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Belcher Street Marsh Dyke Realignment and Tidal Wetland Restoration Project

A Case Study of Nature-based Coastal Adaptation in Nova Scotia

Natural Resources Canada Ressources naturelles Canada

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Making Room for Movement

Saint Mary's University

DALHOUSIE UNIVERSITY

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The Belcher Street Marsh Dyke Realignment and Tidal Wetland Restoration Project: A Case Study of Nature-based coastal Adaptation in Nova Scotia is one of six case studies of nature-based coastal adaptation projects in Nova Scotia prepared as part of the Natural Resources Canada-funded project *Making Room or Movement: a Framework for Implementing Nature-based Adaptation in Nova Scotia,* led by TransCoastal Adaptations: Centre for Nature-Based Solutions, Saint Mary's University.

Team members from the School of Planning at Dalhousie University compiled the cased studies. Other members of the Making Room for Movement project team provided content and insight to one or more of the studies, including Kirsten Ellis, CBWES Inc.; Nancy Anningson, Ecology Action Centre; Dr. Kate Sherren, Dalhousie University; Dr. Danika van Proosdij, Saint Mary's University; Dr. Tuihedur Rahman, McGill University; and Tony Bowron, CBWES Inc,. and team members with CBCL Limited.

Case study project participants contributed to documenting the projects by providing project descriptions and technical information. For this case study—the Belcher Street Marsh Dyke Realignment and Tidal Wetland Restoration Project—the School of Planning project team thanks Kirsten Ellis and Tony Bowron, CBWES Inc.

This project was undertaken in Mi'kma'ki, the unceded ancestral territory of the Mi'kmaq. We acknowledge and pay respect to the traditional stewards of the land on which we live and have conducted this work.

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Case Study Context and Purpose

In Nova Scotia, 244 km of dykes protect 17, 364 ha of agricultural land along with urban land uses and cultural values attached to these landscapes (Sherren *et. al*., 2021). Raising, repairing, and maintaining the infrastructure will demand more resources as rising sea level and storms challenge the ability of this extensive infrastructure to protect the land uses behind it. Assessing the sustainability of the dykes and dykelands suggests the need for new approaches to infrastructure management (van Proosdij, *et al*., 2018). One option is managed dyke realignment. The Belcher Street Marsh dyke realignment project in Kentville, Kings County, Nova Scotia illustrates how government, university, and industry partners collectively implemented a nature-based approach to dyke and dykeland management that, by moving and reshaping a section of dyke, makes room for flooding along a tidal river, increases wetland habitat, improves arable land quality and access, and enhances a community recreation amenity. The case study describes the project context and site; community vulnerabilities to hazard; the local area land uses and planning context; project development, design, and implementation; and project benefits, barriers, and drivers and lessons learned.

Background

Kings County comprises 2127 km^2 in central Nova Scotia (Figure 1) and is home to approximately 60,600 people (Statistics Canada, 2021a). The county borders the Bay of Fundy to the north; the shore of the Minas Basin, a basin of the Bay of Fundy, forms the county's eastern boundary. The North Mountain basalt ridge and South Mountain granite upland frame the lowlands in-between. A large peat bog—Caribou Bog—sits at the divide between the two major rivers of the area: the Annapolis River flows west to the Annapolis Basin and the Jijuktu'kwejk River (Cornwallis River) flows east to the Minas Basin. Runoff from North and South Mountains feeds these rivers and others in the region. Collectively, the region is known as the Annapolis Valley.

Two First Nations and four municipalities comprise Kings County. All of Kings County is part of Sipekne'katik, a district of Mi'kma'ki and unceded territory. Glooscap First Nation is located on South Mountain at the southern edge of Kings County between Kings and Hants counties, above the Avon River estuary. Annapolis Valley First Nation is on the upper reaches of the Jijuktu'kwejk River. The largest municipality, encompassing most of the county, is the Municipality of the County of Kings, which is predominantly rural and includes many small hamlets and villages and an urban commercial strip along the main road through the county, Hwy 1. Kings County municipality surrounds three towns: Wolfville on the Minas Basin, Kentville on Jijuktu'kwejk River, and Berwick just east of the divide between the Annapolis and Jijuktu'kwejk Rivers.

The town of Kentville is the regional centre in the Annapolis Valley with a population of 6,271 at the time of the 2016 Census of Population (Statistics Canada, 2021). The population grew by three percent from 2011, a trend the town expects will continue (Town of Kentville, n.d.).

Annapolis River, Jijuktu'kwejk River, and many other rivers of the region, are tidal rivers. French colonial settlers, called Acadians, began converting the natural marshes of the tidal floodplains to agricultural land (Bleakney, 2004) in the 1600s. To drain the marshes and protect the agricultural lands from tidal flooding, the Acadians created a series of dykes and aboiteaux to keep floodwaters out and promote drainage away from agricultural fields (Robinson, *et al.*, 2004). An aboiteau is a culvert with a hanging gate that allows freshwater from precipitation to drain to the sea while closing during high tides to prevent salt waters from flooding the dykelands. Over the centuries, other settlers expanded the dykes and the area of converted marshland. A period of dyke renewal and redevelopment through the1900s created the dykes and dykeland in place today. Approximately 80% of the Bay of Fundy tidal marshes have been lost since the beginning of European colonization, primarily to dyking for agricultural purposes (NSDE, 2017). The dykeland and mineral upland soils of Kings County and neighbouring Annapolis and Hants counties support much of the province's agricultural production (County of Kings, 2020a).

Figure 1. Case study location and context, Kings County, Nova Scotia (adapted from Google Images, 2020)

Climate change and changing land use have challenged the effectiveness of dykelands and aboiteaux built at a time of lower sea levels (van Proosdij & Page, 2012). Many of the original Acadian aboiteaux and dykes were replaced in the 1950s. However, the designs did not consider climate change or changing land use (van Proosdij & Page, 2012; van Proosdij, *et al.*, 2018). As Nova Scotia's population and demand for developable land increased, the function of dykes expanded to include the protection of infrastructure and people, in addition to their original purpose of protecting low-land agriculture. The economy also began to shift away from agriculture. Some agricultural fields became inactive and a dyke monitoring and maintenance in these areas decreased (van Proosdij & Page, 2012; van Proosdij, *et al.*, 2018).

As noted above, Jijuktu'kwejk River is a tidal river of the Minas Basin. The Minas Basin experiences some of the highest tides in the world. Spring tides have a tidal range of approximately16 m. The strong tides affect the Jijuktu'kwejk River up to 5 km west of Kentville (County of Kings, 2013) which is approximately 15 km from the mouth of the river at the Minas Basin. Dyking has converted most of the Jijuktu'kwejk River tidal floodplain to agricultural land

Land development is required to support a growing population. Over the years, some of this development has occurred in the floodplain of the Jijuktu'kwejk River, with unfortunate consequences. As reported in a study prepared by supervised student researchers at Acadia University for the Town of Kentville Integrated Community Sustainability Planning Group, many residents and developers were unaware that they were building on a floodplain.

"Three feet of water filled the Streets… I'm 82 years old, and I've lived on this street all my life. We've always had floods, but this is the worst." – resident referring to a flood in 1982 (History 3383, 2010)

"We never knew we lived on a flood plain...no one told us, not even the real estate agent...that we were in the nine-metre zone." (History 3383, 2010)

In 2003, a significant flooding event forced many residents to evacuate their homes. Those living on the Jijuktu'kwejk River floodplain were hit the hardest. Because of the flood the town commissioned a study and $750,000 for the construction of a new 10.5 m dyke (History 3383, 2010). In 2008-09 Kentville voted to complete a dyke project and install pumping stations to mitigate flooding in the West Main Street area of town (Starratt, 2010).

With a long ocean coastline and estuaries, the municipality of Kings has also been studying coastal flooding. The municipality identified that the Jijuktu'kwejk River estuary would be heavily influenced by sea-level rise and extreme weather events (County of Kings, 2013). The

Kings County Municipal Climate Change Action Plan (2013) identified that the dyke systems are becoming increasingly vulnerable to rising seas, putting the effectiveness of dyke infrastructure for protecting both agricultural land and community infrastructure against higher tide elevations and storms at risk, Dyke rehabilitation and maintenance are costly. Examining how to manage these costs with innovative approaches to dyke management is an important part of climate change adaptation for dykelands.

Hazards and Risks in Kentville and Kings County Municipalities

Climate change is creating warmer and wetter conditions in Nova Scotia, creating more frequent and intense rainfall events (ECCC, 2019). As sea levels rise, coastal flooding is becoming more common across Nova Scotia, negatively impacting coastal cities, towns, and rural areas. Rising sea level magnifies high tides and storm surges (ECCC, 2019) and flooding risks are greatest when storms occur at high tide. The risk applies to the open coast, bays, and tidal rivers. Tidal rivers may reach capacity more often as sea level rises and storms become more frequent. In dyked tidal rivers, like those in Kings County and Kentville, flooding risks increase when heavy rains occur as the tide is rising. In the first instance, the river has little flood plain to accommodate the larger volumes of water and in extreme cases can overtop a dyke. At the same time, runoff from land inside the dyke is draining to the aboiteaux. Aboiteaux close during high tide to prevent salt water from flooding the agricultural land on the landward side of the dykes. With the aboiteaux shut, water levels rise on both sides of the dyke creating significant flood risks and potential for dyke erosion.

In the dyked marshland at Belcher Street, erosion of dyke infrastructure was increasing the vulnerability of lands on the landward side of the dyke. The Jijuktu'kwejk River is a meandering river, with many curves and bends (Figure 2 and 3). Meandering is the process whereby a river adjusts its course within a gently sloping floodplain, adapting to water volume and energy, provided it has the room to do so. Erosion is greatest on the outside of river bends. As the banks erode, the meander deepens and the banks advance toward one another; eventually a new channel breaks through, cutting off the meander bend and leaving a meander 'scar' in the floodplain. When dykes follow a river course, there isn't much room in the flood plain and the river moves towards the dykes. Figure 2 illustrates how Jijuktu'kwejk River, in the area of Belcher Street Marsh in Kentville, was encroaching on the dyke at several locations.

Pre-restoration, the Belcher Street Marsh was 22.6 hectares of dyked marshland (80% active agriculture, 20% fallow) along the Jijuktu'kwejk River in Kentville and bordering Kings County municipality (Figure 3). Approximately, 1.34 kms of dyke infrastructure followed the Jijuktu'kwejk River closely. Belcher Street Marsh became the site for a dyke realignment and tidal wetland restoration project because of a combination of factors: the presence of abandoned agricultural land; active erosion along the Belcher Street Marsh dykes, as shown in Figure 4; and the desire to protect the active, productive farmland. The evolution of the river, and climate change that brings increased precipitation contributing to river volume in large storms, as well as higher tides in the river channel, means that assets behind the dyke will continuously be at risk of flooding if no changes are made to the dyke and to land use management.

Figure 2. Jijuktu'kwejk River meanders encroaching on the dyke before 2018 and dyke realignment. Points A to E are areas of concern for dyke erosion (Graham *et al*., n.d.)

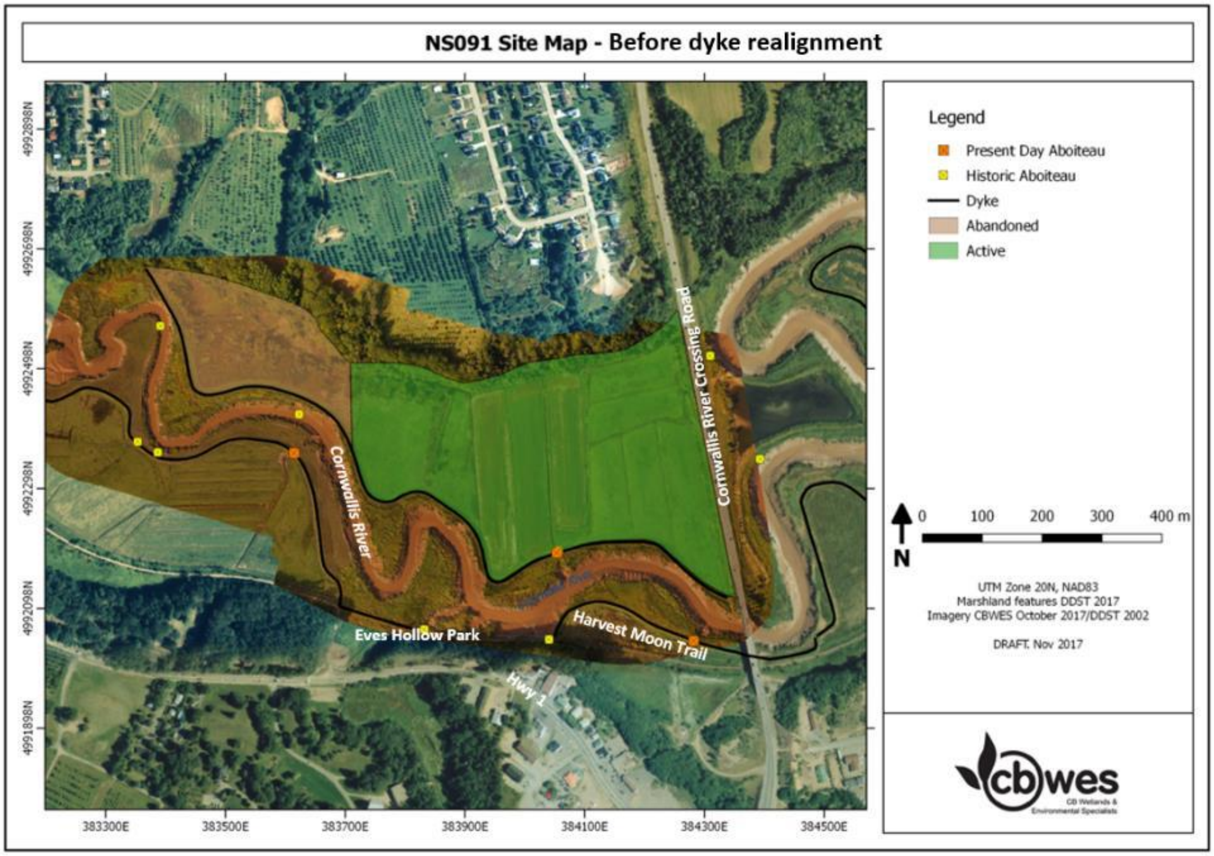

Figure 3: Belcher Street Marsh project site showing the original dyke alignment before 2018, active agricultural land, inactive agricultural land, and adjacent land uses (CBWES, Inc.)

Social Vulnerability to Hazard in Kentville and King County Adjacent the Belcher Street Marsh Dykelands

Natural hazards affect populations differently. The impacts felt by a population, or a population's vulnerability to a hazard (such as flooding), is evident in the ability of the populations ability to respond to, cope with, and recover from the impact of the hazard. A variety of individual and social factors influence vulnerability of a population including income, employment, gender, age, race, education level, household composition, ability to speak the local language, among others. The greater the proportion of the population experiencing conditions that contribute to vulnerability (such as advanced age, unemployment, being a recent immigrant, etc.), the more vulnerable is the population in that area. Vulnerability is described through indices such as the Social Vulnerability Index (Cutter, *et al*., 2003), or a marginalization index (Matheson, *et al*., 2012), or a deprivation index such as the Canada Index of Multiple Deprivation (CIMD) (Statistics Canada, 2019). The analysis for this case study uses the CIMD.

The CIMD is an area-based index created by Statistics Canada using variables from the 2016 Census of Population at the Dissemination Area (DA) level (Statistics Canada, 2019). A Dissemination Area is the smallest population unit for which Statistics Canada reports the full set of demographic and social statistics, about 400 to 700 people. DAs are relatively stable geographic areas. Statistics Canada developed CIMD datasets across three geographic scales: national, regional (two, including Atlantic), and provincial (three), referenced to 2016. This case study used the Atlantic Region CIMD data set.

The CIMD comprises four dimensions of deprivation and marginalization, with each dimension incorporating influencing indicators derived from the census data: residential instability; economic dependency; ethno-cultural composition; and situational vulnerability. The indicators for each dimension are listed in Figures 4 to 7. DA-level factor scores were calculated for each dimension using factor analysis. Scores were then ordered within each dimension into quintiles and the quintiles were assigned a value of 1 through 5, Quintiles represent fifths of a population; the first quintile is the lowest fifth of the data (1% to 20%) and receives the quintile value ‘1’; the fifth quintile is the highest fifth of the data (81% to 100%) and receives the quintile value ‘5’. For the CIMD, ‘1’ represents the scores indicating the least deprived fifth of the population; and ‘5’ indicates the most deprived.

Figures 4, 5, 6, and 7 are maps developed from the Atlantic Region CIMD data set to show the deprivation levels for the Kentville and Kings County area, centred on the Belcher Street Marsh dyke realignment project location. The shades of green on the maps represent lesser (light) to greater (darker) deprivation. The higher the deprivation the more vulnerable is the population to hazards.

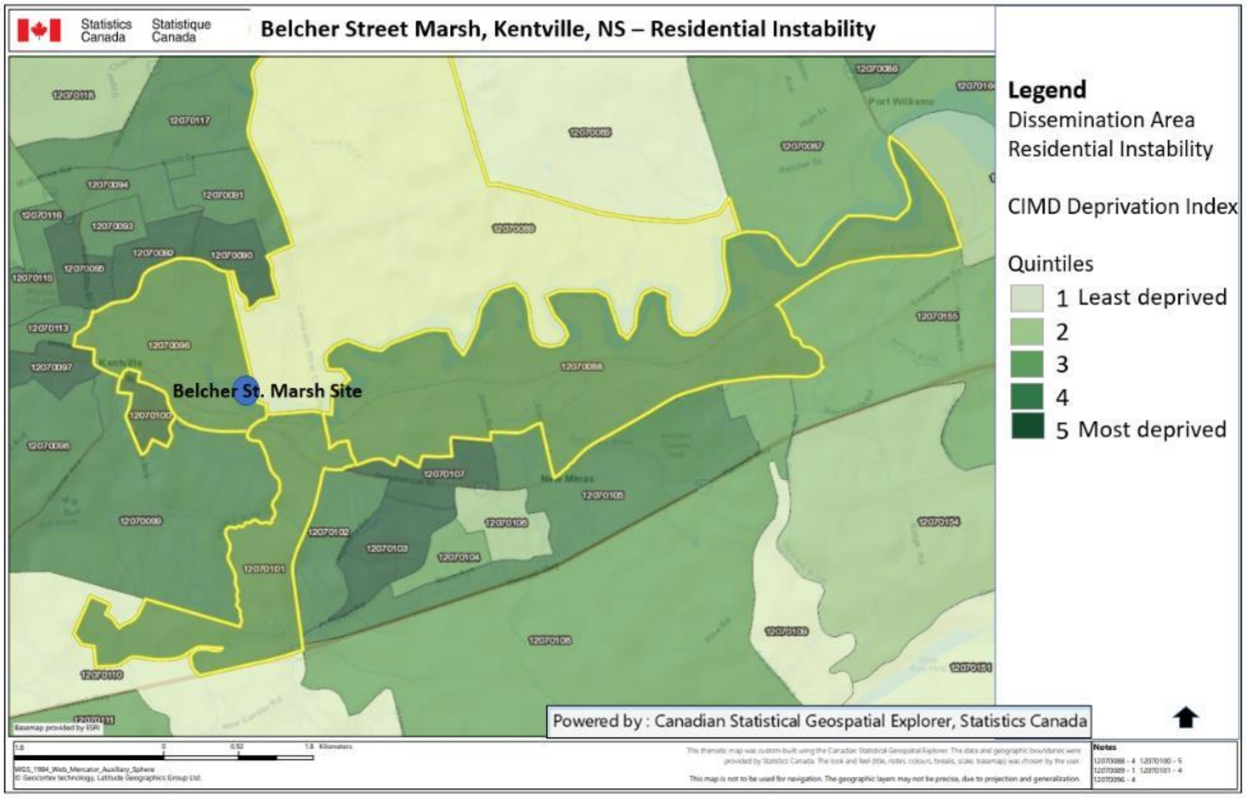

Figure 4. Belcher St., Kentville and area - Residential Instability* at 2016 Canadian Index of Multiple Deprivation –(Statistics Canada, 2019)

*Proportion of persons living alone; proportion of dwellings that are owned, proportion of dwellings that are apartment buildings; proportion of the population that is married or common-law, proportion of the population that moved in the last five years.

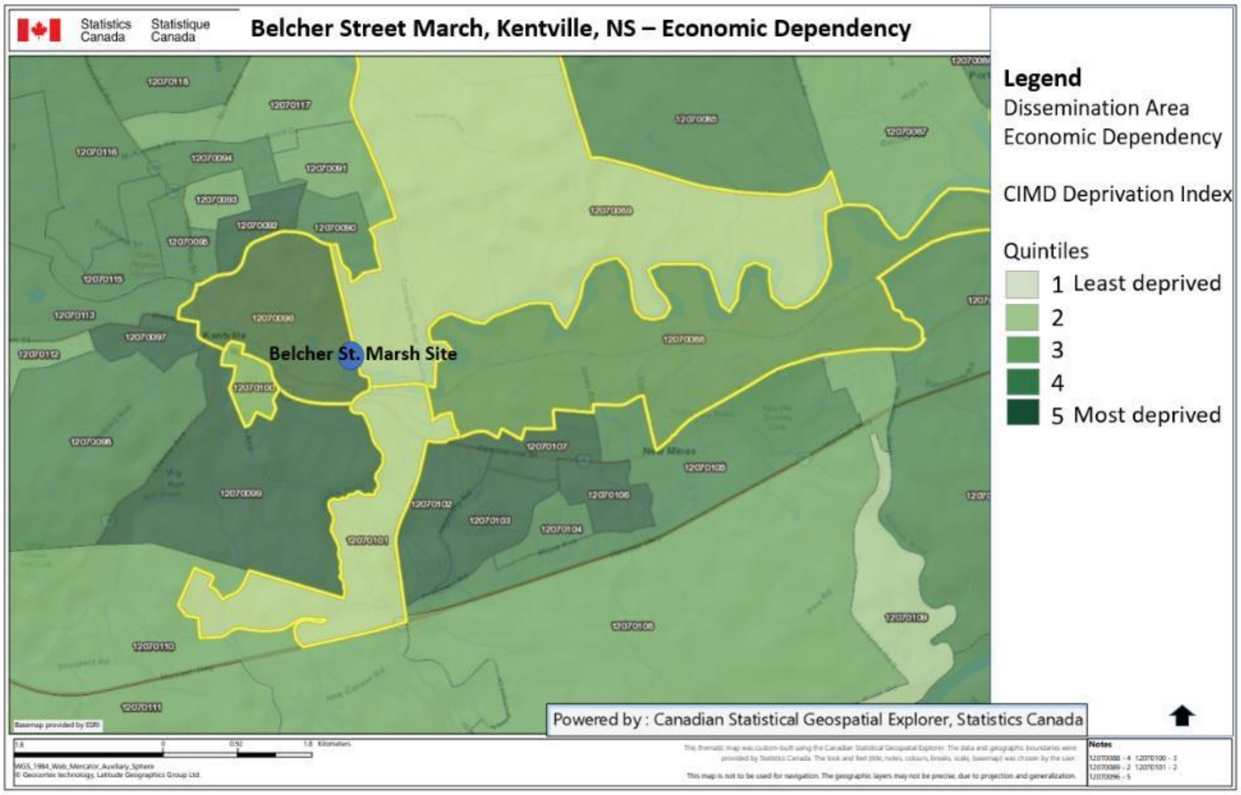

Figure 5. Belcher St. Marsh, Kentville and area - Economic Dependency* at 2016
Canadian Index of Multiple Deprivation - (Statistics Canada, 2019)
*Proportion of population aged 65 and older; proportion of population participating in the labour force -15 and over; dependency ratio (population 0-14 and 65 and over divided by population 15-64; ratio of employment population proportion of population receiving government transfer payments.

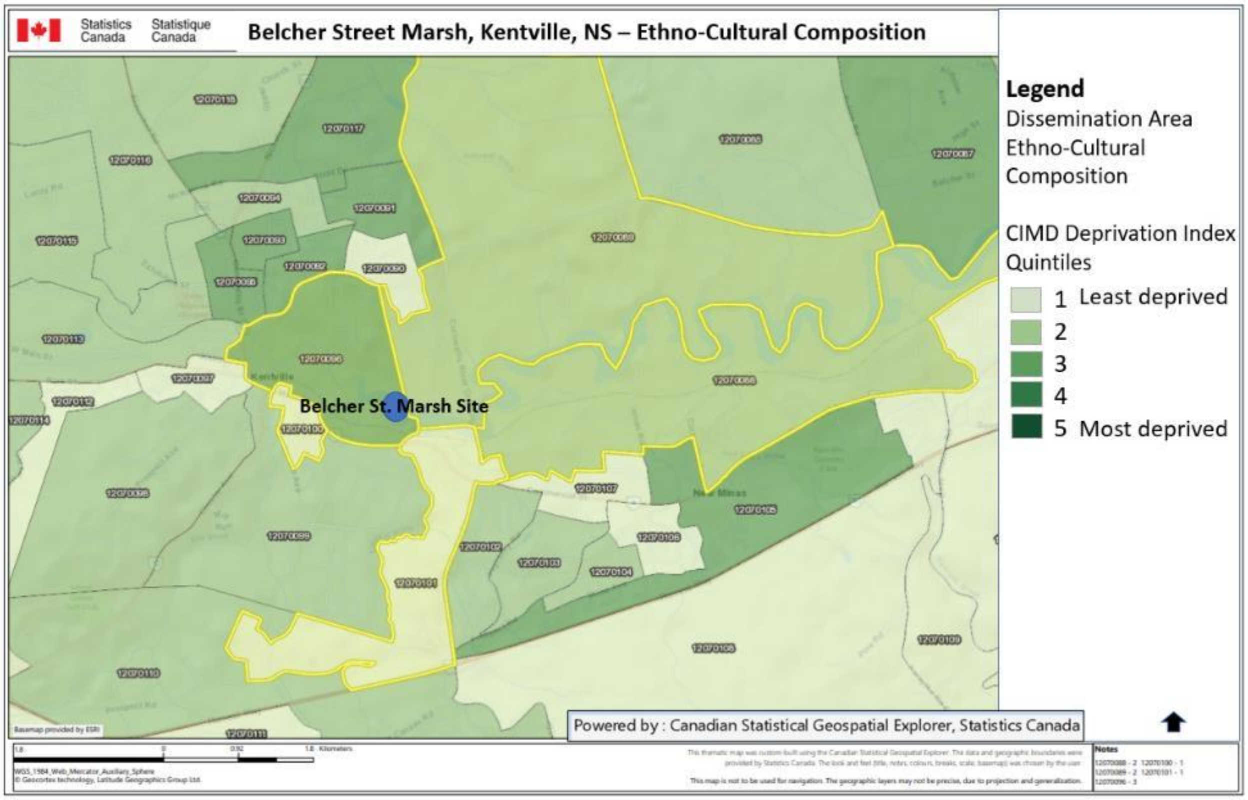

Figure 6. Belcher St. Marsh, Kentville and area - Ethno-Cultural Composition* at 2016 Canadian Index of Multiple Deprivation (Statistics Canada, 2019)

*Proportion of population that is recent immigrants; proportion of population that has no knowledge of either official language.

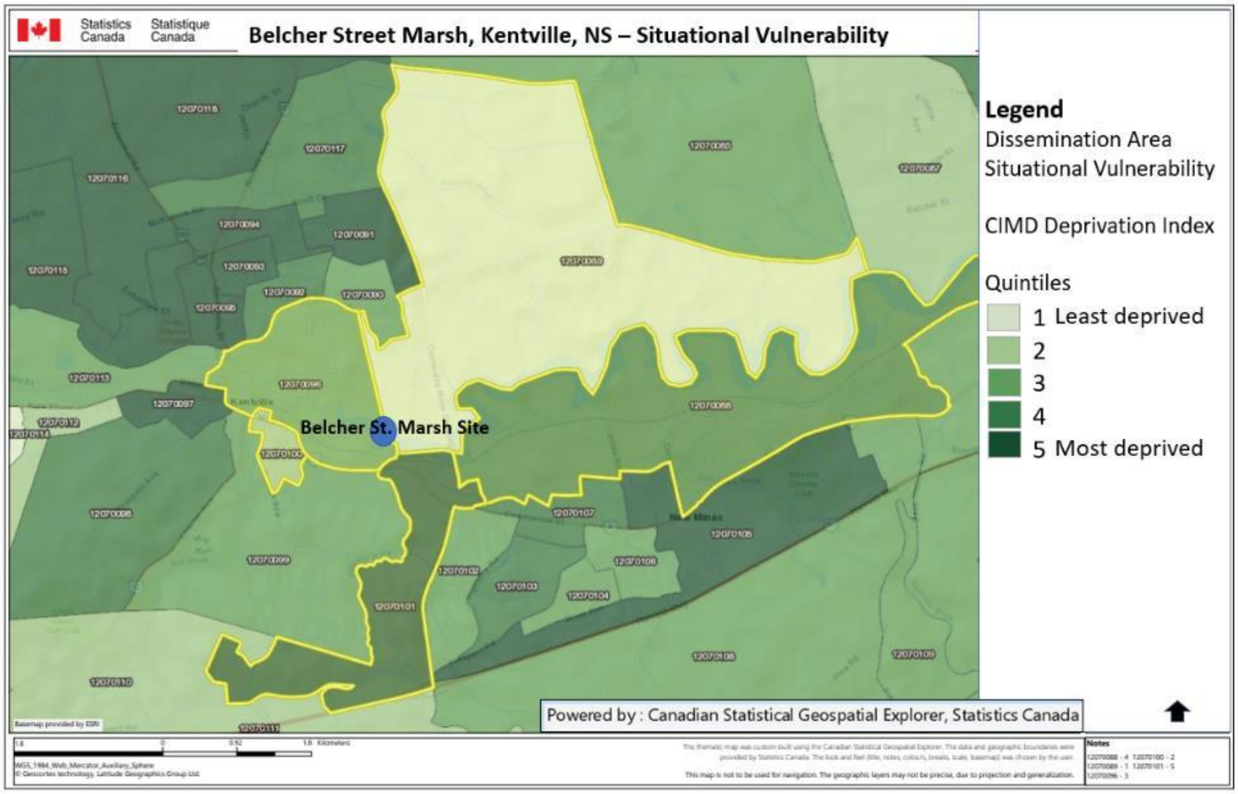

Figure 7. Belcher St. Marsh, Kentville and area - Situational Vulnerability* at 2016 Canadian Index of Multiple Deprivation (Statistics Canada, 2019)
*Proportion of the population that identifies as Aboriginal; proportion of dwellings needing major repairs; proportion of population aged 25 to 64 without a high-school diploma.

Two DAs directly intersect the Belcher St. Marsh project site: DA 12070096 is in Kentville and covers the west side of the site. DA 12070089 is adjacent to the east in Kings County and running along the river. A third DA 12070100 lies to the south of the river and bordering the town DA containing the project site. A fourth DA 12070101 is in the county, abuts the town on its west border, and extends south from the river, crossing Hwy 1 (Main St). A fifth DA 12070088, also in the county, extends east of the study site with the river as its northern boundary. It includes a section of the Hwy 1 commercial core of the county -- New Minas. Combined, the five DAs – two town and three county -- include dykeland, rural settlement, newer low-density residential development on higher ground above the site to the north in both the town and the county, older low-density residential on low-land in town south of the river, and commercial and industrial development with some residential mixed in, town and county.

Patterns of multiple deprivation are complex in this area where the town and county meet. The indices for ethno-cultural composition suggest higher recent immigrant population in the town DA that contains the project site. The adjacent county DAs have lower CIMD indices, suggesting lower immigrant populations in the rural areas.

The residential instability index is low in the rural DA north of the river where the settlement has a rural residential pattern and suburban development and moderate in the three DAs that include the part of town associated directly with the project site, and the county DAs extending south of the river. It is moderate-high in the second town DA located on low-lying land. Furthermore, residential instability indices increase in the town DAs beyond the project site. This pattern suggests a higher proportion of renters or people recently moved into the area and/or people living alone in the urban (town) and more urbanized county area areas on the south side of the river near the marsh.

Economic dependency is moderate-low in the rural and suburban area north of the river and the county DA that extends south of the river and borders Kentville to the west. It is moderate-high in the town DAs and in the urban county DA south of the river. The pattern suggests that there is a higher proportion of older populations and/or of unemployed people of working age in the town area near the project site and the urban county DA, and a lower proportion of older populations and/or unemployed in the rural county DA.

Situational vulnerability is low in the rural county DA north of the river and in the urban DA south of the river, moderate in the urban county DA and town DAs along the river, and high in the county DA that extends south from the river and borders Kentville to the west.

To some extent the pattern shows an urban-rural divide, in some patterns such as ethno-cultural composition, residential instability, economic dependency. The dyke realignment is increasing the available flood plain while also building protection for the dyke with a front-facing marsh and thereby better protection for the agricultural land behind the dyke. An enlarged flood plain eases flooding pressures that could impact the dykes and also some low-lying infrastructure, Hwy 1 in particular at the Eave’s Hollow Park and the residential area contained in DA

10207100. This DA has the highest index for residential instability of the five DAs reviewed here, but lower deprivation indices for the other measures, as well as lower than other town DAs, notably economic dependency.

Governance, Policy, and Planning

The Belcher Street Marsh Dyke Realignment Project was implemented by TransCoastal Adaptations Centre for Nature-based Solutions, Saint Mary's University (SMU) and CB Wetlands and Environmental Specialists (CBWES). The restoration project was in partnership with the Nova Scotia Department of Agriculture (NSDA). NSDA suggested the Belcher Street Mash as a potential wetland restoration site.

Although not partners in the project, Kings County and the town of Kentville are municipal stakeholders. The municipalities have the power to protect the environment, infrastructure, people through land use policy, regulation, and site design standards. By keeping development out of floodplains, they give the river space to flood while reducing the exposure to flood hazards. They control and influence the effectiveness of climate change adaptation at the local level.

Marsh Bodies are other stakeholders in dykeland realignment initiatives in Nova Scotia. A Marsh Body is an association of marshland owners incorporated under the *Agricultural Marshland Conservation Act 2000, c. 22, s.1* (Nova Scotia Legislature. (n.d.) to manage the dykes and marshland under their ownership. Anyone who owns land within a provincially recognized dykeland is a member of the connected Marsh Body. Marsh Bodies have powers similar to a municipality when managing dykelands (Sherren *et al*., 2019). With approval from the Agricultural Marshlands Conservation Commission, Marsh Bodies can create bylaws, buy, sell, and lease property. They also can make decisions about repairing or constructing dykes at the Marsh Body's expense or in partnership with the Minister of Agriculture. There are specific requirements that a Marsh Body must maintain to be considered active. There are 12 Marsh Bodies in the County of Kings (MCCAP, 2013).

Land use, planning and regulation in Kings County and Kentville

The pre-restoration land use at the project site was managed agricultural and fallow agricultural dykelands. Fallow land refers to land that was previously used for agriculture and is now resting and will either remain unused or be replanted once the soil has rejuvenated. The restored area of the Belcher Street Marsh project site included both active and fallow agricultural land. Active agriculture continues on the land behind the realigned dyke, while tidal wetland is now developing on the land between the river and the new dyke.

There is wooded slope along the upland fringe on the north side of the site. The Cornwallis River Crossing Road crosses the river and the marsh at the east end of the site. Land uses adjacent to the site on either side of the river include a recreational trail on the south side of the river that is a former rail bed—the Harvest Moon Trail -- running from Grand Pre to Annapolis Royal; a park off Hwy 1 at the town entrance – Eave's Hollow Park – that provides access to the trail; a loop trail and park to the west of the project site – Miners Marsh trail -- that encircles a Ducks Unlimited managed wetland of the same name; low-density residential development on the bluff overlooking the site, to the north; low-density residential development on low-lying land on the south side of the river, west of the project site and near Miners Marsh trail; low-density residential development along Hwy 1 in Kentville; mixed residential and commercial development along Hwy 1 in King County Hwy 1/Commercial Street runs roughly parallel with but set back from the river and the dykeland in some sections. Although mostly elevated above the marshland, the lowest section is within two meters elevation of the dykeland at Eaves Hollow Park, and 150 metres from the river.

Both municipalities have land use planning and regulation to control development and guide growth in their jurisdictions: the Kentville *Municipal Planning Strategy* (2019a) and *Land Use By-law* (LUB) (2019b) and the Kings County *Municipal Planning Strategy* (2020b) and *Land Use By-law* (2020c). The municipalities also have non-statutory strategic planning that guide sustainable development and climate change adaptation and mitigation, among other matters of municipal responsibility. In 2011, the Municipality of the County of Kings and the three towns within the County—Kentville, Wolfville, and Berwick—signed a *Memorandum of Understanding* to work collaboratively on a project that would guide sustainable development in the region. The sustainable development initiative, *Kings 2050*, incorporates climate change into sustainable development strategies. In 2013 the county municipalities jointly completed a Municipal Climate Change Action Plan (Kings 2050, 2013).

Land use is the activity or development that exists at a site. Land use zoning regulates the permitted uses at a site, including current and future uses. Figure 8 shows the land use zoning at and around the Belcher St Marsh project site. Land within the Belcher St. Marsh project area is zoned for Conservation (O1) and Park and Open Space (P) within the Town of Kentville and as Environmental Constraint (O1) in Kings County.

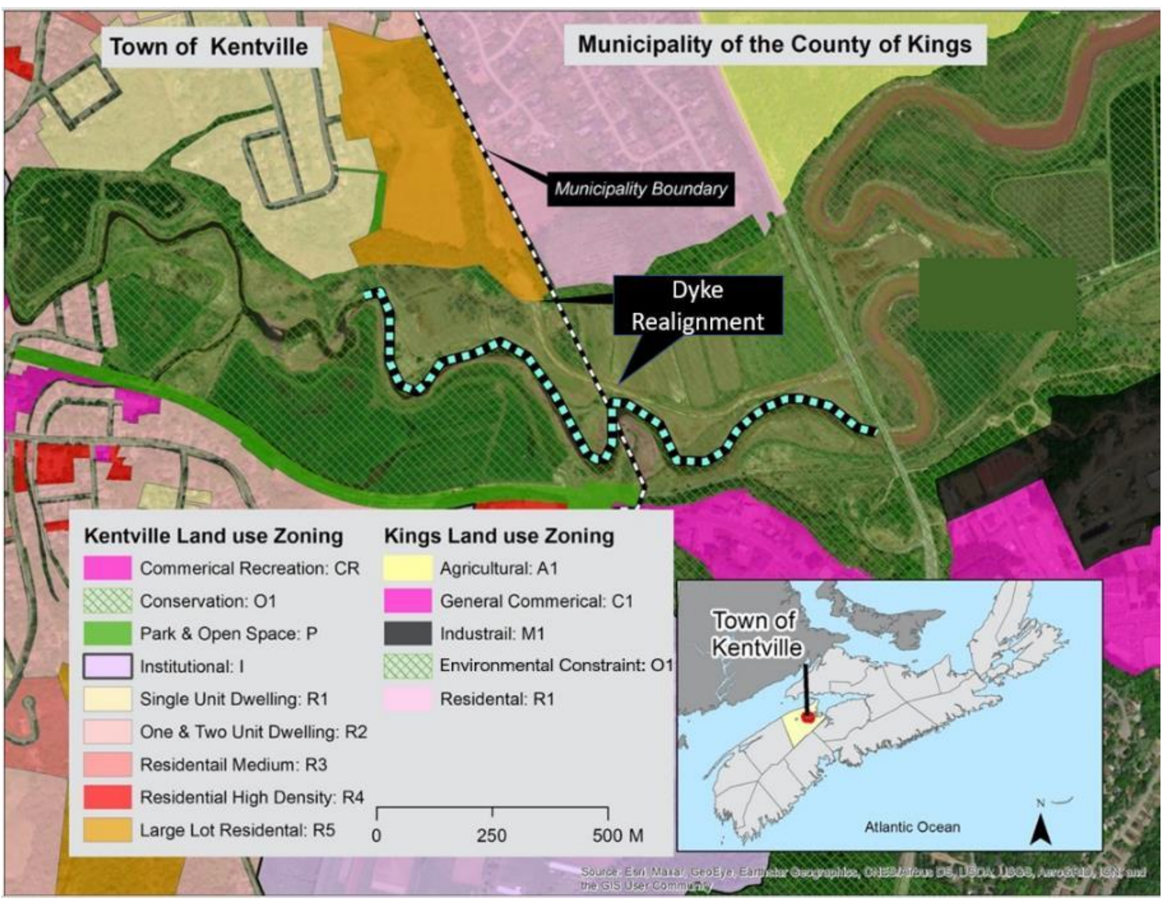

Figure 8. Belcher Street Marsh dyke realignment project area and adjacent municipal land use zoning in Kings County and the town Kentville. (Kentville *Land Use By-law* (LUB) (2019b) and Kings County *Land Use By-law* (2020b)

The town of Kentville Conservation Zone (O1) limits development to low-intensity land uses such as agriculture, open space, and parks. This zoning is helpful for dyke realignment within the town, as land uses incompatible with flooding and erosion hazards are not permitted. There is a small strip of Park and Open Space zone (P) on the south side of the O1 zone. Permitted uses in the zone include community gardens, indoor and outdoor public recreation facilities, off-leash dog parks, playgrounds, parks, trails, water-related recreational facilities, and any associate buildings for the previous uses; many of them are already in place. The land adjacent to the site on the bluff to the north of the site is zoned Large Lot Residential (R5) which permits single-unit dwelling, or manufactured home parks and land lease communities by development agreement. While the adjacent zonings might suggest the potential for land use conflicts with a conservation zone, this land sits 20 to 40 m above the dykeland so direct land use conflicts between the dykeland and marsh and the residential land are unlikely, although it is important to maintain the vegetated slope to protect against slope erosion and urban runoff. Visible under the zoning overlay in Figure 8 is cleared land. Orchards formerly occupied this land which points to a trend of agriculture land conversion which has been a focus of land use planning debate in the municipalities of Kings County.

There is also Low-density Residential zoning (R1 single-unit) above the site to the north and R2 (singe and two-unit dwellings) south of the multi-use trail. An adjacent Commercial Recreation zone (CR) permits uses such as golf courses and mini golf, campgrounds, private parks and recreational facilities or clubs. There is a pocket of high density R4 (apartment) zoning across from the dyke realignment site on the south side of the river, along the multi-use trail.

In Kings County Environmental Constraint (O1) zone limits development because of environmental hazards including flood risk, erosion, and slope failure. Permitted uses within the zone are low-intensity and include agriculture, remote-controlled Aircraft Fields (existing), fishing, and forestry. O1 requires a setback of 12.19m from the watercourse for any activity. A small part of the site in Kings County is zoned Agriculture (A1), which prioritizes agricultural; pre-existing non-agricultural uses are permitted but all other non-agricultural land uses are excluded. There is Residential Single Dwelling zoning applied to land directly adjacent to the restoration site in Kings County. Although there is a buffer of forested land between zones, conflicts may occur over time. New developments are required to establish a watercourse setback requirement of 6.1 m to reduce drainage and preserve and integrate natural drainage features into development plans (Warren, 2020). Several other residential zones permit a variety of development types near the river. Industrial zones permit a variety of uses ranging from indoor recreational uses, to fish plants, and salvage and scrap operations

While some existing residential land use in the area is low lying which exposes it to flood risk, overall, both Kings County and the Town of Kentville have zones that limit future development within marshlands and floodplains. Adjacent land use zoning is mostly low intensity parkland, and low density residential. Zoning on the bluff and highland above the site is residential. Care is required to manage the slope that is the forested hillside buffer between this dykeland and the development to protect against slope erosion and urban runoff.

The Belcher Street Marsh Dyke-realignment and Tidal Wetland Restoration Project

The Belcher Street Marsh dyke realignment and tidal wetland restoration project site is located along the Jijuktu'kwejk River in the town of Kentville at the municipal boundary of Kings County (Figure 10). As previously noted, Jijuktu'kwejk River is a tidal river of the Minas Basin. The Minas Basin experiences some of the highest tides in the world. Spring tides have a tidal range of approximately 16 m. The strong tides affect the Jijuktu'kwejk River up to approximately 17 km from the mouth of the river at the Minus Basin. Thus, the river is tidal along its entire course in the town. (County of Kings, 2013).

Dyking and draining converted most of the Jijuktu'kwejk River tidal floodplain to agricultural land and some of that land has subsequently been converted to urban land uses. The dykes are near the river following each curve and bend. A tract refers to a single length of dyke – from upland termination point to upland termination point – and includes all aboiteaux within that section. Tract 5 is one of the dykes that makes up the Jijuktu'kwejk River dykeland system. It is the section of dyke that enclosed the Belcher St project site and was realigned as part of the

project, shown in Figure 9. Tract 5 runs approximately 1.3 km and protected 22.6 ha of dykeland prior to realignment; 18.1 ha of dykeland were cultivated and 4.5 ha were fallow.
There is one aboiteau on the western end of the dyke, constructed in 1965, and two aboiteaux on the eastern end (Ellis *et al*., 2018).

Dyke realignment is a relatively new method to address failing dyke infrastructure in tidal regions. It integrates nature-based and traditional approaches. Dyke realignment involves moving the dyke landward and reshaping it, typically shortening and straightening (Rahman *et al*., 2019). The realignment creates space for tidal wetlands to re-establish on the seaward side of dykes. Straightening the dyke decreases the length of dyke that needs to be maintained, thereby reducing the cost of maintenance. Also included in the Belcher Street Marsh dyke realignment and tidal marsh restoration project is a living shoreline. A living shoreline involves restoring a coastline to habitats such as a salt marsh or reef that naturally protect the shore from erosion and flooding. Living shorelines have been shown to be more effective at mitigating erosion and are more resilient than traditional shoreline hardening (Gittman *et al*., 2014; Gittman *et al*., 2016). They also increase coastal habitat to support biodiversity (Gittman *et al*., 2014; Gittman *et al*., 2016). The eventual goal of a living shoreline is to create an environment that self-adapts to changing conditions with little maintenance (Mitchell & Bilkovic, 2019).

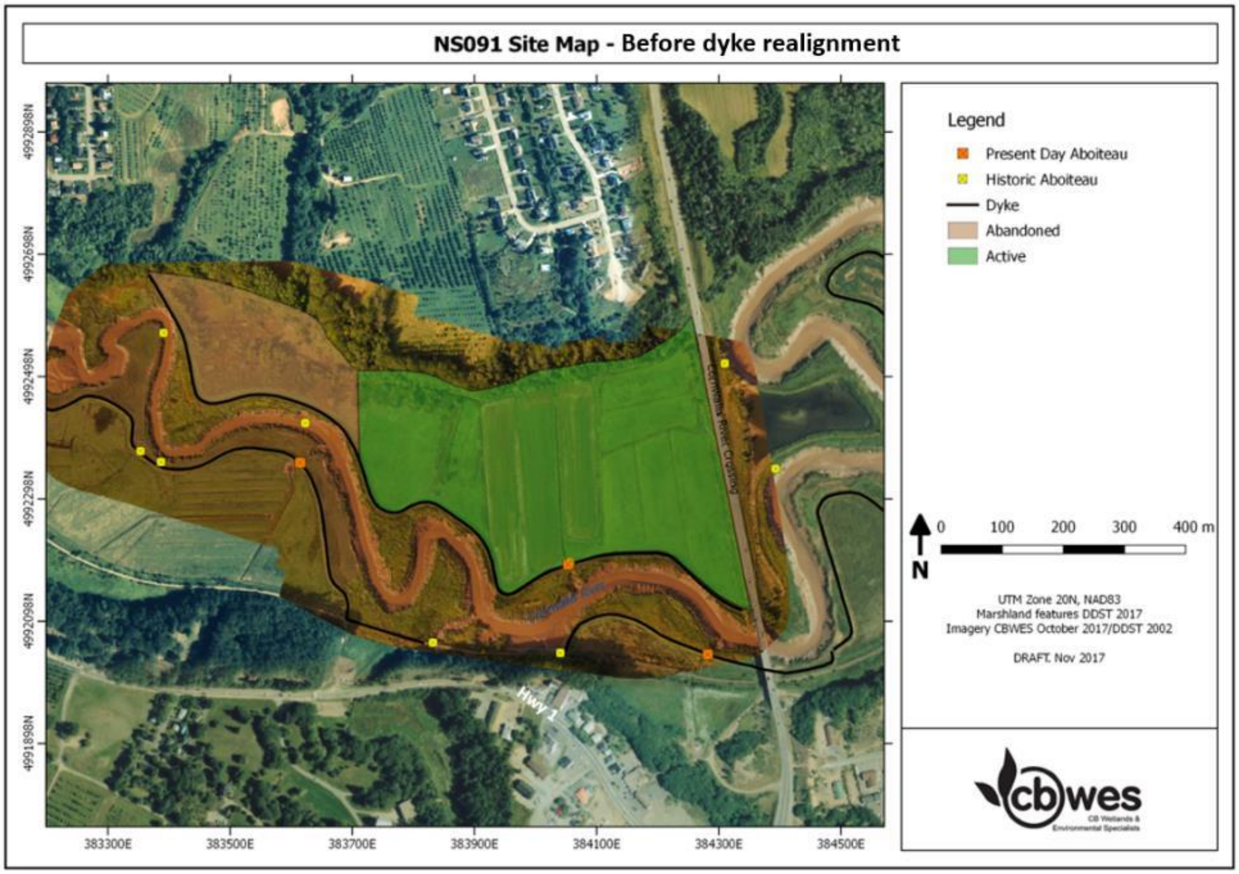

Figure 9. Project site pre-restoration. Tract 5 is shown by the black line along the north shore of the river. (CBWES, 2017)

The Belcher Street Marsh dyke realignment project has six goals (CBWES, 2017):

1. Address immediate erosion and dyke maintenance issues
2. Enhance the protection of intact agricultural land
3. Reduce the vulnerability of the dyke system and increase resiliency to climate change
4. Reduce ongoing dyke maintenance costs for NSDA
5. Restore river floodplain and wetland habitat
6. Contribute to broader ongoing efforts to reduce vulnerability and flood risk

Process

Dykes require on-going maintenance to ensure that are both strong enough and high enough to withstand the constant working of waves against the seawall, and protect the land behind them from the highest floods. With rising sea levels, dykes need to be higher. Raising a dyke also means increasing the width. With stronger storms that accompany climate change, the dykes will need to withstand more battering. The cost of dyke construction and maintenance increases. While raising a dyke is a typical response to keeping up with rising sea levels, it does not necessarily address the problem. At the Belcher Street Marsh, erosion at the foot of the dyke is the primary concern, and this cannot be addressed by raising the dykes.

The dykes along the Jijuktu'kwejk River protect agricultural land, as is the case at Belcher Street Marsh, and urban land that has developed on low land behind some of the dykes, just beyond the agricultural areas. To assess the risk to the urban land uses before implementing any adaptation approach, the Kings and Kentville municipalities needed to understand climate change hazards and vulnerabilities. In 2012, Kentville and Kings participated in a coastal flood risk mapping project, as a part of the Atlantic Climate Adaptation Solutions Association (ACASA) project. ACASA was the Atlantic Provinces program of Natural Resources Canada (NRCan) Regional Adaptation Collaboratives (Province of Nova Scotia, n.d.) and included the four provinces, municipalities, professional organizations, academic, and other partners (Province of Nova Scotia, n.d.). The mapping illustrated storm surge events for 1-in-25-year floods, with predicted sea levels for 2025 and 1-in-100-year floods with the expected increase in sea level by 2100. The mapping project did not include an increase in extreme weather intensity and frequency. The mapping projections suggested that by 2025, much of the coastline, including the tidal rivers by 2025 would experience significant river flooding impacting land uses in low-lying areas. The exercise also suggested that topping-up dykes would not be able to keep pace with sea-level rise. A combination of land use change and new approaches to dyke management were needed.

The Nova Scotia Department of Agriculture (NSDA) was also conducting vulnerability assessment of dykelands and dyke infrastructure (van Proosdij, *et. al.*, 2018). In Kentville, there was an immediate need to address erosion along sections of the dyke at Belcher Street Marsh. It was through the existing relationship between NSDA, Saint Mary's University, and CBWES that the Belcher Street Marsh project was initiated. The project became part of SMU-TransCoastal Adaptation's Making Room for Wetlands project funded by the federal Department and Fisheries and Oceans. Making Room for Wetlands is testing the hybrid nature-based adaptation approach of managed dyke realignment and tidal wetland restoration at sites around the Bay of Fundy.

Work began in 2017 with CBWES completing a feasibility and design study (CBWES & SMU, 2020). The study considered the environment, climate change, and possible long-term dyke maintenance and sustainability issues. Feasibility, Marsh Body consultation, and design are the first part of the project process, followed by baseline, implementation, and post-monitoring.

An initial site visit was carried out in October 2017 to collect baseline data for elevation, vegetation, land use, and dyke conditions, followed by pre-construction monitoring of the project area in the spring of 2018. The monitoring plan identified specific indicators to document changes over the post installation monitoring period. Indicators included soil conditions, vegetation, elevation, hydrology, and winter conditions.

A critical part of project planning is consultation with vested groups including rights-holders, property owners, and other groups with responsibility for, interests in or impacted by aspects of an undertaking. Under the *Agricultural Marshland Conservation Act*, any proposed alteration of marshland that is under the jurisdiction of the Marsh Body requires a consultation process and approval by two-thirds of the Marsh Body. In December 2017, a meeting was held at the Port Williams Community Hall to discuss possible alterations to the Belcher Street Marsh with the NS091 Belcher Street Marsh Body owners (CBWES, 2017). The Marsh Body approved restoration at the project site, allowing access to the site to begin the restoration work.

The municipalities of Kentville and Kings County were not involved in the consultation process because there is no legal obligation to include municipalities in decisions about agricultural dykelands. They are not marshland owners, nor do they have jurisdiction in the marine zone (below high watermark). Nevertheless, they are affected by the efficacy of dykes along the rivers that run through their communities. They also have responsibility for regulating land use including land use that might impact or be impacted by management of the dykes and dykelands.

Physical work on the project began in May 2018 and continued into June of that year (Bowron, *et al*., 2019). The first step was constructing an access road to the site. Once the access road was in place, the team began the work of constructing the new, realigned dyke, followed by straightening and heightening two small sections of existing dyke that were to remain after decommissioning the old dyke (Figures 10 and 11). Once construction was completed in June, the original dyke at Tract Five was decommissioned by levelling it to foreshore elevation. This allowed tidal waters to flood and restore 9.7 ha of tidal wetland (3.2 ha of foreshore and 6.5 ha of dykeland) (Stewardship Centre for BC, 2020). With the Tract 5 dyke straightened and moved landward, dyke realignment reduced total dyke length by 500 m. Around 1040 m of dyke was decommissioned, and 565 m of new dyke was constructed. The team also topped up 240 m of the original dyke.

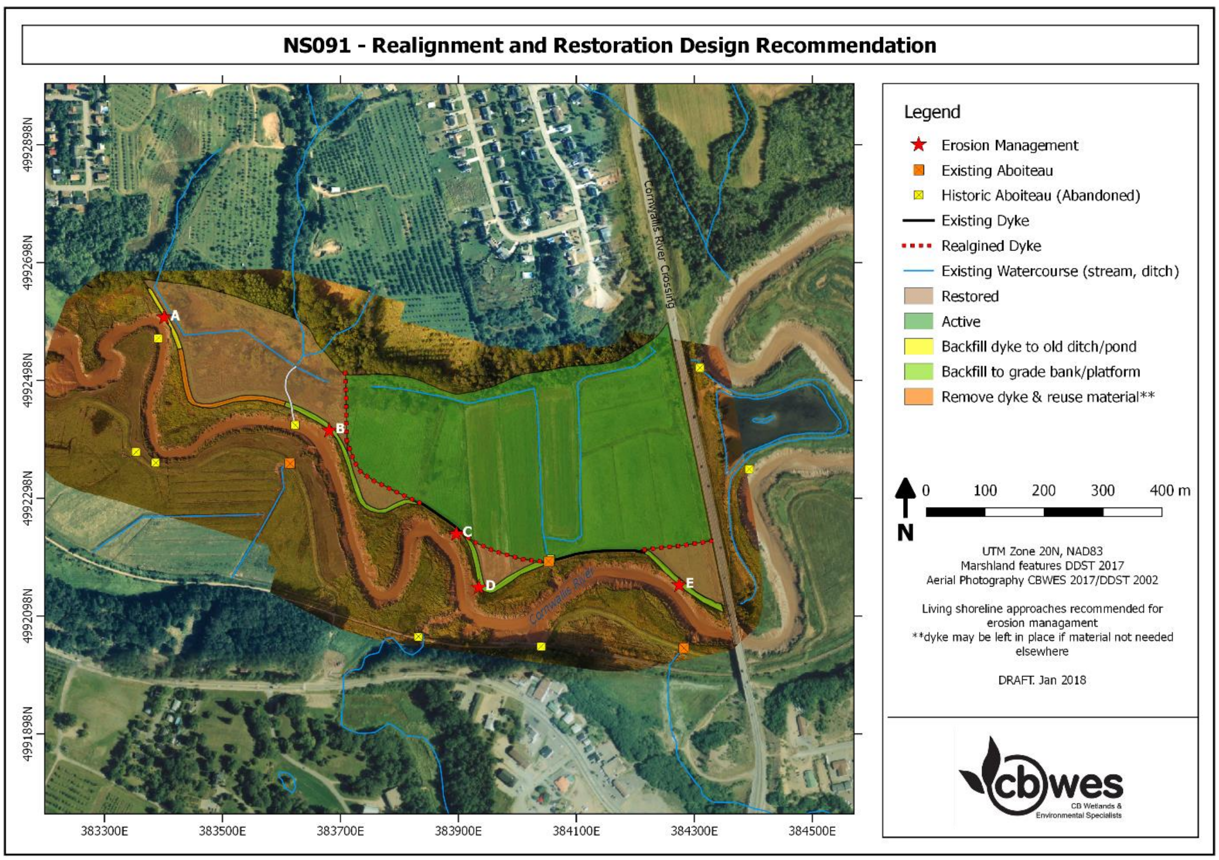

Figure 10. Belcher Street Marsh dyke realignment (dotted redline), remaining Tract 5 dyke sections (black lines) and decommissioned dyke sections (green lines)

Figure 11. Belcher Street Marsh managed realignment site. Pre-restoration (top left); immediate post-construction (top right); year one post-restoration (bottom left);
year two post-restoration (bottom right).

The team also installed a living shoreline on a section of the eroding riverbank that was close to the new dyke, implemented simultaneously with dyke construction. The living shoreline stabilizes the riverbank and reduces erosion while providing habitat. The living shoreline was a root wad revetment with native species plantings. Root wads are tree trunks with attached root systems (Figure 12). These root systems provide roughness that slows flow, prevents scour, and increases sediment deposition (Figure 13).

Figure 12: Root wad revetment at Belcher Street Marsh (CBWES & SMU, 2020)

Figure 13. Root wad revetment immediately post-construction in 2018 and year 3 post-construction in 2021

Immediately after breaching and the first flooding, the Belcher Street Marsh was in the *Transition* phase. During this period, the landscape naturally adjusts to new conditions. There is a large influx of water, new sediments are deposited, and new plants start to grow (Graham *et al*., 2018). The next phase is *Establishment.* During this phase, water will become less visible as plants become well-rooted (Graham *et al*., 2018). At the time of this case study reporting, the site was becoming established. Eventually, a tidal wetland and stable creek network will be established (Graham *et al*., 2018). This is called *Equilibrium.*

Monitoring is an essential component of project implementation. Monitoring shows how the environment responds to restoration and provides insight into areas that may require further intervention. Expectations are that the site will move through phases of evolution to a functioning tidal wetland. Monitoring follows the site's progress. Monitoring at the Belcher Street Marsh site will occur over six years, with one pre-year (completed) and five years of post-restoration monitoring.

Monitoring during 2019 showed that the environment was responding generally as expected. The flooded area transitioned from a mudflat into a vegetated wetland. The project site underwent erosion, deposition, vegetation dieback and growth cycles as the ecosystem works to become balanced. As a site adjusts to the reintroduction of tidal flooding and finds a new equilibrium, some areas may not respond as initially anticipated.
Post-restoration monitoring in summer 2019 identified two areas that were not recovering in the desired way. In one area, water was ponding near the toe of the dyke; in a second area near the root wad living shoreline, the elevation was lower than the surrounding marsh surface resulting in rill formation and scour from the concentration of surface flow and preferential drainage across the living shoreline. Both conditions posed a risk to the dyke's stability and to the recovery of the foreshore marsh.

Assessments for each area led to adaptive management actions to alleviate risk. Adaptive management techniques for this site included:

- hand-digging a channel (runnel) to connect the pond to the larger drainage network at the back of the site. The runnel reduced the amount of trapped water, which improved re-vegetation and soil stability (Figure 14). In 2021, monitoring showed that the ponded area was almost completely revegetated and almost indistinguishable from the surrounding marsh.

- actions to reduce the speed of water flowing across the living shoreline and to increase sediment buildup on the marsh surface. Small coniferous trees were used to fill gaps in the root wad revetment; and wattle fencing and brush mats were strategically placed across rills and in locations of scour to slow the flow of water. Wattle fences and brush were paired with transplanted marsh vegetation to enhance vegetation recovery. The adjustment has increased the elevation of the marsh surface behind the root wads (Figure 15) (Graham et al., 2020). As of 2021, some drainage is still occurring through a small channel across the root wads but the channel does not appear to be scouring or posing a risk to the root wad revetment or the recovery of the marsh and vegetation coverage is increasing.

Figure 14. Rill connecting ponded area to existing drainage network before (left) and after (right) adaptive management (Graham et al., 2020). Revegetation of former ponded area during 2021 monitoring (bottom).

Figure 15: Adaptive management at Belcher Street Marsh managed realignment site – scour around root wads (top left); adaptive management at root wads, 23 July 2019 (top right); sediment deposition behind root wads, 8 August 2019 (bottom left); adaptive management with wattle fences, transplants, and brush matting (bottom right). (Graham et al., 2020)

Project funding

The Belcher Street Marsh Dyke Realignment Project was funded by Nova Scotia Department of Agriculture and the federal Department of Fisheries and Oceans (DFO). NSDA provided funding for the feasibility and design study as well as the earthworks. The Department of Fisheries and Oceans provided funding through the Coastal Restoration Fund for the pre and post-project monitoring, including funding for Saint Mary's University (SMU) and CBWES. The Coastal Restoration Fund provides funding for projects that help to restore coastal aquatic habitats. Environment and Climate Change Canada provided additional funding through the National Wetland Conservation Fund. The Wetland Fund supports on-the-ground actions to restore and enhance Canadian wetlands.

Project Outcomes and Benefits

The Belcher Street Marsh dyke realignment and tidal wetland restoration project met six objectives and achieved the following:

1. A successful dyke realignment and salt marsh restoration initiative

2. Shortening the length of and thereby reducing maintenance needs for the Belcher Street Marsh dykes
3. Protecting the dyke from storm wave impacts/addressing dyke erosion with wetland buffering
4. Protecting productive agricultural lands and reducing the number of development assets susceptible to coastal hazards
5. Habitat creation
6. Nature-based recreation opportunities
7. Reconnecting people with the natural environment
8. Education and training
9. Provision of ecosystem services with the expansion of the tidal wetland

The new realigned dyke protects the active agricultural land behind it. The restored tidal wetland will increase natural absorption of wave energy during storms, thereby protecting the dyke. The expanded floodplain provides more room for floodwaters. The new marsh is now productive natural habitat supporting species diversity. The dykes overlooking the new marsh provide recreational opportunity for enjoying nature and connecting to the restored natural condition of the site. The site is a living laboratory and training site to develop skills in dykeland realignment and marshland restoration.

Lessons, Barriers, and Drivers

The Belcher Street Marsh Dyke Realignment and Tidal Wetland Restoration Project was a large-scale project and the first dyke realignment in Nova Scotia. Lessons will accrue over the course of project monitoring. The monitoring program already demonstrates the need for and value of careful baseline data collection and assessing the site as it evolves through ecological succession to a marsh. It has already demonstrated the need to be ready for adaptive management, necessary when converting or returning a managed site to a wild state.

Knowledge of climate change threats and the precarious state of the infrastructure motivated the project. Funding was available from three sources as well as in kind funding provided through university expertise and students. While the project was relatively large scale, the site was still small enough to manage. The smaller size meant it was easier to identify when processes were not moving as expected and to employ adaptive management quickly.

More involvement from local government might be welcome. Jurisdictional barriers around coastal environments create the environment where it is assumed that municipalities do not have a role although it is obvious from the land uses around the site and from earlier flooding impacts that the municipalities are stakeholders. Expanding the floodplain to make room for flood waters is important for their infrastructure as well as for agricultural lands. Engaging them as partners would potentially strengthen their resolve for better land use controls around the periphery of the site.

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