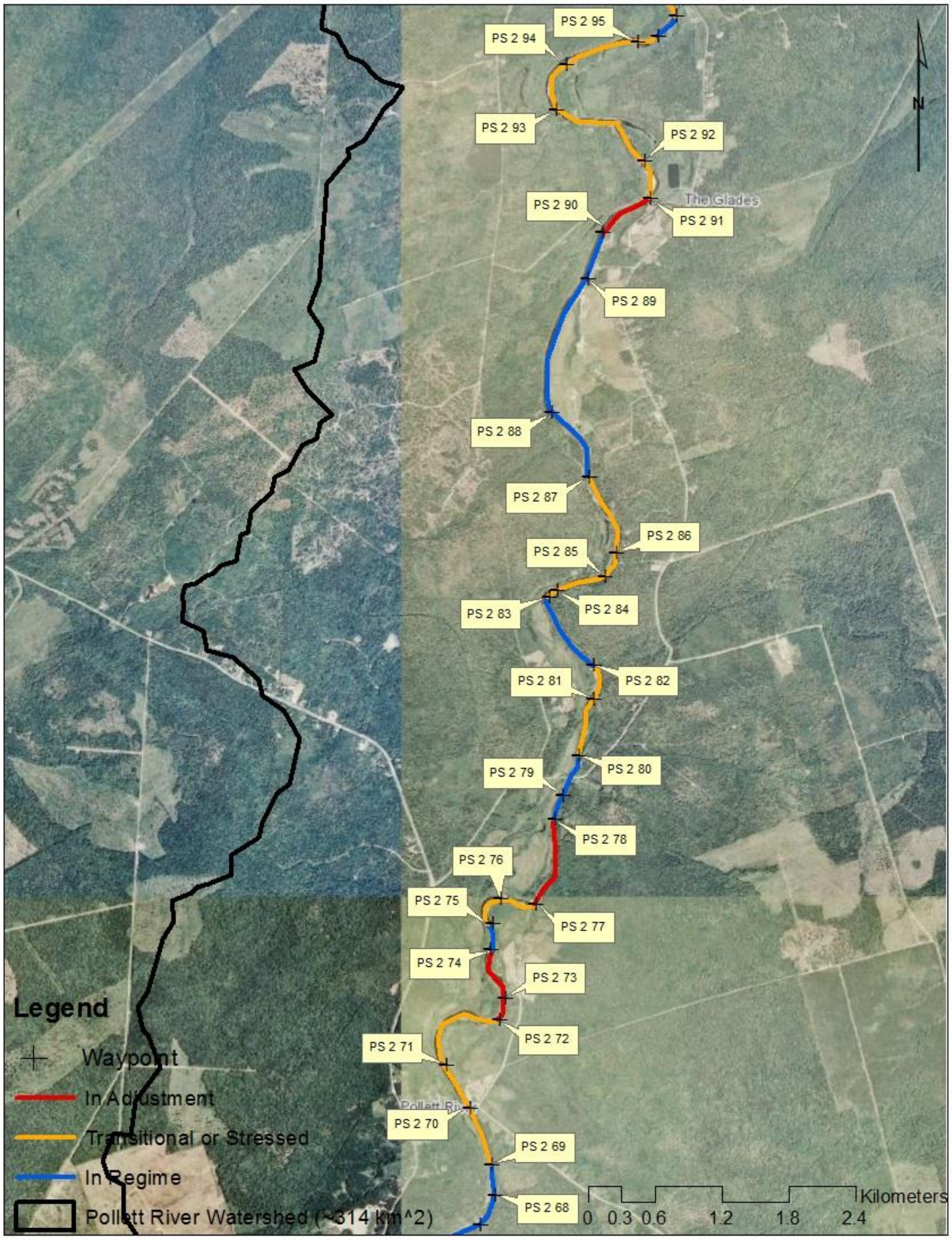


**Figure 3-38:** Stability rankings for Reach 3 part 3 (sub-reaches PS 2 68 to PS 2 95)

The dominant primary geomorphic process for these sub-reaches was aggradation followed by degradation (Figure 3-39). Widening was the primary geomorphic process for 1 sub-reach and planform adjustment was never observed as a primary geomorphic process in this section of sub-reaches. Aggradation was always the primary geomorphic process associated with the most unstable sub-reaches. Sub-reaches alternated between aggradation and degradation as primary geomorphic processes, reflecting alternation between strong erosive forces and subsequent deposition downstream. One sub-reach was widening as a primary process, likely brought on originally as degradation given its location between two degrading sub-reaches and degradation being identified as the secondary geomorphic process within the widening sub-reach itself.

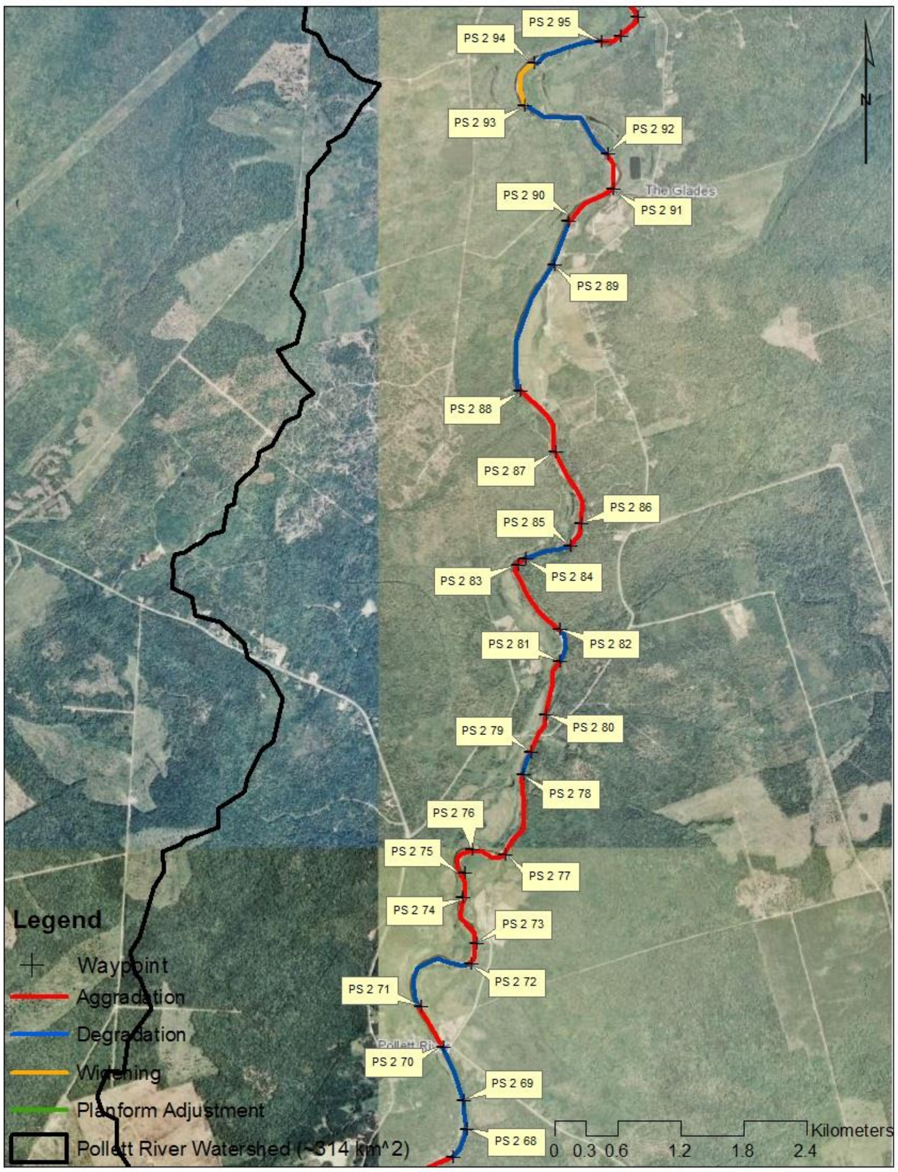


**Figure 3-39:** Primary geomorphic processes for Reach 3 part 3 (sub-reaches PS 2 68 to PS 2 95)

Degradation was again identified as the most common secondary process; with the other geomorphic processes each being identified as secondary processes in some fraction of the sub-reaches as well (Figure 3-40). Once again, sediment sources should be identified and controlled prior to installation of any in-stream structures so as to not jeopardize the work.

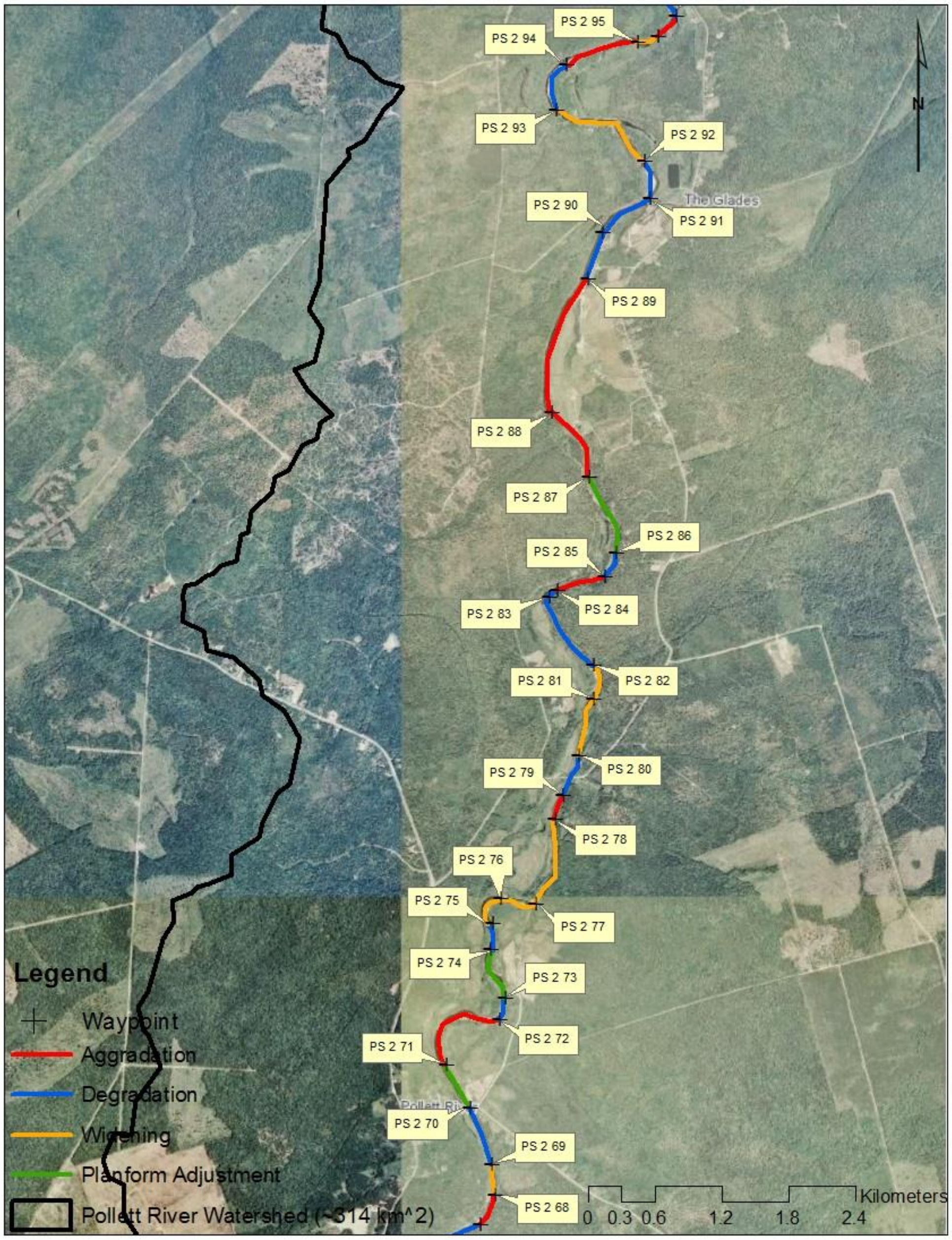


**Figure 3-40:** Secondary geomorphic processes for Reach 3 part 3 (sub-reaches PS 2 68 to PS 2 95)

### Reach 3, Part 4: The Glades to confluence with Petitcodiac (Sub-reaches PS 2 96 to PS 2 125)

This final section of sub-reaches starts just north of The Glades and ends at the confluence between the Pollett River and the Petitcodiac River. This includes approximately 9.1 km of river that was divided into 30 sub-reaches. Transitional or stressed was the most common geomorphic condition. 3 sub-reaches were in a state of adjustment; 10 sub-reaches were classified as in regime (Figure 3-41). In terms of the percentage of sub-reaches in adjustment to the total number of sub-reaches, this section of river is the most stable of all sections discussed in this report.

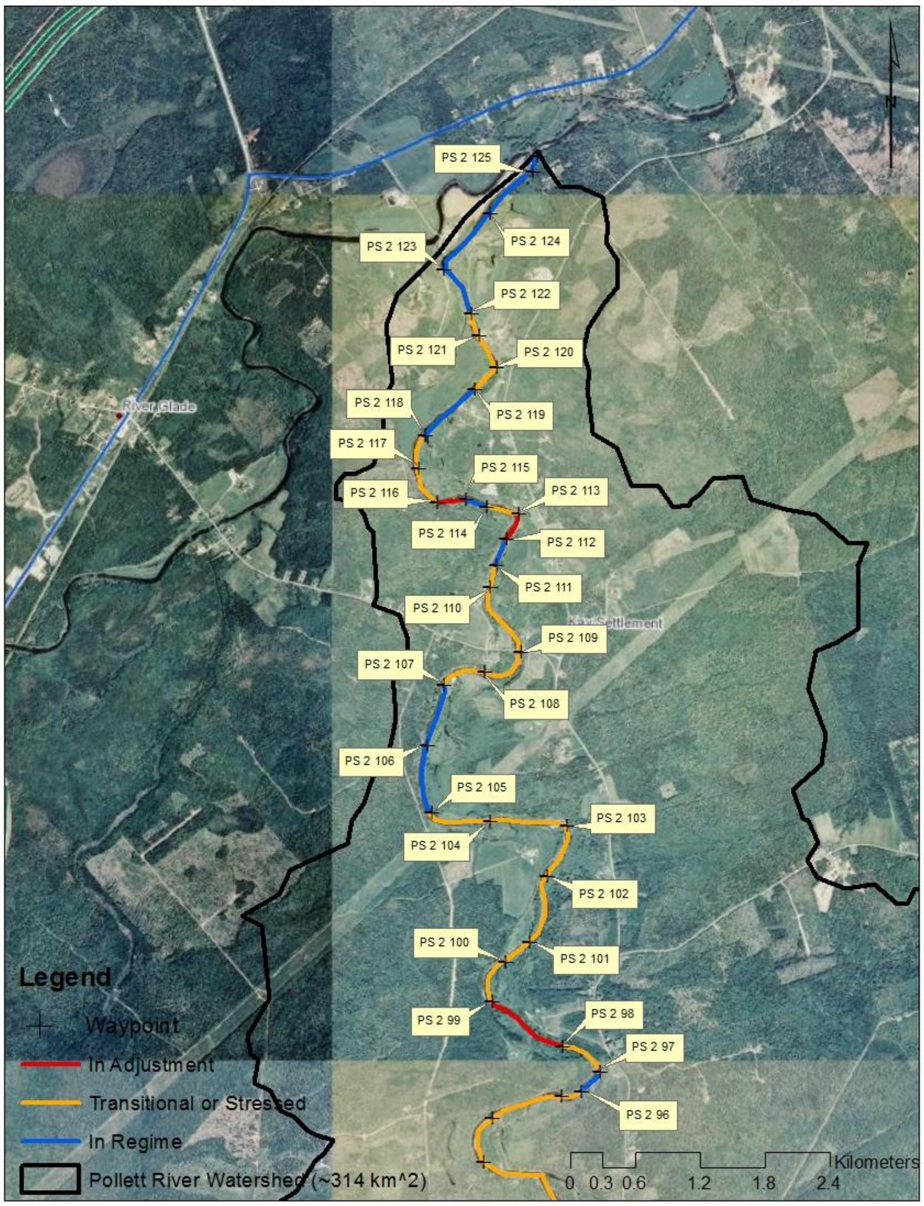


**Figure 3-41:** Stability rankings for Reach 3 part 4 (sub-reaches PS 2 96 to PS 2 125)

The majority of sub-reaches for this section (20 of 30) had aggradation as a primary geomorphic process (Figure 3-42). Degradation was also identified as a primary process in some sub-reaches; unique to this section was the absence of widening and planform adjustment as primary geomorphic process. Once again, aggradation was always the primary geomorphic process associated with the most unstable sub-reaches and sub- reaches alternated between aggradation and degradation as primary geomorphic processes.

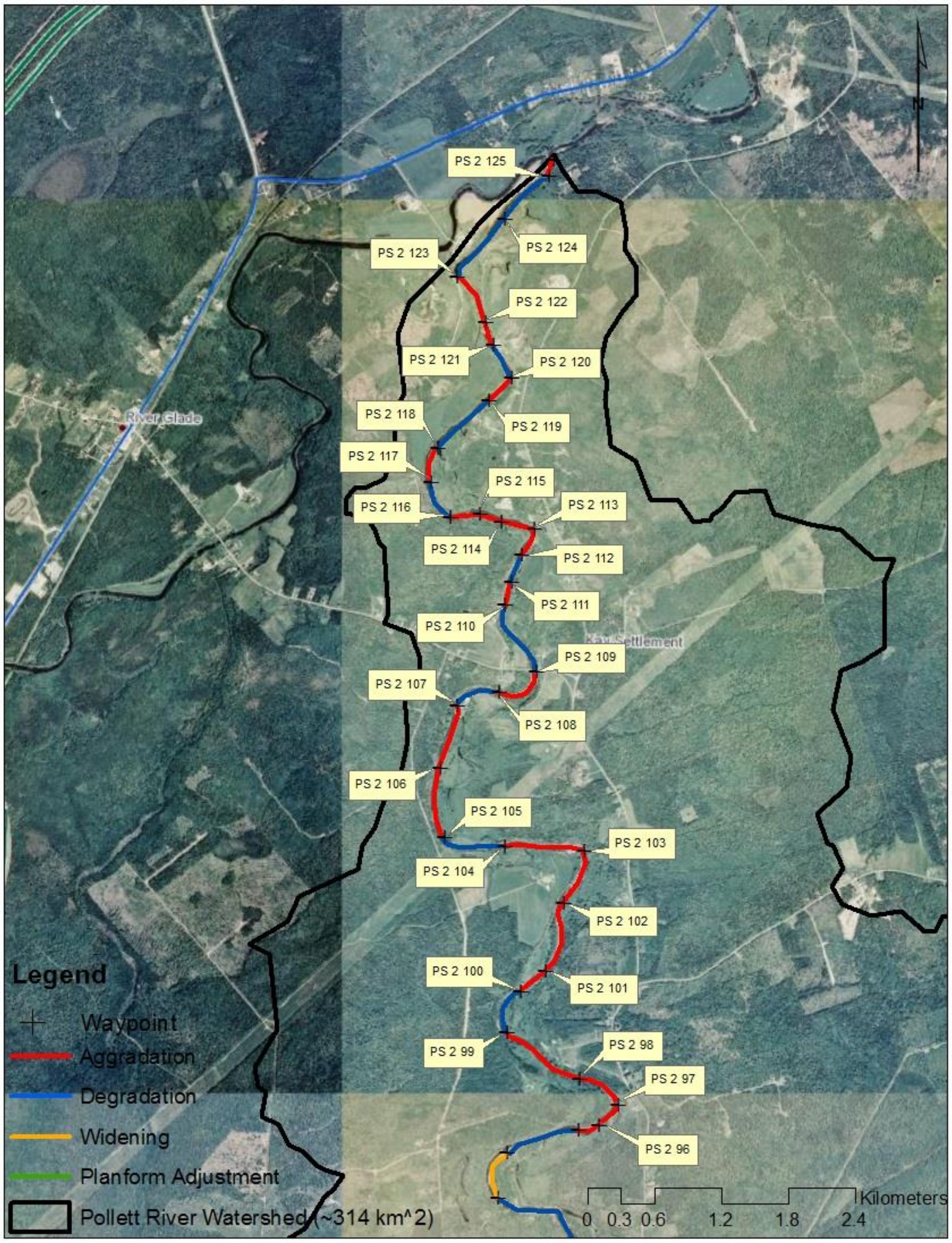


**Figure 3-42:** Primary geomorphic processes for Reach 3 part 4 (sub-reaches PS 2 96 to PS 2 125)

Degradation was again identified as the most common secondary process; with the other geomorphic processes each being identified as secondary processes in some sub-reaches (Figure 3-43).

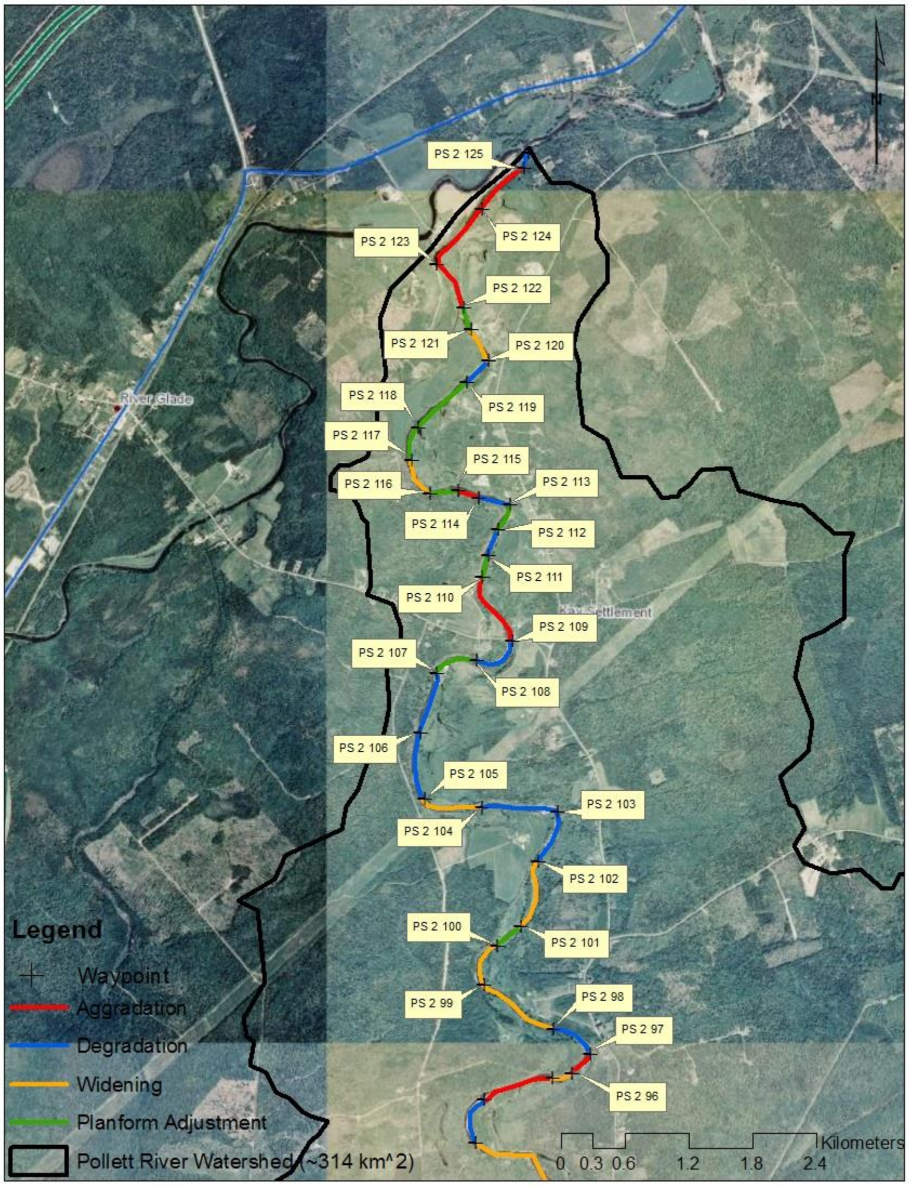


**Figure 3-43:** Secondary geomorphic processes for Reach 3 part 4 (sub-reaches PS 2 96 to PS 2 125)

Being at or near the mouth of the river, these lower sub-reaches are wider in channel widths and have lower grades. As such, this makes them natural areas of deposition for sediments being carried down from upper reaches. Keeping this in mind, any channel or floodplain modifications should be designed with care. Determining bankfull discharge rates and appropriate channel dimensions will be especially crucial for any restoration efforts in these lower sub-reaches.

## Fourth Level Assessment - Aquatic Habitat Rehabilitation Plan

### *Summary of Issues Identified from Geomorphic Assessments*

Aggradation was often identified as the dominant geomorphic process, both in general and in areas of instability, so restoration efforts should focus on reducing sediment sources. Sources of sediment originate along unstable stream banks and degrading stream beds. Stream bank erosion is often a natural process that provides a source of boulders, cobble and gravel for fish habitat. However, when natural levels of erosion are exceeded, fish habitat may be lost and the stream and riparian zone may have difficulty recovering. If landslides/bank failures along a channel are widespread, this is an indication of increased destabilizing processes, such as altered runoff rates. Treatments may not have a reasonable chance of success in these cases and it may not be worthwhile to install localized bank treatments. However, if there are relatively few isolated bank erosion problems, it is probably feasible to stabilize eroding banks. This can be accomplished via a variety of methods using boulder and log structures, revegetation, and removal or relocation of obstructions that are deflecting flow into unstable banks.

**Reach 1: Rt 114 to where Mechanic Lake Brook joins the Pollett (Sub-reaches MLB 2 1 to 2 28)**

Gordon Falls, located in Reach 3, quite some distance below, may be a permanent natural barrier to upstream migration of Salmon into this reach (Elson 1962). As a consequence any activities planned within it should be conducted with that fact in mind when determining how much of a priority they are as compared to those below Gordon Falls. That said, sediment eroded from this reach, can influence conditions downstream.

Identification and control of the sediment sources in this reach should precede any in-stream restoration efforts. Otherwise, the excessive amount of sediments in the system could end up burying installed structures. Possible sources of sediment could be from eroding banks or mobile bed materials, poorly vegetated upslope areas, poorly constructed roads, and poorly managed timber harvests. It has been noted that a large amount of crown timberland and woodland as well as private woodlots exist in the surrounding watershed (GeoNB mapping service). It is important that harvesting activities adhere to existing legislation so that buffer zones maintain their function. The lack of good buffer or riparian zones adjacent to watercourses could lead to increased runoff and larger peak flows. More intense flows have more erosive energy and thus greater potential to carry more sediment. Another potential anthropogenic source of sediment would be at poorly installed stream crossings. Improperly sized or misaligned woods road culverts can lead to erosion of road berms or even road washouts in extreme cases. It would be prudent to ensure that buffer zones and stream crossings on the assessed length of stream and its associated tributaries are in good condition.

Given the many water crossings shown on the tributaries of this reach in Figure 3-7, it is likely to be worth conducting a more systematic inventory of some or all them to assess their condition. While conducting fieldwork work in 2009, The Petitcodiac Watershed Alliance noted excessive sediment load in a tributary of the Pollett that was a consequence of poor culvert installation on a logging road and brought it to the attention of J.D. Irving (Petitcodiac Watershed Alliance 2009). It seems unlikely that this was an isolated situation. In the short term, such a survey is probably the primary activity worth undertaking within this reach. Along it are 14 unpaved and 2 paved water crossings. It is worth noting that above this reach, upstream of Mechanic lake are an additional 4 unpaved and 3 paved crossings, and on another tributary stream an additional 10 unpaved and 2 paved crossings. In reach 2 and the first part of reach 3 are numerous others. Altogether 53 out of the 94 unpaved crossings and 8 of the 47 paved crossings within the watershed are located above Gordon Falls.

**Reach 2: Start of Pollett to Churchs Corner (Sub-reaches PS 3 1 to PS 3 44 & PS 2 1 to PS 2 5)**

Like Reach 1, this reach is also entirely above Gordon Falls, so with regards to Salmon habitat the level of priority assigned to projects within it should be regarded with that context in mind. As with the previous reach, identification and control of the sediment sources in this reach should be the first step towards any restoration efforts. It contains 13 unpaved water crossings and no paved ones.

**Reach 3 Part 1: Churchs Corner to below Elgin near Rt 895 (Sub-reaches PS 2 6 to PS 2 38)**

The first portions of this reach (PS 2 6 to PS 2 22) are above Gordon Falls and subject to the conditions noted in reaches 1 and 2. Additionally, any restoration efforts attempted in the upper sub-reaches of this section should take consideration the very shallow depth to bedrock, where the bedrock often makes up the channel bed and/or banks. In this case, anchoring in-stream or bank stabilization structures will be more difficult compared to areas with a well-established soil layer. Another consideration is the presence of aggradation causing instability in the first sub-reach and immediately upstream of the first sub-reach. This would have to be addressed prior to commencing any in stream works downstream; otherwise the effectiveness of the work could be compromised if the sediments in the upstream sections migrate downstream.

The lower sub-reaches of this section, downstream of the waterfalls, are accessible by salmon, and thus warrant higher priority for work than those above them. These reaches are mostly experiencing instability due to an increase in the bedload as illustrated in Figure 3-31 and Figure 3-32. Restoration efforts should focus on locating the source of the sediment and implementation of strategies such as re-establishment of vegetation via changing land use practises, or bank treatments such as seeding, planting, or possibly slope regrading if banks are severely eroded. Given the large number of land owners in and around Elgin, significant outreach is necessary to identify individuals interested in and capable of undertaking such projects.

Much of the infrastructure for this is already in place in the form of the Pollett River Watershed Project (PRWP). It is an initiative of the Greater Fundy Ecosystem Research Group (GFE) to encourage conservation on private woodlots. Their partner organizations in the project are the Southern New Brunswick Wood Coop (SNB), the Fundy Model Forest, the Kendall Foundation, and numerous private woodlot owners, clustered primarily around Elgin (Steeves et. al 2007). They already have established a Watershed Management Plan for the Pollett River (Betts et al. 2002) that among other things examines and encourages water course buffers in relation to timber harvesting. As noted in Figure 3-33 there is significant aggradation immediately downstream of Elgin. Identifying partners amongst these land owners who are willing to undertake projects to improve buffer zones in this section of river as well as in adjoining tributaries will help meet the need for identification and control of the sediment sources. With regards to water crossings within this reach, there are 18 unpaved (6 of which are above Gordon Falls) and 13 paved (4 of which are above Gordon Falls).

**Reach 3, Part 2: Below Elgin near Rt 895 to Parkindale Bridge (Sub-reaches PS 2 39 to PS 2 67)**

Unstable sub-reaches should be handled appropriately as outlined in previous sections, whether by mitigating erosive forces with stabilization of the grade and/or providing floodplain access for degrading sections or identifying and controlling sediment sources for aggrading reaches. There are 21 unpaved water crossings in this reach, and 16 paved ones. As noted in reach 3 part 1 the large number of small land owners creates some complexity, but also opportunity for partnerships. Additionally the fact that this portion of the river is accessible to salmon makes projects here a higher priority than further upstream.

Other in-stream work here could include channel restoration along widening sub-reaches and should be designed to narrow the channel by accumulating sediments towards the banks. The benefits of channel restoration are: reduced erosion rates, improved water quality and aquatic habitat, increased food web productivity, and overall improvement of the aquatic ecosystem.

Examples of potential projects are brush matting, upstream-V log weirs, and double tree deflectors. Brush mats promote sediment accumulation on point bars and help to narrow and stabilize the stream channel. Upstream-V log weirs are used to scour pools on the downstream side and accumulate gravel on the upstream side. They also direct flows away from the banks, narrow the stream channel and can provide better access to the floodplain. Like the Upstream-V log weir, double tree deflectors are designed to narrow the channel and concentrate flows near the center. They also promote sediment deposition and provide habitat diversity. However care would need to be taken to ensure that such in-stream structures intended to improve stream habitats do not create scour along banks, particularly where the channel is also experiencing degradation. Log wing deflectors provide one means of directing flow away from an unstable bank and holding soil in place. It would also be important to be aware of recreational users along the Pollett in this portion of the river in particular as it experiences significant traffic, particularly during the Pollett River Run. In-stream projects here must be designed and constructed to avoid creating hazards, either real or perceived ones.

**Reach 3, Part 3: Above Parkindale Bridge to The Glades (Sub-reaches PS 2 68 to PS 2 95)**

In terms of interventions, there is little to distinguish this portion of the river from reach 3 part 2 immediately upstream. Once again, sediment sources need to be identified and controlled prior to installation of any in-stream structures so as to not jeopardize the work. There are 11 unpaved water crossings and 7 paved crossings. This is the bottom portion of the Pollett River Run, with most participants exiting the river along this reach. Pollett River Run debris is also significant along this section, and it will be part of the 2014 clean up. Fewer of the landowners along this section are participants in the Pollett River Watershed Project, which suggests that there may be less opportunity here for partnership on projects, or in the very least a need for more outreach, as the distance from Elgin could be a factor.

**Reach 3, Part 4: The Glades to confluence with Petitcodiac (Sub-reaches PS 2 96 to PS 2 125)**

Along this section there are 3 unpaved crossings and six paved crossings. Being at or near the mouth of the river, these lower sub-reaches have wider channel widths and lower grade. That being the case, they are natural areas of deposition for sediments being carried down from upper reaches. Like the reaches immediately upstream there are few participating land owners in the Pollett River Watershed Project along this portion of the river, so additional public outreach in these communities will likely be required.

## *Restoration Activities Undertaken*

**Pollett River Run Clean up**

Significant quantities of debris were in the river from Reach 3 Part 2 on downstream as a consequence of the Pollett River Run which occurs here each year the last weekend in April. Participants launch homemade boats in the midst of the spring freshet, and encouraged by a bit of alcohol, try their luck on the river. As a consequence numerous bits and pieces of wrecked boats are typically scattered along the river. The debris left behind is a hazard or at very least an eyesore for all other river users. In 2014 Fort Folly Habitat Recovery conducted a clean-up of River Run debris along the Pollett. The timeline; map of areas affected (Figure 3-44); debris photos (Figure 3-45); and debris removed (Table 3-3) are listed below.

April 26, 2014 – Pollett River Run took place.

May 6, 2014 – Installation of Pollett River smolt wheel. From this point we were collecting flotsam, presumably washed down from the River Run. Garbage collected was stored at nearby gravel quarry.

May 15, 2014 – Upper fyke net installed. Vigilance required to stop flotsam from damaging equipment

May 21, 2014 – Barrier fence erected. Barrier fence was knocked down by an abandoned raft in 2013.

June 9, 2014 – Last day of fishing smolt wheel

June 10, 2014 - FFHR crew canoed River Run length, picked up small garbage, assessed abandoned rafts to determine methods and tools needed to dislodge and then float rafts to access points such as bridges, old trails and camps where the garbage can be loaded onto pickup trucks for removal.

June 17, 2014 –FFHR & PWA crews using 2 canoes float from Beaman pool to the smolt wheel site. Noted large debris sites, assessed abandoned rafts, and picked up smaller garbage along the way

June 18, 20, 25, 27, 2014 – Using canoes, the 5 person FFHR, PWA team dislodged and floated large debris, mainly abandoned rafts to access points for removal.

June 19, 23, 24, 2014 – FFHR crew, used canoes continue to collect garbage from the river and move to temporary dump site.

June 26, July 2, 3, 4, 2014 – FFHR crew used hand tools, come along and chain saw to dismantle rafts and load pieces for removal to temporary dump site.

July 7, 8, 9, 2014 - FFHR crew conduct final inspection and litter clean up with canoes. Cover the entire length from Elgin to the mouth of the Pollett, and then continue down the Petitcodiac to the head of tide at Salisbury.

November 14, 17, 18, 19, 2014- FFHR crew sort debris, separating construction material from landfill garbage. Debris taken to local solid waste facility. Total of 2,170 kg removed.

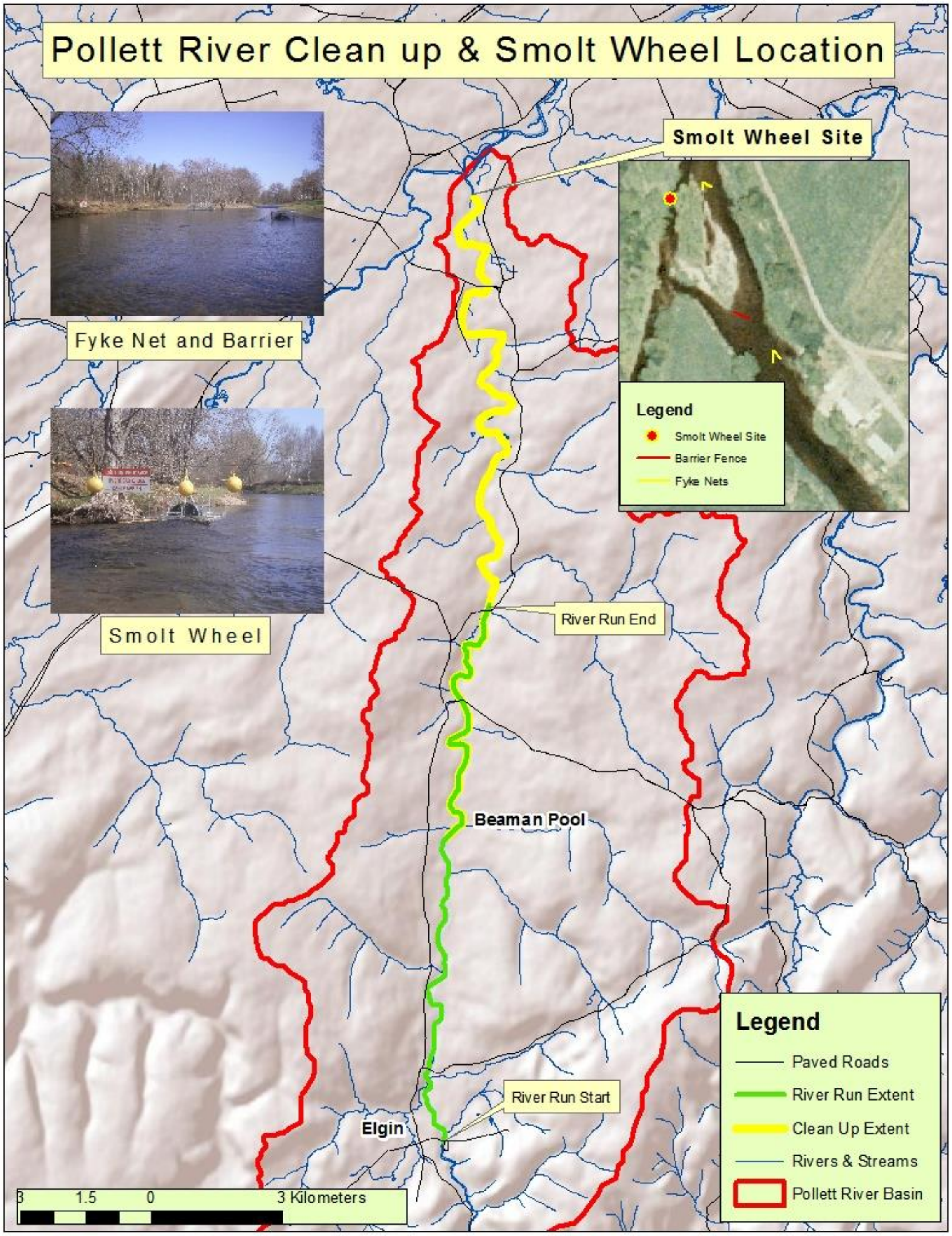


**Figure 3-44:** Pollett River Run, and extent of area cleaned it its aftermath in 2014

**Figure 3-45:** Pollett River Run Debris Photos

**Table 3-3:** Pollett River Run Debris Clean up in 2014

| Date | Weight by Destination (kg) | | Tipping cost ($) | Notes |
|---|---|---|---|---|
| | Construction | Landfill | | |
| Nov 14 | 220 | | $5.50 | Wood, car grill |
| Nov 17 | 260 | | $6.50 | Wood |
| Nov 17 | 350 | | $8.75 | Wood |
| Nov 17 | 330 | | $8.25 | Wood |
| Nov 17 | | 80 | $5.75 | 6-50 gallon drums, 2-20 gallon drums |
| Nov 18 | | 110 | $7.92 | 1 raft, cooler, stereo, backpack, 2 chairs |
| Nov 18 | | 120 | $8.64 | 4-50 gallon drums |
| Nov 18 | 200 | | $5.00 | Wood |
| Nov 18 | | 180 | $12.96 | 6 folding chairs, 2 office chairs, ottoman, 1-50 gallon drum, 3-20 gallon drum, BBQ frame, 6 bags of miscellaneous garbage |
| Nov 19 | 320 | | $8.00 | Raft |
| Total kg | 1,680 kg | 490 kg | | |
| Total $ | | | $77.27 | |

**Debris cleared from culverts**

During the course of the 2014 culvert surveys, several candidates were identified for immediate action. Removing debris build-up is a simple and effective way of improving fish passage. All four debris removals were completed in the Pollett River basin. The first removal effort was conducted at the inflow of Culvert C012 (Figure 3-9) on Colpitts Brook. In order to improve fish access to approximately 7 km of upstream habitat in length and 31.43 km² in area, 3 trees were removed and placed above the high water mark (Figure 3-46).


**Figure 3-46:** Before and after photos of C012, located where Kaye Road crosses Colpitts Brook.

A second debris removal took place upstream of triple culvert C021-ABC, where willow growth had choked off the watercourse to the extent that it was scarcely visible (Figure 3-47). Willows were removed to enable fish passage to 6 km in length and 12.42 km² of upstream habitat


**Figure 3-47:** Before and after photos of culvert C021-ABC, where Church Hill Road intercepts Sheffer Brook.

The third debris removal took place at culvert C022-ABC approximately 3 kilometers upstream of triple culvert C021-ABC. Debris build-up was removed from the inflow of the middle culvert (Figure 3-48), allowing fish improved access to 9.27 km² of upstream habitat.


**Figure 3-48:** Before and after photos of C022-ABC, located where Church Hill Road intercepts Sheffer Brook

Two large trees were removed from the inflow of culvert C041, located where an Irving logging road intercepts the Popple-Intervale Brook. 7 km in length and 27.23 km² of upstream habitat was made more accessible for aquatic species.


**Figure 3-49:** Before and after photos of C041, where an Irving logging road crosses the Popple Intervale Brook.

**Van De Brand Property**

Anthony and Wanda Van De Brand own a farm, located at the mouth of the Pollett (Figure 3-50), which had a streambank that was experiencing significant erosion and threatening a cultivated field. That site, located in Reach 3, Part 4 was defined over all as "in regime" (Figure 3-41). The primary geomorphic process there is aggradation (Figure 3-42), and the secondary geomorphic process is degradation (Figure 3-43). Figure 3-51 illustrates the erosion occurring on the site prior to intervention.

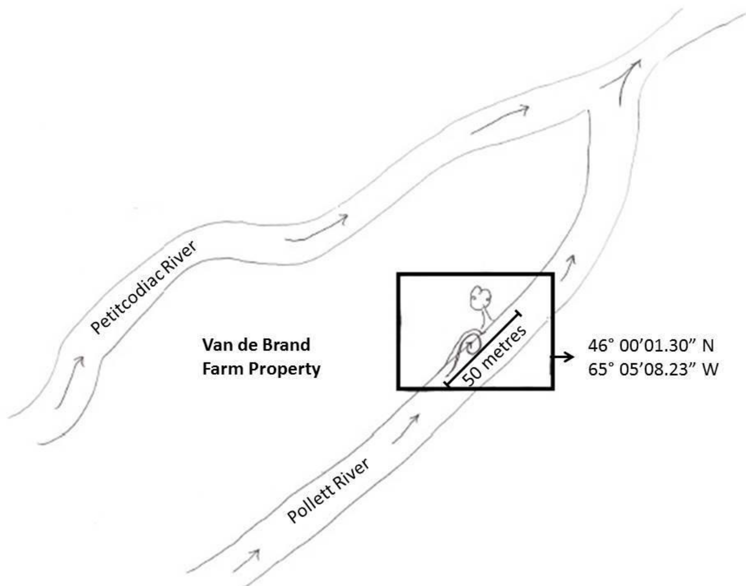


**Figure 3-50:** Location of Van de Brand project

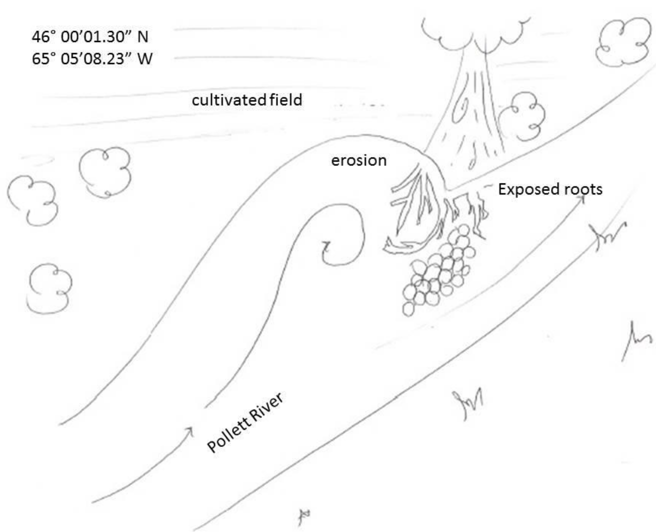


**Figure 3-51:** Site prior to stream bank stabilization

Initially 25 tonnes of large rock were installed at the site (Figure 3-52). That was not intended to be the full project, though, the results of this initial were briefly monitored, prior to proceeding. It became clear that erosion was continuing and so prior to final planting, additional rock was required. A total of an additional 100 tons of smaller rock was then added to the site (Figure 3-53), after which 100 Silver Maples and 4,000 live willow stakes were planted.

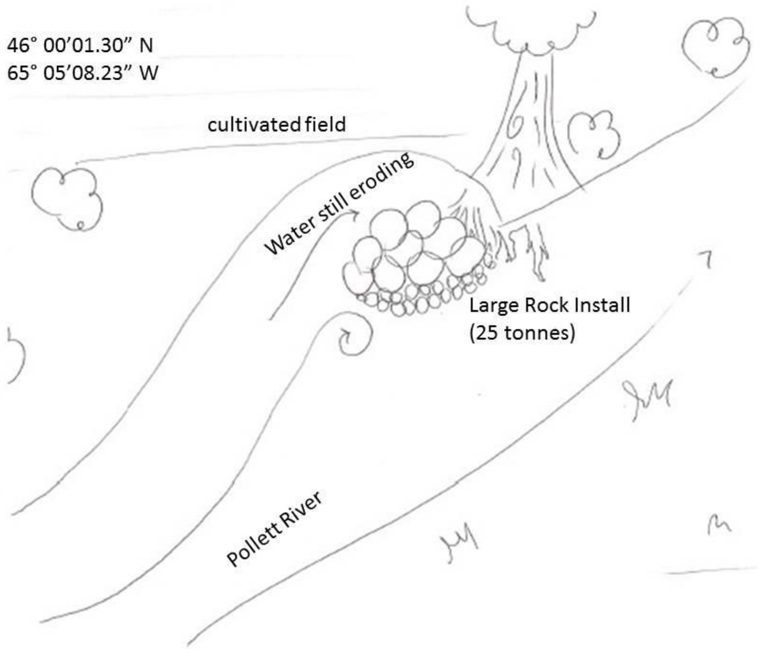


**Figure 3-52**: First riprap installation

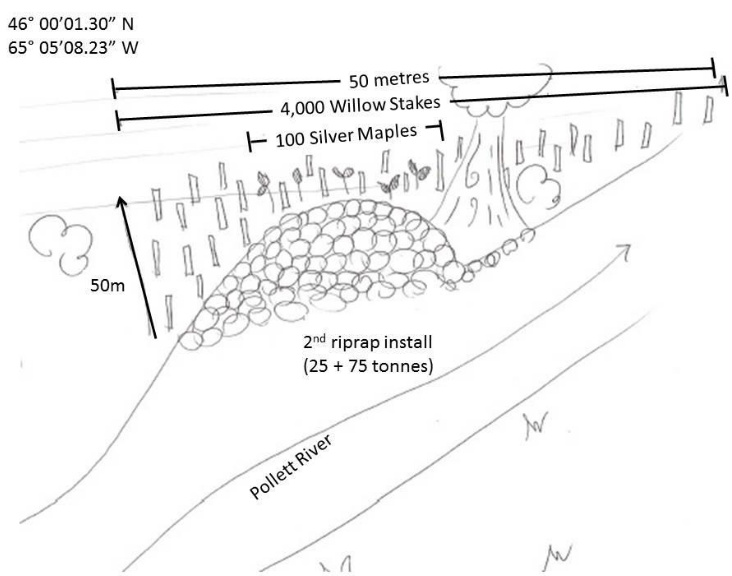


**Figure 3-53:** Second riprap installation, and planting with silver maples, and willow live stakes

### *Opportunities for Future Restoration Activities*

The 2014 Pollett River Run debris clean-up was deemed to have been a worthwhile activity, not just in terms of protecting research equipment such as the fyke nets, smolt wheel, and fish net trap downstream, but also in terms of improved state of the river itself. In 2015 Fort Folly Habitat Recovery and the Petitcodiac Watershed Alliance will be cooperating to raise awareness during the Pollett River Run, encouraging participants to reduce their impacts and remove their own debris. Public Service Announcements will be run on Radio Station XL 96 prior to the event. A dumpster will be provided at take out location at the end of the run, and one or more canoes will be in the river, participating in the run itself. After the run there will no doubt still be debris in the river to be cleaned up and a process like the work done in 2014 will be implemented. This will likely become an annual activity.

Beyond that, identification of sources of sediment within the watershed is an important first step in order to develop further priorities for specific action. As a result of the geomorphic work the in-stream sources of sediment from reaches experiencing degradation along the main stem of the Pollett are now known. Completion of the inventory of water crossings, particularly in the upper reaches of the watershed where the majority (77%) of the crossings of tributaries are unpaved would be a useful addition to that. There are 62 water crossings that have been identified in the GIS layer that have not yet been assessed. Due to equipment constraints, (need for ATV) 37 of these were not located either because they were deemed inaccessible, or in some cases they may not have been found because they do not exist, possibly identified in error due to errors in the road and water layers of the GIS. There was not an attempt in 2014 to locate the other 25. So completion of the survey (with an ATV) would be useful in order to fine tune the list and properly rank priorities. The state of watercourse buffers along such tributaries ought to be assessed by the same crew at the same time.

In 2014 the work done with culverts found 4 that were partial barriers and 21 that were full barriers to fish passage. Of these, 2 of the partial barrier culverts (C022 and C041) have already been addressed (Figure 3-9) through the work described above. The remaining 23 should be ranked in order prioritize them (by factors such as complexity of repair (due to either technical or landowner issues), upstream habitat made accessible, etc.). Then starting with those where action is most practical & beneficial they should modified as needed to make them no longer barriers to fish passage.

A second step is undertaking closer interaction with the Pollett River Watershed Project in order to facilitate contact with stakeholder groups, and build upon the work that the PRWP has already done, and the existing networks of landowners they have established within the community. This will minimize duplication of effort, and perhaps provide opportunities to join in on the implementation of priorities and projects that they have already identified.

Once the worst problem sites are known, and willing landowners have been identified as partners then the third step would be to work with such individuals on bank treatments such as revegetation to improve watercourse buffers, or upgrading inadequate water crossings. Both of these activities will help to reduce the rates at which sediment and runoff are entering the river. Downstream of Gordon Falls fish passage at these crossings would also be a concern, but up stream of the falls passage should be considered less of a priority. Development of such contacts should allow access to conduct in-stream work along sites where degradation is occurring, as landowners are likely to favor projects like log wing deflectors to protect their property, and may have resources such as money, labour, or machinery to contribute.

This is also the point where more ambitious in-stream projects such as brush matting, upstream-V log weirs, and double tree deflectors are likely to become practical. Specific information about such projects would be premature, as precise needs and sites have yet to be determined. When it is time to develop and implement those projects, Melanson et al. (2006) note that interventions must be properly designed by trained individuals spending several days doing a proper layout. Structures not sited properly are unlikely to produce the desired improvements to habitat, instead becoming buried, washed out, or creating worse problems than were present prior to installation. The presence of threatened and endangered species (salmon, eels, and wood turtles) in the watershed also means that such projects must be planned and implemented with awareness of the vulnerabilities of these species. Fort Folly Habitat Recovery has developed project checklists (Appendix A) based on species biology to provide guidelines to help avoid or minimize the risk of negative impacts.

## NORTH RIVER

The North River flows entirely within Westmorland County, New Brunswick. Its headwaters begin north of Moncton near the bases of Lutes Mountain and Indian Mountain, from which it drains from northeast to southwest, ending where it and the Anagance River come together, near the Village of Petitcodiac, to form the main stem of the Petitcodiac River. The North River watershed covers 264.8 km2, making it the third largest tributary within the Petitcodiac River system. Its drainage area lies almost exclusively in the Eastern Lowlands Ecoregion (New Brunswick Department of Natural Resources 2007). The river has low gradient, dropping just 80 metres along the 49 kilometers from its headwaters near Route 126 to its confluence with the Anagance (Natural Resources Canada 1997; Natural Resources Canada 2008). From the communities of Monteagle to Second North River, the river is characterized by very low flow rates, huge log jams and grassy beaver meadows. It is a highly convoluted, meandering river

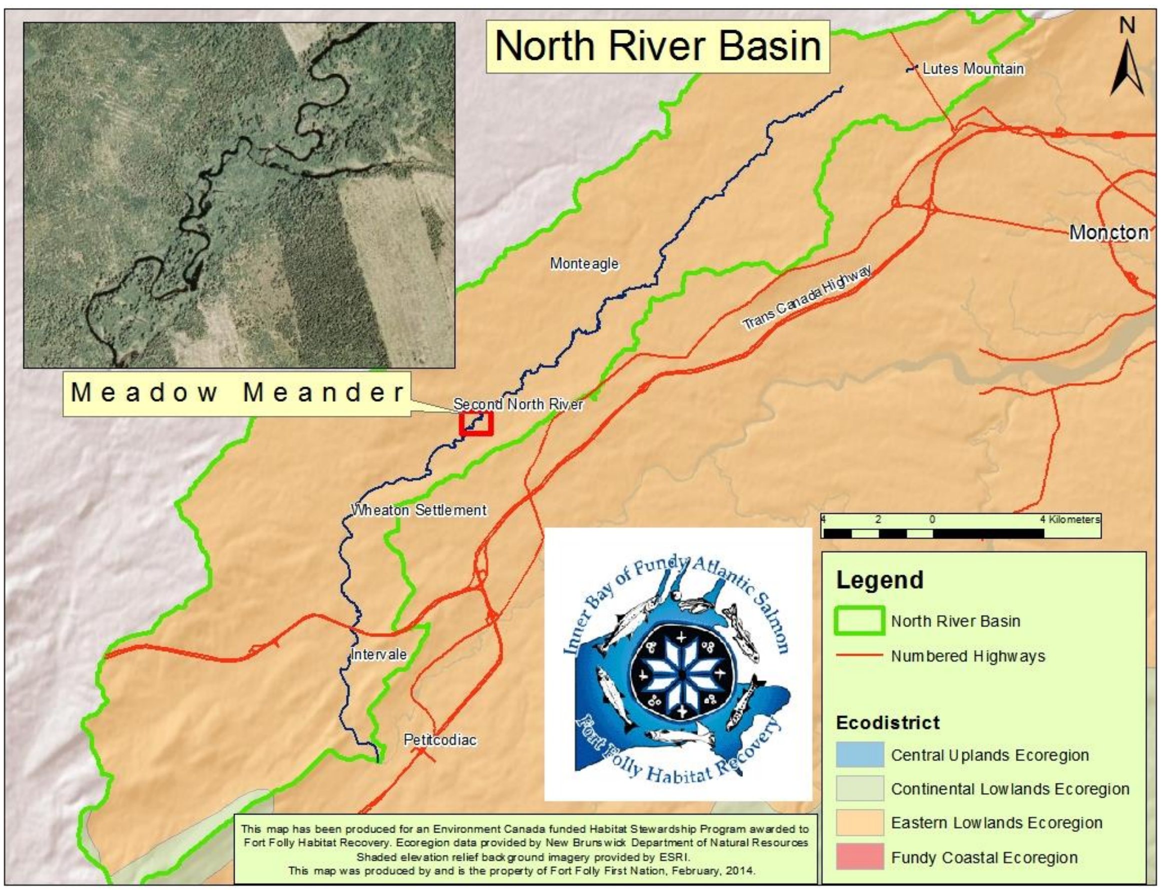


**Figure 4-1:** North River watershed

with numerous oxbows and deep calm pools. It is known as a trout producing river. There are no known historic salmon angling pools on the North River. In addition to its main stem, named tributaries of the North River include: Bennett Brook; Blakney Brook; Blakeney Brook; Killiam Brook; Lewis Mountain Brook; McLeod Brook; Mongomery Brook; Salt Springs Brook; and Walker Brook (Natural Resources Canada 1997; Natural Resources Canada 2008).

Unlike other tributaries of the Petitcodiac, the name of the North River appears to be rather self-explanatory. The North effectively defines almost the entire northern portion of the Petitcodiac River watershed, draining in a southwesterly direction, a short distance north of the main stem of the Petitcodiac. Where it and the Anagance meet (and the main stem of the Petitcodiac begins) the channel then curves, heading back in an easterly direction before bending again at Moncton, and heading southeast into Shepody Bay.

**Figure 4-2:** Log jam

## First Level Assessment – Land Use History of the Watershed

An understanding of the historical land use in a watershed has the potential to help explain the underlying cause of issues present in a watershed. The following outlines historical land use in the areas surrounding North River in Westmorland County. Communities in the area surrounding North River include: Dobsons Corner; Fawcett Hill; Indian Mountain; Intervale; Lewis Mountain; Lutes Mountain; Petitcodiac; River Glade; Steeves Mountain; Second North River; and Wheaton Settlement.

**Table 4-1:** Brief historical background summary for communities bordering North River, NB.

| Community | Settlement Type and Dates | Points of Interest |
|---|---|---|
| Dobsons Corner *(North River)* | Settled: Not Available<br>Farming | **1898** population 25, post office |
| Fawcett Hill *(North River)* | Settled: prior to 1832<br>Farming | **1898**: population 50, post office, railway siding on the Elgin, Petitcodiac and Havelock Railway |
| Indian Mountain *(North River)* | Settled: 1840<br>Farming and lumbering | **1898** population 150, 1 post office |
| Intervale *(North River)* | Settled: Not available<br>Farming | **1898** population 30, was a siding on the Elgin, Petitcodiac and Havelock Railway, post office |
| Lewis Mountain *(North River)* | Settled: Not Available<br>Farming | **1898** population 75, post office, 1 church |
| Lutes Mountain *(North River)* | Settled 1811 by Lutes family<br>Farming | **1866**: farming community<br>**1898**: population 500, post office, 1 store, 1 grist mill, 1 shingle mill, 1 cheese factory, 2 churches |
| Petitcodiac *(Petitcodiac River)* | Settled: 1786 by Blakeney family<br>Farming and lumbering | **1898** population 700, Station on Intercolonial Railway, central depot for The Elgin, Petitcodiac, & Havelock Railway, post office, 6 stores, 2 hotels, tannery, sawmill, carriage factory, furniture factory, 4 churches |
| River Glade *(Petitcodiac River)* | Settled: Not Available<br>Farming and lumbering | **1898** population 75, post office, store, sawmill, station on the Intercolonial Railway |
| Steeves Mountain *(North River)* | Settled 1812 by Steeves family<br>Farming | **1904** population 100, post office |
| Wheaton Settlement *(North River)* | Settled: 1803 by Daniel Wheaton<br>Farming | **1898** population 120, post office, 1 church |

(Source: Provincial Archives of New Brunswick, 2015)

The Maritimes have had human inhabitants for the last 11,000 years (Wicken 2002), though for most of that time precise cultural identities are impossible to determine today. By the early 1600s, when Europeans arrived, much of the native population of coastal Atlantic Canada shared a common culture and language identifying themselves as the L'nuk, "the People", and recognized by Europeans as the Mi'kmaq. Traditionally, the Mi'kmaq lived in large villages along the coasts from April to November, and then dispersed during the winter, migrating inland to hunt moose and caribou. During this time physical impacts on the watershed were few compared to what was to follow.

Ganong's (1905) map of known First Nations villages and campsites includes a Mi'Kmaq site downstream of the North River at Salisbury located along the north bank of main stem of the Petitcodiac, near the head of tide between the mouths of Little River and the Pollett River. A native leaving Beaumont (where there was another camp in the lower Petitcodiac estuary) could ride the 13 km per hour tidal bore upstream to Salisbury, greatly facilitating such travel (Petitcodiac Heritage River Committee 2000). The importance of the Salisbury encampment was due to its location both at the head of tide and near the ends of a pair of portage routes leading to the Saint John River system. The more highly traveled of the two routes crossed from the main stem of the Petitcodiac River to the Canaan River (Ganong 1914) downstream of what is now the Village of Petitcodiac, as doing so provided the best access to the upper St. John and on to the St. Lawrence (Petitcodiac Heritage River Committee 2000). The other route crossed from the Anagance River, to the Kennebecasis River (and from there to the lower portion of the Saint John River system). In fact the name Anagance comes from Maliseet "Oo-ne- guncé" meaning portage (Ganong 1896), presumably a reference to the link provided by that tributary.

In the 1630's the French began to make a serious effort to colonize Atlantic Canada, beginning to arrive in numbers significant enough to develop an enduring Acadian identity (Laxer 2006), at a fairly similar time frame to the English colonies further south. By 1676 the first Acadian settlers arrived at Beaubassin, near the current Nova Scotia Visitor's Centre along the Trans-Canada Highway at the New Brunswick border (Larracey 1985). Then, 34 years later in 1710, Acadians and Mi'kmaq in peninsular Nova Scotia fell under British control, which was subsequently formalized in 1713 under the treaty of Utrecht. In 1751 Fort Beausejour was built at the border to protect Acadian communities in what is now New Brunswick from attack by the British. By this time the Acadian population near the Fort had grown to 1,541 people, with an estimated additional 1,100 spread out at Shepody and along the Petitcodiac and Memramcook Rivers (Larracey 1985). The Acadians built dykes and tidal control structures turning marshland along the lower Petitcodiac estuary into pasture, and established their settlements nearby (Wright 1955). Their physical impacts on the North River, what for them was a remote hinterland, were limited.

Ganong (1899) notes that like First Nations, the French made use of the Kennebecasis-Petitcodiac portage along the Anagance in order to maintain communication between Fort Beausejour and Acadian settlements on the lower St. John. However the French route between the Canaan and the Petitcodiac to access the upper St. John was slightly different than the one favoured by First Nations. They went further upstream, proceeding into the North River before crossing overland to the Canaan, rather than starting their portage on the main stem of the Petitcodiac, and then crossing over the North River (as First Nations tended to do) on their way to the Canaan (Raymond 1891). From there messengers from Fort Beausejour, and the Fortress of Louisbourg passed up along the St John to reach Quebec.

After the fall of Fort Beausejour in 1755, the British attempted to expel the Acadians, to open up land for English settlers. There is a record of an Acadian settlement, Village Victuare, downstream of the North River in Salisbury, near to the Mi'kmaq encampment there (Ganong 1930). It was documented in 1758 by British Major George Scott as he was forcefully removing Acadian families from the upper Petitcodiac (Scott 1758). The village appears to have been composed of approximately 10 homesteads, settled in about 1751, and was reportedly the largest Acadian village along the Petitcodiac upstream of Beausoleil Village, modern day Allison. Ganong (1930) suggests that it is likely that in the wake of the expulsion, Acadians briefly occupied locations such as Fourche-à-crapaud at the mouth of Turtle Creek, and on the Coverdale (Little), and Pollett Rivers in order to be near the head of tide and thus above the reach of English Ships. Major Scott apparently found the tidal bore on the Petitcodiac problematic during his raids in 1758, nearly losing two ships on one occasion (Pincombe and Larracey 1990). Presumably the North River, being remote and not particularly navigable, served as little more than a portage route for Acadians during this time.

The Mi’kmaq sided with the French (Wicken 2002), participating in the defense of Fort Beausejour, as well as the short guerilla war which followed its capture (Grenier 2008). There were several reasons that Mi’kmaq in New Brunswick did so. Prior to the arrival of the British, native communities had already established trade networks with the Acadians for steel tools, weapons and other European goods (Walls 2010). Another source of friction was that the Mi’kmaq had begun to adopt Catholicism from the French, while the British were Protestants, at a time when such differences added fuel to conflicts. Acadians also had had good relations with the Mi’kmaq in part because the lands Acadians occupied either complemented native use, as with fur traders, or were in areas that were marginal to native concerns as in the case of the Acadian farmers on the tidal flats (Mancke 2005). English settlers on the other hand tended to seize land the Mi’kmaq valued, to clear the forest for agriculture (Francis et al. 2010).

The dates that various communities listed in Table 4-1 were first settled (where available) indicate how movement by English colonists into the upper reaches of the Petitcodiac River system above the head of tide occurred first along the more easily accessible main stem, and occurred progressively later the further into the upper reaches one goes. Many of the early dates coincide with the arrival of United Empire loyalists from the 13 colonies (late 1770's - 1780's). After the arrival of the Loyalists, Mi’kmaq in what is now New Brunswick were moved off their lands and onto "reserves" (Walls 2010). This was done partially to provide land to incoming settlers, and partially to punish the Mi’kmaq for aligning themselves with the French. Subsequent generations of English settler families and those that arrived after them then pushed further up the Petitcodiac and into its more remote tributaries such as the Little River, and the Pollett River (Wright 1945).

Given the technology available to early English settlers, there are two important differences between the North River and both the Little and Pollett. The first difference is that while the latter two flow north into the Petitcodiac roughly perpendicular to the main stem, the North flows predominantly southwest, somewhat parallel to the northeasterly flow of the Petitcodiac, offset by a short plateau of land between it and the main stem. As a result the headwaters of both the Pollett and the Little become progressively more remote the further up one goes in them, as much as 30 km overland and 40 to 50 km upstream, while the entire watershed of the North is much more easily accessible. Though its headwaters are a similar 40 to 50 km upstream, the North runs for its entire length not much more than 10 kilometers (often less) overland away from the main stem of the Petitcodiac (Natural Resources Canada 1997; Natural Resources Canada 2008). The second difference is the soil and climate of the North River. While the Little and the Pollett travel a relatively steep gradient downstream starting in the Central Uplands Ecoregion, then descending into the Continental Lowlands Ecoregion, and finally ending in the Eastern Lowlands Ecoregion, the North River is relatively unique in that it flows entirely within the Eastern Lowlands Ecoregion (New Brunswick Department of Natural Resources 2007).

So in addition to being much more accessible throughout its entire length than either the Little or the Pollett, the soils and climate of the North River are on average better suited to agriculture. As a result it appears that English settlers tended to spread overland from the main stem of the Petitcodiac into the North River watershed, rather than up along it’s (often not very navigable) channel. For example Wheaton Settlement, 14 kilometers upstream of the Village of Petitcodiac along the North (5 kilometers overland from River Glade) was settled only 7 years prior to Lutes Mountain in the headwaters, more than 50 kilometers up stream of the Village of Petitcodiac (but only 12 kilometers overland from downtown Moncton (which Lutes Mountain is now a part of)).

## *Forestry Practices*

The relative inaccessibility of the Petitcodiac stood in contrast to the Saint John River, as the comparative lack of long easily navigable tributaries within the Petitcodiac system discouraged commercial logging activities until the mid-1800s (Department of Natural Resources 2007). Instead early settlers cleared the land to allow for agriculture, locally consuming cordwood for fuel, and lumber to build their homesteads, while generating only limited income by selecting marketable timber to send downriver to be sold for shipbuilding or export. As time progressed the latter gradually became a more significant aspect of the local economy. Timber harvest in the Petitcodiac timber district as a whole grew from 260 tons in 1818 to 3,137 tons by 1836 (Wynn 1981), though this paled in comparison cutting in other more accessible portions of the province such as in numerous timber districts along the Saint John and Miramichi Rivers where harvests taking place at the same time were in some cases an order of magnitude greater.

During the early 1800s white pine was gradually culled from New Brunswick Forests to meet the demand for masts for the Royal Navy (Wynn, 1981). The White Pines Act of 1722 established the requirement of a royal license to fell white pines with a diameter exceeding 24 inches unless they were privately owned, and in 1729 Parliament reserved all such trees to the government except those already in private hands before 1690 (Purvis 1999). Since New Brunswick came under British control well after that time, this exception did not apply at all to its forests. During the American Revolution and the Napoleonic Wars from 80 to 90 percent of all masts supplied to the Royal Navy came from Canada, mostly New Brunswick (Williams 1992). The Napoleonic blockade of the Baltic forced England to expand New Brunswick's lumber production twentyfold, transforming an "undeveloped backwater" of 25,000 people to a bustling colony of 190,000 (Gordon 2014). Pines could still be found in 1850, but few of the magnificent trees the region was known for earlier in the century remained. Spruce was more abundant, but the largest had also been cut. Though there were not many extensive cutover tracts, by 1850 the character and composition of the forests in New Brunswick had been drastically modified over the course of just 50 years of harvesting.

The effects of this early economic activity were not limited to just the forests. By 1820 importation of food into New Brunswick was the rule rather than the exception, everything hinged on the timber trade, though there were warning signs of the danger of single source economy (DeMerchant, 1983). James Robb, professor of Natural Science at Kings College in Fredericton (now the University of New Brunswick), was appointed Secretary of the Provincial Board of Agriculture when it was established in 1858. He warned that timber harvesting was so lucrative that it distorted development, and that when the market in Europe declined, the farmer neglecting his homestead to work in the woods would be "surprised to find his fences down, his fields grown up with bushes, and both himself and his snug little clearing generally all gone bad". It was not just agriculture that was falling short of its potential. In the years that shipbuilding boomed at St. John and other towns along the coast, even the fishing industry was neglected as men were drawn to the forest to supply wood (DeMerchant, 1983).

To take advantage of the culled mixed forests during this time, many milling operations sprung up and some communities that had begun as a farming settlements developed into lumbering communities. The first mill in Petitcodiac was a grist mill in 1820, built by Humphrey Hayward, that would later be followed by a carding mill and sawmill owned by the same man (Burrows 1984). It was built on Hayward Brook and the settlement that built up around the mill, Hayward Settlement. The Jacknife Sawmill was in operation by 1833 in Petitcodiac, and a spool manufacturing plant by 1868. Mills were often operated by water, most likely from the river itself or its tributaries. Other milling operations in Petitcodiac included the Petitcodiac Lumber Company on the North River, and the Humphreys and Trites Mill on the mouth of the Anagance and North Rivers.

By 1860 the European and North American Railway linked Saint John and Moncton, passing near the mouth of the North River, through Petitcodiac Village (New Brunswick Railway Museum 2015b), at the time known as Humphrey Corner (Village of Petitcodiac 2015). It's route followed the Kennebecasis / Anagance / Petitcodiac watersheds, similar to the old First Nation and French portage route. Fuel for the engines was cordwood in three to four foot lengths purchased from farmers along the line (Stronach 1969). Farmers received "tokens" (redeemable for cash) for wood used by the railway company from piles placed along the track at designated locations. Petitcodiac Village itself served as a hardwood fueling station, and a lumber shipping station that would have rivaled larger cities of the time (Burrows 1984).

At that point the age of wooden ships was beginning to wind down however, causing a reduction in the scale of the demand for timber exports both as wood and manufactured into ships. By the end of the Crimean war in 1856, virtually all of the ships in the British Royal Navy were already fitted with steam engines rendering masts irrelevant (Evans 2004), and the conversion to iron hulls began within a decade thereafter.

A non-timber forest product that was commercially significant was maple sugar. Some of the lands bordering the North River were converted (perhaps by fire) to sugar bushes (Plummer 2013). Though the precise years of his bottling operation are unknown, Arthur Briggs (born 1852, died 1936) spent years producing and selling Maple syrup at Stilesville just north of Lutes Mountain (Briggs Maples 2015), along the divide between the North River and the Shediac River (Natural Resources Canada 2008). Early on, birch from local trees was used to make pots to transport their product in to town. They also used these timber by-products as molds for maple sugar candy (Plummer 2013).

## *Agricultural Practices*

As noted in the timber section, before crops could be planted settlers were faced with cutting and clearing the forest. Stumps were often left a few years to rot, and crops were sown amongst them (DeMerchant, 1983). Early English settlers, like the Blakeneys who settled the Village of Petitcodiac in 1786, would have cleared the land and planted gardens that they may have later expanded to crop fields (Burrows 1984). In Perley's (1857) Handbook of Information for Emigrants to New Brunswick, he suggests that "No emigrant should undertake to clear land and make a farm, unless he has the means of supporting his family for 12 months." However, it was not just a matter of the financial resources of individuals. Since in the early 1800's the province as a whole was not self-sufficient agriculturally, it is unlikely the communities along the North River were either. However, given the logistical challenges of transporting food to remote homesteads, it is doubtful that importation of food was as practical as in urban centres. More likely for the early settlers, subsistence agriculture was supplemented with food available from the forest and river. The area surrounding North River, especially the New Canaan District was famous for its moose hunting (Burrows 1984). There are historic records of salmon in the North River (Dunfield 1991), and extensive fishing dating back to early settlement. Even as late as 1876 fishing regulators noted that farmers devoted a significant portion of their time to fishing salmon, with most of the entire catch being used for home consumption (Commissioner of Fisheries 1877). This pattern had already been established a generation previously downstream along on the main stem of the Petitcodiac. In 1783 while Robert Colpitts first crop at his farm near Salisbury was ripening, his family's main source of food was salmon (Moncton Daily Times, Thursday August 26th 1920).

By 1850 over 25% of the land in coastal Parishes such as Hopewell, Dorchester, and Westmoreland had been cleared for agriculture, and Sackville Parish had 16,000 of its 100,000 acres fit for cultivation (Wynn 1981). Only in Elgin and Salisbury Parish did the population density remain less than 5 people per square mile. Salisbury Parish included all of the lower end of the North River from where it is joined by the Anagance and becomes the Petitcodiac, up to a point along the river slightly northeast of Salisbury. Quality of land wasn't the limiting factor however. Atkinson (1842) in his Emigrant's Guide to New Brunswick, British North America, noted that, "there is much ungranted land of a good quality" on the North River, and described it as follows, "On the banks of this river there are numerous and extensive tracts of intervale and it is a well settled country having been peopled during the last forty years. The soil on the uplands is highly fertile and there are natural meadows that afford abundance of pasture." Monro (1855) acknowledged some short comings, but echoed much of this assessment, endorsing both the land immediately along the Petitcodiac, as well as further upstream in the North River watershed, but not the upland plateau between them stating, "With the exception of the intervale along the valley of the Petitcodiac the land in the front of this parish is generally of an inferior quality; that in its north west portion (along the North River immediately above the Village of Petitcodiac) is much better but additional roads are required to render it available for settlement. In consequence of there being so much bad land along the line of railway and the mail road agricultural operations in this parish are much retarded."

Intervale is a term local to the region that refers to fertile bottomlands, and was felt so apt, that one community along the river 4.5 km north of the Village of Petitcodiac actually adopted Intervale as its name, which it still goes by today. Traveling overland from Moncton to Saint John, Johnston (1851) described what he saw in that area, "We found some good farms along this part of the North River and good land derived from the mixed calcareous and sandstone debris The limestone was hard, destitute of apparent fossils, and as subsequent analyses showed very pure and admirably fitted for agricultural purposes. It had been quarried for building but the application of lime to the land was in this district scarcely known."

No doubt the arrival of the European and North American Railway in 1860 (Stronach 1969) at Petitcodiac Village reduced many of the logistical constraints both on bringing supplies into North River watershed, and just as importantly, moving marketable surpluses out to trade. This had substantial benefits going forward both for settlement and agriculture. The railway only passed the river near its end at the Village of Petitcodiac, where the North River becomes the main stem of the Petitcodiac River. However, since the Petitcodiac runs roughly parallel to the North, no point in the entire North River watershed up to its headwaters near Moncton was more than about 8 to 10 kilometers (often half that) from the rail line (Natural Resources Canada 1997; Natural Resources Canada 2008). The train made it possible to travel from Moncton to Saint John in about 6 hours (New Brunswick Railway Museum 2015b). So the Petitcodiac station, being not quite midway, would have been just a few hours travel away from either end. The connection to Saint John provided rapid year round access to an ice free port from which most of New Brunswick's exports were shipped overseas. In 1869, two years after Confederation, the line became part of the Intercolonial Railway system, which by 1876 (through Moncton) provided access from Halifax all the way to Upper Canada (New Brunswick Railway Museum 2015b). Also in 1876, the construction of The Elgin, Petitcodiac, & Havelock Railway branch line, turned Petitcodiac Station into a local rail hub.

Dawson (2005) shows that by 1878 the road network within the watershed showed some improvement over what Monro reported in 1855. It looked quite recognizable to the modern eye, with roads of some kind already present along many (but by no means all) of the routes significant enough to be paved today, though obviously these wouldn't have been developed to that extent then. In-between the Village of Petitcodiac and Moncton, there were no fewer than six north-south roads, each crossing over from the main stem of the Petitcodiac River to provide access to settlements in nearby portions of the North River. The biggest single modern difference to the 1878 road network is the Trans-Canada Highway which cuts through the southwestern end of the North River watershed before crossing over into the Petitcodiac watershed. The path it follows shows no 1878 precedent.

On the whole, however, the 1878 road network in the North River suggests that by that time, development, and by extension agriculture, had progressed significantly, but (as one might expect), was less than today. Interestingly, a similar comparison between the Little River in 1878 and today shows almost no change in road coverage during the same period; while on the Pollett, the number of roads in the upper reaches of that river was actually greater in 1878 than it is today. So while the North River watershed has continued to develop, the Little has not (comparatively speaking), and settlement on the Pollett actually appears to have contracted somewhat relative to 1878. This is consistent with the point made in the introduction that in addition to being much more accessible throughout its entire length than either the Little or the Pollett, the soils and climate of the North River are on average better suited to agriculture than is the case in much of the other two watersheds. These facts may have made farms in Westmorland County along the North River more resistant to economic downturns following the First World War that caused many people in rural Albert County to leave the area during that time to search for more arable land out west (Department of Natural Resources 2007; Degraaf et al. 2007). For that matter, those not wishing to move so far away, may have simply added instead to population growth along the North River and along the main stem of the Petitcodiac. As a consequence of all this, today more land in the North River basin is dedicated to agriculture than in Demoiselle Creek, Pollett River and Little river combined (Department of Natural Resources in 2014).

Crops reported being raised in the area by 1890 included: hay; grains (wheat, buckwheat, oats, and barley); vegetables (potatoes, carrots, and turnips); and fruits (apples, and plums) (New Brunswick House of Assembly 1890). Livestock included: cattle (Ayrshires, Jerseys, and short horns); sheep (Shropshire Downs); and pigs (Yorkshires and Berkshires). Dairy products were among those perishable products whose production and transport to market was made possible by the expanding road network and rail service. By 1891 a cheese factory was established just outside the watershed nearby at Corn Hill (New Brunswick Department of Agriculture 1892). Shortly thereafter, North River watershed farmers were among those supplying the Corn Hill Cheese and Butter Company with raw products (Burrows 1984).

### *Mining Practices*

The potential for production of agricultural lime noted by Johnston (1851), was eventually realized. The Geological Survey of Canada (1890) concluded that, “gypsiferous beds in the vicinity of the salt springs along Salt Springs Brook and in the North River valley near Petitcodiac enrich the soil in these particular localities.” The Petitcodiac Mining and Manufacturing Company (1860-1909) developed the lime resources of the Glenvale district along Salt Springs Brook (Burrows 1984). Years later Goudge (1934) noted the remains of the quarry just south of Glenvale, that had supplied local farmers with raw agricultural lime.

## Second Level Assessment – Current Impacts

### *Forestry Practices*

The North River basin (Figure 4-3) covers 264.8 km², of which private woodlots are 137.1 km² (51.8%), Crown forests cover 6.6 km² (2.5%), Industrial freehold leases 33.8 km² (12.8%).

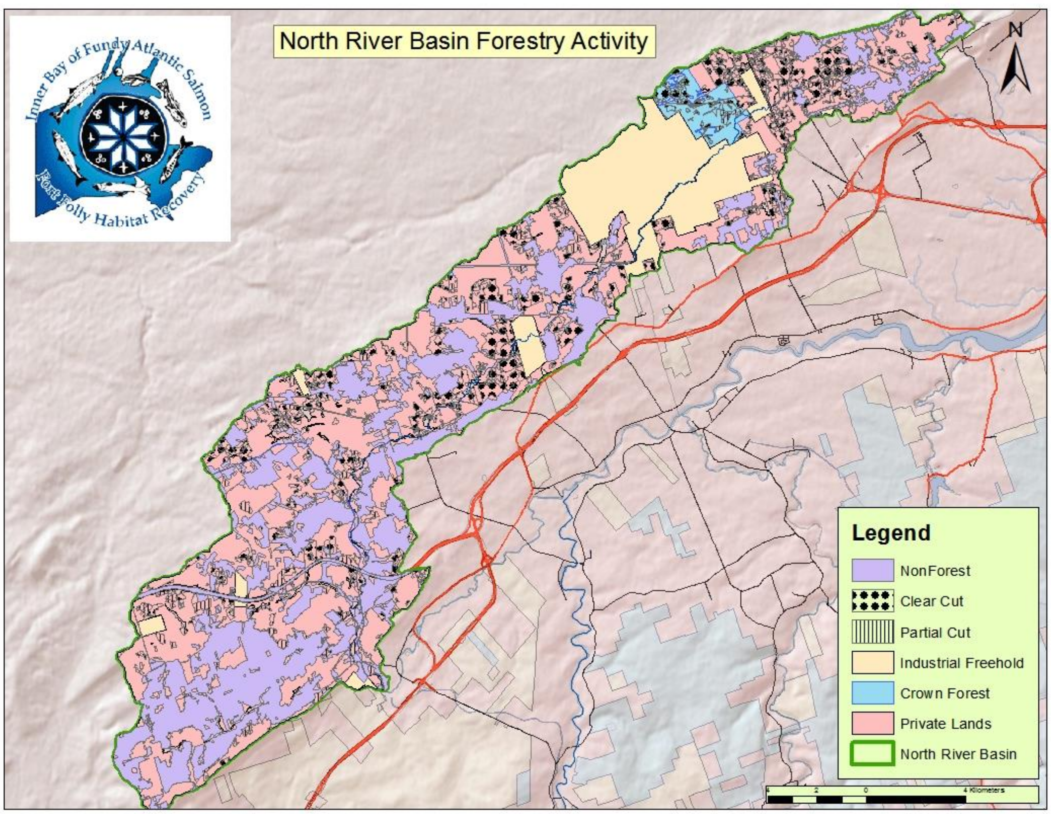


**Figure 4-3:** Forest tenure and management in the North River

## Agricultural Practices

Nonforest Land Use data obtained from the New Brunswick Department of Natural Resources shows 31.6% of the watershed is used or purposes other than forestry. Agricultural activity dominates, covering 26.5% of the basin (Figure 4-4). More land in the North River basin is dedicated to agriculture than in Demoiselle Creek, Pollett River and Little river combined (Department of Natural Resources in 2014).

Land use is classified as: Settlement (4.63 km² or 1.75% of the basin), Industry (2.09 km² or 0.79% of basin), Crops & Grains – including hayfields ( 60.49 km² or 22.85% of basin), Pasture (9.28 km² or 3.5% of basin), Blueberry production (0.06 km² or 0.02% of basin). 2 golf courses are located in the watershed (1.26 km² or .48% of basin)

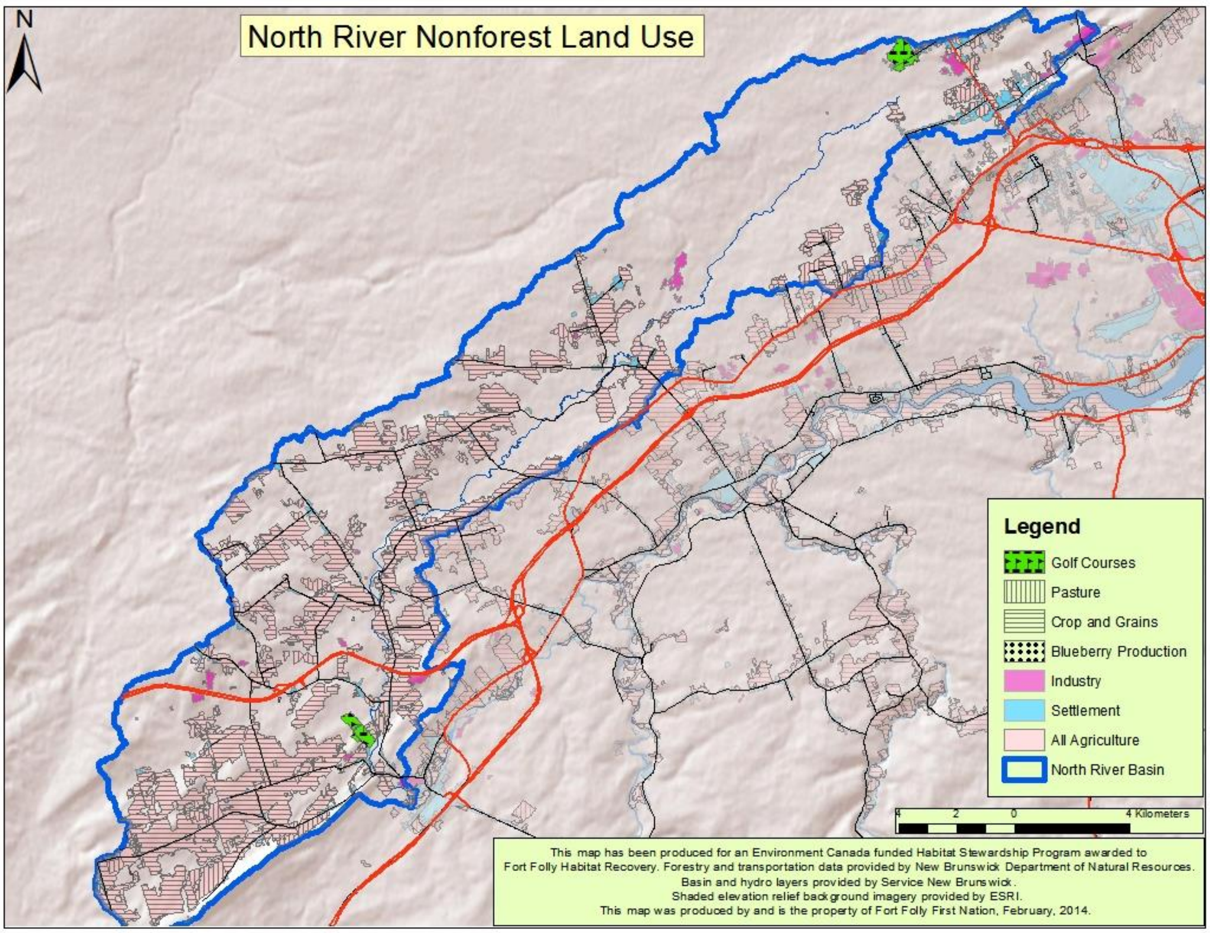


**Figure 4-4:** Non-forest land use in the North River watershed.

### Urban Development

A database was developed to house property boundary and landowner information. The property boundary information is incorporated in to a GIS layer for the North River watershed. Additionally, an excel database, Property Boundary and Landowner Information 2012-2013, contains information from Service New Brunswick on owner or business names, location addresses, place names, and associated PIDs and PANs.

### Transportation Development

Discussions with New Brunswick's Department of Transportation identified one culvert (WM20) over 3 feet in diameter that crosses the North River. There may be additional culverts less than 3 ft in diameter within the watershed that are the responsibility of the DoT (Figure 4-5), however, records were not available for these. If a problem culvert is identified and there is a question of whom is responsible for it (private landowner versus the DoT), GPS coordinates should be taken and responsibility confirmed through further discussions with the DoT.

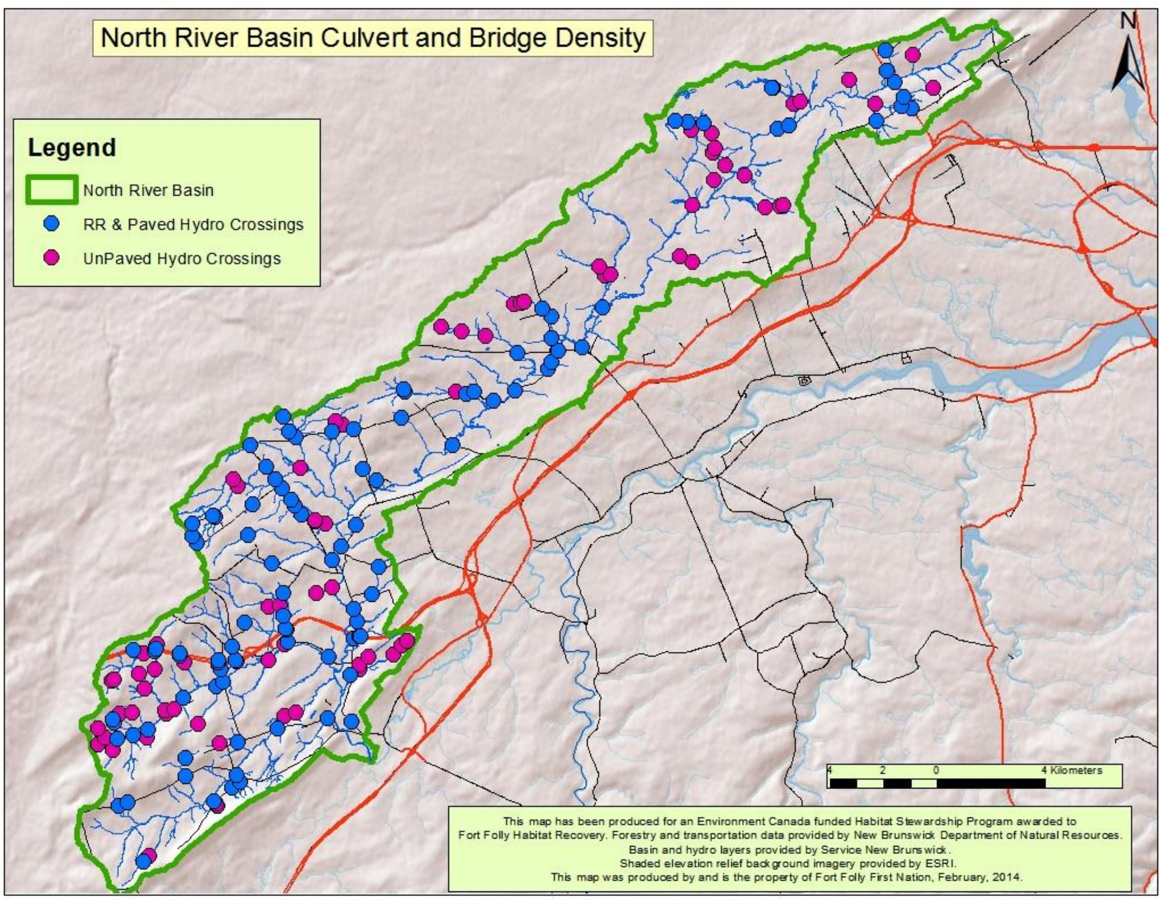


**Figure 4-5:** Water Crossings on the North River

Culvert inspection reports were provided by the DoT for the aforementioned culvert. Selected information from this report is provided below. For more detailed information, contact Fort Folly Habitat Recovery at (506) 379-3401.

The culvert WM20 is located under a two lane asphalt road on Route 126 at Control Section #R0126 009-9.550 (Figure 4-6). It was last inspected on August 13, 2012. There are two structures, a CSP component and a concrete arch. Both structure conditions are designated as FAIR to POOR. The following recommendations for this culvert are as follows:

- The vegetation on both sides of the road should be removed
- The debris and fill inside the culvert should be removed
- The scouring hole and the water drop should be eliminated
- The wheel ruts should be repaired
- The pipe sections that have separated should be repaired
- The undermining and erosion should be stopped and repaired
- A sign indicating the Culvert Number “WM20” should be stenciled on the guard rails over the culvert

**Figure 4-6:** Culvert WM20.

In addition, there are 11 bridges that cross the North River for which the DoT is responsible (Figure the bridges identified from the DoT maps are: N505; N510; N512; N513; N520; N523; N525; N530; N535; N540; and5301. If there are concerns with any of the identified bridges from ongoing discussions with resource users, follow up will be necessary with the DoT. Locations of these bridges and culverts have been incorporated in to a GIS layer.

The rail line from Moncton to Saint John passing through the Village of Petitcodiac is still in operation today, though the Intercolonial Railway has now become part of the Canadian National Railway. By 1915 key railroad companies were floundering and Canada was faced with supporting unprofitable yet necessary railroads (Solomon 2013). As more lines required attention, the Canadian National Railway (CNR) was formed in 1918, and the Intercolonial Railway was among the first to join it. Today Canadian National Railways maintains an Intermodal Terminal in Moncton, with rail freight service to Saint John along the Petitcodiac / Anagance / Kennebecasis rail corridor (Canadian National Railways 2015).

In 1968, approximately 40 kilometers downstream of the North River, along the main stem of the Petitcodiac, the Moncton to Riverview Causeway was built instead of a bridge, in order to accommodate vehicular traffic between the two cities. The fishway built into it proved to be ineffective. The causeway gates created a barrier to fish passage with significant consequences for native fish species in the river, and led to the decline in the populations of species such as alewife, blueback herring, rainbow smelt, and sea-run brook trout. Some species disappeared altogether from the upland reaches of the Petitcodiac (such as the North), including Atlantic tomcod, American shad, and striped bass (Locke, et al. 2003). Atlantic salmon only remained present in the river as a consequence of ongoing stocking efforts (AMEC 2005)

In April 2010 the Moncton to Riverview Causeway gates were opened as part of the Petitcodiac River restoration project. Five years of monitoring from 2010 to 2014 following the restoration of fish passage (Redfield 2015) found American shad, striped bass, and Atlantic tomcod returning to the river. Of these, the latter two have shown sustained and progressive increases in numbers over the years, while invasive non-native smallmouth bass have declined. Consequently it is clear from these results that the fish community of the Petitcodiac has the capacity to recover, given the right conditions, and appears to be on its way to doing so.

### *Herbicide and Pesticide Use*

Based on general information provided by Service New Brunswick, two forestry operators (JD Irving as Forest Patrol and Natural Resources) may have conducted work in the North River watershed. While intended blocks of land to be treated were identified by operators that does not necessarily mean that they were treated with herbicides. Products used in these industries may contain the active ingredient glyphosate. Glyphosate is found in several formulations under the trade names Arsenal (PCP 23713), Forza (PCP 26401), Vantage (PCP 26884), Vision

(PCP 19899) and Vision Max (PCP 27736). The active ingredient triclopyr has also been used in the past as Release (PCP 22093).

In addition, two industrial operators (Asplundh and NB Power Transmission) may have conducted work with respect to an industrial right-of-way perspective (rail, transmission lines, etc.) in the Demoiselle Creek and North River watersheds. These companies may have used triclopyr as Garlon 4 (PCP 21053), Karmax (PCP 21252) and any of the aforementioned glyphosate products.

Private growers must be individually certified (hold a valid pesticide applicator certificate) but do not report their usage. Likewise, vendors must report total sales but do not provide a breakdown relevant to individual purchasers. It is difficult to find information of individual grower or vendor pesticide or herbicide use.

### *Mining Practices*

Oil and Natural Gas lease rights within the North River watershed are currently registered both Corridor Resources Inc. and SWN Resources Inc. (Government of New Brunswick 2015). Corridor Resources is a Canadian energy company. Its lease extends up into the North River watershed to a point just downstream of Wheaton Settlement. SWN is a wholly owned subsidiary of Southwestern Energy Company in the US (SWN 2015). Its lease begins where Corridor Resource's ends, and includes essentially the entire North River watershed upstream of Wheaton Settlement. Seismic testing by SWN in New Brunswick on Mi'kmaq traditional lands north of Moncton was halted following protests that became violent in 2013 and attracted national media attention. On March 17th 2015 SWN received an extension on its licenses which were due to expire (Canadian Broadcasting Corporation 2015). The former Provincial government made a clear commitment to promoting shale gas development in New Brunswick (Alward 2014). However, shortly after coming into office, the new government enacted a moratorium on expansion (Canadian Broadcasting Corporation 2014). If wells are eventually drilled in the North River watershed, impacts will include freshwater extraction from streams, habitat destruction and sedimentation during road building, and the potential for wastewater spills contaminating surface waters.

## Third Level Assessment – Aquatic and Riparian Habitat Assessment

### *Wildlife*

Several species of wildlife that warrant specific attention are found or have been found in the North River watershed: Atlantic salmon, American eels, and wood turtles. Atlantic salmon (*Salmo salar*) Inner Bay of Fundy (iBoF) populations were listed as endangered under the Species at Risk Act in 2003 (DFO, 2010; SARA Registry, 2013a), and the species is considered to be extirpated from the Petitcodiac River system, except for those introduced in stocking programs (AMEC, 2005). American eels (*Anguilla rostrata*) were designated as "Special Concern" by COSEWIC in 2006 (COSEWIC, 2006). Their status was re-examined and raised to "Threatened" in May 2012 (COSEWIC, 2014). This species is being considered for listing under the federal Species at Risk Act, but currently it has no status (SARA Registry, 2013b). Wood turtles (*Glyptemys insculpta*) were designated as "Special Concern" by COSEWIC in 1996 which was raised to "Threatened" in 2007 (COSEWIC 2007; COSEWIC 2011). This species is listed as "threatened" under the Species at Risk Act (SARA Registry, 2012). Guidelines for projects in areas with these species are in Appendix A.

The decline in numbers of iBoF salmon is a marked contrast to the abundance described by early settlers (Dunfield 1991). Though numbers of this species had been decreasing for some time (Elson 1962) construction of the Moncton to Riverview causeway in 1968 eliminated fish passage for adult salmon and smolts and effectively (but for ongoing intervention) extirpated the species from a river system that represented 20% of the total iBoF population (Locke, et al. 2003). Fort Folly Habitat Recovery has not encountered salmon in the course of its field work on the North River, but DFO has extensive records of interaction with salmon on the North River (Elson 1941).

Similarly American eels have not been encountered by Fort Folly Habitat Recovery along the North River, due in part to the limited amount of electrofishing done there (two sites in 2012). However, historically they have been found in the North River watershed (Andrews 1943), and unlike salmon, eels were not excluded by the Moncton to Riverview Causeway downstream on the Petitcodiac. In fact while the causeway gates were closed eels were found to be the most abundant resident species upstream of the headpond (Flanagan 2001), and one of the dominant species within the headpond (Locke et al 2000). So though there is no recent data available on eel numbers within the North River watershed, unlike salmon there is no reason to think that they are absent.

Though no systematic targeted search have been made for Wood turtles on the North River, they have been encountered at several locations within the watershed during the course of conducting other field work. Due to their small home range, encounters with wood turtles are considered to be sensitive information, and so are being withheld here.

### Water Quality

Water quality on the North River has been monitored by the Petitcodiac Watershed Alliance as part of their Petitcodiac basin wide water monitoring program, which has data going back to 2005 available online (Petitcodiac Watershed Alliance 2015). The 2012 results are presented here (Petitcodiac Watershed Alliance 2012). They maintain a fixed monitoring site on the upstream side of the Route 885 bridge over the North River at Intervale, a short distance south of where the Trans-Canada Highway crosses the river. As a single site within the watershed there is a limited amount that can be concluded from it, however being located near the point where the North meets the Anagance and becomes the Petitcodiac, it does provide useful insight to the watershed upstream. The fact this location has been monitored since 2005 also provides some significant time depth. Conductivity readings for the North are quite high compared to both the Little and the Pollett, however it is likely that this reflects in part the location of the sampling site along the North, a short distance upstream of the mouth of Salt Springs Brook. As a consequence, while obviously not directly influenced by Salt Springs Brook itself, presumably there is related substrate in the area that is contributing to the elevated conductivity readings.

**Table 4-2:** Water Quality on the North River in 2012 (Petitcodiac Watershed Alliance 2012)

| Monthly at Site | Dissolved Oxygen | Conductivity | Temperature °C | pH |
|---|---|---|---|---|
| April | 8.72 mg/L | 201 µS | 10.2 °C | 6.73 |
| May | 10.01 mg/L | 315 µS | 12.3 °C | 8.08 |
| June | 12.85 mg/L | 330 µS | 17.7 °C | 7.56 |
| July | 6.36 mg/L | 415 µS | 20.3 °C | 7.65 |
| August | 6.86 mg/L | 345 µS | 17.6 °C | 7.59 |
| September | 7.36 mg/L | 412 µS | 14.1 °C | 7.55 |
| Average | 8.69 mg/L | 336 µS | 17.7 °C | 7.53 |

### *Rapid Geomorphic Assessment (RGA) and Rapid Stream Assessment (RSAT)*

The following is taken from the report prepared by Parish Geomorphic and is based upon the rapid geomorphic assessments (RGAs) and rapid site assessments (RSATs) Fort Folly Habitat Recovery conducted on the North River in 2012.

The North River was segmented into 138 sub-reaches within six main reaches. The assessment of the North River started just east of Route 126 at Indian Mountain and ended at the confluence with the Anagance River in Petitcodiac. The total length of river covered was approximately 46 km.

#### *Geomorphic Analysis*

The RGA and RSAT data were used to determine the geomorphic condition and stability of the assessed sections of North River. In order to interpret the geomorphic data, the watercourses are highlighted on their respective maps according to the sub-reach stability. A bar graph is also associated with each sub-reach and illustrates the dominant geomorphic process. The geomorphic processes identified included aggradation, degradation, channel widening, and planform adjustment.

**Aggradation**

Channel aggradation may occur when there has been a significant decrease in flows, a significant increase in sediment supply, or a significant decrease in slope due to irregular meander migrations. Depending on upstream processes and the boundary conditions of the reach, channel widening may occur in association with channel aggradation.

Indicators of aggradation include:

- Shallow pool depths
- Abundant sediment deposition on side bars and non-vegetated mid-channel bars, extensive sediment deposition at obstructions, channel constrictions, at the upstream end of tight meander bends, and in the overbank zone
- Most of the channel bed is exposed during typical low flow periods
- High frequency of debris jams
- Coarse gravels, cobbles, and boulders may be embedded with sand/silt and fine gravel
- Lateral migration of thalweg
- Soft, unconsolidated bed
- Mid-channel bars
- Deposition on point bars

**Degradation**

The process by which a stream's gradient becomes less steep, due to the erosion of sediment from the stream bed. Bed lowering can move in both an upstream direction (as a headcut or nick point) and/or downstream. This can occur from a rapid removal of streambed material due to an increase in discharge, water velocity, or a decrease in sediment supply.

Indicators of degradation are:

- Elevated tree roots
- Bank height increases as you move downstream
- Absence of depositional features such as bars
- Head cutting of the channel bed
- Cut face on bars
- Channel worn into undisturbed overburden/bedrock
-

**Widening**

When the stream becomes incapable of transporting its sediment load, sediments collect on the stream bed, forming mid-channel bars that concentrate flows into both banks, and lead to a wider channel. Streams that score poorly under channel aggradation may also score poorly for the channel widening parameter. Channels also become over-widened due to an increase in flows or to a decrease in sediment supply, which is not necessarily related to bed aggradation but may be seen in association with degradation. In these cases widening is the dominant process.

Indicators of widening include:

- Active undermining of bank vegetation on both sides of the channel; many unstable bank overhangs that have little vegetation holding soils together;
- Erosion on both right and left banks in riffle sections;
- Recently exposed tree roots;
- Fracture lines at the top of the bank that appear as cracks parallel to the river; evidence of landslides and mass failures;
- Deposition of mid-channel bars and shoals
- Urbanization and storm water outfalls leading to higher rate and duration of runoff and channel enlargement typically in smaller watersheds with a high percentage (>10%) of impervious surface (urban land use).

**Planform Adjustment**

Changes to the planform can be the result of a straightened channel imposed on the river through different channel management activities, or a channel response to other adjustment processes such as aggradation and widening. This migration process will start with degradation if the channel slope is increased or with aggradation if the slope is decreased.

Indicators of planform change are:

- Flood chutes, which are longitudinal depressions where the stream has straightened and cut a more direct route usually across the inside of a meander bend;
- Channel avulsions, where the stream has suddenly abandoned a previous channel alignment;
- Change or loss in bed form structure, sometimes resulting in a mix of plane bed and pool-riffle forms;
- Island formation and/or multiple thread channels;
- Additional large deposition and scour features in the channel length typically occupied by a single riffle/pool sequence (may result from the lateral extension of meander bends).
- Thalweg not lined up with planform. In meandering streams the thalweg typically travels from the outside of a meander bend to the outside of the next meander bend. During planform adjustments, the thalweg may not line up with this pattern.

***Watercourse Channel Stability***

A key piece of data obtained from the Rapid Geomorphic Assessment is stream geomorphic condition based on the degree of departure of the channel from its reference stream type, which is evaluated by the magnitude and combination of adjustments that are underway in the stream channel. With respect to stream equilibrium and natural variability, the degree of departure is captured by the following three terms:

**In Regime:** A stream reach in reference and good condition that is in dynamic equilibrium which may involve localized, insignificant to minimal change to its shape or location while maintaining the fluvial processes and functions of its watershed over time and within the range of natural variability.

**In Adjustment:** A stream reach in fair condition that has experienced major change in channel form and fluvial processes outside the expected range of natural variability; and may be poised for additional adjustment with future flooding or changes in watershed inputs that could change the stream type.

**Transitional or Stressed:** Refers to a stream experiencing extreme adjustment outside the expected range of natural variability for the reference stream type; likely exhibiting a new stream type; and is expected to continue to adjust, either evolving back to the historic reference stream type or to a new stream type consistent with watershed inputs and boundary conditions.

### *Geomorphic Assessment*

The North River was divided into 6 main reaches with 138 sub-reaches and covered approximately 46 km of channel from near Indian Mountain at Route 126 on downstream to the Village of Petitcodiac where it merges with the Anagance River, below which point the channel becomes recognized as the Petitcodiac River. The fieldwork was conducted in a discontinuous manner, and the named sub-reaches do not reflect this more intuitive, flow based order. To make the collective analysis easier to read and understand they have been reassembled into reaches that follow flow based order. However the names of the original sub-reaches were maintained in order to minimize further confusion by making it possible to readily access site specific data without needing to go back and forth constantly translating between two different numbering systems.

**Reach 1: Route 126 to Pacific Junction Road (sub-reaches 6-0 to 6-8)**

Reach 1 starts on the east side of Route 126, just south of Indian Mountain and ends at Pacific Junction Road. The assessed reach is approximately 2.4 km and is divided into 8 sub-reaches. The first four sub-reaches, 6-0 to 6-3 cover approximately 900 metres of the North River. Sub-reaches 6.0 and 6.1 head east from Route 126 while sub-reaches 6.2 and 6.3 move west from Route 126. There is approximately a 2.0 km gap on the river that was not assessed between sub-reaches 6-3 and sub-reach 6-40. From comments on the RGA/RSAT forms, the stretch of the North River that was not assessed was due to the density of the alders within that reach. Figure 4-8 illustrates sub-reaches 6-0 to 6-5.

With the exception of sub-reach 6-5, the remaining sub-reaches are in a state of transition. Sub-reach 6-5 is in a phase of adjustment and is experiencing channel degradation. The dominant geomorphic process occurring in sub-reaches 6-0 and 6-1 is aggradation. Sub-reaches 6-2 and 6-3 are undergoing channel degradation while the dominant geomorphic process occurring in sub-reach 6-4 is channel widening.

The plunge pool on the downstream side of the culvert passing under Route 126 likely explains some of the degradation occurring in sub-reaches 6-2 and 6-3 (Figure 4-7).

**Figure 4-7:** North River, plunge pool at Route 126.

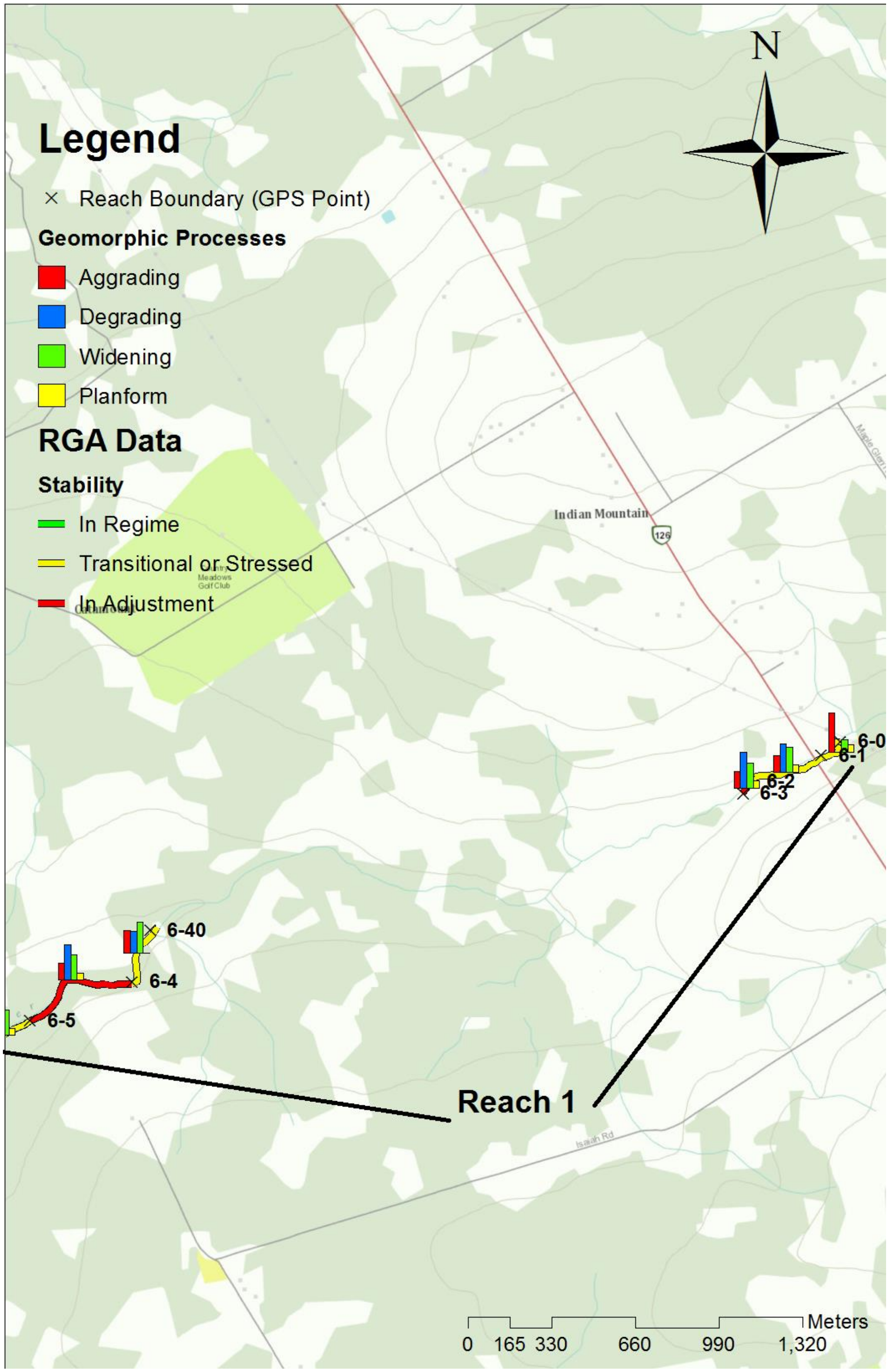


**Figure 4-8:** North River Reach 1 (Sub-reaches 6-0 to 6-5).

Figure 4-9 illustrates that sub-reaches 6-6, 6-7, and 6-8 are in a state of transition with the dominant geomorphic processes being aggradation, degradation, and aggradation, respectively

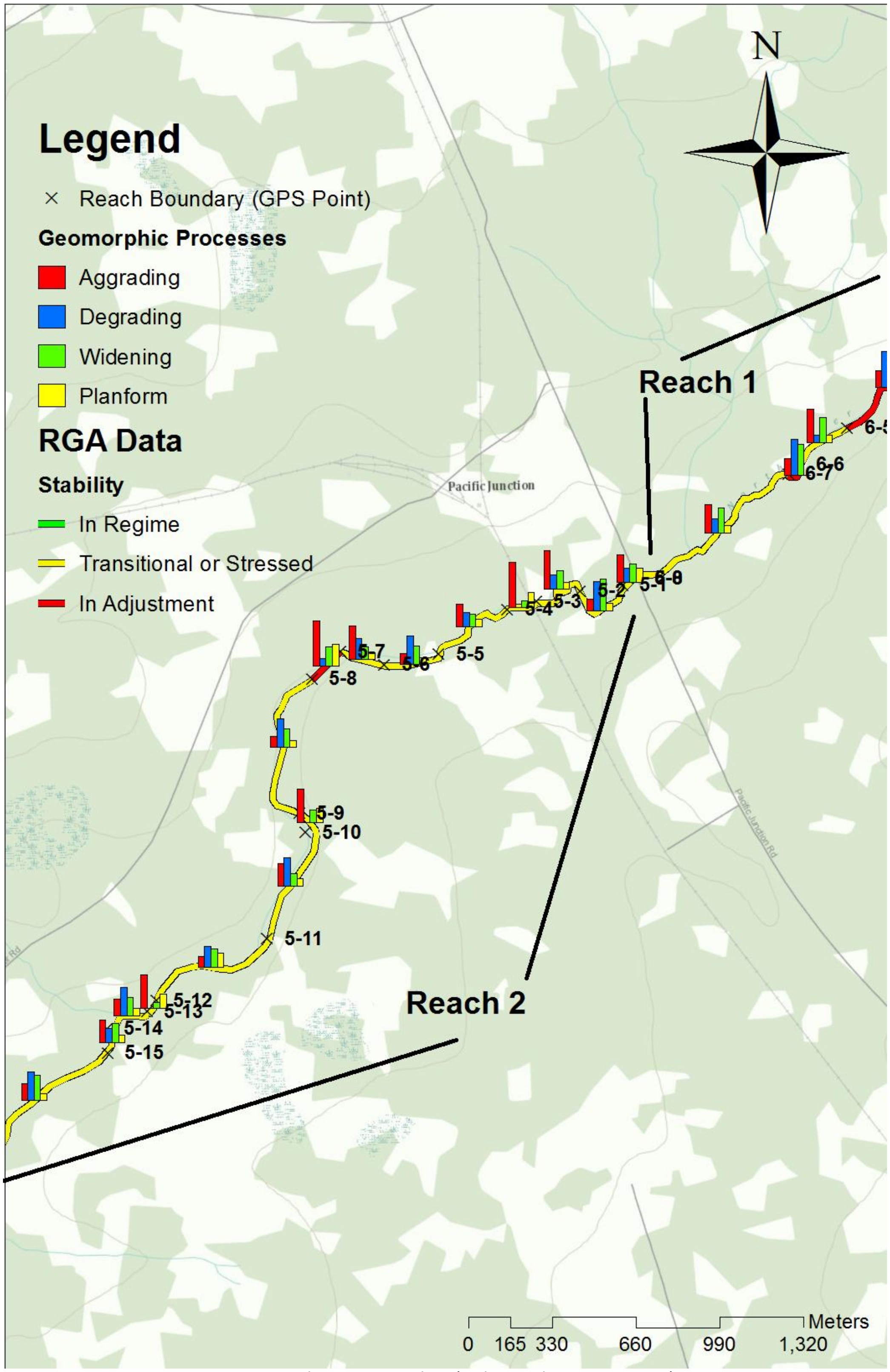


**Figure 4-9**: North River Reach 1 (Sub-reaches 6-6 to 6-8).

With the dense alder cover in sub-reaches 6-0 to 6-3 (Figure 4-10), restoration efforts in these reaches would be difficult.

**Figure 4-10:** North River, alder cover.

**Figure 4-11:** North River, Culvert under Rte 126.

If fish passage is a priority, the culvert under Route 126 is an issue with the downstream invert hanging above the streambed. The culvert appears to be able to handle the flows as the oxidization line on the pipe is approximately a third of the way up from the bottom (Figure 4-11). It is also noted that looking though the culvert, based on the photograph, the pipe may be collapsing. However, this could simply be the angle the photograph was taken and further investigation may be warranted.

**Reach 2: Pacific Junction Road to Taylor Road (Sub-reaches 5-1 to 5-40)**

Reach 2 has 40 sub-reaches and covers approximately 13 km of the North River. The reach begins on the west side of the Pacific Junction Road and goes to the east side of Taylor Road. The channel condition of sub-reaches 5-1 to 5-15 is under stress. The dominant geomorphic process is aggradation. Sub-reaches 5-6, 5-9, 5-10, 5-11, and 5-14 are experiencing channel degradation. Channel widening is occurring in sub-reach 5-2. This is illustrated in Figure 4-12.

As aggradation is the most dominant geomorphic process occurring within the upper sub-reaches of Reach 5, finding the source or cause of the increase in bedload needs to be determined prior to instream or bank restoration work of this area. Any restoration efforts need to consider the natural bankfull conditions for sub-reaches 5-1 to 5-15 to ensure that the channel is maintained by the natural deposition and erosion of material occurring in these sub-reaches.

Sub-reaches 5-16 to 5-30 vary in channel conditions from undergoing adjustment to a state of transitional or stressed. One sub-reach, 5-20 is in a state of regime (stable). This sub-reach may be used as a reference reach for gathering natural channel characteristics of Reach 5. As shown in Figure 4-13, the dominant geomorphic process is aggradation.

As with any increase in sediment load to a watercourse the source needs to be determined prior to implementing any instream restoration structures. Otherwise there is an inherent risk that the instream structures will be buried. Once the source or cause of the excess sediment in the system has been determined proper restoration or mitigation measures can be taken to assist with the natural movement of the material through the reach. By creating deposition or scour areas, equilibrium of sediment load through the system can be achieved ensuring that any instream habitat structures function as intended.

Half of the sub-reaches between 5-31 and 5-40 are in adjustment and the other half are in a state of transition. Figure 4-14 demonstrates this but also shows that dominant geomorphic process includes aggradation, degradation, widening and planimetric adjustment. The RGA data for these sub-reaches of Reach 5 indicate that a slight shift in a couple of identifying factors could result in any of the geomorphic process becoming the dominant process. Restoration efforts, whether for instream habitat or bank erosion, therefore need to consider what the end goal of the restoration is and the effects that will result from implementing such measures on upstream and downstream banks and instream features.

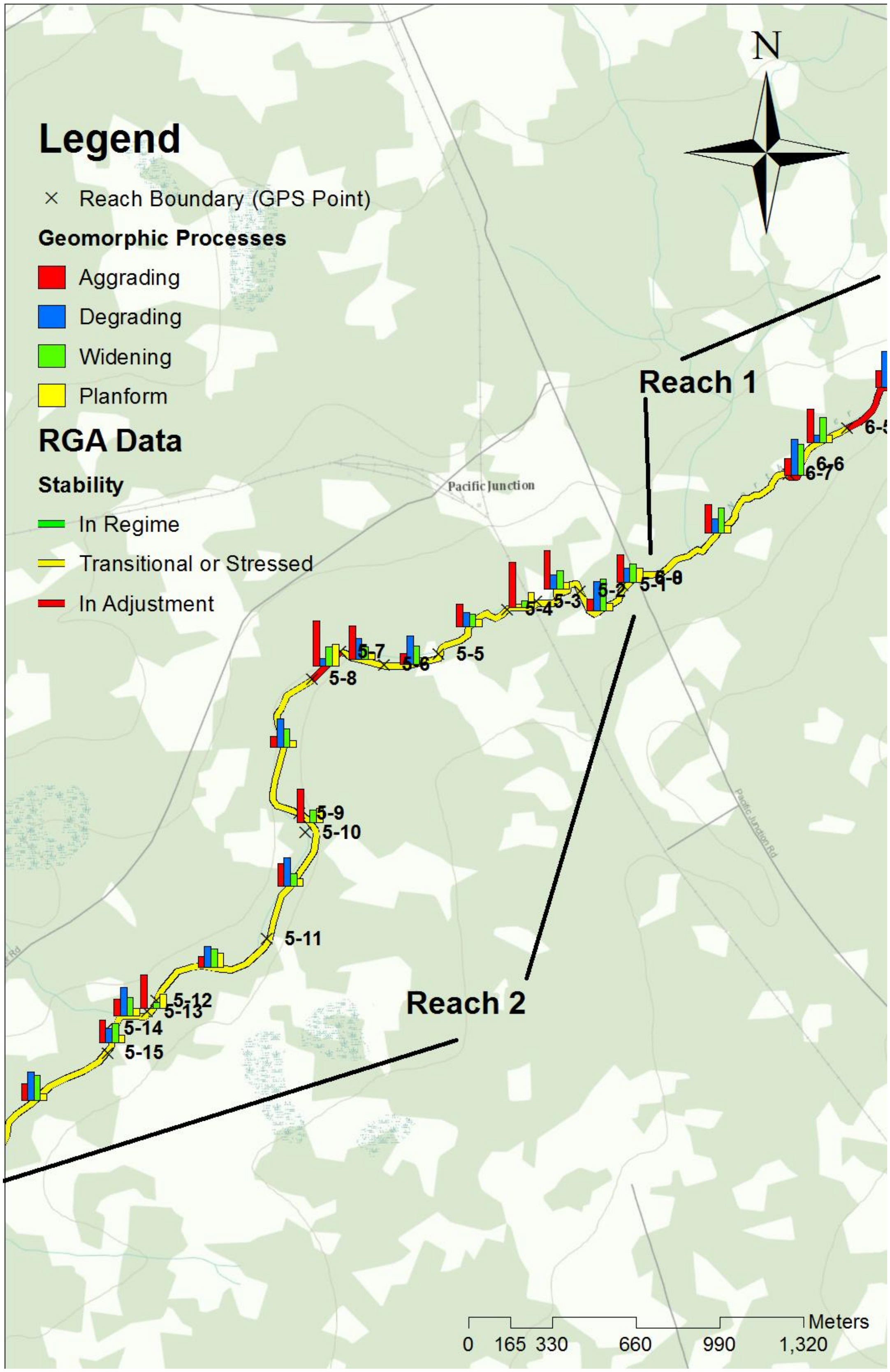


**Figure 4-12**: North River Reach 2 (Sub-reaches 5-1 to 5-15).

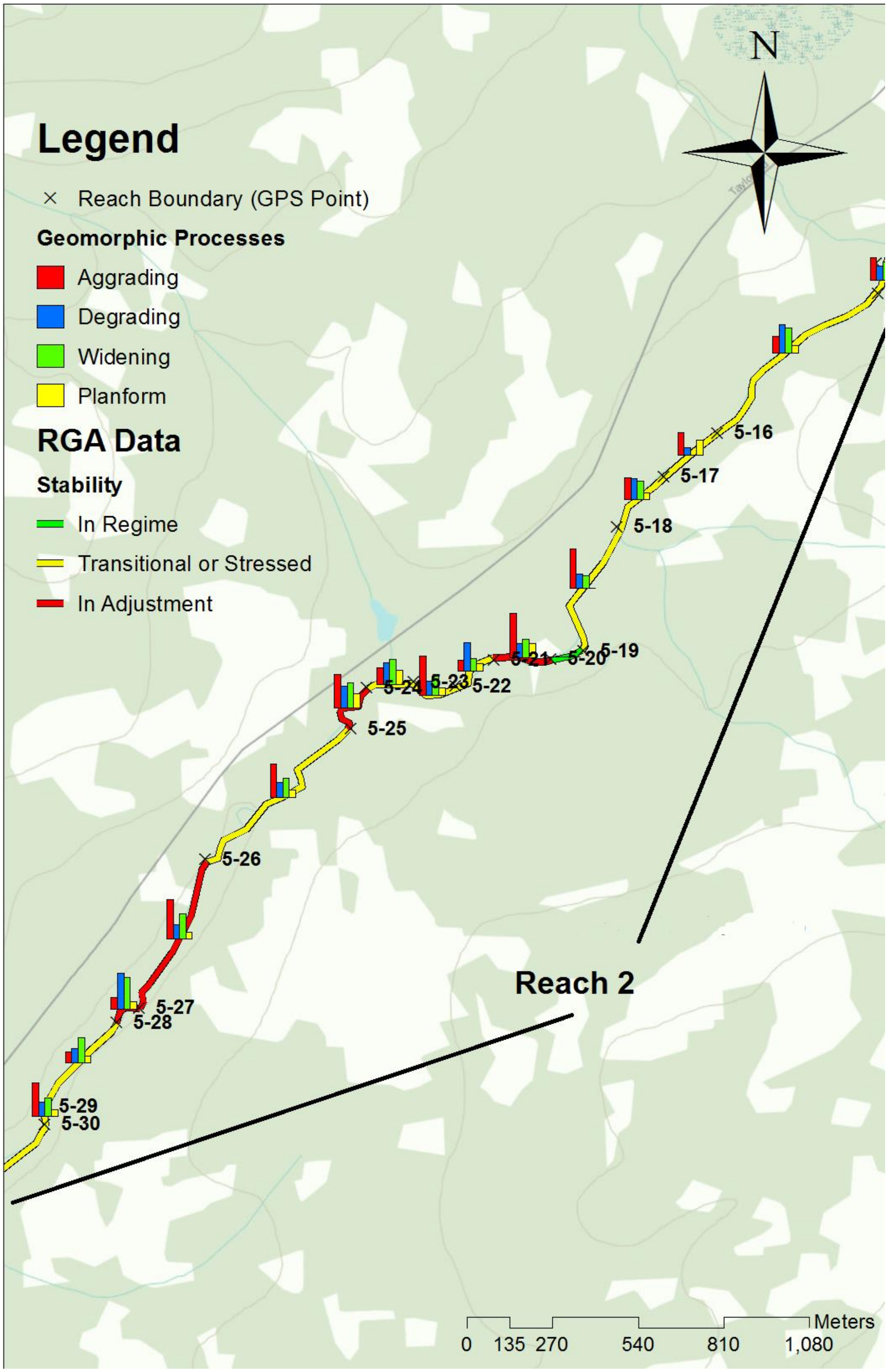


**Figure 4-13:** North River Reach 2 (Sub-reaches 5-16 to 5-30).

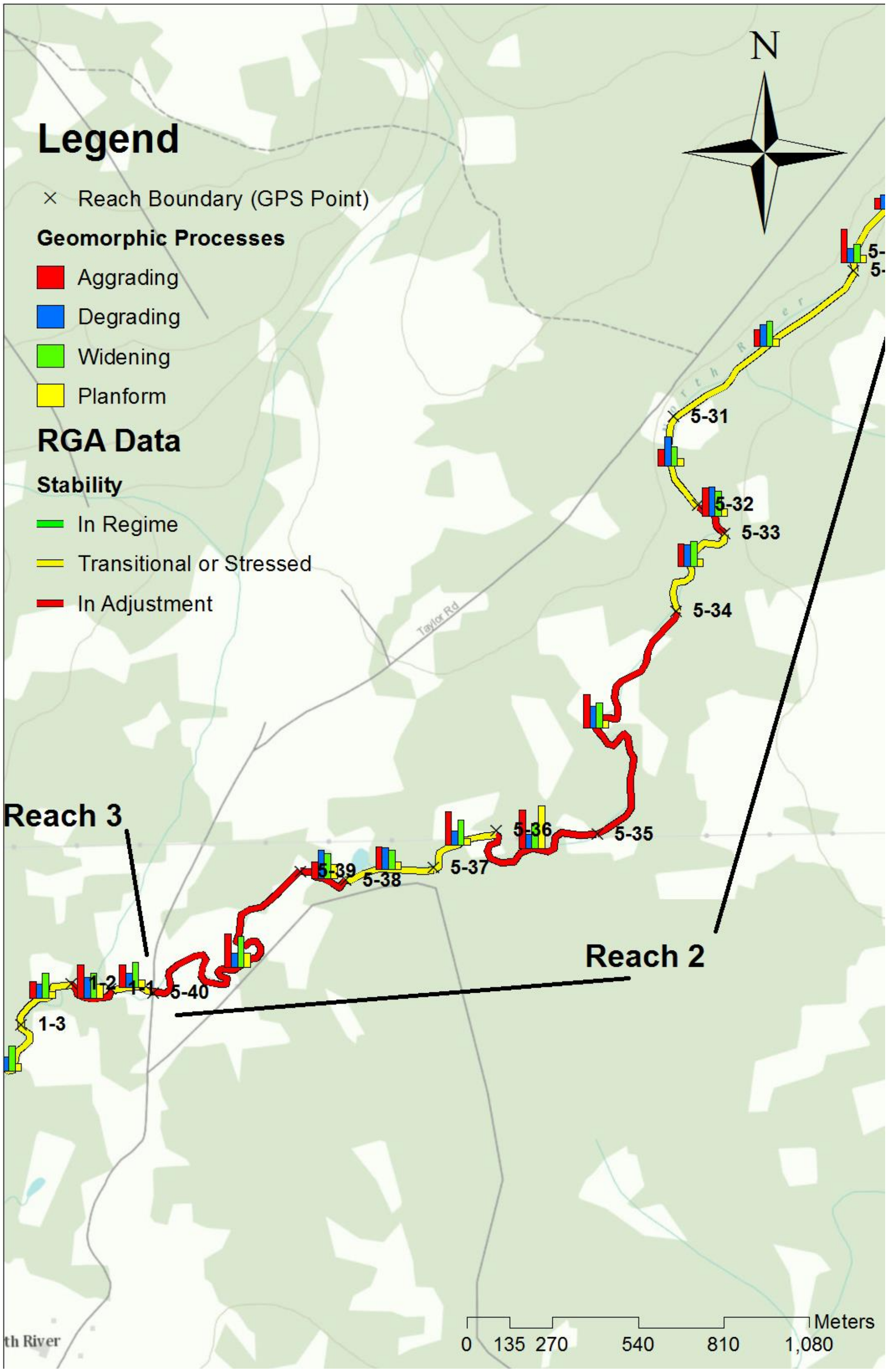


**Figure 4-14:** North River Reach 2 (Sub-reaches 5-31 to 5-40).

**Reach 3 Taylor Road to Scott Road (Sub-reaches 1-1 to 1-36)**

The length of Reach 3 is approximately 11.9 km and extends Taylor Road to Scott Road. Reach 3 was further divided into 36 sub-reaches. Generally, the channel is in a state of transition or under stress with the exception of sites: 1-2, 1-22, 1-28, 1-30, and 1-33 as seen in Figure 4-15, Figure 4-16, and Figure 4-17. These five sites are exhibiting characteristics that suggest the channel is in a state of adjustment due to an increase in bedload material (aggradation).

The dominant geomorphic process identified through Reach 3 is channel widening followed by aggradation. Sub-reach 1-29 was the only site to show degradation as the primary geomorphic process. As the data shows, sub-reaches that are widening are followed by sub-reaches that are accumulating sediment and aggrading in channel bed elevation. However, the second most dominant geomorphic process identified is channel degradation. Exposed cobble in the channel bed is one indication that the bed material has most likely been eroded away, revealing the parent channel material. The RGA data shows that the dominant geomorphic process in sub-reach 1-6 is widening with the secondary geomorphic process being degradation. Channel restoration efforts in Reach 3 should be designed to narrow the channel by accumulating sediments towards the banks. Accumulated sediments would develop lateral bars that would naturally narrow the channel.

It should be noted that any design structures intended for improving instream habitat should also be constructed to assist in narrowing channel width and not create scour along the banks. Bank restoration efforts in Reach 3 need to be designed to narrow the channel to a more natural width but able to handle varying discharges without creating erosion issues. The designs need to incorporate floodplain access, particularly where the channel has degraded or widened beyond the natural bankfull discharge width/depth.

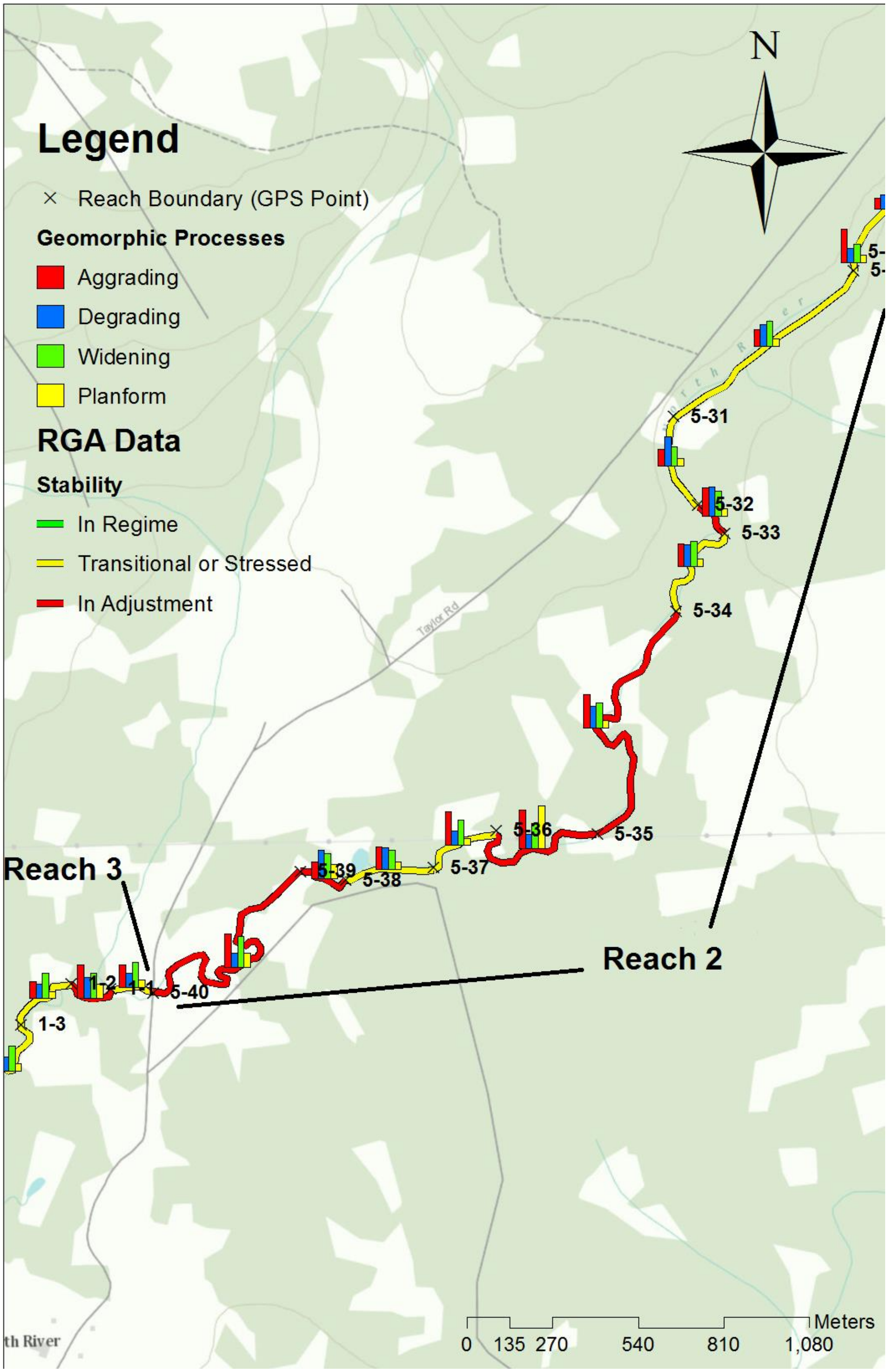


**Figure 4-15:** North River Reach 3 (Sub-Reaches 1-1 to 1-3)

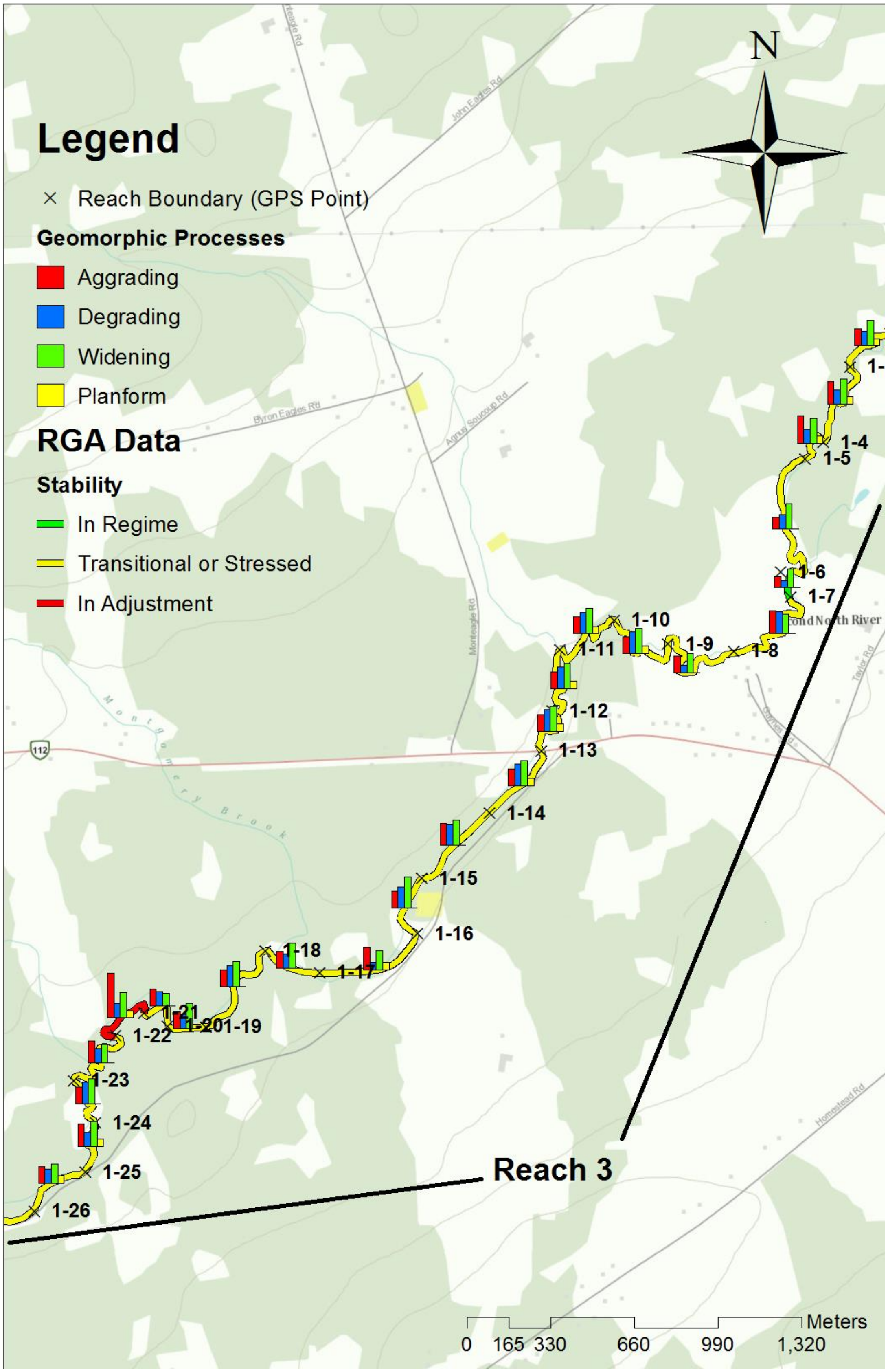


**Figure 4-16:** North River, Reach 3 (Sub-Reaches 1-4 to 1-26).

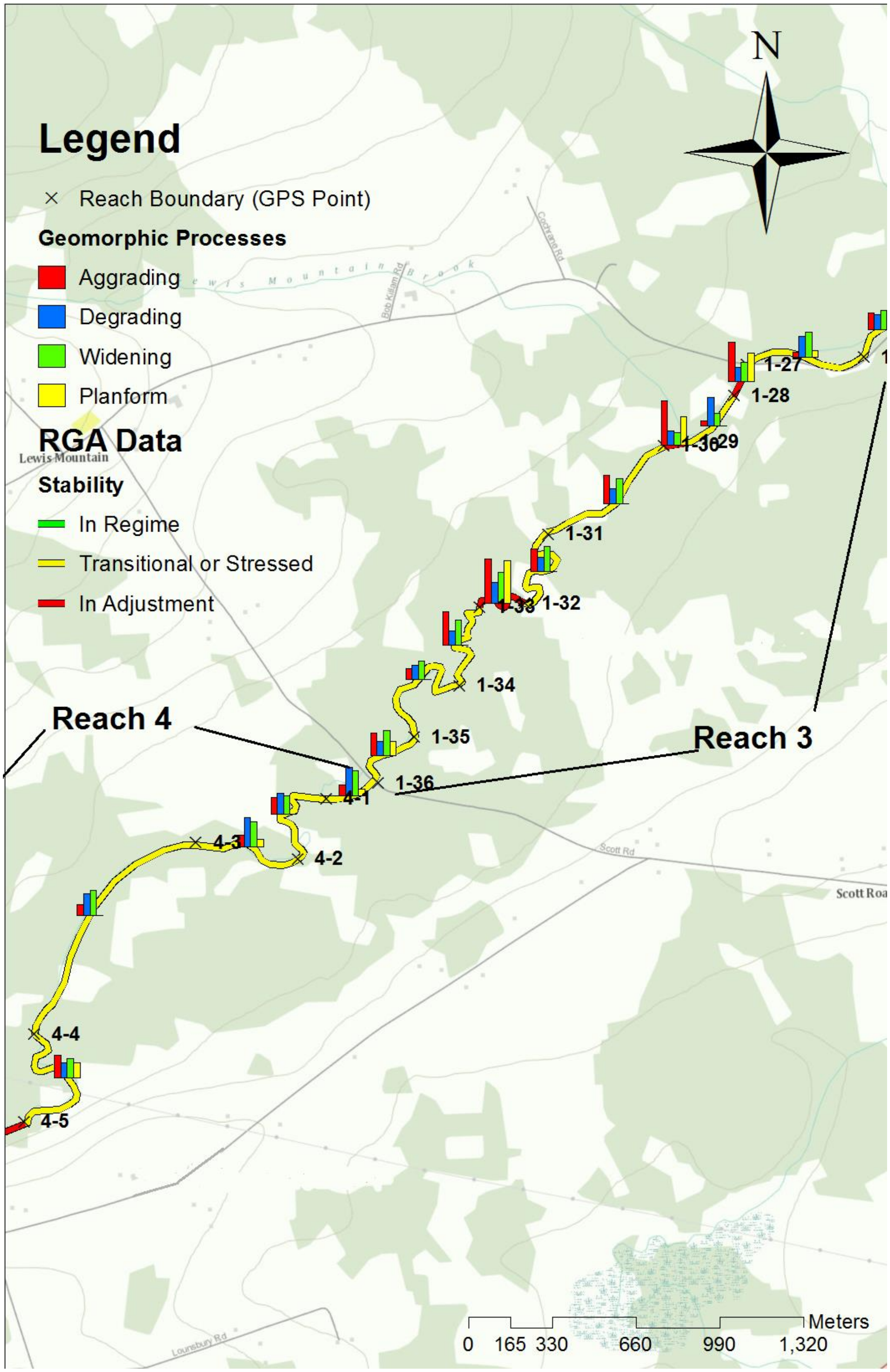


**Figure 4-17:** North River, Reach 3 (Sub-Reaches 1-27 to 1-36).

**Reach 4 Scott Road to Morton Road (Sub-reaches 4-1 to 4-8)**

Reach 4 starts at on the west side of Scott's Road, which is located south of Lewis Mountain. The RGA/RSAT assessments on this section of the North River covered approximately 4.7 km and ended on the east side of Morton Road, near Wheaton Settlement. The reach was divided into eight sub-reaches depicted in Figure 4-18 and 4-19. The entire length of Reach 4 is in a transitional state with the exception of sub-reaches 4-6 and 4-8. Sub-reach 4-6 is undergoing a channel adjustment while sub-reach 4-8 is in a state of stability. The dominant geomorphic process varies between aggradation and degradation; however, sub-reach 4-4 is slightly more towards channel widening than degradation.

Sub-reach 4-8 could be used as a reference reach for Reach 4 and the upper sub-reaches of Reach 3. Bank or aquatic habitat restoration efforts should ensure that designs implemented do not increase sediment loads where there is already aggradation occurring or decrease sediment loads in areas where there is already degradation of the channel occurring.

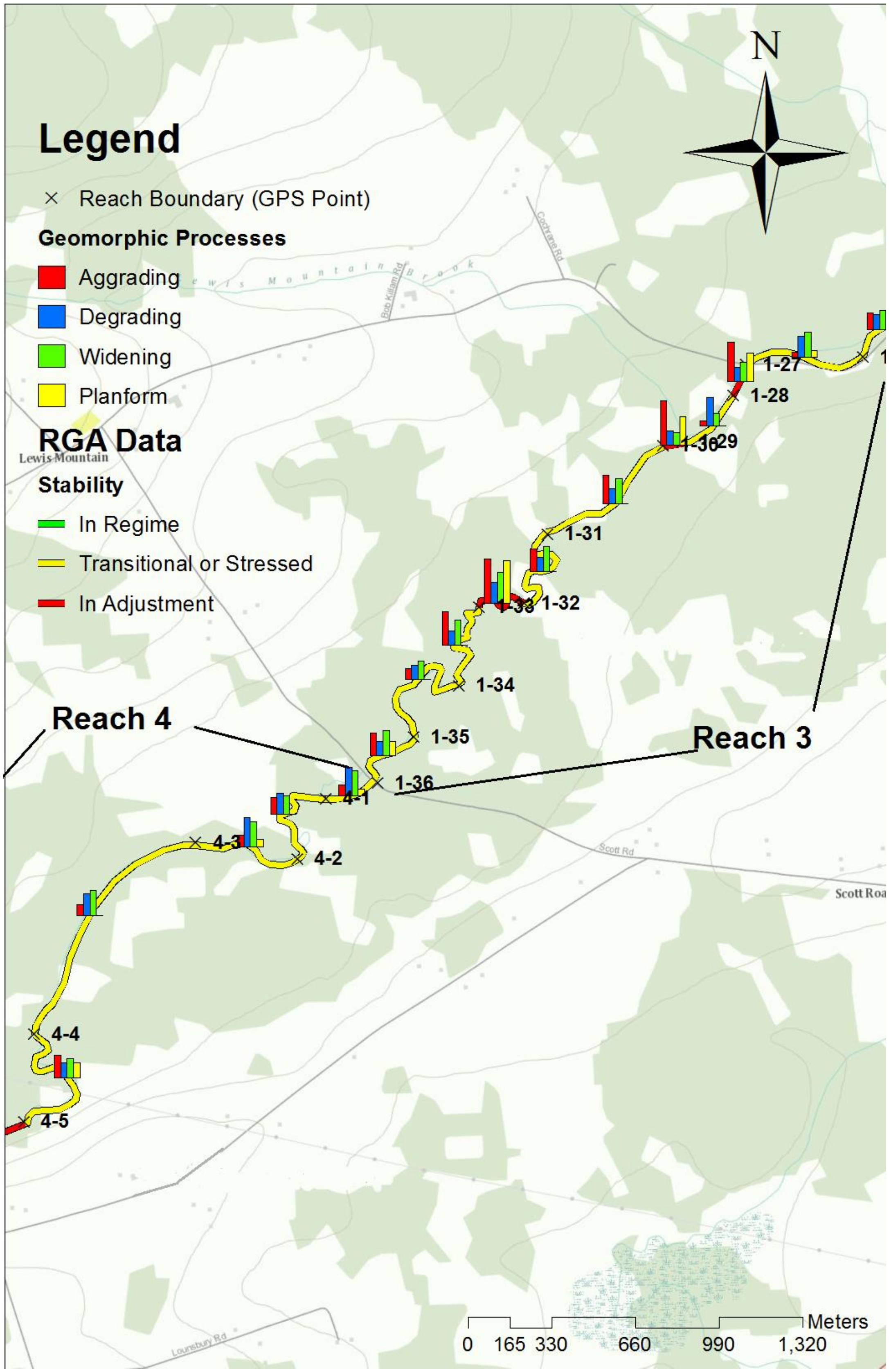


**Figure 4-18:** North River Reach 4 (Sub-reaches 4-1 to 4-5).

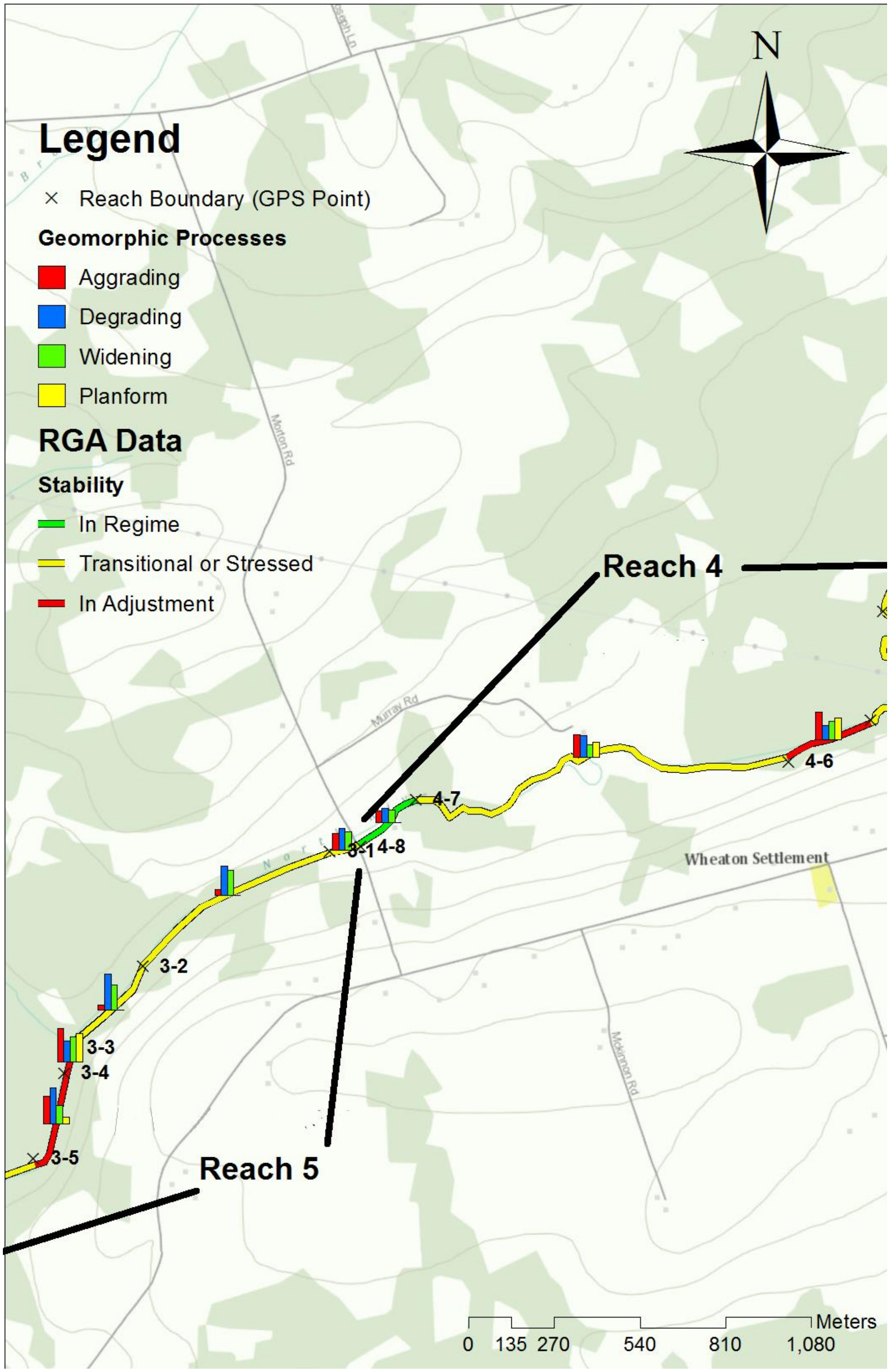


**Figure 4-19:** North River Reach 4 (Sub-reaches 4-6 to 4-8).

**Reach 5: Morton Road to Wheaton Settlement Road Access point (sub-reaches 3-1 to 3-8)**

Reach 5 begins at Morton Road near Wheaton Settlement and goes southwest down the North River, ending just north of Fawcett at a point where Wheaton Settlement Road supplies ready access to the river from the east bank. There are eight sub-reaches within Reach 5 covering 2.8 km of the North River. With the exception of sub-reaches 3-4 and 3-5, Reach 5 is in a state of channel transition. Sub-reaches 3-4 and 3-5 are going through a phase of channel adjustment.

Sub-reaches 3-1 to 3-3 are experiencing channel degradation as shown in Figure 4-20. As sub-reach 3-1 begins to the west of Morton Road (the downstream side of the bridge) further investigation should be given to determine the reason for channel degradation in these sub-reaches. One possible issue may be with the bridge constricting flow during higher discharge events. However, flow capacity through the bridge would need to be modeled to determine if there is any channel constriction occurring from this structure.

Aggradation of the channel bed is occurring in sub-reaches 3-4 and 3-5. The bedload material is coming from the upper sub-reaches but further field investigation would be needed to determine the source of this material.

The remaining sub-reaches, 3-6, 3-7, and 3-8, are dominated by the geomorphic processes, degradation, channel widening, and aggradation, respectively, as illustrated in Figure 4-21. However, the RGA data indicates that any one geomorphic process could easily become dominant within these three sub-sections of Reach 3.

Before any restoration efforts begin in Reach 5, the source of the additional sedimentation to the streambed needs to be determined. Once the root source and cause of the sediment has been identified, channel restoration and/or bank restoration designs need to bring the channel into a state of stability through equalizing the sediment movement in this reach. In other words, the amount of sediment coming into Reach 5 should reflect the sediment load moving out of Reach 5.

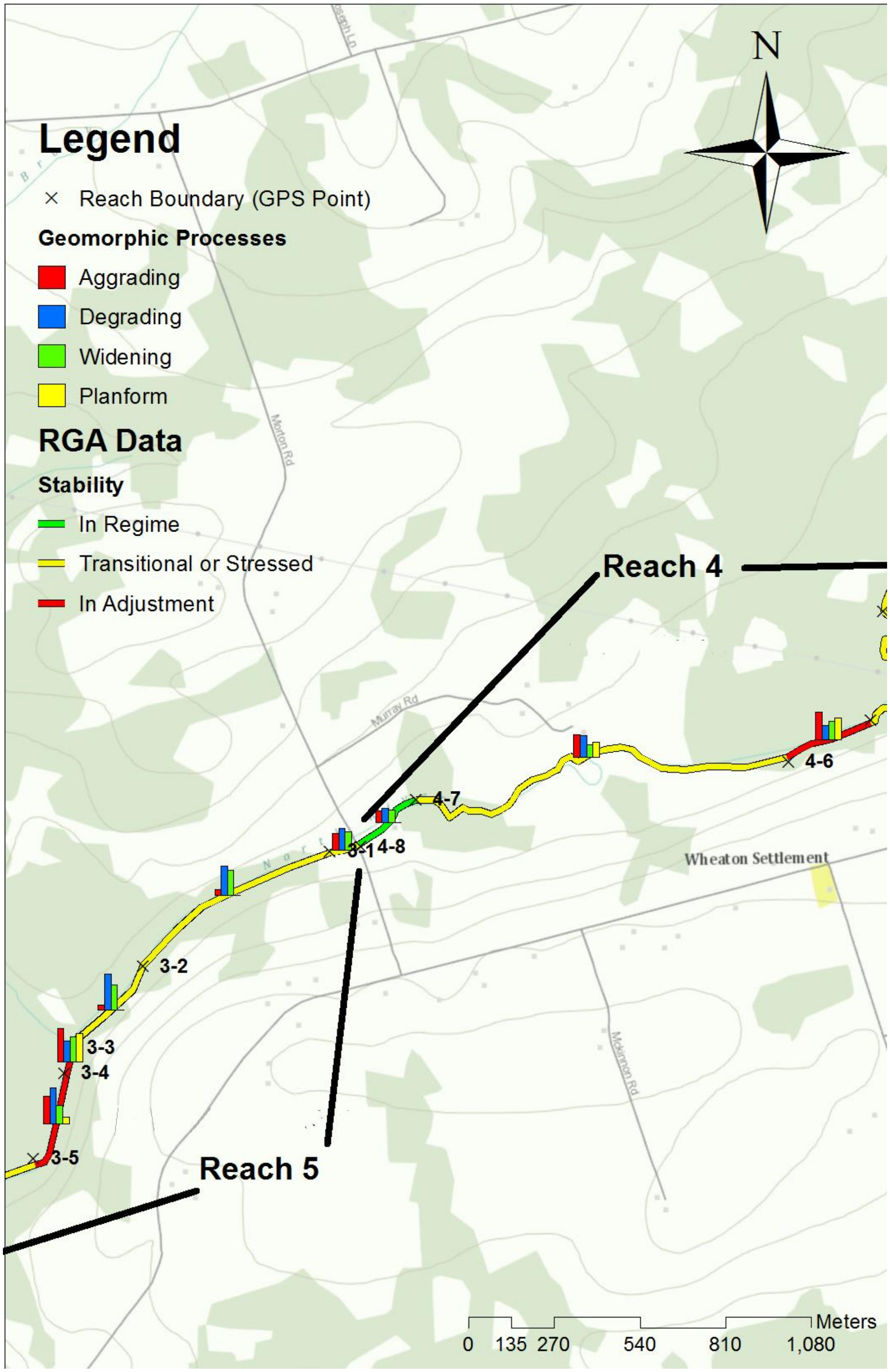


**Figure 4-20:** North River Reach 5 (Sub-reaches 3-1 to 3-5).

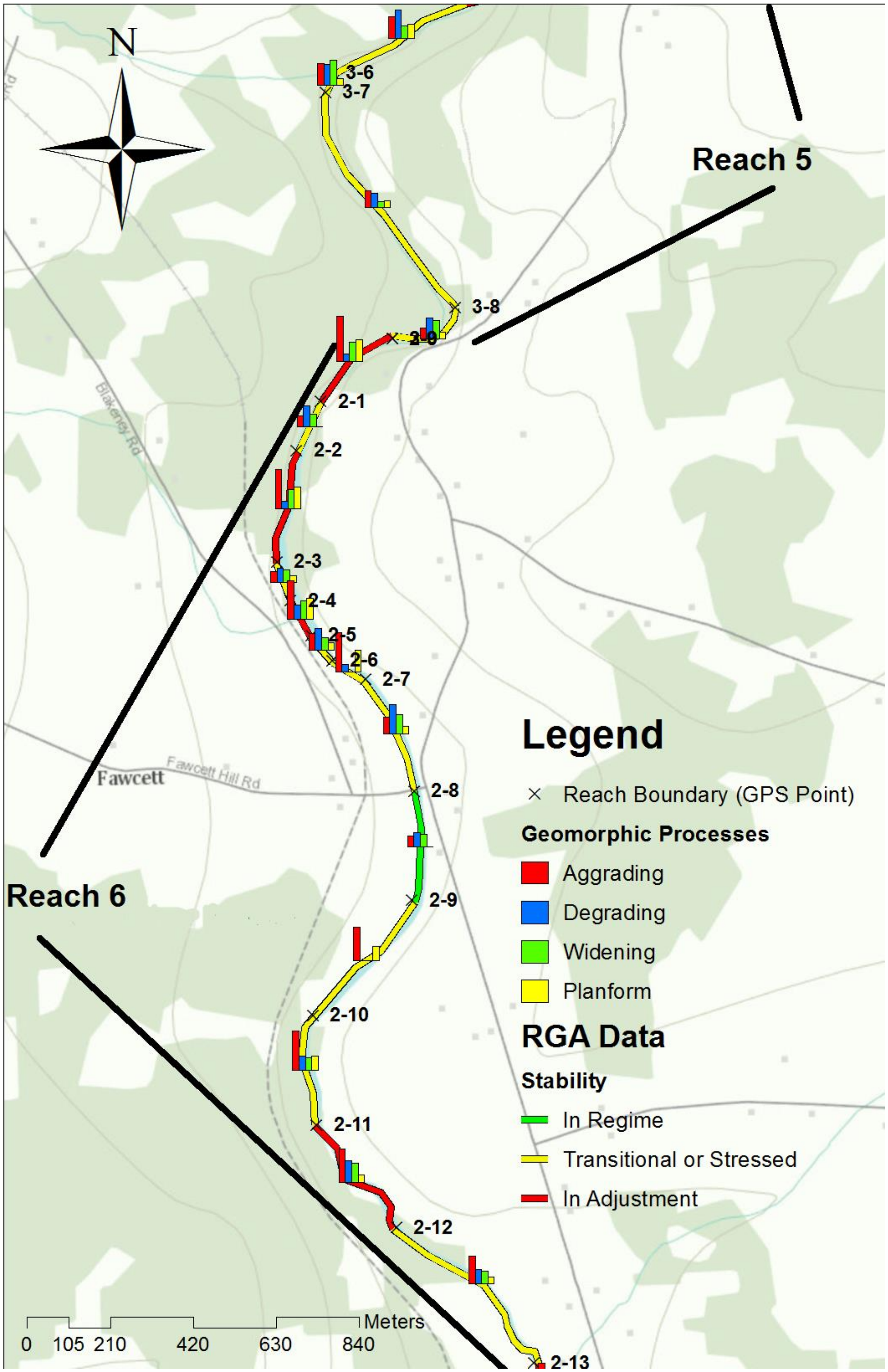


**Figure 4-21:** North River Reach 5 (Sub-reaches 3-6 to 3-8).

**Reach 6: Wheaton Settlement Road Access point to Anagance River (Subreaches 2-1 to 2-38)**

Reach 6 extends from the Wheaton Settlement Road Access point to the confluence of the North and Anagance rivers, below which the channel is recognized as the Petitcodiac River. This reach covers approximately 11 km of the North River and was divided into 38 sub-reaches. The geomorphic conditions identified through the RGA/RSAT assessment indicate that the channel of the North River in Reach 6 has a few stable sub-reaches as well as sub-reaches that are in a transitional state and in phases of adjustment. The stable sub-reaches are: 2-8, 2-17, 2-28, and 2-33; these should not be considered for restoration but rather as reference reaches. Monitoring cross-sections could be established in these reaches as well as thalweg profiles to provide a location to collect baseline data that would be measured yearly or after a large flow event. This would allow for identifying changes to the watercourse as a result of an event and provide some insights as to the changes that may occur elsewhere in the river system.

There are 24 sub-reaches in Reach 6 that are in a geomorphic state of transition or stressed. The dominant geomorphic process identified by the RGA data indicates through sub-reaches 2-0 to 2-12, eight of the sub-reaches are experiencing aggradation. This is closely followed by degradation as the dominant geomorphic process occurring in the other five sub-reaches as shown in Figure 4-22. Interestingly, each sub-reach that was identified as undergoing degradation, the next reach or two downstream was experiencing aggradation. Restoration efforts through sub-reaches 2-0 to 2-12 should keep this in mind when designing instream habitat structures.

Sub-reaches 2-13 to 2-27 are dominated by a channel that is under transition. Four of the stub-reaches are in a state of adjustment and one sub-reach is stable. The dominant geomorphic process is aggradation as seen in Figure 4-23.

Restoration efforts within these sub-reaches should first focus on identifying where the additional sediment load is originating. Any instream habitat restoration completed prior to locating the source or reason for the aggradation of the streambed will jeopardize the longevity of the work. If efforts to control or at least identify the source of streambed aggradation are not part of the overall restoration plans for Reach 6, eventually structures to improve instream habitat will most likely be buried through these sub-reaches.

In Reach 6, the sub-reaches 2-28 to 2-38 are in the lower section of the North River as it joins with the Anagance River to become the Petitcodiac River. The North River through these lower sub-reaches has a lower grade and wider channel width than the upper sub-reaches of Reach 6.

This means it is a natural deposition area for sediments being carried by the water from the upper reaches of the North River. The dominant geomorphic process through these lower ten sub-reaches varies between degradation and aggradation. Sub-reach 2-34 is undergoing widening as the primary geomorphic process but only by a slight margin over channel degradation. The other sub-reaches alternate between accumulating sediment or channel degradation. Three sub-reaches, 2-31, 2-37, and 2-38 are in a state of adjustment. Sub-reach 2-33 is considered to be in regime, or in a state of relative stability. The remaining sub-reaches are going through a transitional phase. Figure 4-24 illustrates these features.

Restoration efforts, whether it is instream habitat, bank stabilization, or floodplain creation, in sub-reaches 2-28 to 2-38, should be attempted with caution. Determining bankfull discharge rates and depth/width ratios will be an important factor in any channel or floodplain restoration modifications through these lower sub-reaches of Reach 6.

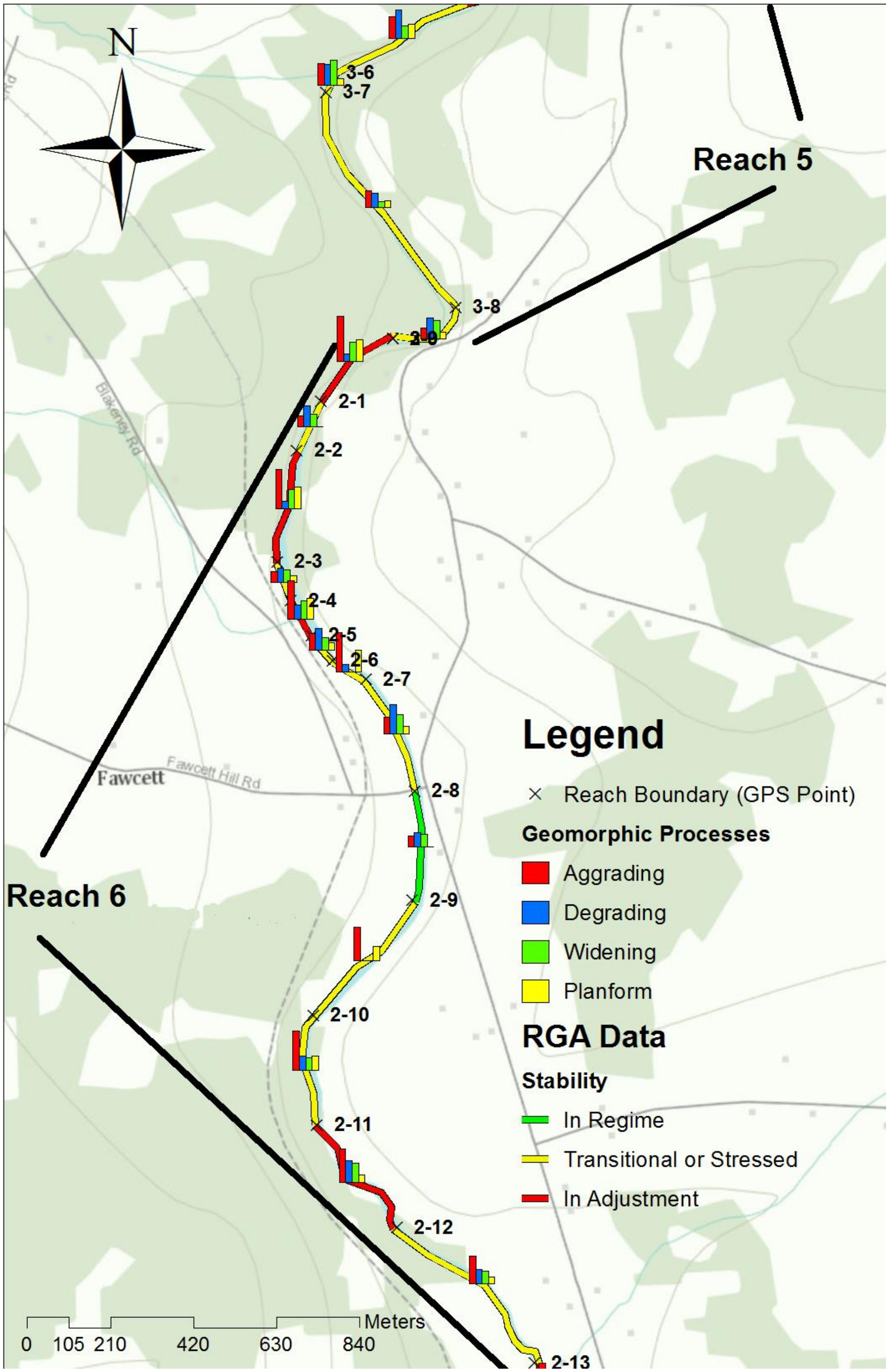


**Figure 4-22:** North River Reach 6 (Sub-reaches 2-0 to 2-12).

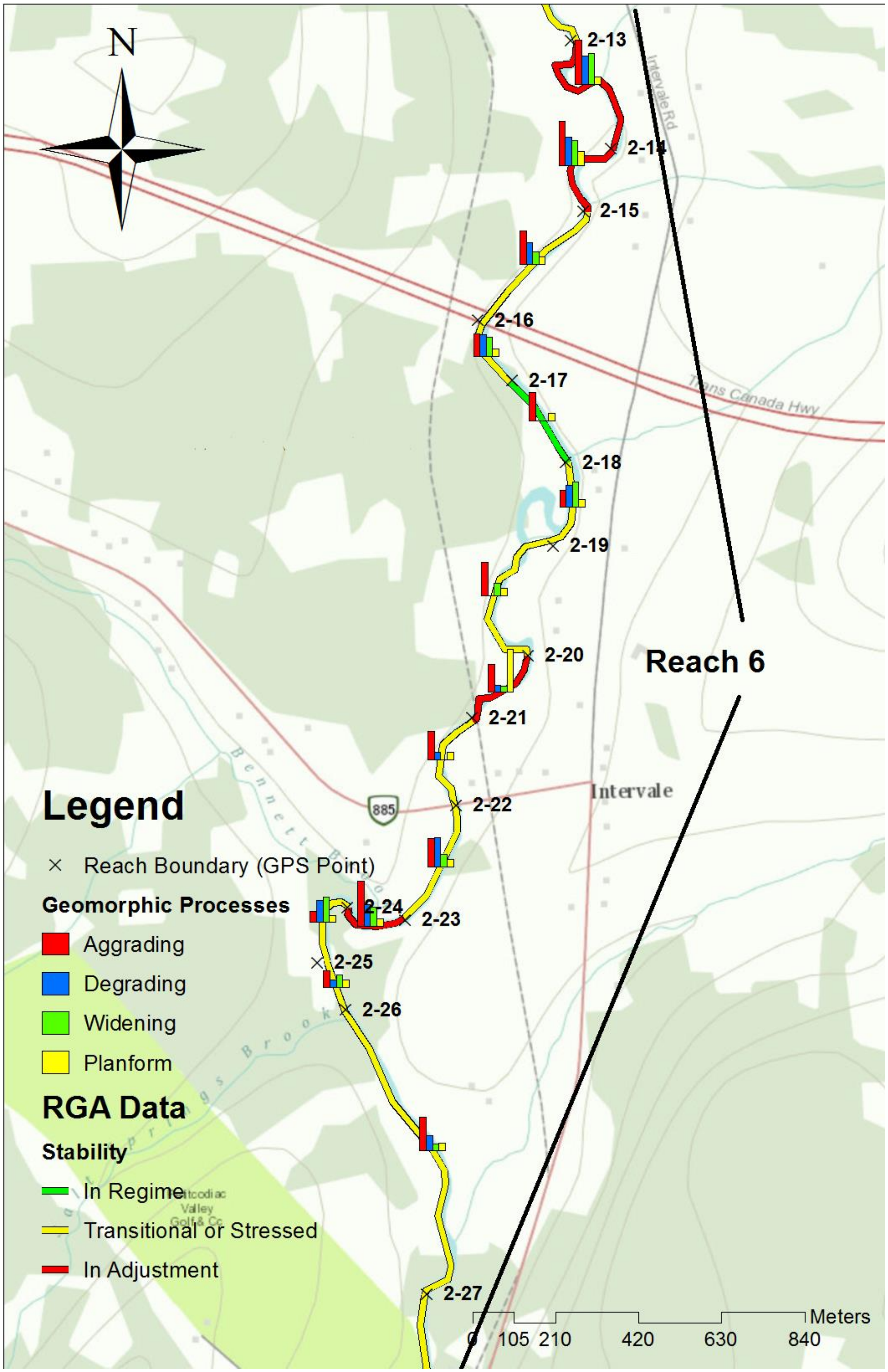


**Figure 4-23:** North River Reach 6 (Sub-reach 2-13 to 2-27).

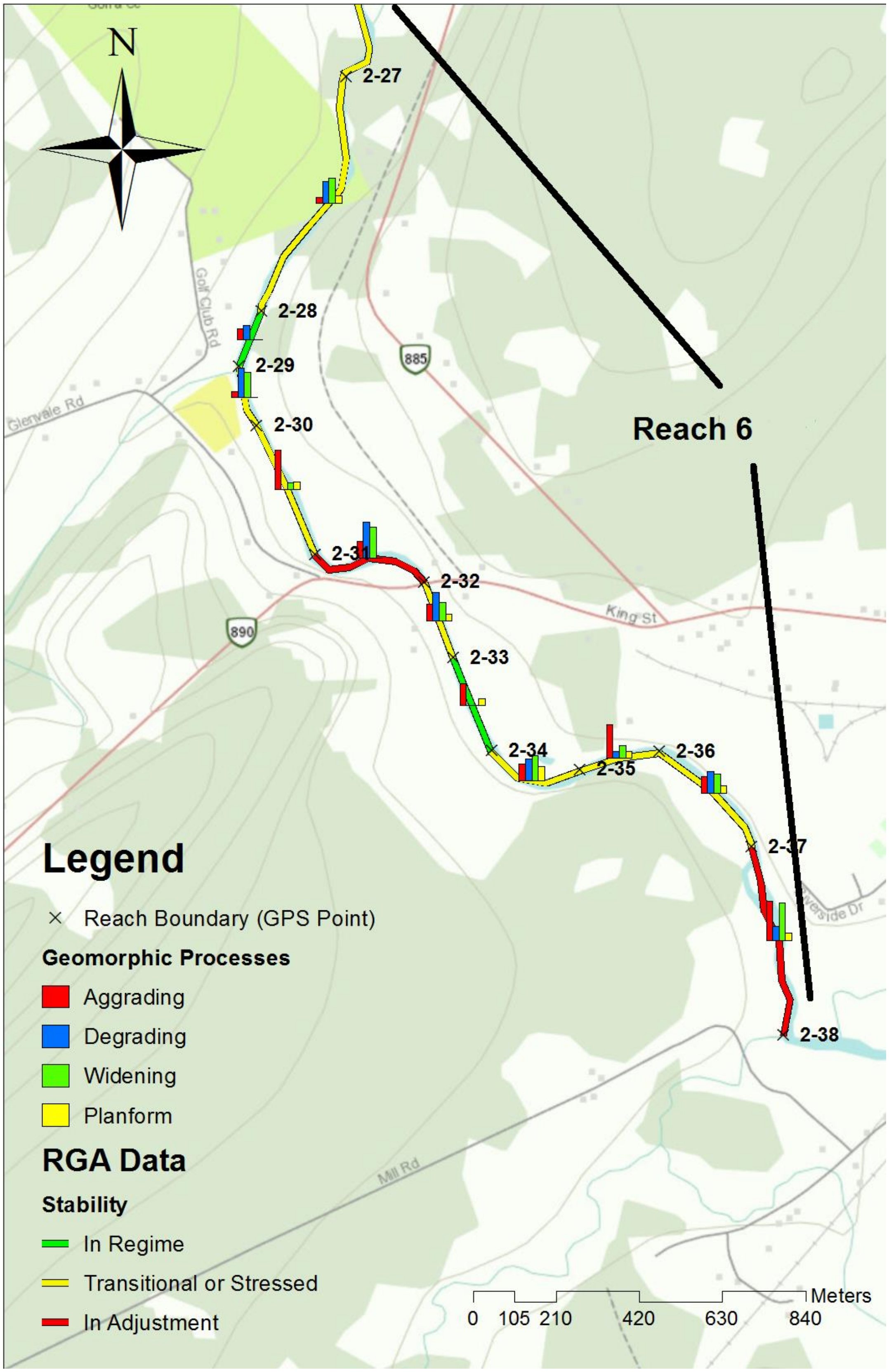


**Figure 4-24:** North River Reach 6 (Sub-reaches 2-28 to 2-38).

## Fourth Level Assessment – Aquatic Habitat Rehabilitation Plan

### *Summary of Issues Identified by Resource Users and Stakeholder Groups*

The following issues were identified by stakeholders to date:

- Debris in the river:
- Whole cars near Intervale
- Cattle access to river
- Run-off from farms polluting the river
- Algal blooms
- Erosion prevention needed so that houses stop falling in to the river

### *Summary of Issues Identified from Geomorphic Assessments*

**Reach 1: Route 126 to Pacific Junction Road (sub-reaches 6-0 to 6-8)**

If fish passage is a priority, the culvert under Route 126 is an issue with the downstream invert hanging above the streambed. The culvert appears to be able to handle the flows as the oxidization line on the pipe is approximately a third of the way up from the bottom (Figure 4-7). It is also noted that looking though the culvert, based on the photograph, the pipe may be collapsing. However, this could simply be the angle the photograph was taken and further investigation may be warranted.

**Reach 2: Pacific Junction to Taylor Road (Sub-reaches 5-1 to 5-40)**

As with any increase in sediment load to a watercourse the source needs to be determined prior to implementing any instream restoration structures. Otherwise there is an inherent risk that the instream structures will be buried. Once the source or cause of the excess sediment in the system has been determined proper restoration or mitigation measures can be taken to assist with the natural movement of the material through the reach. By creating deposition or scour areas, equilibrium of sediment load through the system can be achieved ensuring that any instream habitat structures function as intended. Restoration efforts, whether for instream habitat or bank erosion, therefore need to consider what the end goal of the restoration is and the effects that will result from implementing such measures on upstream and downstream banks and instream features.

### Reach 3 Taylor Road to Scott Road (Sub-reaches 1-1 to 1-36)

Channel restoration efforts in Reach 3 should be designed to narrow the channel by accumulating sediments towards the banks. Accumulated sediments would develop lateral bars that would naturally narrow the channel. It should be noted that any design structures intended for improving instream habitat should also be constructed to assist in narrowing channel width and not create scour along the banks. Bank restoration efforts in Reach 3 need to be designed to narrow the channel to a more natural width but able to handle varying discharges without creating erosion issues. The designs need to incorporate floodplain access, particularly where the channel has degraded or widened beyond the natural bankfull discharge width/depth.

### Reach 4 Scott Road to Morton Road (Sub-reaches 4-1 to 4-8)

Bank or aquatic habitat restoration efforts should ensure that designs implemented do not increase sediment loads where there is already aggradation occurring or decrease sediment loads in areas where there is already degradation of the channel occurring.

### Reach 5: Morton Road to Wheaton Settlement Road Access point (sub-reaches 3-1 to 3-8)

As sub-reach 3-1 begins to the west of Morton Road (the downstream side of the bridge) further investigation should be given to determine the reason for channel degradation in these sub-reaches. One possible issue may be with the bridge constricting flow during higher discharge events. However, flow capacity through the bridge would need to be modeled to determine if there is any channel constriction occurring from this structure. Before any restoration efforts begin in Reach 5, the source of the additional sedimentation to the streambed needs to be determined. Once the root source and cause of the sediment has been identified, channel restoration and/or bank restoration designs need to bring the channel into a state of stability through equalizing the sediment movement in this reach. In other words, the amount of sediment coming into Reach 5 should match the sediment load moving out of it.

**Reach 6: Wheaton Settlement Road Access point to Anagance River (Sub-reaches 2-1 to 2-38)**

Restoration efforts within these sub-reaches should first focus on identifying where the additional sediment load is originating. Any instream habitat restoration completed prior to locating the source or reason for the aggradation of the streambed will jeopardize the longevity of the work. If efforts to control or at least identify the source of streambed aggradation are not part of the overall restoration plans for Reach 6, eventually structures to improve instream habitat will most likely be buried through these sub-reaches. Restoration efforts, whether it is instream habitat, bank stabilization, or floodplain creation, in sub-reaches 2-28 to 2-38, should be attempted with caution. Determining bankfull discharge rates and depth/width ratios will be an important factor in any channel or floodplain restoration modifications through these lower sub-reaches of Reach 6.

### *Summary of Issues Identified from Information on Current Impacts*

To date, the culvert, identified as WM20, located under a two lane asphalt road on Route 126 at Control Section #R0126 009-9.550 was indicated as being as in fair to poor condition. Not surprisingly, this is the culvert identified in the 2012 surveys from Reach 1.

### *Opportunities for Future Restoration Activities*

The Petitcodiac Watershed Alliance and the Village of Petitcodiac have been examining options for a bank stabilization project protecting civic infrastructure in the form of Route 106 on the left side of the river and the Village sewage lagoon on the right side of the river. The location is actually 1.8 kilometers downstream of the confluence of the North and the Anagance Rivers and so is technically on the main stem of the Petitcodiac, not the North River. Though not within the North River watershed, given that the site is located immediately downstream, essentially all of the First Level historical, and Second Level current impact assessment data for the North River remain applicable, and as such provide relevant context for the project. The involvement of the Village of Petitcodiac as a stakeholder is another reason to include it here both because the relatively high profile of the project impacts the awareness of individuals a short distance upstream along the North River, and the outcome of this project will influence any future collaborative activity with the Village of Petitcodiac on the North River itself.

In 2014 the Petitcodiac Watershed Alliance and the Village of Petitcodiac contracted with Parish Geomorphic Ltd. to evaluate the identified threats to infrastructure and develop recommendations for an intervention to solve it. The results of their analysis are presented in Figure 4-25.

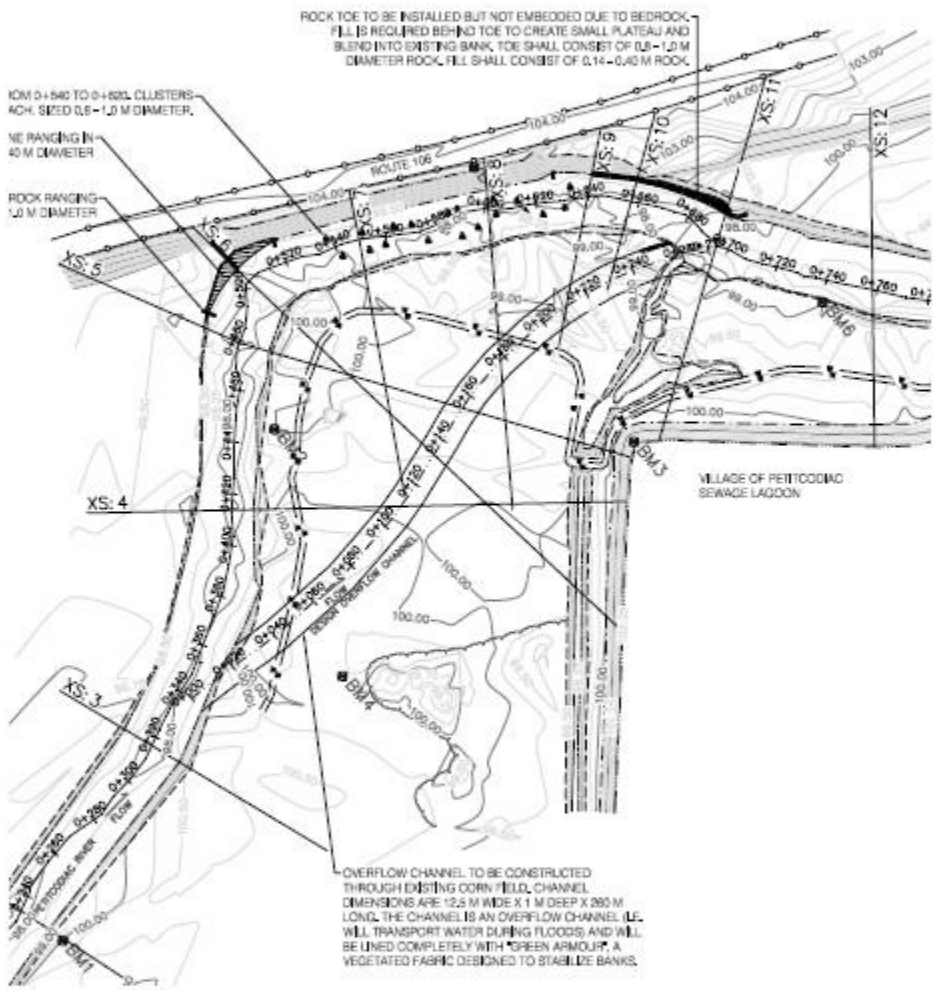


**Figure 4-25:** Parish Geomorphic Ltd. plan to protect the Route 106 and Village of Petitcodiac sewage lagoon

The proposed plan involves two options. The first (less expensive) option, calls for installation of rock spurs and boulder clusters along the toe of the slope below Route 106. The second (more expensive) option involves creation of an overflow channel running between the sewage lagoon and the existing main channel in order to shift stormflow away from Route 106, but do so in a regulated manner that preserves the sewage lagoon.

In 2015 the first option will be implemented by The Petitcodiac Watershed Alliance as the project lead, in collaboration with Parish Geomorphic Ltd. Fort Folly Habitat Recovery will be involved in the project by accessing funds to help support it through the Habitat Stewardship Program. It is not yet clear when or if the second option (the overflow channel) will be implemented, though it seems quite possible that, even if the initial effort focuses on only the first option, the second may eventually become necessary in order to fully address the issues at the site, and provide adequate protection for the sewage lagoon. Table 4-3 lists estimates provided by Parish Geomorphic of the costs and requirements of each option.

**Table 4-3:** Option 1 and Option 2 Material and Cost Estimates

*Option 1 Rock Spurs / Boulder Clusters*

| Phase | Description | Cost |
|---|---|---|
| Materials | Fill for 150 $m^3$ area | $5,000 |
| | Boulder Clusters (20 clusters, 3 rocks per cluster) | $4,000 |
| | Rock Spurs | $3,000 |
| | Rock Toe & Fill (by House) | $13,500 |
| Material Total | | $25,550 |
| Construction | Contractor Cost | $14,000 |
| | Construction Oversight & Project management | $6,500 |
| | Post Construction Survey | $8,000 |
| Construction Total | | $28,500 |
| Additional costs | Mileage/Accommodations | $3,000 |
| Option 1 Total | | $57,050 |

*Option 2 Overflow Channel in Floodplain*

| Phase | Description | Cost |
|---|---|---|
| Materials | Green Armour Installation | $110,000 |
| | Boulders for downstream tie-in (10 rocks) | $1,000 |
| Material Total | | $111,000 |
| Construction | Site Layout | $3,500 |
| | Channel Construction (~260 m Channel Length) | $33,800 |
| | Construction Oversight & Project Management | $9,000 |
| | Post Construction Survey | $6,000 |
| Construction Total | | $52,100 |
| Additional costs | Mileage/Accommodations | $5,000 |
| Option 2 Total | | $168,100 |

*Recommended Monitoring Plan*

| Phase | Cost |
|---|---|
| 3- Year Monitoring Plan | $8,000/Year |

**costs estimated based upon preliminary design and may change in finalized design*
**cost to be verified by contractor based on finalized design*
**time based upon 10 hr work days*
**costs do not include applicable taxes*

Other possible restoration activities within the North River Watershed are described below; targeted artificial debris removal, and culvert replacement. We do not anticipate any negative effects to the target species or their respective habitats. All of the prospective activities would improve the quality of the aquatic habitat for American Eel, Atlantic salmon and wood turtle. The removal of artificial instream debris could improve the water quality of the surrounding habitat by removing possible contaminants. It could also help prevent bank erosion depending on the location of the debris and help restore fish passage where debris is prohibitive of movement. Culvert replacement could help restore passage in areas where it is currently blocked by faulty infrastructure. Restoring passage will be most beneficial to iBoF salmon as they are the least able of the three target species to navigate past barriers. American eels and wood turtles are both capable and known to cross barriers via terrestrial terrain to navigate around barriers.

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# APPENDIX A: PROJECT CHECKLISTS TO MINIMIZE IMPACTS ON PROTECTED SPECIES

## Checklist for projects in Atlantic Salmon (*Salmo salar*) habitat

1). Determine if there are any obvious downstream natural or manmade barriers to fish passage (waterfalls, dams, perched culverts, etc) that could prevent salmon from accessing the site.
☐ Done  Comment ________________________________________

2). If manmade barriers are found, note them for possible future action, or, if practical, consider mitigating them as part of the current project.
☐ Done ☐ Does not apply  Comment __________________________

3). Even where such barriers exist, electrofish or otherwise sample the site to confirm current presence or absence of salmon as part of project planning, prior to any modification of site.
☐ Done  Comment ________________________________________

4). If no salmon are found and the reason is determined to be a natural barrier, reconsider the need for the project. Perhaps the site should not be considered a priority unless reasons other than promotion of salmon are motivating factors, as resources might be better used elsewhere.
☐ Done ☐ Does not apply  Comment __________________________

5). If no salmon are found at the site but there is no barrier to fish passage (manmade or natural) it is likely that this is a result of the declining population of wild salmon in the region. If salmon are found elsewhere on the river then treat the site as if it has salmon. If no salmon are found in that river then reevaluate the need for the project as resources might be better used elsewhere.
☐ Done ☐ Does not apply  Comment __________________________

6). Plan project thoroughly and allow sufficient lead time to secure necessary permits and schedule work during optimal work conditions. This will help minimize the duration of in stream work, reduce negative impacts, and control costs.
☐ Done  Comment ________________________________________

7). In sites where salmon are found, observe an operating window of July 1st to September 30th to time any earth moving operations between the end of alevin emergence and the start of spawning.
☐ Done ☐ Does not apply  Comment __________________________

8). In sites where salmon are found, always assume that juveniles and / or migrating adults are present while doing any work during the operating window allowed in item 7. The window indicates reduced sensitivity of fish, not their absence. Care must still be taken to minimize direct harm to fish during work.
☐ Done ☐ Does not apply  Comment __________________________

9). Incorporate erosion and sediment control practices into work plan as laid out in Section 3 of DFO's Land Development guidelines for Protection of Aquatic Habitat (http://www.dfo-mpo.gc.ca/Library/165353.pdf)
☐ Done  Comment ________________________________________

10). Retain riparian vegetation to protect natural stream conditions and structure and promote stability of the bed and banks. Doing so maintains shade, water temperatures, dissolved oxygen, food supplies, organic debris, cover etc.
☐ Done  Comment ________________________________________

APPENDIX A: Project Checklists to minimize impacts on protected species

## Checklist for projects in American Eel (*Anguilla rostrata*) habitat

1). Determine if there are any obvious downstream natural or manmade barriers to fish passage (waterfalls, dams, perched culverts, etc) that could prevent eels from accessing the site.
☐ Done Comment________________________________________

2). If manmade barriers are found, note them for possible future action, or, if practical, consider mitigating them as part of the current project.
☐ Done ☐ Does not apply Comment___________________________

3). Even where such barriers exist, electrofish or otherwise sample the site to confirm current presence or absence of eels as part of project planning, prior to any modification of site.
☐ Done Comment________________________________________

4). Evaluate and estimate quantity and quality of watershed upstream of site for value to eels to better understand and document potential impacts of any gain or loss of access
☐ Done Comment________________________________________

5). Where upstream habitat warrants it, ensure that project design will not create a barrier to eel passage when complete. The best means of maintaining unobstructed passage will be site and project specific, varying significantly between fords, dams, culverts etc.
☐ Done ☐ Does not apply Comment___________________________

6). If the project site is within 200 meters of the head of tide then time operations for July and August if possible in order to minimize risk of direct harm to elvers migrating upstream (May/June) and eels migrating downstream (September) that could be concentrated and sheltering amid substrates.
☐ Done ☐ Does not apply Comment___________________________

7). If the project site is more than 200 meters beyond the head of tide then if possible avoid operations during September in order to minimize risk of direct harm to eels migrating downstream that could be concentrated and sheltering amid substrates.
☐ Done ☐ Does not apply Comment___________________________

8). The primarily way that humans spread the swim bladder nematode (*Anguillicola crassus*) is by moving infected eels into unimpacted watersheds. Most restoration projects pose no risk of this. None the less, understand the nematode's lifecycle, and ensure that the project avoids spreading it.
☐ Done Comment________________________________________

APPENDIX A: Project Checklists to minimize impacts on protected species

## Checklist For Projects in Wood Turtle (*Glyptemys insculpta*) habitat

1). Conduct series of 3 surveys of the site and surroundings at appropriate time of year (spring is best) to determine presence of turtles as part of project planning, prior to any modification of site.
☐ Done Comment ____________________

2). In addition to looking for individual turtles, assess project site (and surrounding area) to identify turtle nesting sites (best done during nesting season (May/June) the prior year).
☐ Done Comment ____________________

3). Consider value of site for turtles (if present) relative to other species: stream bank stabilization may benefit salmon, but harm turtles. On a non salmon bearing stream that is home to turtles, taking no action may be the best management.
☐ Done ☐ Does not apply Comment ____________________

4). Be aware that shortly prior to nesting females concentrate in undisturbed sites adjacent to nest sites, so minimize impacts on the immediate surroundings of nest sites during nesting season.
☐ Done ☐ Does not apply Comment ____________________

5). If turtles or nest sites are present then plan to conduct restoration activities at both time of year and time of day to try to avoid encounters with turtles.

| Time of year | Stage | distance from water | habitat use | most active |
|---|---|---|---|---|
| Jan/Feb/Mar | hibernating | in pools | in stream | not active |
| Late Mar/Apr | pre nesting | 100 m | aquatic | morning & late afternoon |
| May /Jun | nesting | 3km + | terrestrial | morning & early evening |
| Jul/ Aug/Sep | post nesting | 100 m | aquatic | morning |
| October | pre hibernation | 100 m | aquatic | morning & late afternoon |
| Nov/Dec | hibernating | in pools | in stream | not active |

☐ Done ☐ Does not apply Comment ____________________

6). If turtles are present, do not stabilize or vegetate any sites that possess ALL of the following characteristics, as these may be nest sites:

a) full sun exposure to afternoon / evening sun (SW aspect)
b) slope less than 40 degrees (nests usually atleast 1.5 m above water surface)
c) sand or sand gravel substrate with little or no ground vegetion (>20% cover)

☐ Done ☐ Does not apply Comment ____________________

7). If intervention on nesting sites is unavoidable, then mitigate:

- time work either prior to nesting or after hatching (either April or November) if possible, to avoid destroying existing nests
- create compensatory habitat (witch characteristics of item 6: a, b, & c) nearby

☐ Done ☐ Does not apply Comment ____________________

8). If manipulating project site in turtle habit in July or August and air temps remain over 26° C, search directly affected portions of site for estivating turtles prior to beginning operations.
☐ Done ☐ Does not apply Comment ____________________

9). Maintain access across finished project site to adjacent suitable nest sites- a low profile wood structure with sod cap is preferable to large rocks or other material that results in slippery surface
☐ Done ☐ Does not apply Comment ____________________

10) If project has increased human access to site, protect nests with predator exclusion boxes, as human activity increases the density of nest predating species like raccoons and skunks.
☐ Done ☐ Does not apply Comment ____________________