Stewardship Plan for the main stem of the Petitcodiac River:

Fort Folly Habitat Recovery

Fort Folly First Nation

2024 Edition

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Disclaimer:

This document claims no authority by which to drive its implementation. Instead, it is intended simply to serve as a public resource that organizes available information and helps inform future decision making by identifying, and prioritizing needs and sites for restoration activities that will enhance habitat quality and promote species recovery. This is a reference, not intended to be read cover to cover. It is also a living document, current and definitive to the time of writing, but constantly evolving and will never assume an absolute “final” form. Instead, it will be updated and superseded by subsequent editions as additional information becomes available.

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Introduction

This Stewardship Plan for the main stem of the Petitcodiac River is one of a series of seven such documents compiling, detailing, and presenting information about tributaries of the Petitcodiac River and surrounding watersheds. The purpose of these documents is to enable prioritization and planning of restoration activities within the following watersheds: 1) Demoiselle Creek, a small watershed that drains directly into Shepody Bay, near the mouth of the Petitcodiac River estuary, 2) the Memramcook River, immediately adjacent to the mouth of the Petitcodiac River at Fort Folly Point, 3) the main stem of the Petitcodiac extending between the Village of Petitcodiac (where the Petitcodiac "begins") down to the head-of-tide at Salisbury, and four tributaries of the Petitcodiac River system, 4) Little River, 5) Pollett River, 6) Anagance River, and 7) the North River. The location of these 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" (Melanson et. al 2006). The first level of assessment is 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 brings this information together to develop an aquatic habitat rehabilitation plan that identifies priorities and opportunities for interventions within each watershed to advance habitat restoration.

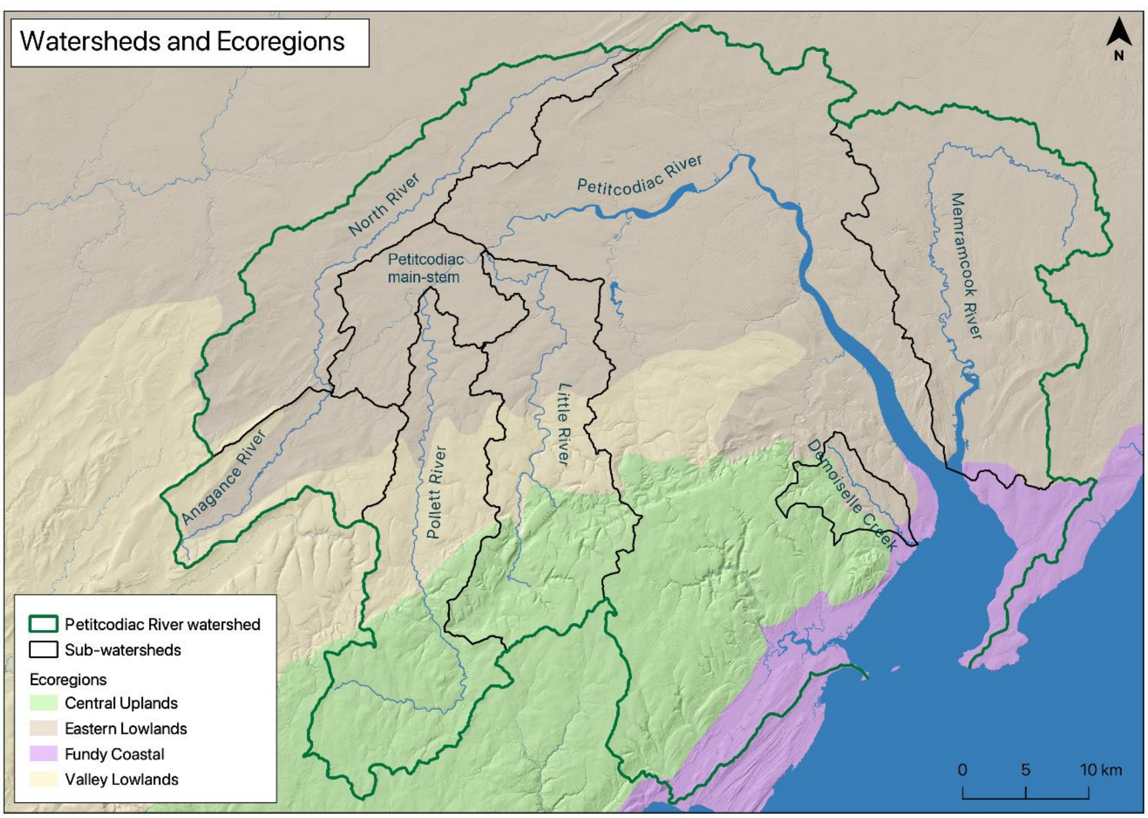

Figure 1: Location of the main stem within the Petitcodiac system.

Main Stem of the Petitcodiac

The “main stem of the Petitcodiac” refers to the 22 kilometers of river and associated watershed between the confluence of the Anagance River and the North River at the Village of Petitcodiac where the Petitcodiac River is said to “begin”(Figure 2), and the head of tide in the Village of Salisbury, where the freshwater portion of the river ends and the Petitcodiac estuary starts (Natural Resources Canada 1997). Along the way the Petitcodiac is joined by the Pollett River and the Little River, and the channel widens substantially, from 15 to 20 metres at the confluence of the Anagance and the North (Figure 3) to about 60 metres at the lowest portion of the head of tide (Figure 4). The main stem of the Petitcodiac lies entirely within the Eastern Lowlands Ecoregion (Department of Natural Resources 2007). As is typical for that ecoregion, the gradient of the river is low, falling about 20 metres over those 22 kilometres, and the water is slow moving, with an occasional cobble or bedrock dominated bottom, but mostly sand and gravel substrate. This portion of the Petitcodiac watershed drains 115.2 km^2, which is smaller than but somewhat comparable in area to the various tributaries joining it. The GeoNB watershed data layer (Department of Natural Resources in 2023) defines this portion of the watershed as two segments: the

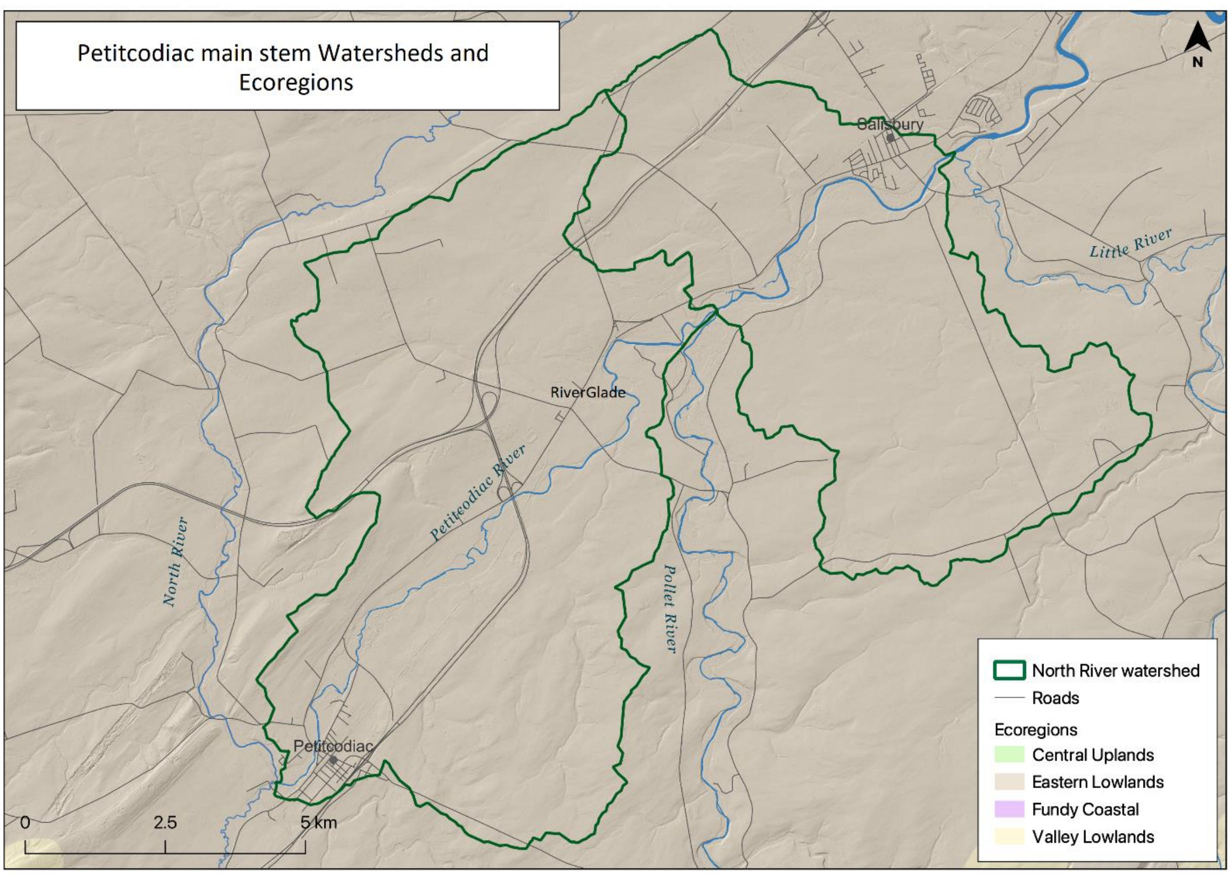

Figure 2: Comprised of the O’Blenis Brook composite and the Bannister Brook composite.

O’Blenis Brook Composite and the Bannister Brook Composite, the latter of which ends at the mouth of the Little River on the river right bank and excludes the McNaughton Brook basin on the river left bank. That point is well into the head of tide, below which strong tidal influences dominate. Beyond that, the estuary continues to the east before bending at Moncton, to drain southeast into Shepody Bay, then Chignecto Bay, and on into the Bay of Fundy.

Dominant land uses within the watershed are forestry and agriculture. Approximately 81 % of the watershed is forested: 59 % private woodlots, 2.3 % crown land, and 20 % industrial freehold. 12% of the watershed has been converted to agriculture, 10.1% row crops or grains, 1.2% pasture, and 0.04% Orchards (Department of Natural Resources 2023).

Figure 3: At the mouth of the Anagance River: the North River (main channel upstream to left), becomes the Petitcodiac main stem in centre of photo (channel 15 to 20 m wide) and flows downstream to right.

Figure 4: Petitcodiac main stem at head of tide in Salisbury, Railroad bridge below mouth of Little River just above the mouth of McNaughton Brook (channel approximately 60 m wide).

In addition to the major tributaries (North, Anagance, Pollett, Little), named streams joining the Petitcodiac along the main stem include: O'Blenis Brook, Trites Brook, Nigus Brook, Chapman Brook, Hasty Brook, Bannister Brook, and French Brook.

While the name Petitcodiac might appear at first glance to be French in origin, that is an indication of the local Acadian influence. The name is actually a Francophone corruption of the Mi'kmaq name, "Petigotiag" (Knockwood 2022, personal communication) which is varyingly translated as "river that bends around back" (Rayburn 1975) , or the somewhat more poetic, "river that bends like a bow" (Petitcodiac River Heritage Committee 2000). The "bend" is often identified with "le Coude" (the elbow) the Acadian name for what is now Moncton where the river, which had been flowing east abruptly turns south to flow towards Shepody Bay. Petitcodiac was widely held to be a corruption of the French "petit coude" meaning, "little elbow" in reference to the "Bend" at Moncton "le Coude". Ganong (1896) dispelled that notion and confirmed its Mi'kmaq origin, demonstrating that though the word was found in French documents, it never once had the form that the "petit coude" theory required, or anything like it. Instead, what alternate forms existed were consistent with Francophone adaption of the name from Mi'kmaq.

An early record (Scott 1758) of an English version of the name is Pittuiquack, from a map drafted by British Major George Scott while forcefully removing Acadian families from the upper Petitcodiac. However, Anglophones appear to have adopted the more familiar Petitcodiac quickly. By 1786, early settler of the Village of Petitcodiac David Blakeney signed as a "resident of the River Petitcodiac" on a petition for a mail road to the City of Saint John (Burrows 1984). Uncertainty as to origin of the name persisted for some time, however.

Ganong (1914a) suggests the name is more likely a description of the way the Petitcodiac bends back upon itself, as Mi'kmaq names are typically descriptive, and in the case of rivers often inform what it is like to ascend them. From the headwaters in the North River (Figure 1) near Magnetic Hill in Moncton, the main channel flows southwest to be joined by the Anagance at the Village of Petitcodiac where the government officially begins to recognize it as the Petitcodiac, at which point the river then turns to flow back northeast. By the time it reaches Moncton at "the bend" (le Coude) the river has already flowed in excess of 75 km yet is only about 14 km south of where it started, near Magnetic Hill, in Moncton.

First Level Assessment –Land Use History of the Watershed

Understanding historical land use in a watershed helps explain underlying causes of issues present today. Table 1 outlines historic milestones along the main stem of the Petitcodiac between the Village of Petitcodiac and the Village of Salisbury, the two population centres at either end of this portion of the river. Between them lies River Glade, which had a railway station and road access to adjacent communities in the North River watershed on the opposite side of the plateau between them, as well as the lower portions of the Pollett River watershed.

Table 1: Brief historical summary for communities along the main stem of the Petitcodiac

Community	Settlement Type and Dates	Notes
Petitcodiac (*Head of Petitcodiac*)	Settled: c. 1786 by Blakeney family Farming and Lumber	**Pre-European** Mi'Kmaq Portage Route **1786:** Arrival of United Empire Loyalists **1836:** Overnight Coach stop on Carriage Route between Saint John and Amherst **1839:** First bridge over the Petitcodiac **1860** European and North American Railway connects Saint John to Moncton **1869** renamed Petitcodiac **1898** population 700, Station on Intercolonial Railway, depot for The Elgin, Petitcodiac, & Havelock Railway, post office, 6 stores, 2 hotels, tannery, sawmill, carriage factory, furniture factory, 4 churches **2023:** part of The Community of Three Rivers
River Glade *(North River Platform)*	Settled: 1770's Farming and Lumber	**1861** Post office & road to North River **1866** 27 resident families **1871** Station on European and North American railway, Population 100 **1898** 1 post office, 1 store, 1 sawmill **1903** renamed River Glade **2023:** part of The Community of Three Rivers
Salisbury	Settled: c. 1774 by Geldart family Farming and Lumber	**Pre-European** Mi'Kmaq Village **1751** Acadian Settlement (Village Victuare) **1758** Acadians expelled by British **1774** Geldart Family arrives **1860** European and North American Railway connects Saint John to Moncton **1866** 100 resident families **1877** Junction of Salisbury Albert Railroad with the Intercolonial Railway **1898** population 400, Station on Intercolonial Railway, Post Office, 6 stores, 2 hotels, 1 carriage factory, 3 churches

(Sources: Provincial Archives of New Brunswick, 2023; Canada's Historic Places 2019)

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. During this time, the Mi'kmaq lived in large villages along the coasts from April to November. They grew corn in small garden plots but were mostly dependent upon fish and game for food. Therefore, they tended not to stay in one place for long given the need to follow their food sources so dispersed inland during the winter to hunt moose and caribou (Wicken 2002). Estimates of the pre-contact population vary between 15,000 to 35,000 in what is now Nova Scotia and New Brunswick (Miller 1976, Marble 1993). This declined between 75% to 90% due to social disruption and epidemics brought by Europeans (such as smallpox) during the first century of contact. By 1616, Jesuit priest Pierre Biard estimated the population as 3,500 (Mooney 1928). 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 1914b) 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 Wolastoqey "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). During this time there was much Acadian and Mi'kmaq intermarriage (Marshall 2011) weaving a complex web of family relationships. French authorities encouraged intermarriage to produce a colonial hybrid population, while further south the English tended to aggressively enforce racial segregation (Prins 1996). Meanwhile 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 maintained 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).

By 1710, Acadians and Mi'kmaq in peninsular Nova Scotia fell under British control, which was subsequently formalized in 1713 under the treaty of Utrecht. Previous to the treaty, the French had claimed that the borders of Acadia reached all the way to the Kennebec River (well within in what is now Maine). After the treaty however French Authorities claimed that Acadia was just Port Royal (renamed Annapolis Royal by the British after they seized it in 1710) and the peninsula (modern Nova Scotia excluding Cape Breton). Based on that assertion, the French continued to occupy the mainland (now New Brunswick), in addition to the territory they retained officially under the treaty (Martin 1995) i.e.: Île Saint-Jean (Prince Edward Island), and Île Royale (Cape Breton Island). The British were not in a position to contest this reality due to a lack of soldiers and settlers (Ganong 1901). By 1730 the Acadian community in the Petitcodiac was thriving precisely because they were under the jurisdiction of neither Great Brittan nor France (Faragher 2005). That situation did not last, however. With no agreed boundary between English and French territory provided by the Treaty of Utrecht, the French eventually adopted and defended the Missaquash River as the de facto boundary between the two powers (Milner 1911), the same boundary that is in modern use between New Brunswick and Nova Scotia. To Europeans the treaty had merely changed the status of Nova Scotia from a fairly uninhabited French territory with disputed boundaries, to a fairly uninhabited British territory with disputed boundaries (Martin 1995). It was rather more personal to the Mi'kmaq and Acadians who lived there.

Meanwhile, after 1713, New England fisherman pushed more aggressively into Nova Scotia's coastal waters sparking conflict with the Mi'kmaq (Wicken 2002). By 1726 the Mi'kmaq and the British signed the first of a series of Peace and Friendship treaties. What the British wanted from the agreement was native recognition of the Treaty of Utrecht whereby natives agreed not to molest His Majesty's subjects in "lawfully" made settlements, and the Crown could regulate the movement of European nationals into Acadia – i.e., exclude the French. In exchange the British agreed not to interfere with native hunting, fishing, planting activities.

In June 1749 Edward Cornwallis established Halifax with 2,500 settlers as a new capital for Nova Scotia (Beck 1979) and constructed the citadel there as a fortress to defend it. This marked the beginning of meaningful efforts by the British to settle the Maritimes. Prior to this time British authority at Annapolis Royal "had been no more than a mock government" that "did not extend beyond the cannon reach of the fort" (Philipps 1720). The Mi'kmaq immediately recognized the implications of this change and reacted with outrage to what they regarded as establishment of an unlawful settlement in violation of the Treaty of 1726, and theft of their land. No responsible indigenous leader could ignore the reality that environmental change brought about by such agricultural settlement was the most lethal threat that British imperial expansion posed to the existing economy, livelihood, and health of the Mi'kmaq (Reid 2013). Violence escalated until by late 1749 Governor Cornwallis proclaimed a policy aimed at "extirpation" of the Mi'kmaq (Paul 2000).

The French built Fort Beausejour in 1751 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). Their physical impacts on the freshwater reaches of the main stem of the Petitcodiac River, what for them was a remote hinterland, were limited.

In 1752 the British signed yet another treaty with the Mi'kmaq reaffirming the 1726 treaty and also modifying it to formalize a commercial relationship between the British and the Mi'kmaq (Wicken 2002), encouraging not only hunting and fishing, but ensuring "free liberty" to sell the products of such activities in Halifax or any other settlement. For the British this provision was critical as an attempt to wean the Mi'kmaq from their friendly relationships with the Acadians and French officials in Louisburg. This treaty subsequently formed the basis of the 1999 Supreme Court Marshall decision and subsequent ongoing modern lobster fishery disputes.

Ganong (1899) notes that like First Nations, the French made use of the Kennebecasis-Petitcodiac portage along the Anagance 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 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).

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 2023). 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 2023), 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).

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. In addition to intermarriage, 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).

Throughout 1760 and 1761 the British also signed a series of Peace and Friendship treaties with individual native communities, reaffirming the treaties of 1726 and 1752 (Wicken 2002), with the signature at Chignecto/ Missaquash occurring on July 8th, 1761. The important distinction with this iteration of the treaties was the provision by which natives agreed not to trade with the French. To ensure that such trade did not occur the British agreed to establish "truck houses" as points of trade near native communities.

The Treaty of Paris in 1763 ended the Seven Years War, with France ceding its territory in Canada and the Maritime region to Britain, except for the small islands of St. Pierre and Miquelon in the Gulf of St. Lawrence (Ganong 1901; Faragher 2005). The latter France retained in the interest of preserving its access the lucrative fishery in the Gulf of St. Lawrence and the Grand Banks (MacNutt 1970). Shortly thereafter a royal proclamation set the boundary between Canada (Québec) and Nova Scotia as being the watershed between the Saint Lawrence and points south until reaching the north coast of the Bay of Chaleur. All of Nova Scotia north of the Bay of Fundy (modern New Brunswick) was made part of Cumberland County. In 1765 that was changed to make the Saint John River into Sunbury County. There was no formally defined boundary between Sunbury and Cumberland Counties until 1770 when it was set as a somewhat arbitrary line beginning at Mispec (a short distance along the coast east of the mouth of the Saint John River) headed due north to the Canadian (Québec) border (Ganong 1901).

With peace, in 1763, Acadians throughout the region became British subjects, but this was not the case for First Nations, whose situation was more complex (Beaulieu 2014). The

British defeat of France at Louisburg in 1758 encouraged the political collapse of the Mi'kmaq population in Nova Scotia as a fighting force as the peace and friendship treaties signed between 1760 and 1761 brought an end to Indigenous-French relations and alliances (Patterson 1993). Between typhus brought by the d'Anvill expedition, violence promoted by LeLoutre, and Cornwallis' policy of Mi'kmaq extirpation, by 1763 First Nations had been decimated by decades of warfare and disease, with some estimates suggesting that there may have been fewer than 500 individuals remaining in the Maritimes (Statistics Canada 2020).

In 1764 the British government began to allow Acadians to resettle in Nova Scotia with the provision that they remain in small groups scattered throughout the province (MacNutt 1963). Initially they were not allowed to settle in groups larger than 10 persons, the goal being to keep them at great distances from each other, or even ultimately discourage them from remaining in the colony at all. Since the authorities did not give those Acadians who remained a fully legal position by making grants of land, their status was little better than squatters (MacNutt 1963). It is an important and sobering reminder that eighteenth-century people understood that military disruptions did not have the long-term permanence that they might want, without civil validation (Mancke 2019). Consequently, the ultimate dispossession of Acadians came not through the barrel of a gun, but through the power of the pen, and less in the heat of war, than in the quiet of peace.

During the American Revolution, control of Fort Cumberland (formerly Fort Beausejour) was briefly contested by rebels in 1776. Though unsuccessful, the participation of Mi'kmaq and Wolastoqiyik in the siege highlighted the vulnerability of Nova Scotia and prompted the Crown to enter into what became the final round of Maritime Peace and Friendship Treaties with First Nations in 1778 and 1779, reaffirming the previous treaties (Patterson 2009).

The American Revolutionary War ended with yet another Treaty of Paris, this one in 1783 (MacNutt 1963, Ganong 1901). Early in the war the Americans had taken it for granted that winning their independence also implied the acquisition of the two provinces (Nova Scotia and Canada) that had not revolted. In the end however, the agreed terms established rough boundaries between British holdings and the newly recognized United States, that while not yet finalized along the St. Croix River, were distant from the Petitcodiac River. The peace fell short of the hopes and expectations both sides had harbored during the war, but despite the distance from the border, was not without implications for the Petitcodiac. For every Loyalist within British lines, there were five left living within territories dominated by the Continental Congress (MacNutt 1963). To such Loyalists, peace and recognition of the United States meant surrender of themselves and their possessions to those that had been their enemies. Although the Treaty of Paris promised Loyalists a safe return to their pre-war homes, persecution of "Tories" escalated with the rebel victory (Dallison 2003). An attractive and safer alternative became clear. Across the water lay Nova Scotia, a (comparatively) vacant land which remained beneath the British Crown (MacNutt 1963).

As things warmed in the spring of 1783 the movement began, with all parts of the coastline receiving refugees, many of which landed on the north shore of the Bay of Fundy (Squires 2000), of which approximately 11,000 eventually stayed on (Wynn 1981a), tripling the population from a little more than 5,000 to more than 16,000 in less than a year. Almost 10% of the refugees were black loyalists, and 10% of those (i.e., approximately 1% of total Loyalist refugees) arrived in the region as slaves. (Hodges 1996). The main point of penetration was the Saint John River Valley, however, the Petitcodiac, Memramcook, and Chignecto regions each received a share Loyalist refugees as well (Wright 1945, Milner 1967, Bowser 1986).

Even before departure from New York, Loyalists had begun to contemplate a separate and distinct province (Dallison 2003), and support for the concept only grew once they arrived in Nova Scotia. Governor Parr began escheating parts of pre-Revolution grants immediately to provide lands for the newcomers jamming into port towns clamoring for land (Fellows 1971). The need for land was paramount as it meant survival, food, and fuel- as well as status and wealth. Parr's inability to release land quickly enough frustrated Loyalists (Snowdon 1983) and was a key factor driving calls for partition (Gilroy 1933). Edward Winslow, an individual responsible for settling Loyalist Regiments in Nova Scotia became a leading proponent for partition arguing in a letter to his friend Ward Chipman in 1783, "Take the general map of this province (even as it is now bounded) observe how detached this part is from the rest, how vastly extensive it is, notice the rivers, harbours, etc. Consider the numberless inconveniences that must arise from its remoteness from the metropolis and the difficulty in communication. Think what multitudes have and will come here, and then judge whether it must not from the nature of things immediately become a separate government" (Winslow 1783).

Halifax was opposed to Nova Scotia being subdivided for obvious reasons (Chipman 1784), however the authorities in London agreed (Gilroy 1933). On June 18th, 1784, Nova Scotia was partitioned, and the north shore of the Bay of Fundy became New Brunswick, a self governing "Loyalist" province. Once again the Missaquash River was selected as the boundary (Allison 1916), with the Petitcodiac River watershed falling within what became Westmorland County (Ganong 1901). Thomas Carleton arrived in November 1784 to establish the new government and direct the colonization of New Brunswick (Fellows 1971). With access to title to land having been a driving factor in its formation, the newly established Province of New Brunswick required that existing land grants be re-registered both to facilitate escheat and to establish clear title for active landowners (Kernaghan 1981), and the House of Assembly focused on allocation of land as one of its initial priorities (Fellows 1971).

The dates that various communities listed in Table 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

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 1981b), 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, 1981b). The White Pines Act of 1722 had 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).

Sawmills at this time were typically driven by energy from falling water, often enhanced with the assistance of a dam. The low gradient along the main stem of the Petitcodiac offered less energy for such operations than did its various tributaries. Table 1 indicates that sawmills were present in both the Village of Petitcodiac and River Glade in 1898, but Salisbury meanwhile, though described as a lumbering community at one time, had no sawmills at that point. The first mill in the Village of 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, which is actually up off the main stem, in the Anagance watershed. The Jacknife Sawmill was in operation by 1833 in Petitcodiac, and a spool manufacturing plant by 1868. Other milling operations in Petitcodiac included the Petitcodiac Lumber Company on the North River, and the Humphreys and Trites Mill, at the mouth of the Anagance and North Rivers, i.e. the very start of the main stem. The sawmill in River Glade in 1898 was may have been powered by either Chapman Brook or perhaps a steam engine, as there doesn't appear to be a record of a dam. The Village of Petitcodiac was electrified in 1928 (Village of Petitcodiac 2019), so River Glade, with a smaller population, probably would not have had electricity to power a mill until at least then.

By comparison the Pollett River was described by Elson (1962) 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 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 these rivers 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, and was likely a factor at the start of the main stem of the Petitcodiac below the Humphrey and Trites Mill.

By 1860 the European and North American Railway linked Saint John and Moncton, passing down the Anagance valley, through the Village of Petitcodiac (New Brunswick Railway Museum 2015), and along the south bank of the Petitcodiac, until crossing a bridge a short distance before North River Platform (River Glade) and continuing along the north bank through Salisbury on its way to Moncton (Dawson 2005), essentially the same line operated today by CN. Fuel for the engines was cordwood in three to four-foot lengths purchased from farmers along the line (Stronach 1969), typically cut from hardwoods growing to either side of the rail line (Elliot 1970). 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).

This was enhanced with the development of branch lines such as the Elgin, Petitcodiac, & Havelock Railway which opened in 1876. The Chignecto Post in Sackville wrote (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." 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."

Further downstream, by 1877 another branch line, The Salisbury - Albert Railway began operating, connecting Hillsborough (in the lower estuary), and Riverside Albert (on the Shepody) to the Intercolonial Railway via the station in Salisbury (Chignecto Post Thursday May 24th, 1877). After crossing the Petitcodiac at Salisbury 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). 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 was tan bark (Elliot 1970). Hemlock trees were cut down, and the bark was stripped off and hauled to the tannery in Petitcodiac. Because the logs would not float, they were often instead put on brooks to make bridges or corduroy roads. Elliot (1970) also notes that maple trees in the area were tapped for sap, with farmers producing syrup, sugar, and candy- though such opportunities were somewhat scattered. The low elevation of the Eastern Lowlands Ecoregion through which the main stem flows limits the availability of sugar maple there. The low relief, poor soil drainage and high acidity create conditions that discourage development of hardwood stands which prefer the well-drained upper slopes and ridges more common along the Pollett and Little which drain through the Central Uplands Ecoregion (Department of Natural Resources 2007).

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 main stem 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). 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). Consequently, 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 on the Pollett, which accounts for the lion's share of the salmon spawning habitat on the Petitcodiac (Pettigrew 1977).

Baillie (1832) indicated that a “tolerably good” road went up the Coverdale (Little) River. However, his idea of that likely differed from modern sensibilities as he went on to qualify the statement by noting that “generally speaking it is not fit for carriages”, suggesting that foot, horse, and perhaps limited cart traffic may have been more the norm on it. Along the main stem of the Petitcodiac however, getting around was easier. The mail road that David Blakeney petitioned for in 1786 had been built by the 1830s - graveled and smooth enough to run a stagecoach at a full trot when the weather was fine (Goodrich 2010). Known as the Westmorland Great Road (Route 106 today), it connected Saint John and “The Bend” (Moncton) via something resembling the Anagance valley portage route and had been already surveyed and well-traveled on foot and by horseback as early as the 1790s. By 1836 the Saint John Stagecoach Company began operating a weekly service between Saint John and Amherst that could make the trip in two days, staying overnight in Petitcodiac (Goodrich 2010), speed that was testament to the relative quality of the road for the time. The first bridge over the Petitcodiac was built in 1839, where the current bridge in the Village is located (Village of Petitcodiac 2019).

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 1981b). Only in Elgin and Salisbury Parish did the population density remain less than 5 people per square mile. Salisbury Parish includes all of the main stem and most of the watershed draining immediately into it between the Village of Petitcodiac and Salisbury, with the southerly portions not part of it, belonging to Elgin Parish. Monro (1855) praised the quality of both the land immediately along the Petitcodiac, as well as that 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 (southeast) of this parish is generally of an inferior quality; that in its northwest 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.” Basically, much of the early transport infrastructure had been built with a focus on reaching points beyond the watershed, rather than providing access within it, such that where access was good, farming wasn’t, while perversely there was insufficient access to places where farming was good (such as on North River).

Intervale is a term local to the region referring to fertile bottomlands, and was felt so apt, that one community a short distance above the Village of Petitcodiac on the North River adopted Intervale as its name. Traveling along the mail road from the “Bend” (Moncton) to Saint John, Johnston (1851) described what he saw around the Village of Petitcodiac, “We found some good farms along this part of the 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."

Despite much of the line being routed through agriculturally poor terrain, it is reasonable to conclude that the arrival of the European and North American Railway (E&NA) in 1860 reduced logistical constraints on bringing in supplies and moving surpluses out to trade. Unlike the forest products (which, given the abundance of forests locally, would likely have been a one-way flow out to market), at least initially, a portion of the total agricultural freight carried may have been inbound for local consumption rather than an outbound surplus being sold elsewhere. That said the E&NA struggled financially and eventually in 1872 was merged into the Intercolonial Railway (Canadian Rail 2001), becoming essentially a branch line connecting Saint John (via Moncton) to the main line from Halifax to Montreal. The Intercolonial Railway (1874) rail schedule indicates that at this point there were three trains a day, and one could leave Saint John at 8:00 am and be in Amherst 6 ½ hours later, a dramatic improvement in mobility of people and freight compared to the 2 days required for such a trip by coach in 1836.

The General Map of the Intercolonial Railway (Fleming 1876) lists stops within the Petitcodiac watershed prior to reaching Moncton as Anagance, Petitcodiac, Pollett River, and Salisbury. The stop at "Pollett River" was also referred to in 1876 to North River Platform, which highlights how this stop served communities in the lower portions of the Pollett River near the main stem as much as it did those across the plateau in the North River. The upper portions of the Pollett after all were being served more directly at that time with the opening of the Elgin, Petitcodiac, & Havelock Railway (Chignecto Post September 14th, 1876). After North River Platform changed its name to River Glade in 1903 (Provincial Archives of New Brunswick 2023) this change was reflected on subsequent railway maps, with the stop at Pollett River renamed River Glade (Intercolonial Railway 1906).
Dawson (2005) shows that by 1878 the road network along the main stem of the Petitcodiac had improved compared to the 1830s, branching out from the Westmoreland Great Road to provide access to much of the valley. Despite that, the limited scope of the 1878 road network along the main stem of the Petitcodiac compared to today's roads suggests that though progress had been made in addressing constraints due to road access indicated by Monro (1855), development, and by extension agriculture, had progressed significantly, but was still less extensive than roads in the area are today. Interestingly, a similar comparison between the Little River in 1878 and today's network shows almost no change in the extent of 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 main stem has continued to develop, the Little has not (comparatively speaking), and settlement on the Pollett actually appears to have contracted somewhat relative to 1878. None-the-less, in 1893 the lack of good roads serving the main stem was still described as one of the greatest constraints on agriculture in the area (The Daily Times, Saturday April 23rd, 1893).

In addition to being much more accessible than much of either the Little or the Pollett, the milder climate (due to the lower elevation), and soils in places (i.e. the intervale floodplain) along the main stem are better suited to agriculture than is the case in much of those two tributary watersheds. These facts may have made farms in Salisbury Parish along the main stem more resistant to economic downturns following the First World War that caused many people in Elgin Parish 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 from Elgin Parish not wishing to move so far away, may have simply added instead to population growth in Salisbury Parish along the North River and the main stem of the Petitcodiac. 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, local farmers were supplying it with raw products (Burrows 1984).

Mining Practices

The potential for production of agricultural lime noted by Johnston (1851) along the North River a short distance upstream of the Village of Petitcodiac, 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. While the quarry site itself was above the main stem of the Petitcodiac, any effects on the quality of water discharged from that site as a consequence of such extraction didn't have far to go before having an impact on the main stem. Meanwhile the availability of agricultural lime locally would have lowered the cost of using such soil amendments making doing so an attractive option that would have both increased both yields, and (likely) the total acreage allocated to agriculture. The fact that the Glenvale mine was in production for almost 50 years suggests that though Johnston (1851) saw little use of agricultural lime locally when he passed through, that the practice went on to be adopted to some degree. Rail access in the Village of Petitcodiac suggests that production from the mine may have also served markets beyond just the local demand.

Indian Affairs

As laid out in previous sections, the Mi'kmaq and the Crown entered into a series of Peace and Friendship treaties between 1726, and 1779 (Nova Scotia Archives 2020), which form the basis of treaty rights held by the Mi'kmaq today (Table 2). These were not treaties that

Table 2: Peace and Friendship Treaties between the Mi’kmaq and the Crown

Year	British Objective	Mi’kmaq Objective
1726	Mi’kmaq Recognition of 1713 Utrecht Treaty, “Lawful” British Settlements to be left undisturbed. British right to regulate Europeans	British Recognition of the legitimacy of Mi’kmaq Hunting, Fishing, and Planting activities
Comment:	When signed, the application of this treaty was within British controlled territory. The British interpretation of the 1713 treaty of Utrecht between them and France was that it gave them claim to all of Acadia including the north shore of the Bay of Fundy (modern New Brunswick), but effectively British authority did not go outside of peninsular Nova Scotia. Arguably it “did not extend beyond the cannon reach of the fort” at Annapolis Royal.	
1749	Reaffirm 1726, to end King George’s War addressing Mi’kmaq cooperation with the Duc d’Anville expedition, and antipathy to British expansion beyond Annapolis Royal i.e. founding of Halifax. From British perspective did not modify 1726 in any way.	Reaffirm 1726 - British recognition of hunting and fishing
Comment:	Nothing new was offered in the treaty, just reaffirmation of the 1726 treaty. The context however was that it demanded acceptance of the fact the British were becoming more assertive than they had been previously. Among the Mi’kmaq, only the community at Chignecto signed - others refused to do so because British founding of Halifax a few months earlier was considered to be a violation of 1726.	
1752	Reaffirm 1726, to calm the effects of Father LeLoutre’s War. Formalized commercial relationship between British and Mi’kmaq to wean Mi’kmaq from relationships with Acadians and French officials in Louisburg.	Reaffirm 1726 - British recognition of hunting and fishing rights, and ensured the “free liberty” to sell the products of these activities in Halifax or any other settlement.
Comment:	By this point the French were actively defending the Missaquash River as the border with British territory in Father LeLoutre’s War. Mi’kmaq in the Petitcodiac watershed were “on the front line”, while those in peninsular Nova Scotia were “behind the lines”, living amongst expanding British settlements. This treaty forms the basis of the Supreme Court of Canada 1999 Marshall Decision affirming the treaty rights of First Nations people all across Canada to hunt and fish and earn a moderate livelihood while doing so (Supreme Court of Canada 1999). Resistance to this ruling by non-native lobster fishermen prompted the Burnt Church Crisis between 1999 and 2002 (Wicken 2002). Recently tensions have flared up over lobster in Saint Mary’s Bay	
1760/61	Reaffirm 1726 after defeat of the French in North America. This ended Indigenous-French relations and alliances, and required natives to end trade with the French.	Reaffirm 1726 - British recognition of hunting and fishing rights, and with the end of French alliances and trade the British pledged to establish “truck houses” near native communities to provide alternative trade now that trade with the French was prohibited.
Comment:	This marked the end of direct relations between the French Government and Native communities in the Maritimes. That was finalized in 1763 with the Treaty of Paris which ended the Seven Years War in which France ceded its territory in Canada and the Maritime region to Britain, except for the small islands of St. Pierre and Miquelon in the Gulf of St. Lawrence, which France retained to preserve access to fisheries there.	
1778/1779	Reaffirm 1726 within the new context of British North America being fractured by the American Revolution	Reaffirm 1726 - British recognition of hunting and fishing rights, and maintain peace going forward to avoid being drawn into violence between the British and American revolutionaries
Comment:	While the French were no longer a concern, the participation of Mi’kmaq and Wolastoqiyik (albeit only a few) in Eddy’s siege of Fort Cumberland in 1776, and Allan’s expedition into the Saint John Valley in 1777 highlighted the vulnerability the Maritimes to attempts by US agents to stir rebellion against the British.	

surrendered land, but negotiations between sovereign entities. The Mi'kmaq never surrendered title to Mi'kma'ki (Mi'gmawe'l Tplu'taqnn 2023). Treaty rights and aboriginal rights are recognized and affirmed in Section 35 of the Constitution Act 1982 (Sanderson 2017). These treaties were briefly described within the chronological context that gave rise to them, to track the evolution of the treaties. However, as these treaties are still in effect and still relevant in New Brunswick from that time up to today, there is also value in compiling these within a single section to provide focus, make them more easily accessible, and by doing so make them more easily understood in their entirety.

The five treaties are listed and identified in Table 2. In several cases a given treaty has more than one year attached to it. That is because of the complexity of negotiations, the large number of signatory communities, and the distances between venues at a time when mobility and communications were challenging meant that in several cases the signing process began on one year and was not completed until the following year.

After the arrival of the Loyalists in 1783, Mi'kmaq in New Brunswick were gradually moved onto "reserves" (Walls 2010), to provide land to incoming settlers. This was made possible in part by a legal technicality. The Treaty of Paris in 1763 ended the French presence in the Maritimes, and the subsequent Royal Proclamation of 1763 recognized the property rights of the native peoples in the recently won portions of North America, but it had never been construed as applying to New Brunswick, which had been part of Nova Scotia at that time (Upton 1974). Safeguards concerning Indian lands and indebtedness, however questionable their ultimate value elsewhere, did not even exist in New Brunswick. Initially there had been little practical need for a policy as Mi'kmaq were few in number, and so scattered that they were not considered a threat to incoming whites. With the arrival of the Loyalists, "the Indians were driven back into the wilderness without much ceremony". The first real expression of concern amongst the government arose during the lead up to the War of 1812 (Upton 1974) that discontent might become a problem if war with the United States created an opportunity for trouble. Despite the fact some lands had been allocated to native people, they still maintained their nomadic way of life; and the colonial government's refusal to do anything further for them led to a complaint of "an injurious distinction between them and the Indians of Canada on one side and those within the limits of the neighboring American States on the other." The first listing of reserved lands was not published until 1838 and it identified 15 reserves in the Province ranging from 10 up to 16,000 acres. About 60,000 total acres had been designated as Indian reserves in the early 1800s, but none were in Westmorland County (Goodrich 2020).

That changed in 1840 when the Provincial Government purchased 63 acres at Beaumont near Fort Folly Point (Goodrich 2020) at the head of Shepody Bay. The Province then conveyed this land to the Magistrates of Westmorland County in Dorchester to hold in trust as a reserve. Then 126 Mi'kmaq moved there from various places within Westmorland County that they had been living to form the Fort Folly Reserve (Perley 1841, Ganong 1899). The land was not turned over to the Mi'kmaq themselves but vested in the county to be held for their exclusive use.

Second Level Assessment – Current Impacts

Forestry Practices

Forests cover 80% of the area within the portions of the Petitcodiac watershed along the main stem (the O'Blenis Composite and the Bannister Composite). Modern land tenure is a mixture of private woodlots crown land and industrial freehold subject to varying levels of management in terms of harvesting planting and thinning (Department of Natural Resources in 2023). This portion of the watershed (Figure 5) covers 115.2 km^2, of which private woodlots are: 67.9 km^2 (59%), Crown forests: 2.7 km^2 (2.3%), industrial freehold 23 km^2 (20 %). This is a mid-range as a proportion of Industrial Freehold compared to other nearby areas, ranked in descending order as follows: Anagance 57.35%; Memramcook 32.7%; Pollett 25.84%; North 12.77%; Demoiselle Creek 9.63%; Little 0.93%. Most forested land here is privately owned.

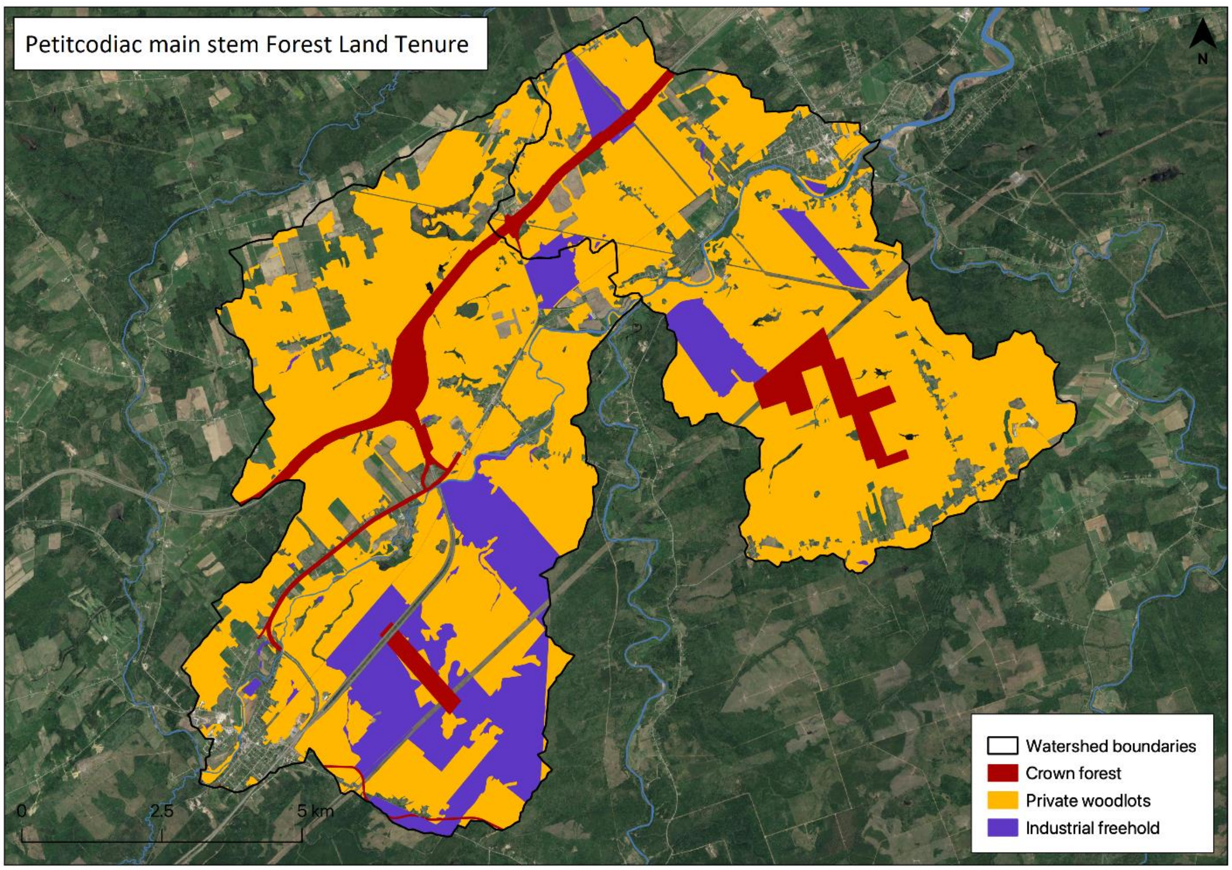

Figure 5: Forest tenure along the main stem of the Petitcodiac.

Agricultural Practices

Agriculture is the dominant non-forest land use within the main stem of the Petitcodiac (Figure 6). 12% of the watershed has been converted to agriculture, 10.1% row crops or grains, 1.2% pasture, and 0.04% Orchards (Department of Natural Resources in 2023).

This activity is concentrated along the main stem near the Village of Petitcodiac and near the Village of Salisbury, with third concentration along the plateau ridge between the North River watershed and the brooks draining directly into the main stem of the Petitcodiac.

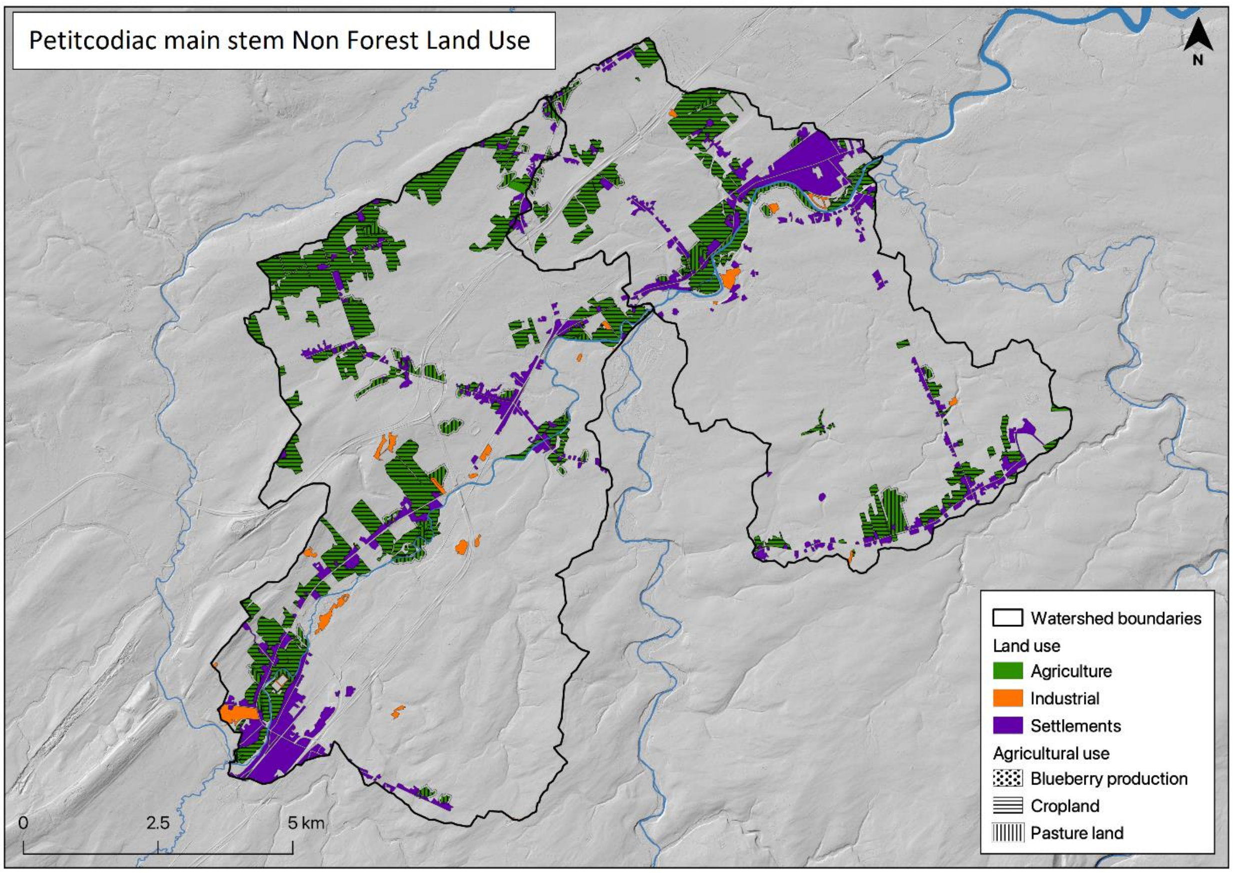

Figure 6: Non-forest land use: Agriculture along the main stem of the Petitcodiac.

Transportation Development

A GIS layer of the road network (paved and unpaved) within the main stem of the Petitcodiac was overlaid on the river and its tributaries, to yield Figure 7. This analysis indicated a total of 95 locations where roads crossed the river or tributary streams. Of this 66 were defined as paved, and 29 were defined as unpaved. Being 69% paved high ratio of compared to the experience elsewhere in the Petitcodiac system, as typically there are numerous water crossings by unpaved roads. That said, the main stem of the Petitcodiac is more populated and developed than the various tributaries, and so a higher proportion of paved roads was to be expected. For comparison's sake, comparable figures for other watersheds for which FFHR has developed stewardship plans ranked according to proportion of paved crossings are as follows: North River 58% paved; Little River 54% paved, Anagance River 42% paved; Demoiselle River 40% paved; and Pollett River 31% paved. The number of crossings appears not unreasonable for the small area involved (115.2 km^2). For comparison's sake the total number of crossings within the 264.8 km^2 of

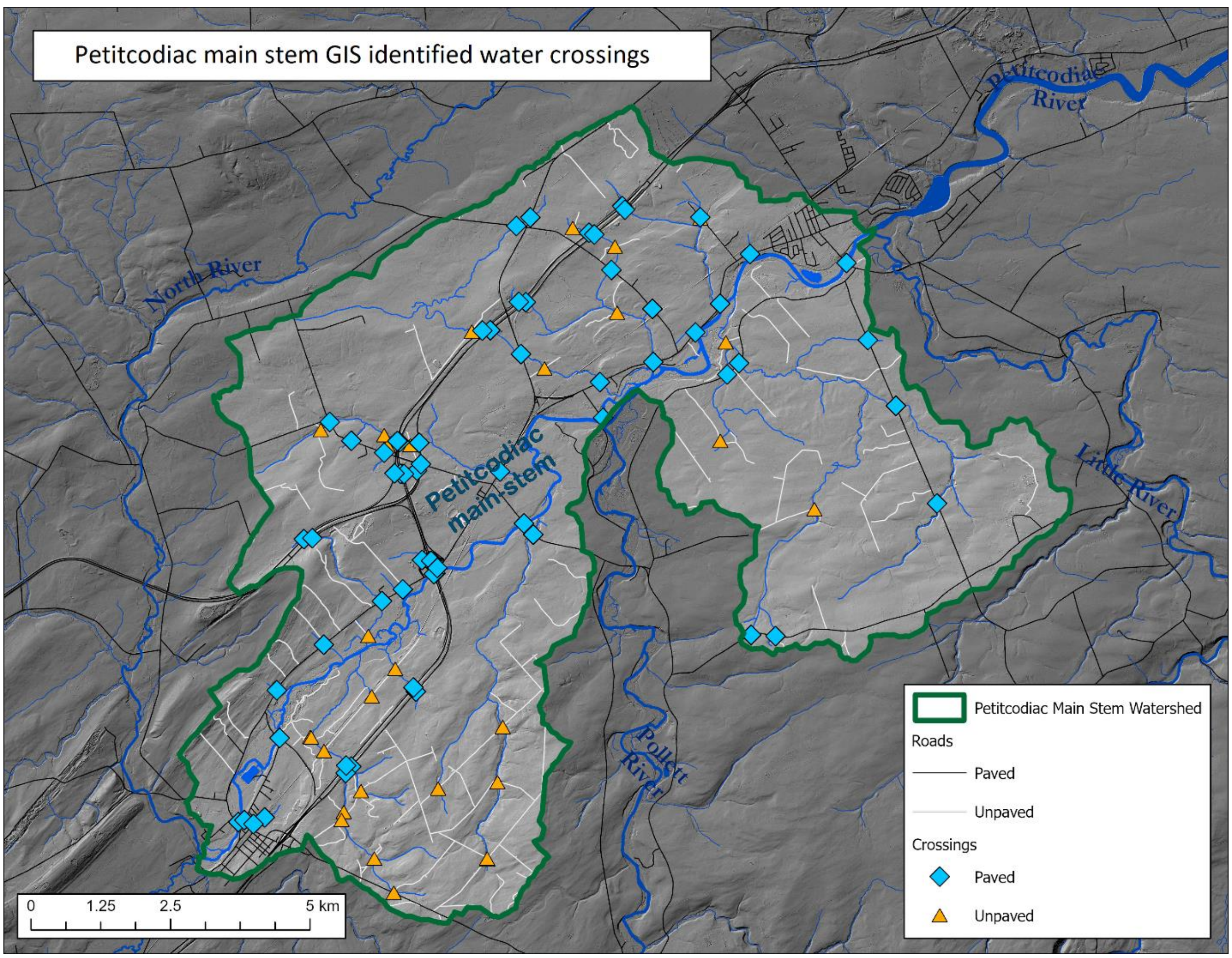

Figure 7: GIS analysis of road / water crossings in the main stem of the Petitcodiac.

the North River watershed is 155, of which there are 90 paved and 65 unpaved. Though a much larger area of watershed, the North is comparable in many ways in terms of the extent of development within the main stem.

A thorough inventory of the condition of all of these crossings is needed to examine the extent to which these may be limiting fish passage. Systematic collection of such data will also provide an opportunity to test the GIS analysis, and determine how many crossings that it has missed, and where they are. While several crossings within the main stem composite basins are known to be bridges such as the Rt 112 bridge in Salisbury, or the Powers Pit Rd Covered Bridge (Figure 8), the majority are likely to be culverts of varying size and condition.

The Petitcodiac Watershed Alliance has carried out a series of culvert surveys throughout the Petitcodiac watershed as part of their Broken Brooks project. Annual reports detailing that work are available for download on the publications section of their website https://www.petitcodiacwatershed.org/ . These reports indicate 37 crossings assessed within the main stem area to date: 12 bridges, 12 fording sites, 3 culverts that were full barriers to fish passage, 3 culverts that were partial barriers to fish passage, 7 culverts that

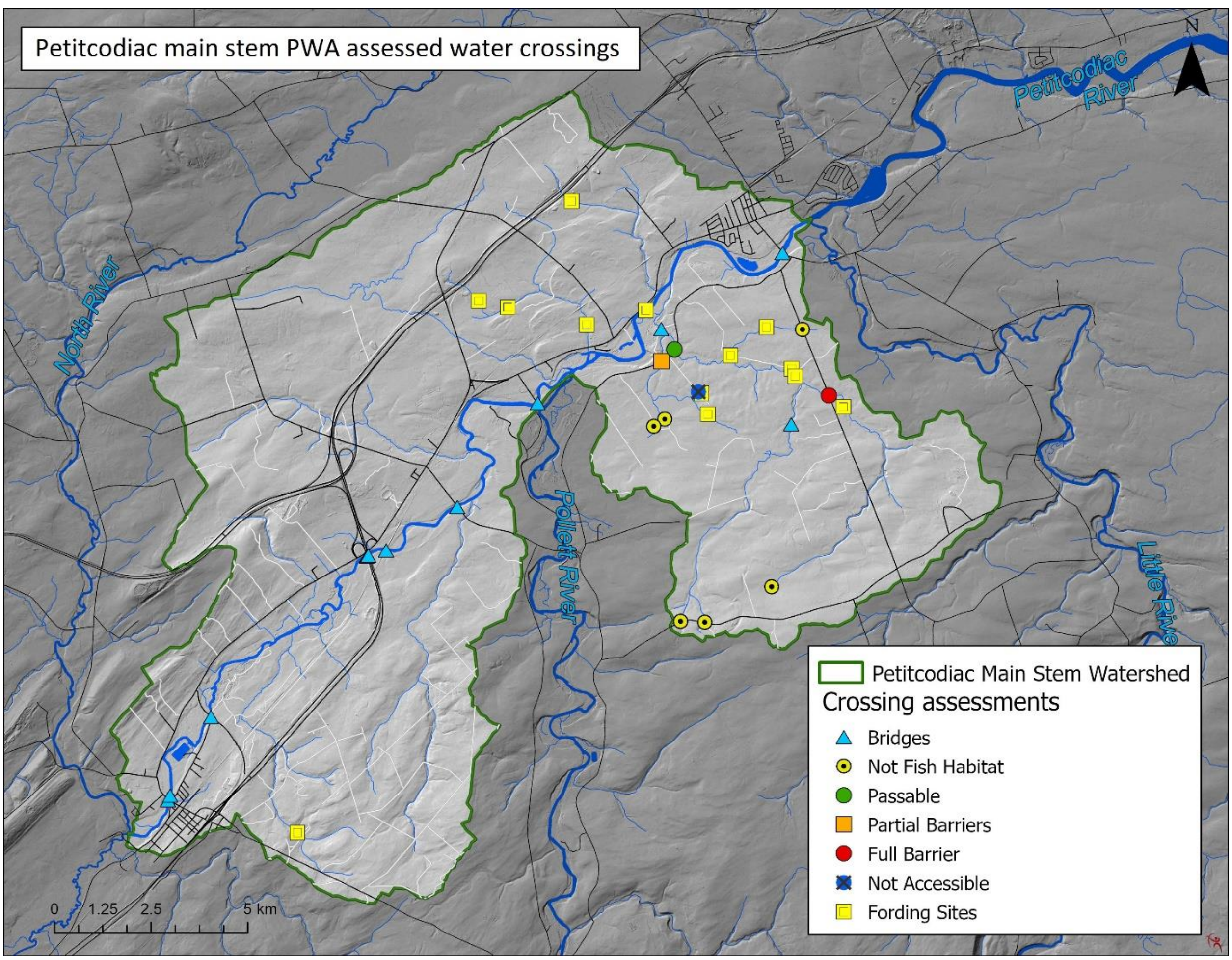

Figure 8: Water crossings visited and assessed by the Petitcodiac Watershed Alliance

Figure 9: Powers Pit Road Covered Bridge over the main stem of the Petitcodiac.

were not fish habitat, and 1 culvert that was not accessible (Petitcodiac Watershed Alliance 2017). Comparison of the crossings that they have assessed to the 95 identified through this GIS analysis indicates that at least 58 water crossings within the main stem of the Petitcodiac remain to be assessed.

Several of crossings that they examined were identified as problem culverts creating barriers to fish passage into useful habitat, potentially benefiting from remediation such as clearing of brush blockages or construction of rock weirs raise water levels in the case of perched culverts (Petitcodiac Watershed Alliance 2016). At least one culvert, on Duncan Brook within the Bannister Brook Composite (N 45.99879 W-65.0234), was noted as a good candidate for replacement (Petitcodiac Watershed Alliance 2017).

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.

In 1968, 22 kilometers downstream of the head of tide, in the Petitcodiac estuary, the Petitcodiac Causeway was built instead of a bridge, in order to accommodate vehicular traffic between Moncton and Riverview. 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 gates of the causeway control structure were opened as part of the Petitcodiac River restoration project. On May 25th, 2021, the new channel was opened underneath the bridge built to partially replace the Petitcodiac Causeway (Figure 10). October 5th, 2023, this bridge was named in honor of the late senator and MLA Brenda Robertson (Government of New Brunswick 2023a). Fourteen years of monitoring from 2010 to 2023 following the restoration of fish passage (Redfield 2024) 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.

Figure 10: Honorable Brenda Robertson Bridge downstream, between Moncton and Riverview

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 along the main stem of the Petitcodiac 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.). 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 about individual grower or vendor pesticide or herbicide use.

Mining Practices

Oil and Natural Gas lease rights in the northern half of the main stem of the Petitcodiac watershed are currently registered SWN Resources Inc. (Government of New Brunswick 2024). SWN is a wholly owned subsidiary of Southwestern Energy Company in the US (SWN 2015). SWN holds two leases along the main stem of the Petitcodiac near Salisbury. One is just north of River Glade with a corner that takes in the mouth of the Pollett River. The other includes Salisbury and the mouth of the Little River. The southern half, around Petitcodiac, is owned by Headwater Exploration Inc (Government of New Brunswick 2024). Headwater Exploration is a Canadian company that operates in Alberta and New Brunswick.

In 2013 seismic testing by SWN in New Brunswick on Mi'kmaq traditional lands north of Moncton was halted following protests that became violent 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 Liberal Provincial government enacted a moratorium on expansion (Canadian Broadcasting Corporation 2014), however the new Conservative Government led by Blaine Higgs has announced its intention to put an end to the moratorium and renew fracking in New Brunswick (Canadian Broadcasting Corporation 2018). If wells are eventually drilled in the portion of the Petitcodiac watershed draining directly into the main stem, impacts will include freshwater extraction from streams, habitat destruction and sedimentation during road building, and the potential for wastewater spills contaminating surface waters.

Fort Folly First Nation

Mi'kmaq never surrendered title to Mi'kma'ki (Mi'gmawe'l Tplu'taqnn 2023), however have limited contemporary presence above the head-of-tide on the main stem of the Petitcodiac River (despite it being their traditional territory). There are relatively few Mi'kmaq, and government policies concentrated these downstream on the Fort Folly reserve at Beaumont (in Shepody Bay), at the mouth of the Petitcodiac. Economic decline of the building stone quarries at Fort Folly Point in the 1890s, profoundly affected the reserve. Many families moved to Shediac or land the band held in Richibucto, while others went to Dorchester and the surrounding area. By 1913 only three or four families remained at Beaumont, the last of which left in 1955. In 1958, Beaumont was no longer occupied, title was lost, which has subsequently been challenged in a land claim (Fort Folly First Nation 2021).

Mi'kmaq continued to be part of the community in and around Dorchester throughout the 1950s and 1960s after Beaumont ceased to be a reserve (Goodrich 2020), living as individual families with "status" but without a reserve. That changed in 1969 when the current Fort Folly First Nation Reserve was established near Dorchester at Palmer's Pond on Rte. 106. It was initially named Palmer's Pond Reserve (Fort Folly First Nation 2021), but the decision was soon made to rename it the Fort Folly Indian Reserve. The present band, which is mostly descended from those who had occupied Beaumont (Kristmason 2004), does not consider this to be a new foundation, but continuity, with a relocation from Beaumont (Goodrich 2020). Fort Folly, which had been the name of the original reserve at Beaumont, was named geographically for the location on which it existed (Perley 1841, Ganong 1899). Today the band has thirty-six members living on reserve, and a further ninety-six living off reserve.

Urban Development

Large areas of privately-owned land along the main stem of the river have been developed into homes, leaving little or no buffer in the riparian zone in order to obtain clear views of the river. Such properties are also a potential source of sewage contamination as rural septic systems are not always properly maintained. In addition to Agriculture, Figure 6 shows the extent of land along the main stem allocated to denser residential development concentrated primarily within the Village of Petitcodiac, and the Village of Salisbury. Together with River Glade these account for 6.7 km^2, which is 5.8% of the land base. Compared to the other watersheds for which FFHR has been drafting stewardship planning documents that is an exceptionally high proportion, an observation consistent with the notion that much more development has occurred here than in more remote tributaries. Local Governance Reform by the Province (Government of New Brunswick 2023b) amalgamated governance to divide the main stem of the Petitcodiac between 2 local governments: Salisbury (from the Salisbury railway bridge to the Route 1 Highway bridge) and The Community of Three Rivers (which runs from where Salisbury ends and takes in the rest of the main stem above that point (including the Village of Petitcodiac).

Wildlife

Several species of wildlife that warrant specific attention are found along the main stem of the Petitcodiac River watershed: Atlantic salmon, American eels, striped bass, brook floaters, and wood turtles. Guidelines for projects in areas with these are in the Appendix .

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 extirpated from the Petitcodiac River system, except for those introduced in stocking programs (AMEC 2005). The decline in iBoF salmon is a marked contrast to the abundance described by early settlers (Dunfield 1991). Though numbers had been decreasing for some time (Elson 1962) construction of the causeway between Moncton and Riverview in 1968 complicated fish passage and extirpated the species from a river system that despite being one of 50 iBoF rivers, represented 20% of the total iBoF population (Locke, et al. 2003). Fort Folly Habitat Recovery encounters salmon (Figure 11) on the main stem of the Petitcodiac at the fish net trap (FNT) it operates at the head-of-tide

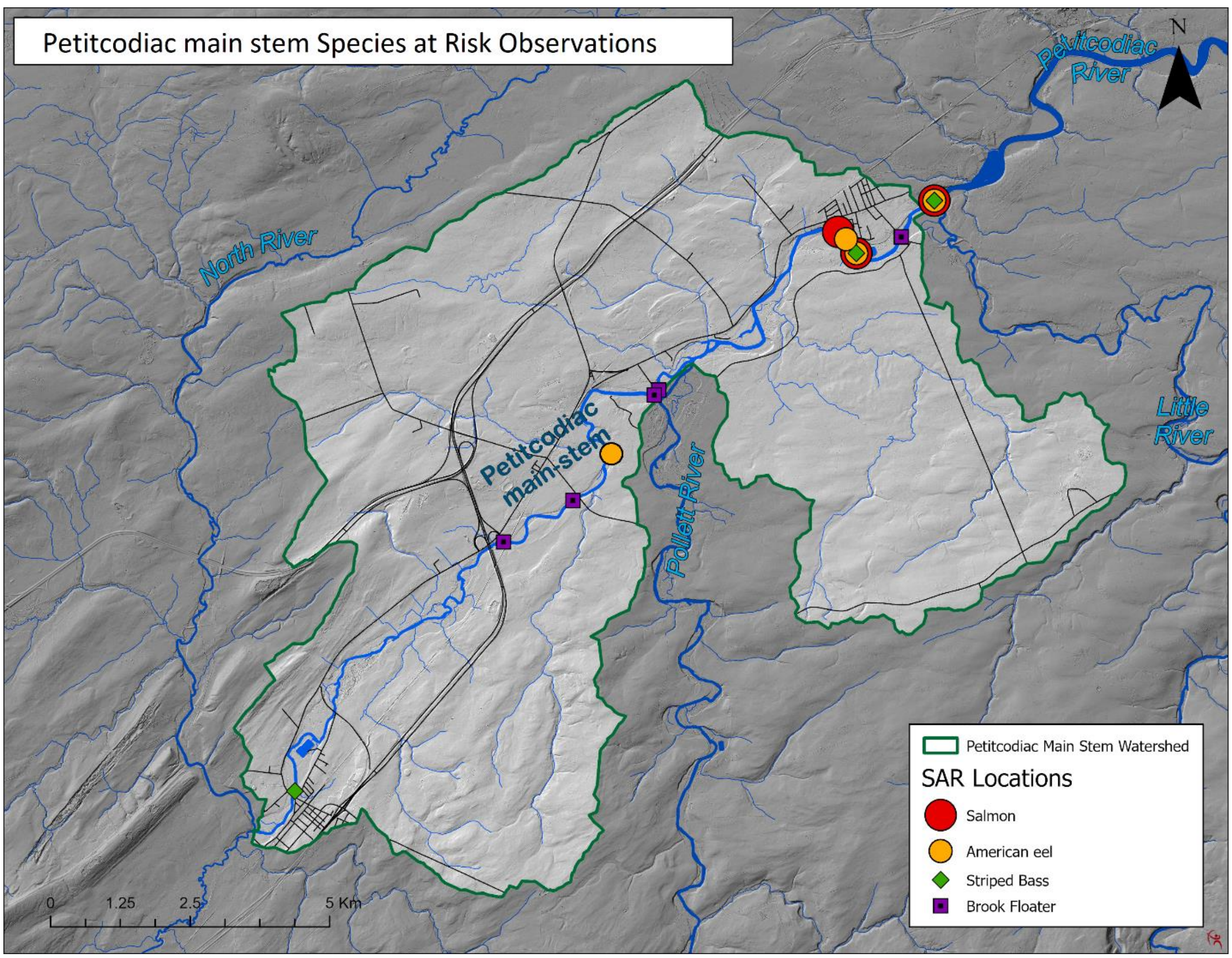

Figure 11: Locations of Encounters with SAR species on the main stem of the Petitcodiac.

in Salisbury. Modern encounters with salmon are effectively all due to recovery efforts, particularly ongoing stocking programs from both DFO's Live Gene Bank at Mactaquac, and from Fundy Salmon Recovery's sea pens on Grand Manan.

Completion of the Honorable Brenda Robertson Bridge (Figure 10) between Moncton and Riverview in 2021 strongly advanced salmon recovery efforts in the Petitcodiac. That fall, the first wild returning adult (cover – top photo) was captured at the FNT. This trap has been operated at two locations each shown on Figure 11 as the sites where Atlantic salmon, American eels, and striped bass have each been encountered. The original trap site, on the main stem just below the mouth of Little River operated from 2010 to 2017. The current trap site is about 2 km further upstream in Salisbury near Highland Park and has operated from 2018 to 2023.

The returning wild adult captured on October 4th, 2021, was distinctive because she lacked both a PIT tag and a floy tag. She showed no scars from having shed either type of tag, nor did it look as though a tissue sample had been taken from her caudal fin. In short, there was no sign that she had been previously handled. Scale and tissue samples were collected to allow further investigation. Stable Isotope Analysis carried out by the Stable Isotopes in Nature Laboratory (SINLAB) at the University of New Brunswick (UNB) confirmed that she was indeed a returning wild iBoF Atlantic salmon (Samways personal communication 2021), never handled by FFHR prior to her capture.

Examination of the scale sample indicated that she was a 2-sea-winter (2SW) fish, who had smoltified and gone to sea in 2019 as a two-year old smolt. As such, she would have been at sea in both December 2019 and December 2020. Having been captured on the main stem of the Petitcodiac beyond the mouth of the Little River, it seems reasonable to speculate that she was on her way upstream back to the Pollett River. Based on that, it is likely that she exited the Pollett as part of the Spring 2019 smolt run. FFHR's 2019 data indicates a Bayesian Pollett smolt run size estimate of approximately 5,465 smolt. The tissue sample has been used for genetic analysis, but the results are not yet available. These may shed light on what part of the Recovery program she resulted from. One way or another, most smolt coming off the Pollett are present due to FFHR's stocking efforts. Having been a two-year old smolt in 2019, she was probably either the offspring of the 126 Fundy Salmon Recovery adults released in October 2016 or one of 47,000 fry (directly sourced from the DFO Live Gene Bank at Mactaquac) released in May 2017. If she wasn't released as a fry in Spring 2017 then one if not both of her parents were presumably among the adults released in the Fall 2016.

She is probably not alone - the FNT merely samples what is in the river. Catching one indicates that numbers have reached a level where the trap can detect them. It is premature to attribute detection of the returning wild salmon in 2021 entirely to the new channel under the bridge. That said, however, she must have passed under the bridge, and the improved passage it provides can only have helped her to do so. No additional returning wild adults were caught during either of the subsequent two years, though tagged adults have been detected by automated readers FFHR operates in both the Little River and the Pollett. The lack of another wild adult at the trap during 2022 and 2023 was noteworthy, and though somewhat disappointing, not particularly surprising. It does not mean that the individual caught in 2021 was a fluke, but merely highlights the fact that catching the first wild return was an unusual event. Two things can be simultaneously true: i.e. the odds of catching a returning wild adult salmon have increased as a result of ongoing iBoF Atlantic salmon recovery efforts, and that such fish remain uncommon enough doing so is unlikely.

A second significant salmon observation occurred in 2023 at the FNT, when 9 precocious parr (Figure 12) were encountered over a three-week period in late September and early October seeking out returning adults to mate with (Redfield 2024). During the previous 5 years at the current trap site, only 1 precocious parr had been seen. Such parr are an important reproductive component of the salmon population, since in years when few males return to spawn, precocious parr help ensure the fertilization of as many eggs as possible (Montgomery 1983). It has been suggested that proportions of mature male parr increase within Atlantic salmon populations (such as IBoF) that are experiencing high mortality at sea (Gibson 1978; Montgomery 1983), as genotypes that become sexually mature in freshwater avoid mortality at sea prior to reproduction (Caswell et al. 1984). However, Myers *et al.* (1986) concluded that it is more likely that observed changes in rates of maturation could be explained by density dependent factors influencing growth and development, rather than by actual shifts in gene frequency in response to selective pressure.

Myers et al. (1986) report once a fork length of approximately 13 to 14 cm is developed, virtually 100% of male parr remaining in rivers are sexually mature. Precocious parr often appear fat, as 20% of their body weight is comprised of testes (Montgomery 1983). The precocious parr in Figure 12 was one of two caught at the FNT on October 16th, 2023, in the

Figure 12: Precocious parr, 18.6 cm: one of two on October 16th, 2023, with an adult female.

company of an adult female who had been released just a few days earlier upstream on the Pollett. Precocious parr are attracted by hormones that adult females excrete in their urine (Olsén et al. 2002). The 7 precocious parr detected at the FNT in 2023 before these 2 were caught prior to October releases of FSR adults on October 13th. Consequently, those individuals were clearly searching for adults independent of 2023 releases. It seems possible they were doing so in response to movement of other adults – perhaps returns from 2022, or wild adult returns. The Pit Tag Antenna on the Pollett had already detected 10 returns of salmon released in 2022 by that time.

Regardless, what this indicates is that the population of juvenile salmon within the Petitcodiac are now actively participating during the spawning season. Salmon were extirpated from the Petitcodiac. For recovery efforts to have progressed to the point now where salmon within the river have developed the capacity to respond collectively to returning adults as a stressed population would, rather than FSR adults just being released into an empty river, is measurable progress.

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 2014a). This species is being considered for listing under the federal Species at Risk Act, but currently it has no status (SARA Registry 2013b). Similarly, American eels are frequently encountered by Fort Folly Habitat Recovery along the main stem. Eels demonstrate significant mobility within the system. In 2016 and 2017 eels tagged while coming downstream on the Little and the Pollett during the spring to feed in the estuary were later recaptured in the FNT (Figure 13) on the main stem coming back upstream in the late summer and fall to overwinter in freshwater. Unlike salmon, eels were

Figure 13: American eels captured at the original FNT site coming upstream in August 2015.

not excluded by the Petitcodiac Causeway downstream. 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). Unfortunately the current trap site (2018 to 2023) does not provide as effective a means of monitoring eels as the original trap site had (2010 to 2017), and as a consequence electrofishing in the headwaters now provides the most effective means of tracking this species.

Striped bass (*Morone saxatilis*) within the Bay of Fundy were designated as "Endangered" by COSEWIC in 2012 (COSEWIC 2014b). This species is being considered for listing under the federal Species at Risk Act (SARA), but currently it has no status (SARA Registry 2018). Striped bass were excluded from the freshwater reaches of the Petitcodiac while the causeway gates were closed (Locke et al. 2003) but have been making a rapid recovery since the gates were opened in 2010 (Redfield 2024), both in terms of numbers of young-of-the-year and adults (Figure 14).

For the first time in 2018 numerous large adults were detected on multiple occasions between August and October in a pool a short distance above the confluence of the Pollett with the main stem of the Petitcodiac, during snorkle surveys for salmon. Prior to 2018 the highest in the system this species had been observed since the gates were opened was the head of tide, however this observation shifted the highest point they'd been 7.5 km further upstream, most of it along the main stem, well above Salisbury. Since then, in 2021, striped bass have been caught by anglers at the railway bridge in the Village of Petitcodiac- at the very top of the main stem, not far below the point where the North River and the Anagance come together and become the Petitcodiac. It is thought that these individuals get so far up in the system while pursuing spawning gaspereau in May and June, as numerous similarly sized striped bass tend to be caught in the FNT at the head-of-

Figure 14: Largest striped bass seen at the FNT (64.6 cm) caught at the original site June 2017.

tide during that time. It is notable however that the threshold at which striped bass becomes legal for anglers to keep on the Petitcodiac is 68 cm. While striped bass that big are caught with some regularity in the estuary at Dorchester or Belliveau Village, striped bass that big are yet to be seen at the FNT in Salisbury.

Brook floaters (*Alasmidonta varicosa*), are a medium sized (Figure 13) species of freshwater mussel listed as Special Concern by COSEWIC (COSEWIC 2009), and as Schedule 1, Special Concern, under the Species at Risk Act in 2013 (DFO 2016).

Brook floaters were well documented along the main stem by DFO in the late 1990s (Hanson and Locke 2001). Their numbers appear to have declined since that time due to a contraction in their habitat in response to silt brought upstream due to increases in tidal amplitude since the opening of the Petitcodiac Causeway gates (Redfield 2019). Of the 7 sites along the main stem of the Petitcodiac at which Hanson and Locke (2001) found brook floaters in 1997-1998 an FFHR survey twenty years later in 2018 detected brook floaters at only 4.

Overall, the decline in numbers of brook floaters appears to be a consequence of cumulative impacts from human activities - eutrophication, channel instability, and contraction of brook floater habitat as the head of tide shifted back upstream in response to the opening of the Petitcodiac Causeway gates. This was perhaps an unanticipated consequence of the restoration of tidal free tidal exchange in 2010. Brook floaters may have actually benefited from the causeway, due to the artificial increase in freshwater habitat near the mouth of Little River and are now losing that habitat as more estuarine conditions reassert themselves.

Figure 15: Brook floater: distinctive orange foot, rays on the shell, and characteristic width.

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). Wood turtles have been encountered at several locations along the main stem while conducting other field work. Due to their small home range, and vulnerability to poaching, encounters with wood turtles are considered to be sensitive information, and so are being withheld here. It is worth noting that the individual shown in Figure 16 is quite small- a juvenile. Adults are typically several times larger and have been seen as well on the main stem.

Figure 16: Juvenile wood turtle encountered along the main stem in 2015.

Head-of-Tide

The lowest 4 km of the main stem lies within the historical head-of-tide on the Petitcodiac. The Bannister Brook Composite, the lower of the two regions that make up the main stem, ends at the mouth of Little River on the right bank, and the mouth of McNaughton Brook on the left bank, just below the railway bridge in Salisbury. The silt flats beneath the railway bridge in Figure 4 have developed during the 14 years since causeway gates were opened. Figure 17 is based on imagery from September of 2015, which shows the silt brought upstream by the tide ending at approximately the Route 112 bridge over the Petitcodiac in Salisbury. There is a notable difference in the colour of the river above that point and below that point. Tides have continued to increase in amplitude since that time such that the channel above the Route 112 bridge in Salisbury which had constantly had a gravel bottom is accumulating silt flats (Figure 18). The furthest extent of tide in 2023 shown in Figure 17

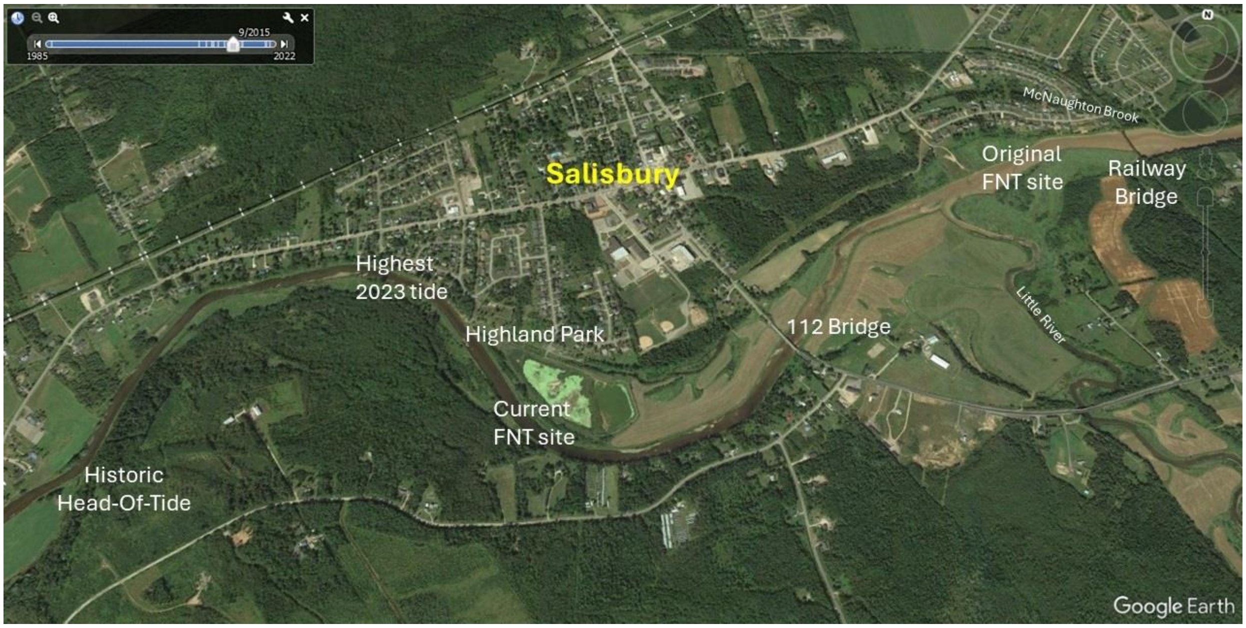

Figure 17: Head-of-tide in September 2015, silt below Route 112 Bridge, freshwater above it.

Figure 18: Silt flats above the Route 112 bridge in Salisbury by September 19th, 2022.

was just beyond Highland Park. That comes close to, but still falls roughly 1 km short of the historic head of tide. Despite the new channel under the Honorable Brenda Robertson Bridge being roughly 160 m wide, tides are unlikely to achieve the historic amplitude, as the pre-causeway channel tides passed through was much larger- approximately 1 km wide.

The Petitcodiac estuary naturally has a high suspended sediment load, typically around 30,000 milligrams per litre (mg/L) (AMEC 2005). To better grasp this, 30,000 mg is 30 grams (i.e., slightly more than 1 ounce) of sediment per litre of water, the colour of which gives the river its nickname - the Chocolate River. The primary source of this sediment is coastal erosion in the Bay of Fundy (Plint 1986; Schell 1998; Haralampides and Rodriguez 2006).

The banks and tidal flats along the estuary have accumulated a large store of this silt and clay and it is easily suspended and redistributed (Bray et al. 1982). Prior to construction of the causeway, the amount of water (tidal prism) flowing into the river from the ocean twice a day on the tide was around 450 cubic kilometres (km^3), which fell to about 200 km^3 when the upper part of the estuary was cut off by the causeway and the downstream channel had filled with silt (Morris and Mitchell 2013). The original tidal prism scoured a massive drainage channel 1 km wide at the causeway site making the river appear larger than it would be based upon its freshwater discharge alone. Elimination of the portion of the tidal prism from above the causeway reduced the volume of water flowing out of the estuary on ebb tides (Schweiger 1986), and resulted in massive sedimentation, as the system shifted towards a new equilibrium (ADI 1979; Bray et al. 1982). Sediment cores extracted near the causeway show layers of silt 3 mm thick, which were deposited on each tide, accumulating to a depth of 7 m over the three-year causeway construction (Haralampides and Rodriguez 2006). This eventually narrowed the channel below the causeway by 92% from 1 km down to 80 m (Harvey 1997), with the effects of this infilling extending 21 km downstream of the causeway (Van Proosdij et al. 2009). As the channel silted in, the bottom elevation of the wetted channel increased as well. The tidal bore, which had ranged from 1 to 1.5 m in height, declined to a small fraction of a metre in the portions of the estuary still subject to tidal influence (Morand and Haralampides 2006).

Tidal bores are a phenomenon created as incoming tides are funneled into a shallow, narrowing river or lake from a broad bay (Chanson 2009). It is a wavefront of water “boring” its way upstream against the natural flow of the river, followed by the rising tide (Dalton 1951). Near the new bridge in Moncton, the arrival of the bore immediately increases the depth of the river by nearly 1 m. Once the bore passes, the tide continues to rise for more than 2 hours, increasing the depth of the river at that site by about 10 m (Lynch 1982). It takes approximately 2.5 hours to go from low water to high water in Moncton, but the tide ebbs gradually, requiring about 9 hours to drop from high to low. The tidal amplitude is much lower at the FNT site upstream at the head-of-tide. Due to the lower amplitude, less time is required to drain back to baseflow at the trap site, but the basic asymmetry between the rising and falling limbs of the tide remains.

Arriving as a wave of focused energy and water funneled upstream by the river channel, such asymmetric tides are not just a consequence of the volume of water, they are also shaped by the energy behind it (Lynch 1982). The bore is like a wave crashing and retreating on a shore; it moves so gradually for such a distance that the tide is rising upriver at Salisbury even as the water level at the Petitcodiac's mouth begins to recede as the tide drains out into the Bay. Friction against the river bottom drains energy from the bore and, if the speed of the bore becomes less than that of the river, it will be swept back downstream.

Prior to construction of the causeway, Elson (1961) described the upper part of the Petitcodiac estuary near Salisbury as a challenging environment that functions as a "rather violent transport area" between freshwater and the more stable sea environment. He noted that the tidal bore was disruptive of fish orientation in the river due to turbidity and turbulence, and that small smolt sized fish were "tossed" by the wave of the bore and preyed upon by gulls during its passage.

The strength of the tides making their way up to this portion of the river increased rapidly once the gates were opened in 2010. This effect accelerated in 2021 after the new 160 m wide channel opened under the bridge. As early as 2012, silt had shifted such that approximately 1 km downstream of the causeway's control structure, the river channel had widened by as much as 20 m and at 10 km downstream it was about 350 m wider than before the gate opening (AMEC 2013).

The widening channel has provided a more efficient conduit and allowed the bore to express itself more strongly. This has likely contributed to the observed growth in the size of tides arriving at the head-of-tide over the years. The maximum tide recorded at the railway bridge in Salisbury has increased markedly from 1.8 m above the baseflow of the river in 2010 to 3.1 m (on five separate occasions) during 2023 (Gemtec 2023). Average tides detected on the Salisbury gauge in 2023 increased even more notably - up 1.19 m compared to 2010, and 0.57 m compared to 2022 (Redfield 2024).

Water Quality

Water quality on the main stem of the Petitcodiac has been monitored by the Petitcodiac Watershed Alliance as part of their basin wide water monitoring program, which has data going back to 2005. The 2021 results are presented in Table 2 (Petitcodiac Watershed Alliance 2022). The PWA maintains a fixed monitoring site on the upstream side of the Route 112 bridge over the main stem of the Petitcodiac at Salisbury. Other relevant sites for water as it enters the main stem are available from: Little River (Route 112 Bridge); Pollett River (Powers Pitt Road); the Anagance River (Mill Road); and the North River (885 Bridge at Intervale). Being a single site within this portion of the watershed there is a limited amount that can be concluded from it, however taken together with these other sites more can be gained. Located just below where the photo in Figure 18 was taken, this area is essentially where the fresh water transitions into the estuary, and this site provides insight to conditions upstream. The fact this location has been monitored continuously by the PWA for years also provides significant time depth.

Table 3: Water Quality on the Petitcodiac main stem at the Route 112 bridge in Salisbury

(Petitcodiac Watershed Alliance 2022)

Monthly at Site	Dissolved Oxygen	Conductivity	Temperature °C	pH
May	12.4 mg/L	81.4 µS	8.3 °C	7.65
June	6.0 mg/L	179.7 µS	23.2 °C	7.53
July	9.2 mg/L	220.9 µS	18.7 °C	7.70
August	8.9 mg/L	115.5 µS	21.3 °C	7.40
September	9.9 mg/L	160.1 µS	13.6 °C	7.32
October	11.5 mg/L	156.4 µS	10.3 °C	7.39
Average	9.6 mg/L	152.3 µS	15.9 °C	7.49

Geomorphic Analysis

Data collected from the Rapid Geomorphic Assessment (RGA) was used to evaluate the geomorphic condition and stability of the assessed reaches of the main stem of the Petitcodiac River. In order to interpret the geomorphic data, the included maps of the watercourse are highlighted according to reach stability as well as the Primary Geomorphic Processes impacting each reach.

Rapid Geomorphic Assessments are used to quantify channel stability based on the presence and (or) absence of key indicators of channel adjustment with respect to four categories: 1) Aggradation, 2) Degradation, 3) Channel Widening, and 4) Planimetric Form Adjustment. Each indicator is 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.

Typical indicators used to identify aggradation include:

- 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 be seen with degradation, as it occurs with an increase in flows or decrease in sediment supply. Widening occurs because the stream bottom materials become more resistant to erosion (harder to move) by flowing waters than 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 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 4: 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 widespread.

The RGA stability index results for the main stem of the Petitcodiac River are shown in Figure 19. Approximately 66 % of the reaches are in adjustment - as per Table 4- the most sensitive state. Only 10 % of the reaches assessed were found to be stable (in regime). The remaining 24 % were transitional between these two states.

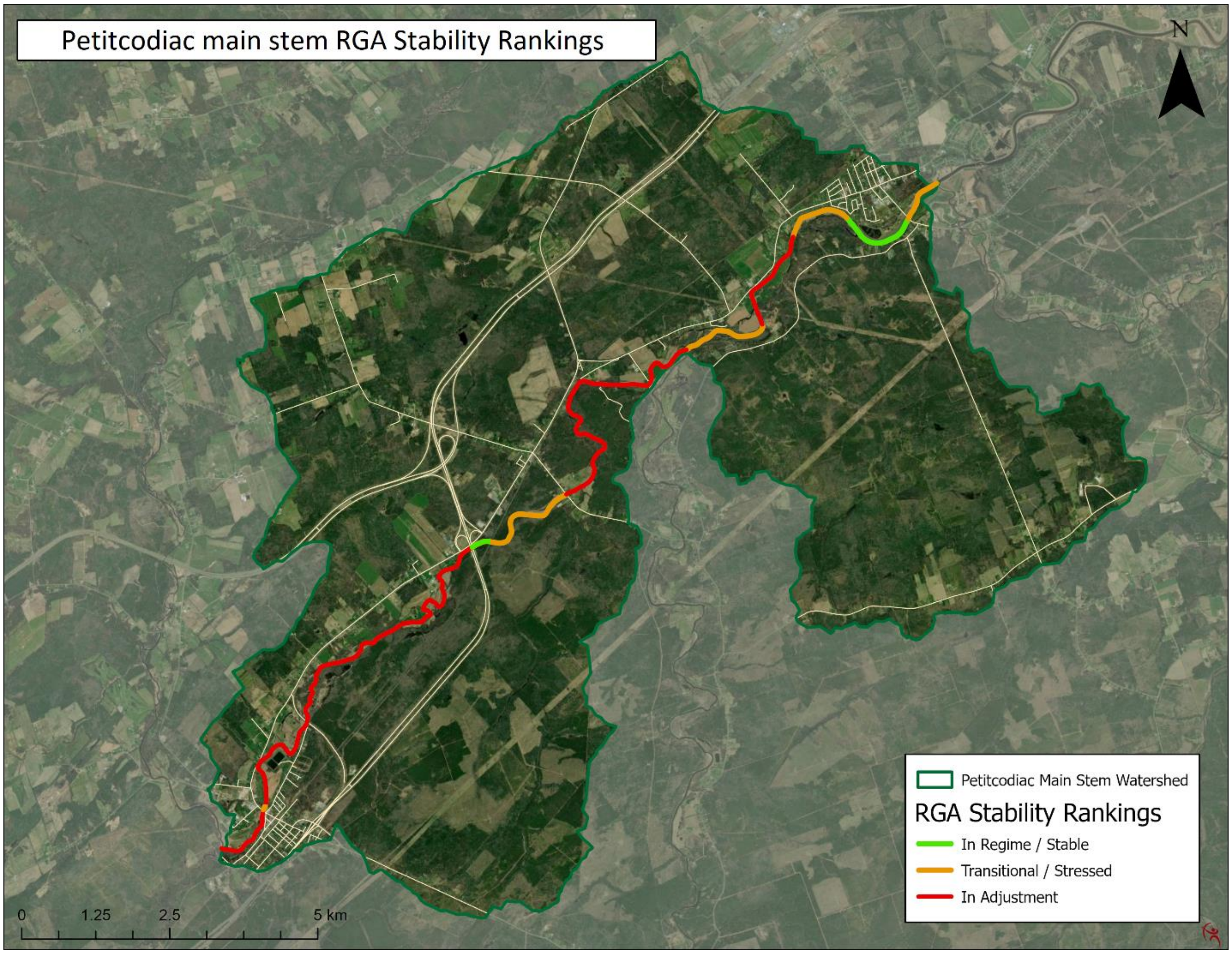

Figure 19: RGA Stability Rankings for the main stem of the Petitcodiac River

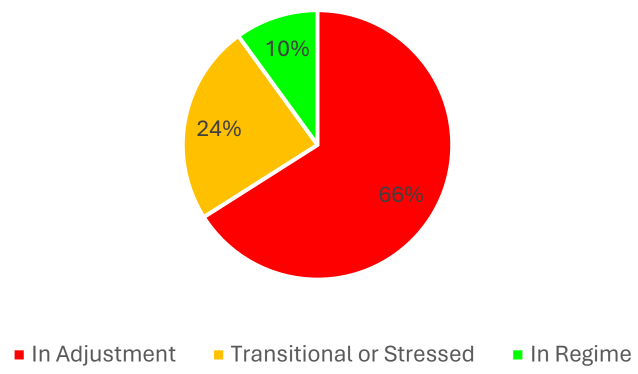

Figure 20: Main stem of the Petitcodiac River Stability Index Based on the Number of Reaches

Table 5: Stability Index Scores from RGA Surveys

Reach	Stability Index	Class		Reach	Stability Index	Class		Reach	Stability Index	Class
R1	0.596	In adjustment		R8	0.595	In adjustment		R15	0.438	In adjustment
R2	0.378	Transitional		R9	0.623	In adjustment		R16	0.272	Transitional
R3	0.438	In adjustment		R10	0.189	Stable		R17	0.462	In adjustment
R4	0.595	In adjustment		R11	0.276	Transitional		R18	0.415	In adjustment
R5	0.564	In adjustment		R12	0.497	In adjustment		R19	0.230	Transitional
R6	0.520	In adjustment		R13	0.572	In adjustment		R20	0.186	Stable
R7	0.766	In adjustment		R14	0.544	In adjustment		R21	0.210	Transitional

Primary Geomorphic Processes

The primary geomorphic process identified on the main stem of the Petitcodiac River are shown in Figure 21. Widening was the most common process observed at 71%, followed by Planiform adjustment 14%, Aggradation 10%, and Degradation 5%.

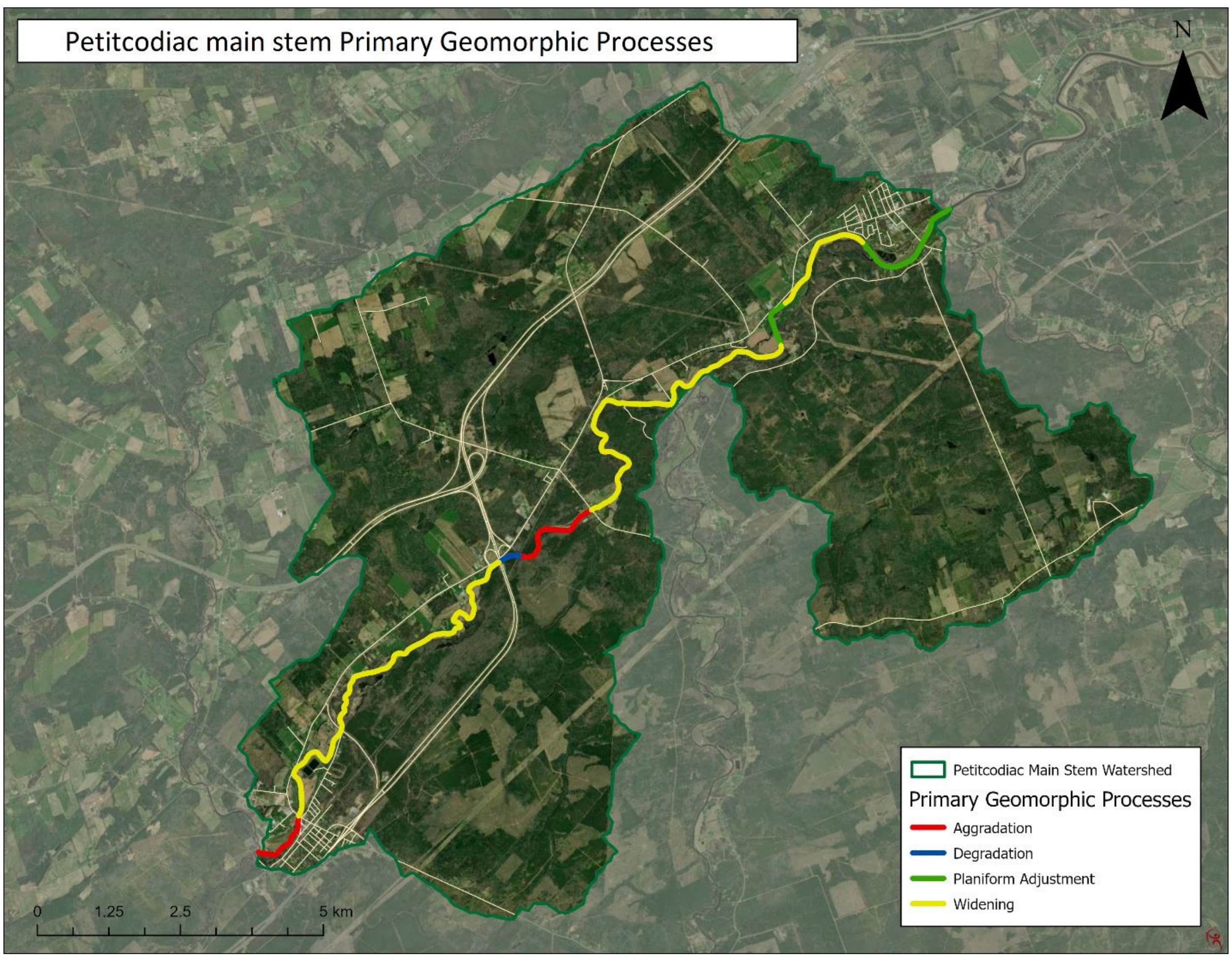

Figure 21: Primary Geomorphic Processes on the main stem of the Petitcodiac River

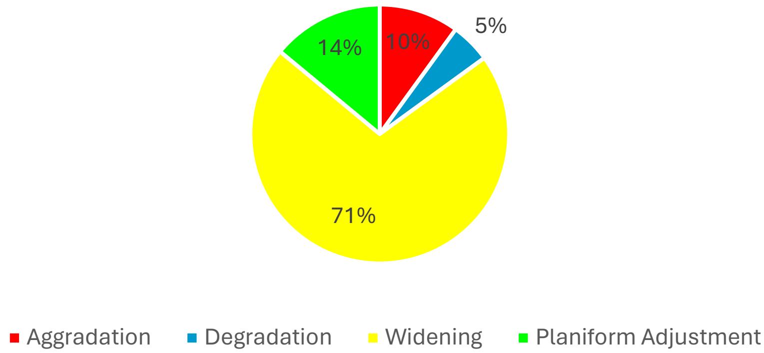

Figure 22: Primary Geomorphic Processes on the main stem of the Petitcodiac River

This RGA data indicates that most of the riverbanks along the main stem of the Petitcodiac River are experiencing some degree of stress and disturbance, with the primary form of this being widening of the channel. The degree of this disturbance is greater the higher one goes in the system, which might initially appear to be different from what is often seen for RGA results within other watersheds in this series of Stewardship plans. However an important distinction between the main stem of the Petitcodiac and the other watersheds examined is that the top of the mainstem is not its headwaters.

Unlike the upper reaches of the various Petitcodiac tributaries (above which by definition there is just a ridge beyond which lies a different watershed), the top of the main stem is simply the somewhat arbitrary point along the river channel where, the North River and the Anagance (actual headwaters) have come together. Here the main river channel stops, being called the North River and is recognized by the government as the Petitcodiac River. As such, unlike in other watershed units, the causes of disturbance on the main stem are not limited to activities taking place within the area examined, but also include those from outside of the area, further upstream. For example the upper main stem of the Petitcodiac is impacted by forestry activity on the Anagance River, and agriculture on the North River. Disturbance within the main stem is widespread. The purpose of RGAs is to identify and prioritize areas needing the most attention- however with so much of the main stem "in adjustment" other factors – such as landowners, and significance to wildlife take on even greater importance in determining which projects to undertake.

Fourth Level Assessment - Aquatic Habitat Rehabilitation Plan

Summary of Issues Identified from Information on Current Impacts

Culvert surveys by the Petitcodiac Watershed Alliance as part of their Broken Brooks program noted 3 culverts that were full barriers to fish passage and 1 culvert that was a partial barrier to passage (Figure 8) within the watershed, a total of 4 impacted culverts. With 95 crossings identified (Figure 7) and only 37 assessed (Figure 8), another factor identified here is the scope for additional assessments of water crossings within the main stem of the Petitcodiac to identify other water crossings in need of attention. Most of the assessed crossings are near Salisbury within the Bannister Brook Composite portion of the main stem. Few assessed crossings are in the O'Blenis Brook Composite in and around the Village of Petitcodiac, indicating that additional work could be done there in particular to address that information deficit and identify future targets for remediation.

Summary of Issues Identified from Aquatic and Riparian Habitat Assessment

Knowledge about wildlife within this portion of the river is concentrated at the head of tide, where the FNT has been operating. Upstream of that area, most of what is known about SAR species comes either as a result of brook floater surveys in 2018, or anecdotal data provided by anglers. This suggests that there might be some value to be had in projects further upstream to address such knowledge gaps.

Rapid Geomorphic Assessments (RGAs) identified roughly 66% of the reaches along the main stem as "in adjustment" indicating that instability is widespread. In only about 5% of the main stem's length was Channel Stability found to be "stable". Widening is the primary geomorphic process taking place on 71% of reaches. Disturbance within the main stem is widespread. The goal of RGAs is to identify and prioritize areas needing the most attention- however with so much of the main stem "in adjustment" other factors – such as landowners, and significance to wildlife take on even greater importance in determining which projects to undertake.

Restoration Activities Undertaken

Two restoration projects have been done within the main stem of the Petitcodiac River. These have both focused on bank stabilization (Figure 23). The first was done in 2015 near the Village of Petitcodiac by the Petitcodiac Watershed Alliance and the second was a two-year project in 2020 and 2021 within the Village of Salisbury Fort Folly Habitat Recovery.

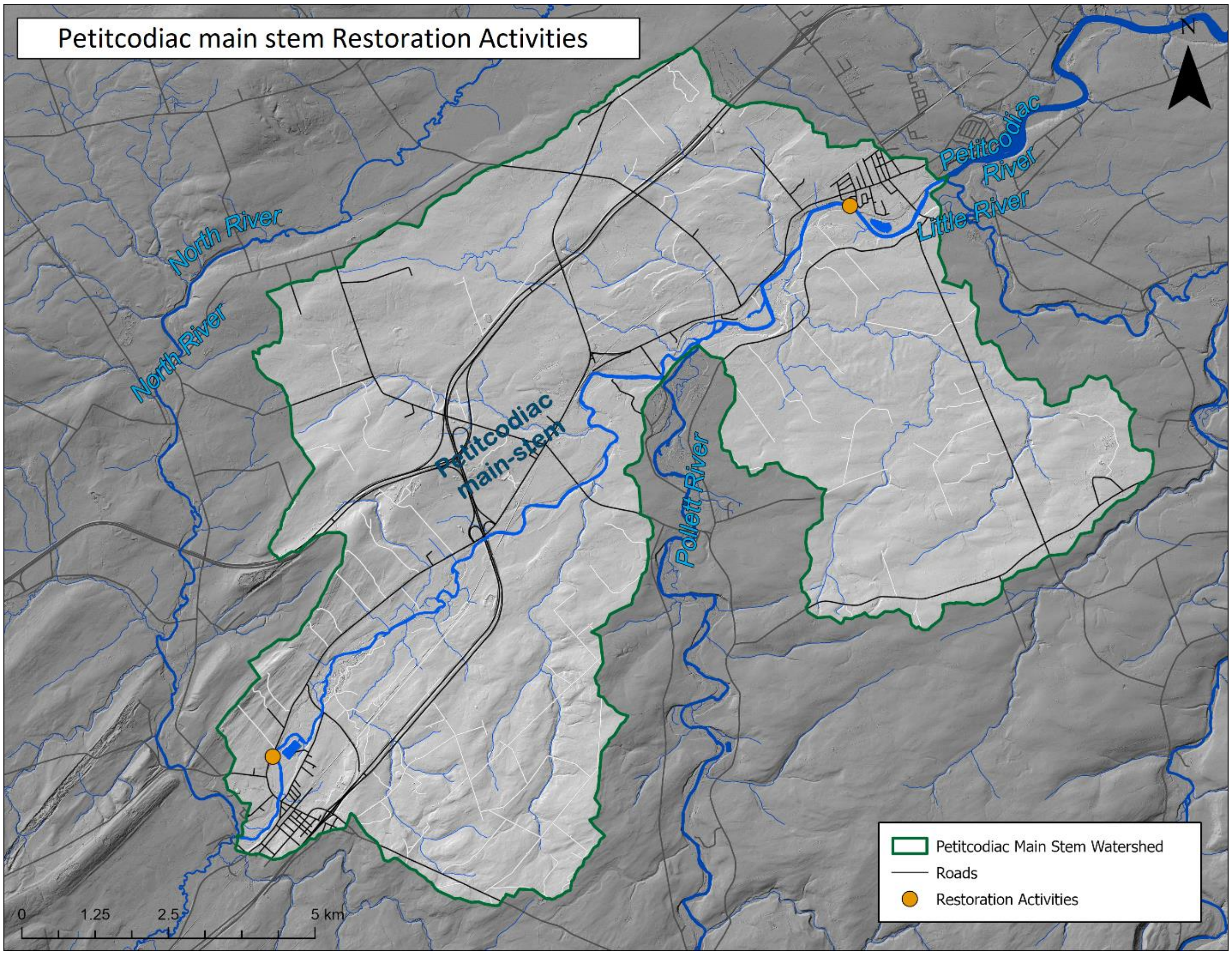

Figure 23: Restoration Activities Undertaken within the main stem of the Petitcodiac River

Bank Stabilization

Village of Petitcodiac (2015) N 45.940193 W -65.178198

The first bank stabilization project on the main stem was done by the Petitcodiac Watershed Alliance in 2015 with the assistance of Parish Geomorphic Ltd. and Fort Folly Habitat Recovery. Part of the goal of the activity was protection local infrastructure– specifically Route 106 on the north side of the river. The issue here was a section of Route 106 (roughly 200 years old, what had been the Westmorland Great Road (Goodrich 2010) which in the modern era has been paved and armoured with riprap (Figure 24) and has created a sharp right-angle turn, beyond which it artificially straightens this portion the river, greatly disturbing flow, resulting in bank erosion both above and below Route 106.

On the opposite bank, The Village of Petitcodiac Sewage Lagoon (Figure 25) was also a source of concern- threatened by flooding and erosion. However the proposed work to build an overflow channel along that bank lay outside the budget eventually awarded. Instead the work that was done was limited to stabilization of a portion the river left (north)

Figure 24: Riprap armoured bank below Route 106

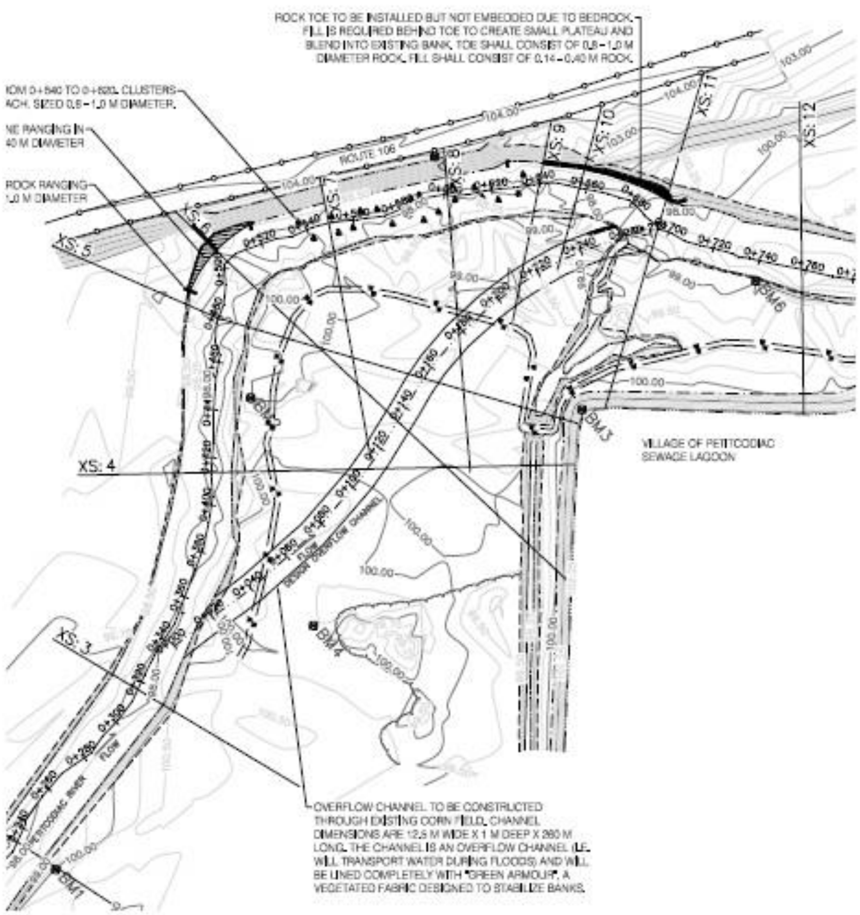

Figure 25: Work on left bank, boulders in river, and proposed overflow channel on right bank.

bank immediately upstream of the riprap on Route 106 and another portion of the left bank immediately downstream of it, as well as placement of boulder clusters within the river channel (the black triangles in Figure 25). These boulder clusters are intended to slow movement of water along the base of the rip rap armoured bank and create sheltered instream habitat there for fish.

The high armoured bank creates a choke point in the river along this curve between Route 106 on the left bank and the Village of Petitcodiac Sewage Lagoon on the right bank. When the river floods, particularly during the spring freshet, it threatens to undermine or even potentially flood the lagoon. The purpose of the overflow channel through the field below would be to mitigate this, by preventing water from backing up by moving it more efficiently through this portion of the river. Though this channel wasn't built in 2015 when the project

Figure 26: Natural overflow channel forming (2019) by action of the river during high water.

was done, the river has been working at creating such a feature on its own. As can be seen four years later in 2019 (Figure 26) the river is working on creating a side channel through the field, which if it is successful may eventually turn this area into an island.

The stabilization of the portion of bank upstream of Route 106 that was done in 2015 is shown in Figure 27 in a series of repeat photographs taken of the site between 2016 and 2019. Unfortunately there is no before photo from 2015. Several things are apparent, however. On the one hand the large woody vegetation that was planted some distance back from the edge in 2015 was thinning out by 2017, difficult to find by 2018, and essentially gone by 2019. While that is unfortunate, the grasses which may have contributed to choking that woody vegetation out have themselves become well established on the site based on a comparison of the site being essentially bare in April of 2016 and yet consistently and increasingly thickly vegetated over the following years. This grass at least appears to be doing a good job of holding the bank together on its own. In depth, ongoing monitoring of this site was not undertaken by Fort Folly Habitat Recovery resource constraints and the fact it was a Petitcodiac Watershed Alliance project.

Figure 27: View upstream of stabilized riverbank seen from Route 106

Village of Salisbury (2020-2021) N 46.021662 W -65.046629

Fort Folly Habitat Recovery, in partnership with the Village of Salisbury and 5R Environmental Consulting Inc., completed a bank stabilization project in Highland Park at the head-of-tide along the main stem of the Petitcodiac River (cover: bottom photo). In addition to Highland Park, the failing bank slope upon which this work took place was mostly Crown Land immediately upstream of the park, sandwiched between the river and private residences (Figure 28 and Figure 29).

The bank at that location lies along the outside curve of the river and is subject to significant erosive force from stormflow and ice during the winter and spring freshet. Some years ago, installation of a hardened municipal stormwater discharge point midway along the bank altered the radius of curvature of the river and promoted eddies and currents against the bank, which produced slumpage and failure of the bank immediately upstream and downstream of it.

The restoration design was focused on re-establishing the natural radius of curvature through this reach of the river while maintaining a channel width that going forward will allow freshet flows and significant stormflow events to pass without creating substantial erosional damage. It did so by constructing an approximately 450 m long rock toe along the base of the bank in 2020, and then reconstructing a 300 m length of the bank slope above that in 2021, at which point the site was seeded and planted with live stakes of willow and dogwood.

Figure 28: Bank Restoration at Highland Park from upstream looking downstream 2018 to 2023.

Figure 29: Bank Restoration at Highland Park from downstream looking upstream 2018 to 2023.

An additional challenge facing this site is ongoing changes in the river as a consequence of the Province of New Brunswick's Petitcodiac River Restoration Project. In April 2021 the new 160-metre-wide channel was opened beneath the recently completed Robertson Bridge linking Moncton and Riverview, 22 kilometers downstream. This bridge replaced the 50-metre channel provided by the gates of the Petitcodiac Causeway control structure. Notably stronger tides began to arrive at Highland Park in late May 2021 just a few weeks later. The following year, on May 17th, 2022, the site experienced a 2.95 m amplitude tide (on the gauge at the Salisbury Railway Bridge more than 2 km downstream), at the time by far the strongest recorded since the causeway gates opened in 2010 (when the maximum had been only 1.8 m amplitude).

That record then fell in 2023 when there were no fewer than 5 tides between May and October which exceeded 3.1 metres on the gauge at the railway bridge. The 1.8 m record tide in 2010 would not even have reached as far upstream as this portion of the bank, whereas the biggest of these 2022 and 2023 tides, being 1.1 to 1.3 m in amplitude beyond that 2010 tide, inundated this section of bank to a depth of 20 to 30 cm, bringing salt, silt, and debris from the estuary along with them. The log in the 2022 photo in Figure 29 was left after being brought upstream by the tide rather than downstream by stormflow as one might have otherwise assumed. Not only will tides such as these continue into the future, but as conditions evolve, tides are likely to become expressed with even more strength over time.

The 2018 photos in Figures 28 and 29 were taken prior to work beginning at the site, while still developing a restoration design and pursuing funding for the project. One can see quite a bit of a difference, as there was more woody vegetation then, which subsequently fell away as the bank was undermined and collapsed prior to work at the site beginning in 2020. The 2021 photos were taken in November of that year after work on the bank had been completed, and the 2022 photos are from September, late in the growing season. Meanwhile the 2023 photos were taken in August.

The late timing of the photos in 2022 was intentional, to capture the full growth and development at the site. A winter storm on February 18th, 2022, had inflicted significant damage on this site before the vegetation planted in the fall of 2021 had sufficient opportunity to become well established. A couple of days of unseasonably warm temperatures (high 11.7 °C) in mid-February 2022, along with 15 mm of rain produced a rapid melt of the accumulated snowpack (from 84 cm on February 16th down to 18 cm on February 19th). With the ground still frozen, combined water from the rain and melted snow flowed into the river, breaking up the ice and generating flooding that according to the river gauge in Salisbury a short distance downstream peaked more than 3 metres above the level the river had been at prior to this event. That storm was an extreme event which produced the highest discharge recorded by the gauge upstream in the Village of Petitcodiac since 1970 (the Salisbury gauge only goes back to 2010). Scouring ice carried by this event did considerable damage to the reconstructed bank. Additional work in the spring of 2022 was required to further rehabilitate the bank, meaning that development of the vegetation was delayed compared to if the site had survived the winter undisturbed.

Vegetation was planted at the site in 2021 as per Figure 30. A mixture of 1,880 willow and 590 dogwood live stakes were distributed evenly across the bank by collecting and planting them in the fall of 2021. Initial density across the approximately 600 m^2 of revegetated bank

Figure 30: Vegetation planted at Highland Park Restoration in 2021

averaged about 4.1 stems per m^2. The purpose of such an initially high density was to a) allow some degree of cushion for anticipated mortality, and b) comply with the requirements of the WAWA permit for the project which understandably makes such an initial built in cushion in stocking levels mandatory. Long-term, as the vegetation becomes established, sustaining a target of 1 stem per m^2 is likely to be sufficient.

As noted previously, the winter storm in February 2022 took quite a toll on the site. . In May 2022 as part of making repairs an additional 674 willow and 65 dogwood were planted along the bank to replace losses from the storm. Vegetation planted in fall 2021 and spring 2022, as well as the results of the survey of established vegetation in the summers of 2022 and 2023 are presented in Table 6. By 2023 there was a stocking rate of 1.06 stems per m^2, with natural recruitment accounting for 9% of the total, and species diversity having jumped from 4 species in 2022 to 12 species in 2023.

Table 6: Live stakes planted and Natural Recruitment at Highland Park from 2021 to 2023

Species	Planted 2021	Planted 2022	Surveyed 2022	Surveyed 2023	Establishment
Willow	1,880	674	931	540	29% of original
Red-osier Dogwood	590	65	49	37	6% of original
White elm	-	-	2	7	Natural Recruitment
White ash	-	-	1	1	Natural Recruitment
Alder	-	-	-	23	Natural Recruitment
Crabapple	-	-	-	1	Natural Recruitment
Chokecherry	-	-	-	10	Natural Recruitment
Grey birch	-	-	-	6	Natural Recruitment
Red oak	-	-	-	1	Natural Recruitment
Trembling aspen	-	-	-	4	Natural Recruitment
Serviceberry	-	-	-	4	Natural Recruitment
Red maple	-	-	-	1	Natural Recruitment
Total	2,470	739	983	635	26% of original
Stems per m^2	4.11	+ 1.23	1.64	1.06	26% of original
% recruits			0.3%	9%	

Figure 31 shows a willow live stake on the bank in July 2023. It is now well established, likely about twice the size it would have been a year previously. Such vigorous growth indicates production of roots that together with the grass and clover growing around it should bind the soil to help provide long term structural stability on reconstructed bank slope.

Figure 31: Willow live stake July 2023

The repeat photography time series of photos in Figure 28 and Figure 29, and the vegetation monitoring are part of the long-term monitoring the FFHR conducts at its sites, following restoration. Since 2022, once the vegetation had an opportunity to become well established, slope stability has remained high. This observation was documented and quantified by surveying a series of cross sections across the length of the site. The initial 2021 post construction survey was made irrelevant by the winter (2021-22) storm. Consequently going forward the post repair survey in 2022 was used as a new baseline, to which the 2023 survey was compared.

In addition to vegetation, repeat photography, and cross sectionals surveys, other long-term monitoring ongoing at the site compared to 2020 pre-construction baselines includes electrofishing to assess how fish are responding to the work done, and Canadian Aquatic Biomonitoring Network (CABIN) wadeable streams monitoring (Environment Canada 2011). The latter examines aquatic insect populations - particularly Ephemeroptera (Mayflies), Plecoptera (Stoneflies), and Trichoptera (Caddisflies)- EPT species- as these are typically the most sensitive to habitat disturbance. Even distribution and high numbers serve as good indicators of water quality. As residents of the site the state of such populations can provide longer term insights into conditions there than conventional water sampling which provides only an ephemeral snapshot in time.

Opportunities for Future Restoration Activities

Restoration Framework –Stewardship Planning, Prioritization and Engagement

To address concerns within the watershed through an efficient use of finite resources (both human and financial), projects must be well prioritized, both in terms of the needs of the river, and those of the landowners on who's property the project is taking place. Fort Folly Habitat Recovery has developed a series of Stewardship Plans on a watershed-by-watershed basis within the Petitcodiac River system, of which this Stewardship Plan for the main stem of the Petitcodiac River is one. These plans provide a means of tackling the challenging task of identifying local problems, determining which ones warrant immediate attention, and determining how to proceed with them once chosen. This process is laid out in Figure 32 and Figure 33.

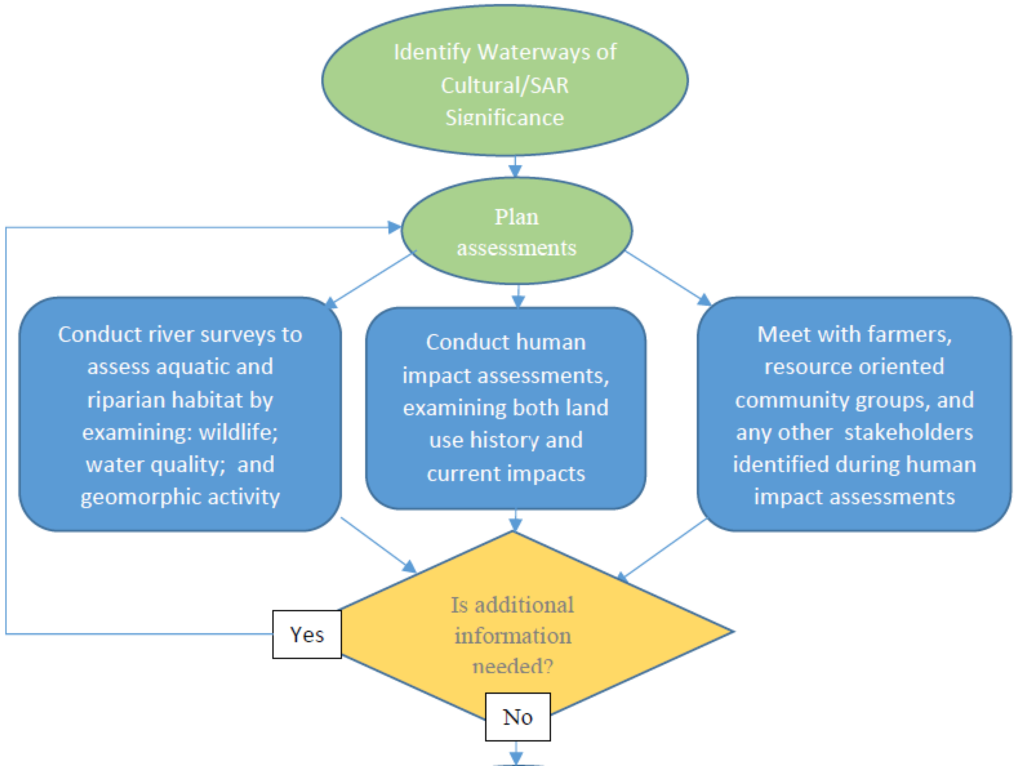

Figure 32: Stewardship Planning Process Part 1: Needs of the River

The field work that makes up the Third Level Assessment (Aquatic and Riparian Habitat Assessment) informs decision making by providing the wide context necessary to prioritize and target project selection. Without it, decisions about which project to undertake would be made without proper appreciation of how needs at a given site compare to those at other sites elsewhere in the system. At this point there is also an opportunity to ensure that efforts are well distributed across the watershed by including consideration of where previous projects have been done, to avoid focusing too much effort in just one area within too short a time period.

Applying such information, project selection can then proceed along the flowchart presented in Figure 33, where once identified, potential projects can be ranked according to their anticipated impact and viability. Viability is determined in part by the costs and benefits of the project, but is also dependent upon landowner interest, which comes from (to the extent practical) incorporation of landowner input into planning the project so that it is consistent with the landowner's needs.

Following this two-part selection process not only aids in decision making within the organization, doing so subsequently builds the case for any individual project when pursuing resources from outside the organization to undertake it, by providing the evidence

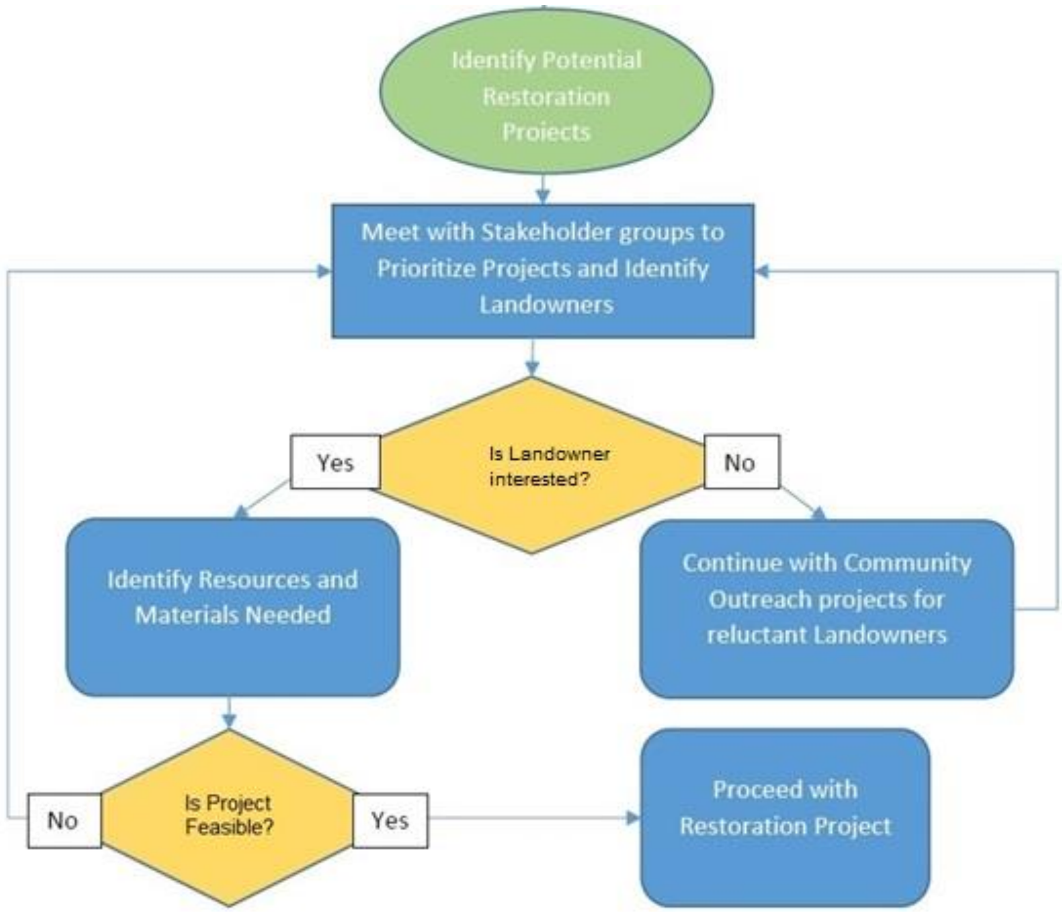

Figure 33: Stewardship Planning Process Part 2: Meeting Landowner Needs

to explain to others why it is necessary. This also creates further opportunities for outreach and engagement with landowners, through accessing and participating in existing social networks. Only once a project has been determined to be both worthwhile and feasible through this process should it then proceed to the design phase.

Given finite resources, the value of a project with regards to advancing salmon recovery is one of the strongest considerations in prioritizing project selection within the Petitcodiac as a whole. The detection of numerous iBoF Atlantic salmon redd sites in both the Little River and the Pollett River from 2011 onward demonstrates the importance of the spawning gravel in both Petitcodiac tributaries. Consequently work within those tributary watersheds is of necessity, a greater priority than along the main stem. Projects on the main stem of the Petitcodiac come at the expense of undertaking similar projects elsewhere that, regarding salmon recovery, are likely to yield greater benefits. The main stem serves mostly as a travel corridor that salmon, such as the wild return caught at the head-of-tide in 2021, pass through to access those tributaries. Likewise the precocious parr seen in 2023 came out of those tributaries looking for returning adults. That being the case, work within those tributaries likely provides the greatest benefit to salmon being seen on the main stem.

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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 ______________________________

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____

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 vegeation (>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______________________________

Checklist for projects in Brook Floater (*Alasmidonta varicosa*) habitat

1). Plan project thoroughly and allow sufficient lead time to carry out necessary site surveys, secure required permits and schedule work during optimal conditions.

☐ Done Comment ____

2) . Compare site to the Petitcodiac map of distribution and abundance of brook floater (https://www.biodiversitylibrary.org/item/108793#page/347/mode/1up) (Hanson and Locke 2001, Canadian Field Naturalist 115(2) 329-340). This habitat lies along the main stem of the Petitcodiac (above the head of tide), and the lower portions of the Little River, and the North River.

☐ Done ☐ Does not apply Comment ____

3). If the site lies within the area identified in #2 then, prior to disturbing it, survey (snorkel or viewing buckets as conditions warrant) to determine if brook floater is present at the site or within 100 metres downstream. Ideal time is June to September (water levels low, turbidity minimal, light penetration best) to allow completion of the work before falling leaves obscure the river bottom in autumn.

☐ Done ☐ Does not apply Comment ____

4). If surveys detect brook floaters at or near the site, then ensure that all subsequent survey work and subsequent long term monitoring (electrofishing, CABIN, etc.) is conducted in a manner consistent with such awareness in order to avoid or minimize impacts on brook floaters.

☐ Done ☐ Does not apply Comment ____

5). If brook floaters detected near site then fording heavy equipment or carrying out in-stream work is problematic. Consult authorities (NB DELG, DFO) as part of WAWA process, and consider alternatives.

☐ Done ☐ Does not apply Comment ____

6). During earthmoving activities with equipment working along the river bank, 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 ____

7.) Retain and if possible enhance riparian vegetation, to protect natural stream conditions and promote the structure and stability of the bed and banks. A healthy riparian zone maintains shade, retains sediment, and filters nutrients keeping them out of aquatic ecosystems.

☐ Done Comment ____

8). If cattle are present, measures to protect newly planted vegetation by excluding cattle (i.e. fencing) will also protect brook floaters. Open access to streams by cattle can cause direct mortality to mussels by trampling of mussel beds and lead to habitat degradation through sedimentation and eutrophication.

☐ Done ☐ Does not apply Comment ____