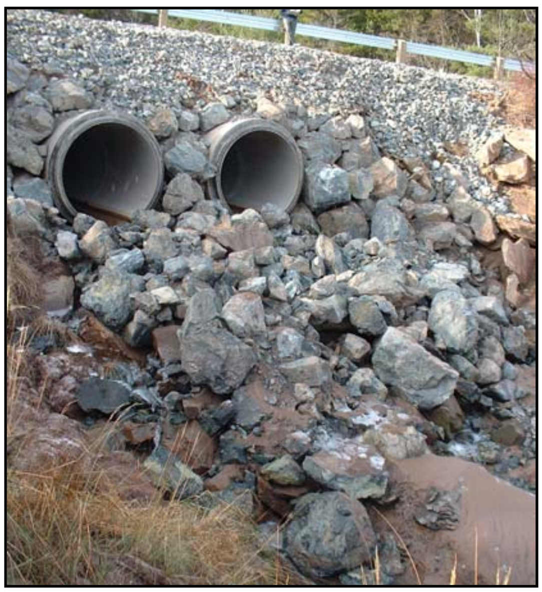
Coastal Issues Committee Special Publication Number 3

# Tidal Barriers & Opportunities for Salt Marsh and Tidal River Restoration in Cumberland County, Nova Scotia



By Nicole Hynes, Tony Bowron
and Dawn-Marie Duffy

April 2005

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Ecology Action Centre

# Tidal Barriers & Opportunities for Salt Marsh and Tidal River Restoration in Cumberland County, Nova Scotia

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Cover photo taken by Tony Bowron
The photograph is of the downstream end of the downstream end of the two round concrete culverts at Christie Brook, a tributary of River Hebert (CCCB13C). These culverts that were installed during the 2003 field season and were assessed by the Tidal Barrier Auditor as being partial restrictions.
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The photographs displayed within this report were taken by the Dawn-Marie Duffy and Tony Bowron, unless otherwise cited.

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## EXECUTIVE SUMMARY

Cumberland County's Bay of Fundy coast was assessed in 2003 and revisited during the 2004 field season to determine the extent of tidal barriers affecting tidal rivers and salt marsh systems. Tidal barriers restrict the natural movement of tidal waters and species into low lying coastal areas. These are most often caused by road crossings, causeways, dykes, dams and wharves. In 2001 the Ecology Action Centre (EAC) began an audit of tidal barriers throughout the Nova Scotia Bay of Fundy coast. Its purpose was to determine the number, location, condition and impacts of tidal barriers, specifically road crossings (culverts, bridges and aboiteaux), that were causing negative ecological effects on tidal rivers and associated salt marshes. Summaries and recommendations for each site were made and opportunities for restoration were highlighted.

Of the 36 tidal crossings assessed for Cumberland County's Bay of Fundy coast, 16 were found to be either partial or complete restrictions to tidal flow and/or fish passage. Large sections of Cumberland County's salt marshes have been and continue to be dyked for agricultural purposes, contributing to the restriction of tidal flooding around portions of coastal lands. Bridges were the dominant type of road crossing, however many of these still posed partial restrictions. Some of the observed effects of these barriers on the rivers and estuaries include: limited fish/species passage upstream, habitat decline, increased erosion, sedimentation, water turbidity, changes in channel size and direction and conversion of salt marshes into brackish and freshwater wetlands.

Data collected for each crossing was primarily a visual assessment of the site conditions. While there is still much to learn about the full extent of the impacts of these barriers on tidal flow and the upstream systems, the work presented in this audit is a first step to educate and engage government and local groups to work towards restoration of tidal rivers and salt marshes through barrier removal.

A concurrent tidal barriers audit was conducted for the Southern Bight of the Minas Basin and a similar report produced at the time of this one titled *Tidal Barriers & Opportunities for Salt Marsh and Tidal River Restoration in the Southern Bight of the Minas Basin, Nova Scotia*. Portions of both reports have common sections (introduction, project background, methodology) due to the timing of publications and the fact that both audits were conducted in the same manner.

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# 1.0 Introduction

The coastal areas of the Bay of Fundy are dynamic places shaped by water, wind, and geography. The region experiences the highest recorded tides in the world, reaching up to 16 meters in the upper Bay. This daily influx of tidal water brings with it nutrients and materials essential to the well-being of coastal habitats. These areas support an array of marine and terrestrial organisms, and perform a wide range of ecological functions and services. Unfortunately due to hundreds of years of human development, the natural movement of tidal waters into low-lying coastal areas and rivers has been considerably modified, resulting in significant ecological change to some of these important and productive ecosystems.

The Ecology Action Centre (EAC), along with our project partners, has been working to identify and assess the impacts of tidal barriers on salt marshes and tidal rivers. Over the past four years tidal barriers audits have been conducted throughout the Bay of Fundy (Nova Scotia side) to determine the amount and severity of road crossings restricting tidal waters and species passage into these systems. This report presents the findings of the tidal barriers audit for Cumberland County, Nova Scotia. This includes an introduction to salt marshes and the impacts of tidal barriers, a brief project background, methods used for the assessment of tidal crossings, results, discussion and recommendations for future action.

## 1.1 Salt Marshes

Salt marshes are a common type of coastal habitat found throughout the Bay of Fundy and range from large coastal wetland complexes to small fringe marshes in tidal inlets or along tidal rivers. Often referred to as the prairies of the Maritimes, salt marshes are characterized by widely fluctuating temperatures, wetness, and salinity. Despite these harsh growing conditions, salt marshes are amongst the most biologically productive ecosystems in the world. Salt marshes are the transition zone between the land and sea. They are highly dynamic ecosystems, responding to the interactions between freshwater, saltwater, and sediments. They are built on mudflats that have formed from the deposition of sediments on low-lying shorelines (Nova Scotia Museum of Natural History, 1996). Salt marshes are typically divided into two distinct zones with respect to the plants and animals, which reflect the daily, monthly, and seasonal changes in tidal flooding and salinity. The lower marsh which spans the tidal range (high tide line to below the mean water mark) experiences flooding twice daily (normal tidal cycle), and is dominated by salt marsh cord grass (*Spartina alterniflora*). The high marsh, above the high tide line, experiences flooding only occasionally throughout the month (spring tides, storms and other extreme tidal events) and is dominated by salt meadow hay (*S. patens*). Freshwater tidal rivers flow from the land into the sea, but during the rising tide, the incoming water overflows the creek banks and carries salt water upstream and over the marsh surface.

Salt marsh pannes are shallow ponds on the marsh surface in areas where poor drainage prevents the tidal water from draining off the marsh surface. If pannes are regularly replenished by tidal waters, they will retain water for much of the summer creating valuable habitat for fish and invertebrates and feeding areas for birds and mammals. (Dalton and Mouland, 2002).

Figure 1. Salt marsh and river system at Advocate Harbour

Salt marshes are a valuable part of the coastal ecosystem, providing a range of functions and services. They provide shoreline protection from storms, reduce erosion and act as a coastal flood buffer. They are an essential part of marine and terrestrial food webs, providing habitat for fish, invertebrates, birds, mammals, insects and plant species. They are spawning grounds for a wide range of migratory fish and other marine species as well as nesting sites for birds. Salt marshes can improve water quality by acting as a filter and the outflow from the system is high in organic material providing a nutritional source for intertidal species. Natural flooding of the marsh surface also helps to control mosquito populations. Aside from the ecological benefits, salt marshes offer recreational, educational and scientific opportunities.

For over 400 years, human activities in the Bay of Fundy have had a significant impact on the extent and distribution of salt marsh and tidal river habitats. The construction of dykes, aboiteaux, causeways, culverts, dams and the in-filling and ditching of coastal wetlands has resulted in the alteration and loss of approximately 80 percent of salt marsh habitat in the upper Bay. Salt marshes depend upon the maintenance of their natural hydrological regimes in order to remain healthy. Structures such as dykes, causeways and culverts restrict and in some causes completely block the movement of tidal waters (and species) into rivers, creeks and wetlands. Human-made structures that partially or completely restrict tidal flow to wetlands are called tidal barriers.

## 1.2 Tidal Barriers

Tidal barriers (or tidal restrictions) are structures that prevent the natural movement of tidal water and species into low-lying coastal areas. They are usually caused by roads, causeways, dykes and infilling. Roads and causeways that are constructed with bridges or culverts can be restrictions when the location or size of the opening is inappropriate for the wetland system in which it is constructed. A culvert or small bridge that is not properly located in the road bed with respect to the natural channel, or too small to allow for the natural movement of water, can affect the amount and quality of habitat both up and downstream and the productivity of the entire system. Tidal barriers also restrict or prevent fish passage into tidal rivers, contributing to the reduction of species such as

Inner Bay of Fundy Atlantic Salmon, American Shad, Striped Bass and American Eel which rely on access to coastal wetlands and rivers to feed, spawn, and for refuge. Tidal barriers can lead to habitat decline, increased erosion, sedimentation, water turbidity, changes in channel size and direction and the conversion of salt marshes into brackish and freshwater wetlands (Harvey, 2004). They can even eliminate the marshland altogether. Tidal barriers come in a variety of forms and restrict waterways in a variety of ways. Some common types of tidal barriers are discussed below.

### 1.3 Tidal Crossings

***Causeways*** are raised roads, usually placed across a waterway or marshland, consisting of rock or fill of some type and are, in most cases, equipped with one or more culverts, aboiteaux or a bridge. Depending on what type of structure a causeway is combined with it can partially or completely restrict tidal flow and/or fish passage. They can have considerable impact on habitats both upstream and downstream, and can cause sedimentation, erosion, reduced species access, habitat decline, conversion or loss.

***Culverts*** are structures of various shapes, sizes and materials that run underneath roads or causeways allowing for varying degrees of water flow from one side of the crossing to the other. Culverts are often designed too small and placed too high in the road bed (hanging culverts) to allow for full tidal water access to upstream systems. They primarily allow for upland freshwater drainage to occur, altering the system as a result. Fish passage may also be seriously impeded by improperly placed and sized culverts.

Figure 2. Double hanging culverts along the River Hebert

***Bridges*** are structures that usually allow for adequate two way flow within a wetland system. Support structures placed in the river or when combined with a causeway can hamper the natural flow of water up or down river and over the marsh surface. Water flow can be restricted when the bridge span is narrower than the width of the river channel, when the bridge abutments or piers are placed on the rivers flood plan or within the river channel itself. The resulting pinching of the river channel can result in reduced tidal flow, altered currents, sedimentation or erosion.

Figure 3. Highway bridge across the Missaguash River.

Figure 4. Mill Creek causewayu-aboiteau (CCCB18A)

***Aboiteaux*** are essentially culverts with a gate installed on the downstream end that prevents salt water from traveling up the system while allowing fresh water drainage from the system. They are historically associated with dykes, but can also be found in roads and causeways, to protect farmland or upstream infrastructure. Aboiteau can cause the conversion of tidal to brackish or freshwater wetlands, complete loss of wetland habitat, and the reduction or loss of fish passage and habitat.

***Dykes*** are constructed embankments that run along shores or tidal waterways to prevent tidal infusion onto low-lying coastal land (Koller, 2001). They most often include an aboiteau to allow for drainage. They are used primarily for the protection of agricultural land. Historically dykes have been used to convert coastal wetlands into agricultural lands.

### 1.4 Salt Marsh Restoration

Salt marsh restoration is the process of reversing some of the damages caused by human activities. Restoration seeks the return of an altered, degraded or lost ecosystem, as closely as possible, to its structure and function prior to human disturbance. The ultimate goal of restoration is to develop a self-sustaining ecosystem that resembles the structure and function of a natural system

Salt marsh restoration efforts can include replacing restrictive tidal crossings with larger, more appropriately placed openings to allow for a more natural tidal flow, removing dykes, plugging ditches, opening or removing tide gates, and re-creating tidal channels. Restoration is a long term process and it may take several decades or more (depending on the size of the system, and the severity of the restriction) for a marsh system to resume its natural functions. However, experience with salt marsh restoration in New England over the past several decades has shown that salt marsh plants, invertebrates, birds, mammals and marine species can and do respond rapidly to restoration efforts.

A full restoration cycle involves: tidal barriers audit, site selection, baseline data collection, designing restoration activities, implementing the restoration plan, and monitoring the results. Restoration activities are most successful if communities are actively involved throughout the restoration process in their area and government agencies support and participate in the process.

## 2.0 Project Background

The EAC has been involved in the protection and restoration of salt marshes and coastal habitats throughout Nova Scotia since 1998. The Salt Marsh and Tidal River Restoration Project was established in response to the loss of coastal wetlands caused by tidal barriers and the lack of action in the province to protect and restore these habitats. The project focuses specifically on identifying the adverse effects that tidal crossings have had on salt marshes and tidal rivers in the Bay of Fundy and highlighting opportunities for the mitigation or removal of barriers. Over the past few years the project has completed a tidal barrier audit for all of the upper Bay of Fundy (Nova Scotia side). The Conservation Council of New Brunswick has been involved in similar work on tidal barrier identification and coastal wetland awareness on the New Brunswick side of the Bay of Fundy.

In November 2001, the EAC produced a report titled *Assessment of Tidal Restrictions along Hants County Highway 215: Opportunities and Recommendations for Salt Marsh Restoration* (Bowron and Fitzpatrick, 2001). This report identified tidal barriers in Hants County with a number of sites identified as having high potential for restoration. As a result of this assessment Cheverie Creek, first salt marsh restoration site in Nova Scotia was identified. The EAC continues to be involved in ecological monitoring and community outreach at the Cheverie site (See Appendix A for more information). *Marshes, Tides and Crossings – Colchester County Tidal Barriers Audit Report 2002* by Dalton and Mouland (2002) continued the tidal barriers audit along the coast of the Minas Basin's Colchester County. This report contained a more detailed introduction to salt marshes and tidal barriers. For more information on salt marsh restoration and the full range of EAC activities, visit our website at www.ecologyaction.ca.

In 2003, an assessment of tidal crossings was carried out for Cumberland County from the New Brunswick-Nova Scotia border to the Cumberland-Colchester County border to determine which crossing were restricting tidal flow. This report presents the findings of the Cumberland County tidal barriers audit. Also produced, in conjunction with this report, was a tidal barriers audit for the Southern Bight region of the Minas Basin titled *Assessment of Tidal Restrictions and Opportunities for Salt Marsh and Tidal River Restoration in the Southern Bight of the Minas Basin and Kings County* (Hynes et al., 2005). Portions of both reports contain similar sections (including the introduction, project background, methodology).

## 3.0 Methodology

The tidal barriers audit conducted involved a visual assessment of the tidal barriers, identifying potentially restricted sites to determine if tidal flow and/or fish passage was partially or completely blocked by the crossing. From this it could be established which crossings have the potential to be modified or replaced in order to restore tidal flow, habitat and fish passage to the upstream system(s). Potential sites were identified using topographical maps and aerial photographs to determine the location of the crossing, and type and size of the system that may be affected. This was followed by one or more site visits. The methodology used for the project was adapted from the Parker River Clean Water Association's *Tidal Crossing Handbook* (Purinton and Mountain, 1998). At each site a Phase I Data Sheet was used to help visually assess the degree of tidal restriction

(Appendix B). This tidal barriers audit did not assess all rail crossings, dykes or aboiteaux in the study area, only those that were in close proximity to a road crossing and easily accessible were included. The Department of Agriculture and Fisheries has records of the dykes and aboiteaux across the province.

To determine the degree of tidal restriction and the restoration potential of a tidal crossing each site underwent a Phase I Assessment. Key features of the Phase I data collection included:

- Visual indicators of restriction (up and downstream): bank slumping, scour pools, water flow, differences in upstream and downstream water levels, ratio of stream width to opening size, divergent channels and vegetation. These visual cues are used to determine whether an adequate amount of tidal flow reaches the upstream system.
- Factors that could potentially influence the assessment: weather, tide level and wind. These factors may influence the amount of tidal flow reaching the crossing and freshwater moving through the system.
- Land use: upstream and downstream. Used to determine if land use is contributing to restriction, if there is a possibility of salt marsh recovery, and if restoration has the potential to adversely impact adjacent activities.
- Quantitative measurements: tidal crossing and stream dimensions. Used to compare the potential and actual amount of tidal flow above and below the crossing. GPS (Global Positioning System) coordinates and photographs were also taken at each tidal crossing for documentation and future reference.
- Crossing condition: obvious causes of restriction due to construction or deterioration of crossing, and/or presence of debris. An old or damaged crossing is more likely to be repaired or replaced than a new or functioning crossing, meaning greater opportunity for restoration.

A Phase II Assessment (Appendix C) measures the tidal range on each side of a crossing to verify if the height of the tidal water differs. This may be done when a Phase I Assessment did not provide adequate information to determine if tidal flow was restricted by a crossing. It may also be conducted on a crossing identified as being potentially restrictive in the preliminary assessment, in order to obtain further quantitative data on the difference of tidal range on either side of the crossing. No Phase II Assessments were preformed as part of this study.

### 3.1 Degree of Restriction

Each tidal crossing assessed was placed in one of four categories based on the degree of tidal restriction (no restriction, partial restriction, complete restriction, and no longer tidal).

***No restriction***: crossings that allow for full tidal flow and fish passage up the waterway, comparable to that of a barrier free system. Some crossings placed in this category may marginally restrict natural flow but with no ill effects to the system (e.g. bridge abutments may pinch the river channel but the overall opening size is large enough to allow for full tidal exchange). Crossings of this type should cause little or no ecological change to the system.

***Partial restriction***: crossings that due to the type of structure, size, placement or condition, obstruct the natural movement of water, species and materials to the wetland system. Partial restrictions, such as undersized bridges or culverts can cause a reduction in the type, amount, and quality of wetland habitat, productivity and fish passage.

***Complete restriction***: tidal crossings that allow for no tidal flow due to the type of structure, the placement of the crossing, or structures that were originally and intentionally constructed to prevent tidal flow, such as a dyke or aboiteau. Complete restrictions such as causeways, aboiteaux and dykes can result in the complete loss of upland wetland habitat and function and prevent fish passage.

***No longer tidal***: crossings constructed within the historical natural tidal range but which no longer experience tidal flooding due to downstream development activities or structures. Crossings categorized as no longer tidal are often located upstream of dykes, railway crossings or dams.

## 3.2 Restoration Priority Level

Each tidal crossing that was assessed and determined to be either a partial or complete restriction to tidal flow was assigned a restoration priority level. This indicates which sites have the potential to restore tidal flow and salt marsh habitat to the system. These were based on the observations and data collected through the audit visits. More in depth monitoring could result in a change in these categories. These priority levels were adapted from the Conservation Council of New Brunswick's 2004 *Return the Tides* campaign publication *Tidal Barriers in the Bay of Fundy, New Brunswick Coast.*

***Level 1 (Green)*** – Small to medium-scale projects that could produce clear environmental benefits and which could be accomplished with modest commitments of time and resources, possibly coordinated by local groups, or handled through routine road maintenance.

***Level 2 (Yellow)*** - High impact barriers requiring high costs and complex engineering solutions, but which would deliver large environmental benefits.

***Level 3 (Orange)*** - Low impact barriers which may not deliver significant environmental benefits.

***Level 4 (Red)*** - Barriers which protect infrastructure or active agricultural land and are not likely eligible for restoration.

Information provided in this report (indicators, degree of restriction, priority levels, etc.) is based on observations made by the tidal barrier auditors at the time of the assessments. Changes may have occurred to certain sites since this date. In addition, since most information detailed in this report was provided through preliminary visual assessments, more in depth examination could result in different ratings.

### 3.3 Study Area – Cumberland County

Parts of Cumberland County, specifically in and around the Cumberland Basin, once consisted of a number of large salt marsh and tidal river systems. Much of these marshlands have been reclaimed as agricultural land through dyking. The Tantramar marshes, running along the Chignecto Isthmus connecting Nova Scotia to New Brunswick, are some of the largest tidal marshes in the world, reaching as much as 10km inland, with many large rivers draining from them. Dyked by the Acadians in the 1700's these marshes provided settlers with fertile agricultural lands and were once referred to as the worlds largest hay field. The Tantramar marshes are an important habitat for migratory birds, and are now home to two bird sanctuaries.

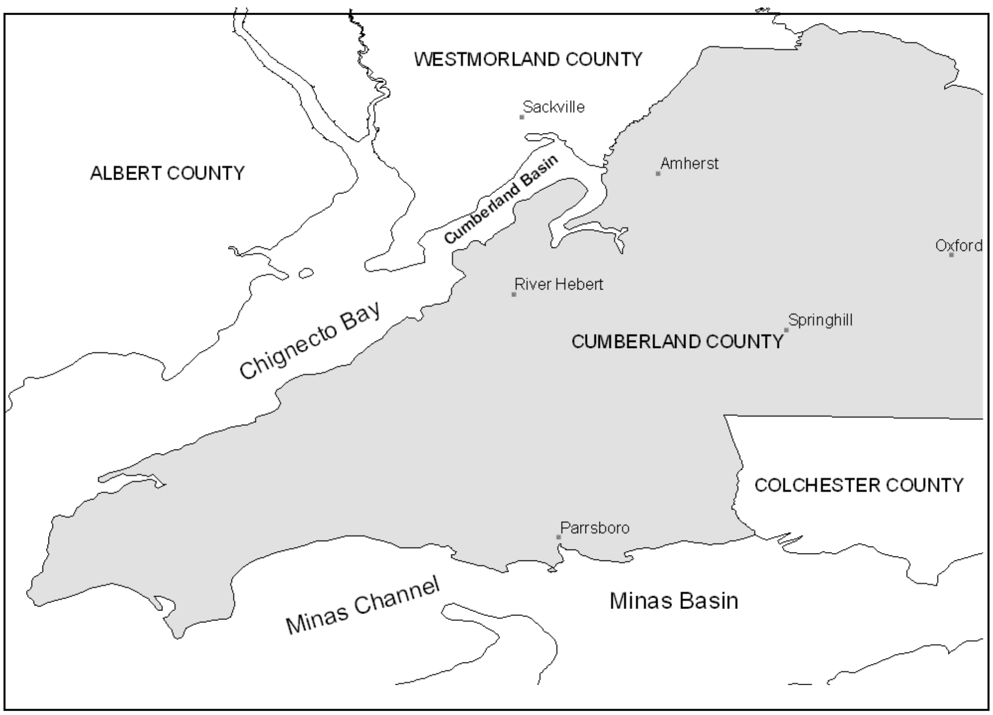

Figure 5. Map of Study Area, Cumberland County

The Cumberland County coast of the Bay of Fundy has been split into two main areas for this audit: Cumberland County Chignecto Bay (CCCB) and Cumberland County Minas Channel and Basin (CCMC). The Chignecto Bay area runs from the New Brunswick border to Spicers Cove. The Minas Channel and Basin area runs along the coast from West Advocate to the border of Cumberland and Colchester County.

## 4.0 Results and Discussion

Each site was assigned a code indicating the study area, the sequential number of the site and the type of crossing (A-aboiteau, B-bridge, C-culvert). In the Cumberland County area a total of 36 tidally influenced crossings were assessed of which 16 were found to have varying degrees of restriction to tidal flow and fish passage. The tables below show the number of crossings in each degree of restriction category and the number of types of crossings. Locations of all crossings can be found in Figure 5. Detailed summaries of selected crossings (partial and complete restrictions) are included below according to restoration priority. A supplementary report “Fact Sheets for Cumberland County Tidal Crossings” included on the CD with this report contains fact sheets on all sites assessed which includes additional information, photographs and maps for each site.

**Table 1. Number of crossings in each restriction category**

| *AREA* | *No* | *Partial* | *Complete* | *No Longer Tidal* | *Total* |
|---|---|---|---|---|---|
| **Cumberland Co.** | 16 | 11 | 5 | 4 | 36 |
| **CCCB** | 11 | 7 | 3 | 4 | 25 |
| **CCMC** | 5 | 4 | 2 | 0 | 11 |

**Table 2. Number of crossing in each crossing type category**

| *AREA* | *Bridges* | *Culverts* | *Aboiteaux* | *Total* |
|---|---|---|---|---|
| **Cumberland Co.** | 24 | 8 | 4 | 36 |
| **CCCB** | 18 | 5 | 2 | 25 |
| **CCMC** | 6 | 3 | 2 | 11 |

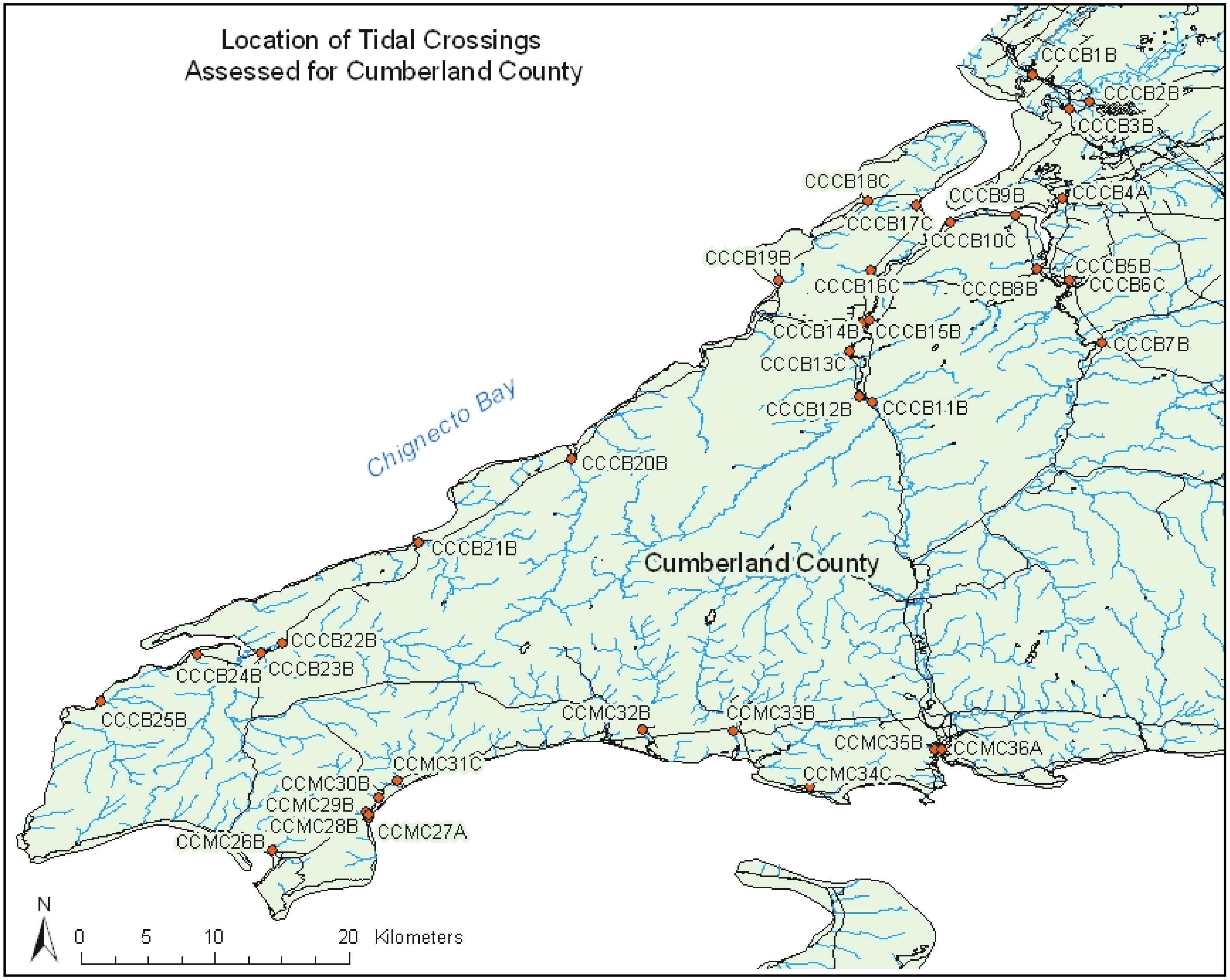


Figure 6. Locations of tidal crossings assessed for Cumberland County

## 4.1 Tidal Crossings Flagged as Potential Restoration Sites

The sites selected as possible restoration sites were chosen for various reasons taking into account:

a. **Crossing condition**: Structures that are in need of repair or replacement are likely to be more favourable for restoration due to the need to address the crossing already.

b. **Land Use**: Land that is used for agricultural purposes and is protected by dykes and aboiteaux, or where there are residential or business areas, may eliminate the possibility for restoration. Land that has not been farmed for many years and left fallow and those areas that are currently marshland can be considered.

c. **Amount of restorable marshland**: The greater the area of land to be restored to salt marsh, the more appealing the site is as a restoration project (greater ecological benefit).

d. **Type of restoration work**: Even if salt marsh restoration is not possible, improving fish passage could still be considered. In cases where restoration of full tidal flow is not an option, the river may still be desirable for fish movement, in which case, fish passage should be the priority.

**Table 3. Summary of tidal crossings flagged as potential restoration sites**

| Crossing Code | Classification | Material | Restriction | Restorable Area | Fish Passage (Yes/No) | Corrective Action (Refer to Codes) | GPS Coordinates | Priority Level |
|---|---|---|---|---|---|---|---|---|
| CCCB5B- St. Georges Brook | bridge | wood | partial | large | yes | RS | N 45º 43' 02.7" W 64º 14' 19.6" | 1 |
| CCCB6C- St. Georges Brook | two culverts | concrete/ wood | partial | large | no | LC EO | N 45º 43' 02.7" W 64º 14' 19.6" | 1 |
| CCCB10C- Maccan Loop | culvert | wood | complete | small | no | LC EO RC SC | N 45º 45' 22.7" W 64º 19’ 06.3" | 1 |
| CCCB18A- Mill Creek | aboiteau | concrete | complete | medium-large | no | FP EO OA | N 45º 46' 15.2" W 64º 22' 27.4" | 1 |
| CCMC27A- Spencer's Cove | aboiteau | wood | complete | small | no | OA EO FP | N 45º 21' 18.1" W 64º 42' 38.3" | 1 |

**Codes**: EO-enlarge opening, FP-install fish passage, GR-in good repair, LC-lower culvert, NR-not restrictive, OA-open aboiteaux, OG-open gate, OM-situated on marsh of interest, RA-replace aboiteaux, RC-repair/replace culvert, RO-remove old, RS-repair structure, SC-site clean-up

**Priority Level**:
1 - Low to medium impact barriers, requiring little cost that can produce obvious ecological benefits
2 - High impact barriers requiring high costs, but can produce large ecological benefits
3 - Low impact barriers with small ecological benefits
4 - Barriers not eligible for restoration due to protection of infrastructure or agricultural land

### 4.1.1 Site: CCCB5B and CCCB6C - St. Georges Brook

*Location*: Maccan River tributary, Maccan, Hwy 302

*Crossing Type:* Bridge and causeway-culvert

Figure 7. CCCB5B. Bridge seen from the downstream rail road. Salt marsh vegetation is visible on either side of the creek.

*Priority Level:* Level 1 (Green)

*Restriction Indicators*:

- Difference in water levels
- Difference in stream width
- Difference in vegetation
- Scour pool
- Aboiteau/tide gate

*Site Description*: At this location the downstream crossing is restricting tidal flow and fish passage to the upstream crossing and wetland system. The road crossing (CCCB5B) is an old bridge in disrepair that spans the width of the current river channel. The downstream railway crossing (CCCB6C) consists of two 1m diameter concrete culverts punched through old wooden culverts, placed 1m above the creek bottom. There is a large wetland upstream of the two crossings with remnants of dead trees on the marsh surface, evidence that at one time this system was completely restricted.

Figure 8. CCCB6C. Downstream of the rail crossing. The new, round, concrete culverts were punched through the old, square, wooden culverts. Photo taken at low tide.

*Comments*: The rail crossing should be replaced with a more appropriately sized and positioned crossing in order to restore a more natural tidal regime and fish passage to the upland system. If this occurs the upstream bridge should be reassessed in light of the increased tidal flow as it may also require replacement by a larger structure and realignment. Pending the replacement of the rail crossing, the current bridge size should be maintained during repairs as it presently does not pose a substantial restriction.

### 4.1.2 Site: CCCB10C – Maccan Loop

*Location*: Maccan River tributary, near Lower Maccan

*Crossing Type:* Wooden culvert, potentially with tide gate.

*Priority Level:* Level 1 (Green)

*Restriction Indicators*:

| | |
|---|---|
| Difference in water levels | Difference in stream width |
| Difference in vegetation | Turbulent water flow |
| Scour pool | Bank slumping |

Figure 9. Upstream side of the culvert is damaged and collecting debris.

*Site Description*: This road crossing poses a complete restriction to tidal flow due to a large amount of rock and other material that has collapsed and blocks the downstream end of the crossing. Due to the amount of material blocking the downstream side it was not possible to determine whether the opening of the 1m x 1m culvert was intact and if it was equipped with a tidal gate. The shoulder of the road on the downstream side is eroding and developing small sinkholes, posing a safety risk to traffic and contributing additional sediment and materials to the stream. The upstream end of the crossing is rotting and starting to collapse.

*Comments*: This site is in serious need of repair to the road surface and shoulder; this would include removal of material blocking crossing and replacement of the aging and inadequately sized structure.

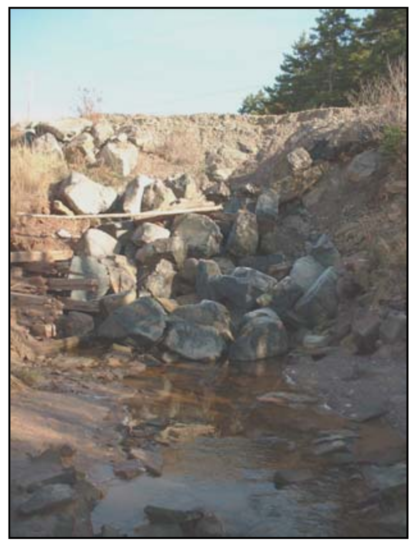

Figure 10. Downstream end of crossing completely buried by rock and other materials. Unclear as to whether a tidal gate is present or not. Damage to shoulder of road surface evident in picture.

**4.1.3 Site: CCCB18A - Mill Creek**

*Location*: Mill Creek

*Crossing Type:* Causeway-culvert with tide gate (aboiteau)

*Priority Level:* Level 1 (Green)

*Restriction Indicators*:

| | |
|---|---|
| Difference in water levels | Turbulent water flow |
| Difference in stream width | Aboiteau/tide gate |
| Difference in vegetation | Slack water |

Scour pool
Bank slumping
Divergent channel

*Site Description*: This crossing is an intact, functioning, aboiteau. However, due to tidal action the downstream end is prone to clogging by debris (sediment, woody debris and ice). There is active farmland adjacent to this marsh on the downstream side, while the land upstream does not appear to be in use (woodland).

*Comments*: There is a substantial amount of tidal wetland habitat that could be restored by initially removing the tide gate and ultimately by installing a larger crossing.

Figure 11. The downstream view of the causeway-aboiteau showing the scour pool and bank erosion.

**4.1.4 Site: CCMC27A – Spencers Island**

*Location*: Spencers Island

*Crossing Type:* Wooden culvert with tide gate (aboiteau)

*Priority Level:* Level 1 (Green)

*Restriction Indicators*:

Difference in water levels
Scour pool
Difference in stream width
Structure failure
Difference in vegetation
Aboiteau/tide gate

Figure 12. Downstream end of the crossing. The broken gate is visible. It is allowing some tidal flow, but should be removed to eliminate the small amount of pooling.

*Site Description*: This structure is a small wooden culvert with a tidal gate (aboiteau) which is wedged partially open, limiting upland drainage and allowing for a small amount of tidal flow. The amount of potential tidal marsh upstream is small and adjacent buildings are protected from flooding by the rise in elevation. This channel flows out into the main channel and marsh area near crossing CCMC28B.

*Comments*: Repair or, more preferably, remove the tide gate from the structure allowing for the unobstructed flow of water through the crossing. While the area of marsh to be restored is small, the work and cost involved should be low and easily conducted as part of regular road maintenance.

### 4.2 Sites with Lower Restoration Potential

These sites have crossings that are either partial or complete restrictions to tidal flow and/or fish passage, however, have not been flagged as high priority restoration sites due to factors such as land use, minimal ecological benefit, low opportunity for wetland habitat recovery, or high cost, effort or potential for controversy. These sites have been identified as additional sites of interests due to the potential for restoration under the right set of conditions.

**Table 4. Summary of tidal crossings with lower restoration potential**

| Crossing Code | Classification | Material | Restriction | Restorable Area | Fish Passage (Yes/No) | Corrective Action (Refer to Codes) | GPS Coordinates | Priority Level |
|---|---|---|---|---|---|---|---|---|
| CCCB4A-Nappan River | aboiteau | concrete/ steel | complete | agricultural land | no | FP OA EO | N 45º 46' 21.1" W 64º 14' 35.6" | 4 |
| CCCB13C-Christie Brook | two culverts | concrete | partial | medium | no | LC EO FP | N 45º 40' 11.6" W 64º 23' 13.4" | 1 |
| CCCB23B-Apple River | bridge | concrete/ wood | partial | large | yes | RS | N 45º 27' 56.6" W 64º 46' 59.2" | 3 |
| CCCB24B-West Apple River | bridge | wood | partial | small | yes | RO | N 45º 27' 56.1" W 64º 49' 36.3" | 3 |
| CCCB25B-Spicer's Cove | bridge | steel | partial | large | yes | RO | N 45º 25' 59.8" W 64º 53' 30.4" | 3 |
| CCMC29C-Spencer's Island/ Hwy 209 | culvert | wood | partial | small | yes | EO | N 45º 21' 31.3" W 64º 42' 45.2" | 3 |
| CCMC31C-Fowler Brook | culvert | wood | partial | medium | limited | SC LC | N 45º 22' 50.0" W 64º 41' 28.8" | 3 |
| CCMC34C-Mill Brook | culvert | wood | partial | small | limited | RO LC EO | N 45º 22' 35.6" W 64º 24' 48.8" | 3 |
| CCMC35B-Farrells Brook | bridge | wood | partial | small | yes | RO EO RS | N 45º 24' 02.3" W 64º 19' 46.0" | 3 |
| CCMC36A-Parrsboro Aboiteau | causeway/ dam | steel/ concrete | complete | large | no | FP | N 45º 24' 04.7" W 64º 19' 28.1" | 2 |

**Codes**: EO-enlarge opening, FP-install fish passage, GR-in good repair, LC-lower culvert, NR-not restrictive, OA-open aboiteaux, OG-open gate, OM-situated on marsh of interest, RA-replace aboiteaux, RC-repair/replace culvert, RO-remove old, RS-repair structure, SC-site clean-up

**Priority Level**:
1 - Low to medium impact barriers, requiring little cost that can produce obvious ecological benefits
2 - High impact barriers requiring high costs, but can produce large ecological benefits
3 - Low impact barriers with small ecological benefits
4 - Barriers not eligible for restoration due to protection of infrastructure or agricultural land

### 4.2.1 Site: CCCB4A – Nappan River

Location: Maccan River tributary, Nappan

*Crossing Type:* Dyke and aboiteau

*Priority Level:* Level 4 (Red)

*Restriction Indicators*:

- Difference in water levels
- Scour pool
- Difference in stream width
- Aboiteau/tide gate
- Difference in vegetation

Figure 13. Downstream view of crossing

*Site Description*: Double chambered aboiteau; total opening size 7m; steel gates. Aboiteau is protecting upstream agricultural croplands. No evidence of modification or adaptations for fish passage. Dykes running parallel to the river channel are present both upstream and downstream of the aboiteau.

Figure 14. Upstream view of crossing

Comments: Since the aboiteau is required to protect the upstream agricultural area from flooding, hydrological and tidal marsh restoration may not be an option unless land use patterns change. Fish passage, however, should be addressed.

### 4.2.2 Site: CCCB13C – Christie Brook

*Location*: River Hebert tributary, near River Hebert Cemetery

*Crossing Type:* Two round concrete culverts

*Priority Level:* Level 1 (Green)

*Restriction Indicators*:

- Difference in water levels
- Difference in stream width
- Difference in vegetation
- Scour pool
- Hanging culvert

*Site Description*: When first assessed in July and August 2003, crossing was a double

Figure 15. Downstream view of the new culverts.

chambered wooden box culvert. Between the August and November site visits, the crossing was replaced by two 1.5m diameter concrete culverts. These culverts have not improved tidal flow or fish passage to the system due to there placement in the roadbed (3m above channel bed) and the placement and collapse of rock and gravel around and in the culverts. Upstream, the stream channel diverges into two separate channels flowing into each culvert. There are also remnants of an old bridge within the channel downstream of the crossing. There is a medium sized wetland system upstream with a mostly wooded riparian zone.

*Comments*: Given that this crossing has already undergone replacement, it is unlikely that additional mitigation or replacement work would be considered for this site in the near future. If such work was to be considered for this site, replacement of the culverts with a free-span bridge and reconstruction of the original stream channel under the roadway would be recommended.

### 4.2.3 Site: CCCB20B – Shulie River

*Location*: Shulie, Hwy 242

*Crossing Type:* Causeway-bridge structure

*Priority Level:* Level 3 (Orange)

*Restriction Indicators*:
- Difference in stream width
- Turbulent water flow
- Slack water
- Divergent channel

Figure 16. Downstream of the bridge clearly showing the build up of the banks with boulders.

*Site Description*: The bridge (17m) is causing a slight restriction due to the placement of the support structures and the location of the partial causeway (ratio of channel width to opening size). River is bordered by fringe marsh and the upland is dominated by forest.

*Comments*: Since this bridge has a large opening the potential for restoration is minimal, however, the channel does appear to be divergent from its original path. Therefore, when replacement is necessary, realignment with the original path should be considered as well as the possibility of enlargement and the modification/removal of rock support structures at the base.

### 4.2.4 Site: CCCB23B – Apple River

*Location*: Apple River, Hwy 242

*Crossing Type:* Wooden Bridge with support structure in middle of channel

*Priority Level:* Level 3 (Orange)

*Restriction Indicators*:

Bank slumping
Turbulent water flow

*Site Description*: This bridge is a wide concrete/wooden structure that appears to be old but still intact. It has a 4m wide support structure in the middle of the river channel causing turbulent water flow around the base and partially restricting natural movement. One side of the river bank is lined with an old wooden structure and there is considerable bank slumping. A large marsh system and a Ducks Unlimited Impoundment are present downstream of the crossing.

*Comments*: While the bridge does span the width of the river, the center support structure which is placed in the middle of the channel does impact hydrology. Removal of this pier should be considered when it is time to repair or replace the bridge. A free-span bridge would be more appropriate for this crossing.

Figu
the l
bank
under the bridge.

Figure 18. Old wooden structure downstream of the bridge, possibly an old wharf. DU impoundment off to the right

### 4.2.5 Site: CCCB24B – West Apple River

*Location*: Apple River tributary, West Apple River

*Crossing Type:* Wooden bridge, remains of older crossing still in place.

*Priority Level:* Level 3 (Orange)

*Restriction Indicators*:

Difference in stream width
Structure failure

*Site Description*: The current bridge structure is old and in need of repair, however, it does span the width of the main river channel. It is the remnants of a previous crossing underneath the existing one that are causing a partial restriction to tidal flow, pinching the river. The area around the crossing is a mix of salt marsh and woodland.

*Comments*: Remove the old structure and maintain the size of the bridge when making repairs.

Figure 19. Downstream of the crossing. The old structure under the bridge is visible.

Figure 20. Upstream of the crossing approaching high tide.

### 4.2.6 Site: CCCB25B – Spicers Cove Brook

*Location*: Spicers Cove near Eatonville

*Crossing Type:* Free-span bridge with remains of older crossing still present

*Priority Level:* Level 3 (Orange)

*Restriction Indicators*:

Difference in stream width
Scour pool
Bank slumping
Turbulent water flow

*Site Description*: The bridge is a large structure that spans the width of the river; however, the banks at the base of the bridge on both sides are pinching the channel. The banks are built up with boulders and wooden cribwork, most likely the remains of a previous crossing at the same location. There does appear to be adequate flow getting through, however, turbulence of the flow is increased due to the restriction (pinching) caused by the remains of the old crossing (turbulent flow and scour pools).

*Comments*: Remove remains of the old crossing and excavate the banks to enlarge the opening under the existing bridge to match the width of the main river channel.

Figure 21. The bridge from the upstream beach (low tide) clearly showing the pinching of the river by the bank support structures.

**4.2.7 Site: CCMC28B – Spencers Island**

*Location*: Spencers Island

*Crossing Type:* Wooden Bridge

*Priority Level:* Level 3 (Orange)

*Restriction Indicators*:

Difference in stream width
Bank Slumping
Scour pool

Figure 22. Upstream of the crossing, salt marsh vegetation.

*Site Description*: A 5.5m bridge that is part of a gravel road constructed along the back edge of a small barrier beach. The bridge does not span the complete width of the river channel, and poses a partial restriction. Upstream of this bridge are two additional tidal crossings that further restrict tidal flow to the upland system (CCMC27A and CCMC29C). Downstream of the crossing is a beach with campgrounds and upstream is a tidal marsh system bordered by additional roads and development.

*Comments*: Enlarge bridge opening, or at the very least maintain the current size when repair or replacement is necessary, since restriction is not severe. Enlarging this opening would increase tidal flow to this system and sites CCMC27A and CCMC29C.

**4.2.8 Site: CCMC29C – Spencers Island**

*Location*: Spencers Island, Hwy 209

*Crossing Type:* Wooden Culvert

*Priority Level:* Level 3 (Orange)

*Restriction Indicators*:
- Difference in water levels
- Turbulent water flow
- Scour pool
- Slack water
- Bank slumping
- Divergent channel

Figure 23. Upstream view of the culvert showing that the culvert is placed slightly off to one side with some pooling and slack water occurring to the sides of the culvert.

*Site Description*: 2.5m x 1.3m wooden culvert in good condition located upstream from site CCMC28B. Culvert is partially restricting flow as evidenced by scour pools, bank slumping and swirling water forming downstream of the crossing. Wooden armouring of the bank on the upstream end is damaged. There is tidal marsh habitat on both sides of the crossing, grading into a freshwater marsh further upstream.

*Comments*: Enlarge opening to improve tidal flow and fish passage. This crossing should be considered in conjunction with site CCMC28B since a change in the bridge opening downstream would increase tidal flow to this crossing, requiring a larger opening to accommodate the increased flow. Pending bridge enlargement downstream, the system could benefit from a larger opening on its own.

**4.2.9 Site: CCMC31C – Fowler Brook**

*Location*: Between Spencers Island and Fraserville, Hwy 209

*Crossing Type:* Large Wooden Culvert (hanging)

*Priority Level:* Level 3 (Orange)

*Restriction Indicators*:
- Difference in water levels
- Bank slumping

Difference in stream width
Scour pool
Turbulent water flow
Hanging culvert

*Site Description*: Large hanging wooden culvert 2m x 3m in good condition. There was evidence of a beaver dam that has since been removed on the downstream side of culvert. This crossing is likely at or very near the tidal extreme and may experience tidal flow only during larger tidal events. The land around the crossing is wooded and has little opportunity for wetland habitat restoration.

Figure 24. Downstream of crossing. The large pool in front of the culvert is visible as well as the high placement of the culvert.

*Comments*: Lower culvert in order to be flush with creek bottom. Removal of large woody debris from both the upstream and downstream channel would improve hydrology. Concern at this site is mainly fish passage and stream habitat.

### 4.2.10 Site: CCMC34C – Mill Brook (Black Rock)

*Location*: Black Rock

*Crossing Type:* Double Chambered Wooden Culvert

*Priority Level:* Level 3 (Orange)

*Restriction Indicators*:
Differences in water levels
Bank slumping
Difference in stream width
Structure failure
Difference in vegetation
Slack water
Scour pool

Figure 25. Downstream view of the culvert that has not been placed flush to the creek bottom.

*Site description*: Aging double chambered wooden culvert (3m x 1.5m) showing considerable disrepair (rotting wood & buckling), that is placed too high from the creek bottom on the downstream end, creating a partial restriction. There is a wetland, dune and beach system downstream of the crossing.

*Comments*: Replace structure with an open bottom crossing or install new structure even with the bottom of the channel.

### 4.2.11 Site: CCMB35B – Farrells Brook (Parrsboro)

*Location*: Parrsboro, tributary of Parrsboro River

*Crossing Type:* Wooden Bridge

*Priority Level:* Level 3 (Orange)

*Restriction Indicators*:

- Difference in stream width
- Bank slumping
- Scour pool
- Structure failure

Figure 26. Downstream view of the bridge with the old structure visible under bridge.

*Site description*: Current bridge was built directly over the remains of the previous crossing which is in considerable disrepair. New bridge spans the width of the river, however, the old bridge is partially restricting flow by having its support structures in the channel. Land use both upstream and downstream is low-level residential housing built at an elevation beyond the reach of the river. A ribbon of tidal wetland habitat borders the river both up and downstream of the crossing.

*Comments*: Remove the remains of the previous crossing from the river channel in order to reduce/eliminate the restriction at this location. In its current condition, the crossing does not present an obstacle to fish passage, however, failure/collapse of the old cribwork into the stream channel in the future could present an impediment.

### 4.2.12 Site: CCMB36A – Parrsboro Aboiteau

*Location*: Parrsboro River, Parrsboro.

*Crossing Type:* Caueway-Dam with spillway

*Priority Level:* Level 2 (Yellow)

*Restriction Indicators*:

- Difference in stream width
- Difference in vegetation
- Bank slumping
- Turbulent water flow
- Difference in water levels
- Scour pools
- Aboiteau/tide gate present

*Site Description*: Causeway-dam structure with a 21m spillway opening, presenting a complete restriction to tidal flow and fish passage. There is no obvious accommodation for fish passage. The area upstream of the crossing is residential and commercially developed with a large head pond. Downstream of the crossing is mainly salt marsh, farmland and low-level development.

*Comments*: Restoration of tidal flow and fish passage to the upstream system by replacing all or a portion of the causeway-dam with a bridge may not be feasible due to development and current land use activities upstream of the crossing. If fish passage mechanisms are not currently in place, consideration should be given to the installation of such measures.

Figure 27. Downstream view of the Parrsborro Causeway-Dam.

## 4.3 Complete List of Tidal Crossings

**Table 5. Summary of Tidal Crossing – Cumberland County**

| Crossing Code | Classification | Material | Restriction | Restorable Area | Fish Passage (Yes/No) | Corrective Action (Refer to Codes) | GPS Coordinates | Priority Level |
|---|---|---|---|---|---|---|---|---|
| CCCB1B-Missaguash River | two bridges | concrete | no restriction | N/A | yes | NR | N 45º 51' 22.1" W 64º 15' 47.4" | N/A |
| CCCB2B-LaPlanche River | hwy-bridge rail-bridge | wood | no longer tidal | N/A | yes | N/A | N 45º 50' 14.9" W 64º 13' 31.8" | N/A |
| CCCB3B-LaPlanche River | two bridges | concrete | no longer tidal | N/A | yes | N/A | N 45º 49' 58.4" W 64º 14' 18.6" | N/A |
| CCCB4A-Nappan River | aboiteau | concrete/ steel | complete | agricultural land | no | FP OA EO | N 45º 46' 21.1" W 64º 14' 35.6" | 4 |
| CCCB5B-St. Georges Brook | bridge | wood | partial | large | yes | RS | N 45º 43' 02.7" W 64º 14' 19.6" | 1 |
| CCCB6C-St. Georges Brook | two culverts | concrete/ wood | partial | large | no | LC EO | N 45º 43' 02.7" W 64º 14' 19.6" | 1 |
| CCCB7B-Little Forks River | bridge | steel | no restriction | N/A | yes | NR | N 45º 40' 33.1" W 64º 12' 58.7" | N/A |
| CCCB8B-Maccan River | bridge | concrete | no restriction | N/A | yes | NR | N 45º 43' 29.3" W 64º 15' 37.4" | N/A |
| CCCB9B-Maccan River tributary | bridge | wood | no restriction | N/A | yes | NR RS | N 45º 45' 40.0" W 64º 16' 29.1" | N/A |
| CCCB10C-Maccan Loop | culvert | wood | complete | small | no | LC EO RC SC | N 45º 45' 22.7" W 64º 19’ 06.3" | 1 |
| CCCB11B-River Hebert/ Haycock Brook | bridge | steel/wood | no restriction | N/A | yes | NR | N 45º 38' 08.5" W 64º 22' 18.6" | N/A |

| Crossing Code | Classification | Material | Restriction | Restorable Area | Fish Passage (Yes/No) | Corrective Action (Refer to Codes) | GPS Coordinates | Eco/Net Benefits |
|---|---|---|---|---|---|---|---|---|
| CCCB12B- Mill Creekk | bridge | steel/wood/ concrete | no restriction | N/A | yes | NR | N 45º 38' 21.3" W 64º 22' 49.4" | N/A |
| CCCB13C- Christie Brook | two culverts | concrete | partial | medium | no | LC EO FP | N 45º 40' 11.6" W 64º 23' 13.4" | 1 |
| CCCB14B- Latta Brook | bridge | wood | no restriction | N/A | yes | NR RS | N 45º 41' 21.1" W 64º 22' 40.0" | N/A |
| CCCB15B- River Hebert | bridge | concrete | no restriction | N/A | yes | NR | N 45º 41' 25.3" W 64º 22' 24.7" | N/A |
| CCCB16C- John Curry Brook | culvert | wood | no longer tidal | agricultural land | yes | RS | N 45º 43' 25.3" W 64º 22' 18.9" | 4 |
| CCCB17C- Minudie/ Barronsfield | culvert | wood | no longer tidal | agricultural land | no | RS | N 45º 46' 05.3" W 64º 20' 32.0" | 4 |
| CCCB18A- Mill Creek | aboiteau | concrete | complete | medium-large | no | FP EO OA | N 45º 46' 15.2" W 64º 22' 27.4" | 1 |
| CCCB19B- Little R | bridge | wood | no restriction | N/A | yes | RS SC | N 45º 43' 03.7" W 64º 26' 02.8" | N/A |
| CCCB20B- Shulie River | bridge | steel/wood | partial | | yes | EO | N 45º 34' 47.0" W 64º 34' 34.0" | 3 |
| CCCB21B- Sand River | bridge | steel/wood | no restriction | N/A | yes | NR | N 45º 32' 27.0" W 64º 40' 38.0" | N/A |
| CCCB22B- East Apple River | bridge | steel | no restriction | N/A | yes | NR | N 45º 28' 21.0" W 64º 46' 08.0" | N/A |
| CCCB23B- Apple River | bridge | concrete/ wood | partial | large | yes | RS | N 45º 27' 56.6" W 64º 46' 59.2" | 3 |
| CCCB24B- West Apple River | bridge | wood | partial | small | yes | RO | N 45º 27’ 56.1" W 64º 49’ 36.3" | 3 |
| CCCB25B- Spicer's Cove | bridge | steel | partial | large | yes | RO | N 45º 25' 59.8" W 64º 53' 30.4" | 3 |
| CCMC26B- Advocate Harbour | bridge | concrete | no restriction | N/A | yes | NR | N 45º 19' 59.2" W 64º 46' 33.3" | N/A |

| Crossing Code | Classification | Material | Restriction | Restorable Area | Fish Passage (Yes/No) | Corrective Action (Refer to Codes) | GPS Coordinates | Eco/Net Benefits |
|---|---|---|---|---|---|---|---|---|
| CCMC27A-Spencer's Cove | aboiteau | wood | complete | small | no | OA EO FP | N 45º 21' 18.1" W 64º 42' 38.3" | 1 |
| CCMC28B-Spencer's Island | bridge | wood | no restriction | N/A | yes | NR RS EO | N 45º 21' 25.7" W 64º 42' 38.8" | 3 |
| CCMC29C-Spencer's Island | culvert | wood | partial | small | yes | EO | N 45º 21' 31.3" W 64º 42' 45.2" | 3 |
| CCMC30B-Mahoney Brook | bridge | wood | no restriction | N/A | yes | NR | N 45º 22' 05.8" W 64º 42' 13.7" | N/A |
| CCMC31C-Fowler Brook | culvert | wood | partial | medium | limited | SC LC | N 45º 22' 50.0" W 64º 41' 28.8" | 3 |
| CCMC32B-Fox River | bridge | wood | no restriction | N/A | yes | NR RS | N 45º 24' 58.0" W 64º 31' 34.0" | N/A |
| CCMC33B-Ramshed River | bridge | wood | no restriction | N/A | yes | RS | N 45º 24' 47.4" W 64º 27' 51.4" | N/A |
| CCMC34C-Mill Brook | culvert | wood | partial | small | limited | RO LC EO | N 45º 22' 35.6" W 64º 24' 48.8" | 3 |
| CCMC35B-Farrells Brook | bridge | wood | partial | small | yes | RO EO RS | N 45º 24' 02.3" W 64º 19' 46.0" | 3 |
| CCMC36A-Parrsboro Aboiteau | causeway/ dam | steel/ concrete | complete | large | no | FP | N 45º 24' 04.7" W 64º 19' 28.1" | 2 |

**Codes**: EO-enlarge opening; FP-install fish passage; GR-in good repair; LC-lower culvert; NR-not restrictive; OA-open aboiteaux; OG-open gate; OM-situated on marsh of interest; RA-replace aboiteaux; RC-repair/replace culvert; RO-remove old; RS-repair structure; SC-site clean-up

**Priority Level**:

1 - Low to medium impact barriers, requiring little cost that can produce obvious ecological benefits
2 - High impact barriers requiring high costs, but can produce large ecological benefits
3 - Low impact barriers with small ecological benefits
4 - Barriers not eligible for restoration due to protection of infrastructure or agricultural land

# 5.0 Final Remarks

One of the goals of the EAC's tidal barriers audit work is to increase awareness about the occurrence of tidal barriers throughout Bay of Fundy and the ecological changes they are causing to our coastal wetlands. It is hoped that individuals, groups and government will be able to use this information to better understand and recognize the implications of coastal development activities and see tidal barriers as a serious problem facing NS's coastal habitats and species. Having an inventory of the tidal crossings around the province will help allow government and communities alike to identify sites within their areas where restoration efforts could be undertaken.

A 1999 study on the environmental impacts of barriers on rivers around the Bay of Fundy concluded that the full scope of environmental impacts of most of the barriers and the potential benefits of remediation efforts are not well understood. This is due in part to the complexity and interdisciplinary nature of the problem, the generally low profile of the issue, and the shortage of resources to study the problem in an integrated manner in the depth that it deserves (Wells, 1999). Since that time, interest in the impacts of tidal barriers and restoration activities throughout the Gulf of Maine has increased and the current knowledgebase continues to expand. Environmental organizations such as the EAC and the Conservation Council of New Brunswick (CCNB) along with their project partners (Saint Mary's University, BoFEP) are helping to collect and disseminate this information for the Bay of Fundy, and initiating restoration measures.

Along the Bay of Fundy coast of Cumberland County nearly half of the tidal crossings assessed present a partial to complete barrier to the movement of tidal waters, materials and species in coastal and estuarine wetlands and rivers. A number of the rivers assessed did have large bridges in place, however, in many cases these same river systems were found to be substantially restricted downstream due to activities such as dyking and rail crossings. A number of the crossings observed were no longer tidal as a result of this situation, particularly around the Cumberland Basin where agricultural dyking of salt marshes can be traced back to the early 1700's. In some areas within these systems, salt marsh habitat restoration may be possible where dykes are no larger needed. In areas where this is not possible, there may still be the potential to restore fish passage to the rivers, through various mechanisms (fish ladders, self regulating tide gates, installation of tide gates equipped with holes) that would allow for fish passage but would not interfere with agricultural activities or increase the risk to local infrastructure.

While the number of bridges assessed doubled the number of culverts and aboiteaux combined, many of these, while only partially restricting tidal flow, were found to pinch the rivers and influence the surrounding habitat. While enlargement of bridges would be costly, tidal flow for most of those discussed above would be improved through the modification or removal of the rock/wooden/concrete embankments/piers at the base of the bridges or through removal of old structures still present under or immediately adjacent to the new bridges.

Of the tidally restrictive culverts assessed, restoration would most likely require replacement of the undersized or misplaced structures with larger and more appropriately located ones, or replacement with a bridge. Aboiteaux in the area, most often associated with dyked farmland, require an assessment of land use upstream and the possibility of removal of the tide gates, installation of a larger culvert or the breeching/removal of the dyke(s) entirely. At the very least, if the existing aboiteau is not allowing for fish passage and it is not feasible to remove the structure completely, options should be explored to modify it in order to allow for fish passage. Five of these sites were flagged as priority sites and hopefully now that they are identified, restoration options will begin to be explored and undertaken in the near future. Under the right circumstances any of the listed partially and completely restricted sites have the potential for restoration.

Restoration is not an easy process and will depend on the commitment of many individuals, groups and agencies. Community support is at the heart of all successful restoration projects (Koller, 2001). A community can contribute significantly to a restoration project through their knowledge of local tidal and land use history, equipment use, labour, and future monitoring and care of the salt marsh. Restoration through the removal or replacement of a tidal crossing will require government support, particularly that of the Department of Transportation and Public Works and the Department of Agriculture and Fisheries, who are responsible for the maintenance of these structures. The support of the NS Department of Environment and Labour, NS Department of Natural Resources and the federal departments of Fisheries and Oceans and Environment Canada, who are the provincial and federal regulatory agencies, is also essential.

While ecological restoration is a mechanism to reclaim a portion of the 80% of the original salt marsh habitat that has been lost in the Bay of Fundy, it is important to remember that 20% still remains and needs to be protected. Therefore it is also essential to identify the existing salt marshes and to educate the public, businesses and government on their importance and the need for conservation.

For more information regarding salt marshes, tidal barriers, and ecological restoration please contact the EAC's Coastal Issues Committee. Other EAC publications and general resources on these issues can be found in the References and Resources section of this report. As well, the Coastal Issues Committee is active on a variety of other issues and initiatives involving Nova Scotia's coastal habitats and we encourage readers to check out our website or contact us directly at the coordinates provided at the beginning of this report.

## References and Resources

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## Appendix A – Background Information

The ***Ecology Action Centre*** (EAC) is Nova Scotia's oldest and most active environmental organization. For over three decades the EAC has been a strong advocate for environmental change. Our mission is to encourage a society in Nova Scotia which respects and protects nature and provides environmentally and economically sustainable jobs for its citizens. We have seven active issue committees: Coastal, Energy, Food Action, Marine, Urban, Transportation and Wilderness.

The goal of the ***Coastal Issues Committee*** (CIC) is to promote coastal conservation and sustainable coastal communities in Nova Scotia. We do this by educating ourselves, the public and government about coastal issues facing Nova Scotia and encourage their involvement and support. We identify habitats at risk and support community efforts to protect them. We review coastal legislation and answer questions from the media and public. Areas we are currently concerned with include habitat loss, coastal access, sustainable coastal industries, coastal development, and coastal policy.

The ***Salt Marsh and Tidal Rivers Restoration Project***, of which the tidal barriers audit is a part of, has focused on protecting, restoring and raising awareness about the beauty and significance of Nova Scotia's coastal wetlands. Cheverie Creek is our pilot salt marsh restoration site located in Cheverie, NS. This is a tidal river and salt marsh system crossed by a causeway/culvert that partially restricts tidal flow to the upstream habitats. Over the past several years the EAC has been promoting this site for restoration and has conducted field research at the site to collect baseline ecological data about the marsh and explore the potential for restoration through culvert replacement. Collaboration with project partners, community groups and government agencies resulted in the planning and design of a new crossing aimed at maximizing tidal flow and the restoration of salt marsh habitat and fish passage. Education and community outreach programs are key aspects of the project.

## Appendix B – Tidal Barriers Audit Data Sheet: Phase 1 Visual Assessment

Visual assessments are to be done approximately two hours before the high tide. Preferably, they will also be done during the peak tides of the lunar cycle.

**Name:**_______________________ **Date:**_______________ **Time:** ______________

**Location:**____________________________________________________________

**GPS Coordinates:** _______________________ **Crossing code:** _________________

**Weather:** [Check Environment Canada web site] ___________________________________
**Wind velocity and direction**: ________________________________________________

**Rain** [circle one]: Heavy Moderate Light. **Fresh water flow conditions** [from station?]
___________________________

**Tide conditions** [height and time as recorded in tide book, adjusted for area]: High tide__
________________ Low tide ________________________. Mean high tide for area [in metres]:
_______________________

**Crossing characteristics** [circle one]: Bridge; Culvert B corrugated concrete steel PVC wooden block

**Crossing condition** [circle one]: Is original design intact? Yes No. Describe condition if in need of repair: _________________________________________________________________
_________________________________________________________________________

**Width of road** [in metres] ____________________ **Length of opening** [in metres]:___________

**Describe dominant land use or features**: Above the crossing:_______________________
_________________________________________________________________________
_________________________________________________________________________

Below the crossing:_______________________________________________________
_________________________________________________________________________
_________________________________________________________________________

**Restoration potential, if restricted**: Area with restoration potential [in hectares] _______
_________________________________________________________________________
_________________________________________________________________________

Type of restoration work [circle one]: Culvert repaired Culvert replaced Culvert installed Bridge installed Bridge widened Other ___________________________________
_________________________________________________________________________
_________________________________________________________________________

**Photographic record checklist:** Crossing upstream ___ Crossing downstream ___ Landscape upstream ___Landscape downstream ___ Dominant plants upstream ___ Dominant plants downstream ___ Water flow at crossing: upstream ___ downstream ___ Erosion evidence: upstream ___ downstream ___

**Crossing measurements:** Please indicate on diagram where measurements were taken

| Measurement | Upstream (cm) | Downstream (cm) |
|---|---|---|
| Stream width at opening* | | |
| Opening diameter | | |
| Opening height | | |
| Vertical distance, creek bottom to road surface (estimate if necessary, in metres) | | |

*May be X distance away from opening as long as you are consistent with upstream and downstream.

**Bank / channel erosion assessment:**

| Evidence of bank/channel erosion | Upstream (Yes No) | Downstream (Yes No) |
|---|---|---|
| Bank slumping | | |
| Scour pools | | |
| Current channel appears divergent from original channel | | |
| Other | | |

**Flow restriction assessment:**

| Evidence of flow restriction | Upstream (Yes No) | Downstream (Yes No) |
|---|---|---|
| Smooth flow | | |
| Turbulent flow | | |
| Slack (still) water | | |
| Eddies, swirling water | | |
| **Flow direction** | **Upstream** | **Downstream** |
| Choose one: straight; angular; reversed | | |
| **Water level variance** | **Yes** | **No** |
| Is there a visible difference in water level on each side of the crossing? | | |

**Vegetation comparison:**

Is there a significant difference between downstream and upstream vegetation [circle] : Yes No

| Obvious plants | Upstream Yes No | Downstream Yes No |
|---|---|---|
| Cordgrass: *Spartina alterniflora* | | |
| Salt marsh hay: *Spartina patens* | | |
| Cattails | | |
| Phragmites | | |
| Other????? | | |

## Appendix C – Tidal Barriers Audit Data Sheet: Phase 2 Tidal Measurements

The primary tool for determining whether a crossing is restrictive is the Visual Assessment (Phase 1). Measurements of tidal crossings will be made where it is uncertain whether there is a restriction, or where there is a need for more information about the degree of restriction (Phase 2). Measurements will be made over approximate 6-hour period, from three hours flood tide to three hours ebb tide. Ideally, measurements will be made during the highest tides of the month (spring tide). This should capture a "worst case" normal -- as opposed to abnormal scenario - which would most likely demonstrate restricted flow if there is any. It is important to determine whether the restriction is ongoing or periodic. If possible, the site should be visited twice under different tidal conditions to make this assessment.

**Name:**________________________________**GPS Coordinates:**______________________

**Crossing code:** ___________________

**Crossing characteristics** [circle one]: Bridge Culvert B corrugated concrete steel PVC wooden block

**Visit #1**. **Date:** __________________

**Weather:** [Check Environment Canada web site]:________________________________

Wind velocity and direction: ____________________

**Rain** [circle one]: Heavy Moderate Light. **Fresh water flow conditions** [from station?] ____________

**Tide conditions** [height and time as recorded in tide book, adjusted for area]:

High tide ____________ Low tide ____________

**Tidal Range Measurements**: [from a reference point on each side of the crossing to the water surface Refer to Tidal Audit Handbook, either Parker River or CCNB version, for a full explanation of the methodology].

| Tide Time (high tide = 0) | Actual time | Upstream (in cm) | Actual time | Downstream (in cm) |
|---|---|---|---|---|
| 0 - 3 | | | | |
| 0 - 2 | | | | |
| 0 - 1.5 | | | | |
| 0 - 1 | | | | |
| 0 - .5 | | | | |
| 0 | | | | |
| 0 + .5 | | | | |
| 0 + 1 | | | | |
| 0 + 1.5 | | | | |
| 0 + 2 | | | | |
| 0 + 3 | | | | |