Highway 101 Twinning Three Mile Plains to Falmouth Environmental Assessment

Environmental Assessment Registration

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Table of Contents

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

Executive Summary

Nova Scotia Transportation and Infrastructure Renewal (NSTIR) proposes the twinning and upgrading of the existing two-lane section of Highway 101 from Trunk 14 (Exit 5) at Three Mile Plains to an area 2.5 km west of the Falmouth Connector (Exit 7) in Hants County, Nova Scotia (the Project). As part of the twinning Project, NSTIR is partnering with Nova Scotia Department of Agriculture (NSDA) to upgrade an existing tidal gate structure (aboiteau) on the Avon River at the Avon River causeway. The Project therefore involves the construction, operation and maintenance of approximately 9.5 km of two-lane controlled access highway to twin the existing Highway 101 and aboiteau upgrade at the Avon River. The Project will be jointly funded by the provincial and federal governments. Construction is expected to take place over five years and could be initiated in the fall of 2017. It is anticipated that the system will be maintained and remain in operation indefinitely.

Highway 101 is part of the National Highway Core System, and stretches approximately 300 km from the Highway 102 interchange in Bedford to Starrs Road in Yarmouth. It provides a vital link serving the Annapolis Valley area and provides connections to provincial entry points at ferry terminals in both Digby and Yarmouth. Due to safety and performance concerns during the past twenty years, NSTIR has been preparing plans to complete a four-lane controlled access highway from Bedford to the Coldbrook interchange west of Kentville, a distance of about 91 km. By separating eastbound and westbound travel lanes, the potential for head-on collisions is decreased significantly, thereby decreasing risk of injuries and fatalities associated with these types of accidents. Highway 101 has been twinned from Highway 102 in Bedford to Three Mile Plains, as well as an approximately 11 km section from west of Falmouth to meet the 3 km pre-existing section of divided highway at the Avonport Exit 9 interchange. This currently proposed twinning Project will represent completion of about 67 km of continuous four-lane divided highway between Bedford and Hortonville, increasing safety and comfort for motorists travelling on Highway 101.

This Project is subject to provincial regulatory approval under the Nova Scotia *Environment Act*. This Environmental Assessment (EA) has been prepared to satisfy requirements for registration of a Class I Undertaking under the Environmental Assessment Regulations (undertaking disrupts more than two hectares of any wetland).

NSTIR has met with provincial and federal regulatory agencies, local municipal governments and community representatives, and the general public about this current Project, dating back to 2001. Since this time, NSTIR has also engaged with the Kwilmu'kw Maw'klusuaqn Negotiation Office (KMNO), Millbrook First Nation, and Sipekne'katik First Nation to gain an understanding of Aboriginal issues and concerns and provide Project updates. In the fall of 2016, NSTIR initiated a community liaison committee (CLC) to facilitate ongoing Project communications with local stakeholders. The first meeting was convened on January 30, 2017.

The EA focuses on Valued Components (VCs) which are components of the biophysical and socio-economic environments that, if altered by the Project, may be of concern to regulatory agencies, the Mi'kmaq of Nova Scotia, scientists, and/or the general public. Eight VCs have been selected for this assessment to focus the EA on the most important Project-environment interactions, including:

- Atmospheric Environment
- Groundwater Resources
- Aquatic Environment
- Vegetation
- Wetlands
- Wildlife and Wildlife Habitat
- Land Use
- Archaeological and Heritage Resources

The assessment includes an evaluation of the potential Project-related environmental effects for construction, operation and maintenance, and accidents and malfunctions. Potential Project-related effects from Project construction include direct and indirect effects to the terrestrial and aquatic environments through loss or alteration of habitat and/or mortality of wildlife species including species of conservation concern. Construction activities may also restrict or change access to lands and resources used by the community members and the general public. Adverse effects related to Project operations and maintenance activities are less prominent due to the ongoing operation and maintenance of the current Highway 101.

In general, potential adverse effects on these VCs will be short term and/or highly localized and can be effectively mitigated through technically and economically feasible methods recommended in this report. Mitigation, including best management practices, site-specific measures, and habitat compensation have been proposed to reduce or eliminate potentially adverse effects for each VC. With respect to the mitigation of effects on fish and fish habitat and wetlands, compensation to offset predicted losses is proposed in accordance with the *Fisheries Act* and Nova Scotia Wetland Conservation Policy, respectively. A significant component of aboiteau design will include mitigation efforts to meet fish passage requirements.

Follow-up and monitoring programs have been proposed to collect additional baseline information prior to construction, observe and measure changes in the environment and/or confirm effectiveness of mitigation and compensatory habitat restoration.

With the implementation of the proposed mitigation (including compensation) and monitoring, no significant adverse residual environmental effects are predicted for most VCs due to routine Project construction or operation and maintenance activities. However, residual environmental effects of the construction of the Project on wetlands are predicted to be significant. Although compensation will be provided by NSTIR to achieve no net loss, the direct and indirect alterations to salt marsh habitat, which is recognized as a Wetland of Special Significance (WSS) under the provincial Wetland Conservation Policy, represents a significant effect. However, NSE is expected to authorize this alteration of a WSS because the construction of the highway and aboiteau will provide necessary public function and the proposed compensation restores more WSS at several nearby locations than affected by the Project (2:1 compensation).

The main purpose of a 100 series highway network in Nova Scotia is the safe, convenient and efficient movement of large volumes of people and goods over long distances at high speeds while reducing negative economic, social and environmental impacts. This Project will provide benefit to the local region as well as the Province of Nova Scotia as it will (1) improve the current safety performance and level of service along this stretch of Highway 101: (2) sustain other public and private links (rail, active transport , telecommunications, and power) that have developed on the Avon River causeway over the past 50 years; and (3) protect communities, infrastructure, and agricultural land from anticipated climate-related changes in sea level, precipitation and storm surge.

Abbreviations

AADT	average annual daily traffic
AC CDC	Atlantic Canada Conservation Data Centre
ACER	Acadia Centre for Estuarine Research
ARIA	Archaeological resource impact assessments
ASTM	American Society for Testing and Materials
AT	active transport
BBS	breeding bird survey
BMPs	best management practices
BoFEP	Bay of Fundy Ecosystem Partnership
CABIN	Canadian Aquatic Biomonitoring Network
CACs	criteria air contaminants
CAIT	Climate Analysis Indicators Tool
CCA	Canadian Construction Association
CCME	Canadian Council of Ministers of the Environment
CLC	community liaison committee
CMM	Confederation of Mainland Mi'kmaq
CO	carbon monoxide
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CRA	commercial, recreational, or Aboriginal
CWS	Canadian Wildlife Service
dB	decibels
dbh	diameter-at-breast-height
DEM	digital elevation model
DFO	Department of Fisheries and Oceans
EA	Environmental Assessment
ECCC	Environment and Climate Change Canada
ECM	environmental compliance monitoring
ECPs	environmental control plans
EEM	environmental effects monitoring
EGSPA	*Environmental Goals and Sustainable Prosperity Act*
EPP	environmental protection plan
ESC	erosion and sediment control

FHWA	Federal Highway Administration
FNA	Flora of North America
GHG	greenhouse gas
GPAC	Global Programme of Action Coalition
GPR	ground penetrating radar
GUDI	groundwater under the direct influence
HADD	harmful alteration, disruption or destruction
HMVK	hundred million vehicle kilometres
IBA	Important Bird Area
iBoF	inner Bay of Fundy
IRVM	Integrated Roadside Vegetation Maintenance
JWEL	Jacques Whitford Environment Limited
KMKNO	Kwilmu'kw Maw-klusagn Negotiation Office
mASL	m above sea level
MBCA	*Migratory Birds Convention Act*
MBWG	Minas Basin Working Group
MCG	Mi'kmaw Conservation Group
MEKS	Mi'kmaq Ecological Knowledge Study
MKS	Mi'kmaw Knowledge Study
MPS	Municipal Planning Strategy
NaCl	sodium chloride
NAPS	National Pollutant Surveillance Program
NO_2	nitrogen dioxide
NO_X	nitrogen oxide
NPA	*Navigation Protection Act*
NRCan	Natural Resources Canada
NS ESA	Nova Scotia *Endangered Species Act*
NSCCH	Nova Scotia Department of Communities, Culture and Heritage
NSDA	Nova Scotia Department of Agriculture
NSDNR	Nova Scotia Department of Natural Resources
NSE	Nova Scotia Environment
NSOAA	Nova Scotia Office of Aboriginal Affairs
NSTIR	Nova Scotia Transportation and Infrastructure Renewal
NSTPW	Nova Scotia Transportation and Public Works

NWWG	National Wetlands Working Group
O_3	ozone
PAHs	polycyclic aromatic hydrocarbons
PDA	Project Development Area
PDO	property damage only
PM	particulate matter
PM10	particulate matter less than 10 microns
$PM_{2.5}$	particulate matter less than 2.5 microns
POLs	Petroleum, oils, lubricants
RoW	right-of-way
RWIS	road weather information system
SANS	Snowmobilers Association of Nova Scotia
SAR	species at risk
SARA	*Species at Risk Act*
SMP	Salt Management Plan
SO_2	sulphur dioxide
SOCI	species of conservation interest
SOx	sulphur oxides
SPL	sound pressure levels
TAC	Transportation Association of Canada
TSP	total suspended particulate
US EIA	United States Energy Information Administration
US EPA	United States Environment Protection Agency
VC	Valued Component
VOCs	volatile organic compounds
vpd	vehicles per day
WC	watercourse
WHRC	Windsor and Hantsport Railway Company
WRI	World Resources Institute
WSS	Wetland of Special Significance

1.0 INTRODUCTION

Nova Scotia Transportation and Infrastructure Renewal (NSTIR) proposes the twinning and upgrading of the existing two-lane section of Highway 101 from Trunk 14 (Exit 5) at Three Mile Plains to an area 2.5 km west of the Falmouth Connector (Exit 7) in Hants County, Nova Scotia (the Project) (refer to Figure 1.1). As part of the twinning Project, NSTIR is partnering with Nova Scotia Department of Agriculture (NSDA) to upgrade an existing tidal gate structure (aboiteau) at the Avon River causeway along the route. This Project is subject to provincial regulatory approval under the Nova Scotia *Environment Act*. This Environmental Assessment (EA) has been prepared to satisfy requirements for registration of a Class I Undertaking under the Environmental Assessment Regulations.

The Project will be jointly funded by the provincial and federal governments. Construction is expected to take place over five years and could begin later in 2017. It is anticipated that the highway will be maintained and remain in operation indefinitely. A more detailed description of the Project components and activities is provided in Section 2.

1.1 PROJECT BACKGROUND

The Project represents the next stage of twinning of Highway 101, and extends from Exit 5 at Three Mile Plains to 2.5 km west of Exit 7 at Falmouth. The Project involves the construction, operation and maintenance of approximately 9.5 km of two-lane controlled access highway to twin the existing Highway 101 as well as auxiliary lanes connecting the existing interchanges. This section of the highway will be operated as a Controlled Access Freeway with a posted speed limit of 100+ km/hour. The Project consists of the following main components:

- 9.5 km of new twinned lanes
- modifications to four interchanges
- eight conventional bridge structures including road and railway overpasses
- eleven minor watercourse crossings (including a potential crossing by a realignment of Bog Road if required)
- widening and elevating of the causeway
- upgrading of the aboiteau structure

Construction is expected to take place over five years and could begin later in 2017. It is anticipated that the highway will be maintained and remain in operation indefinitely. A more detailed description of the Project components and activities is provided in Section 2.

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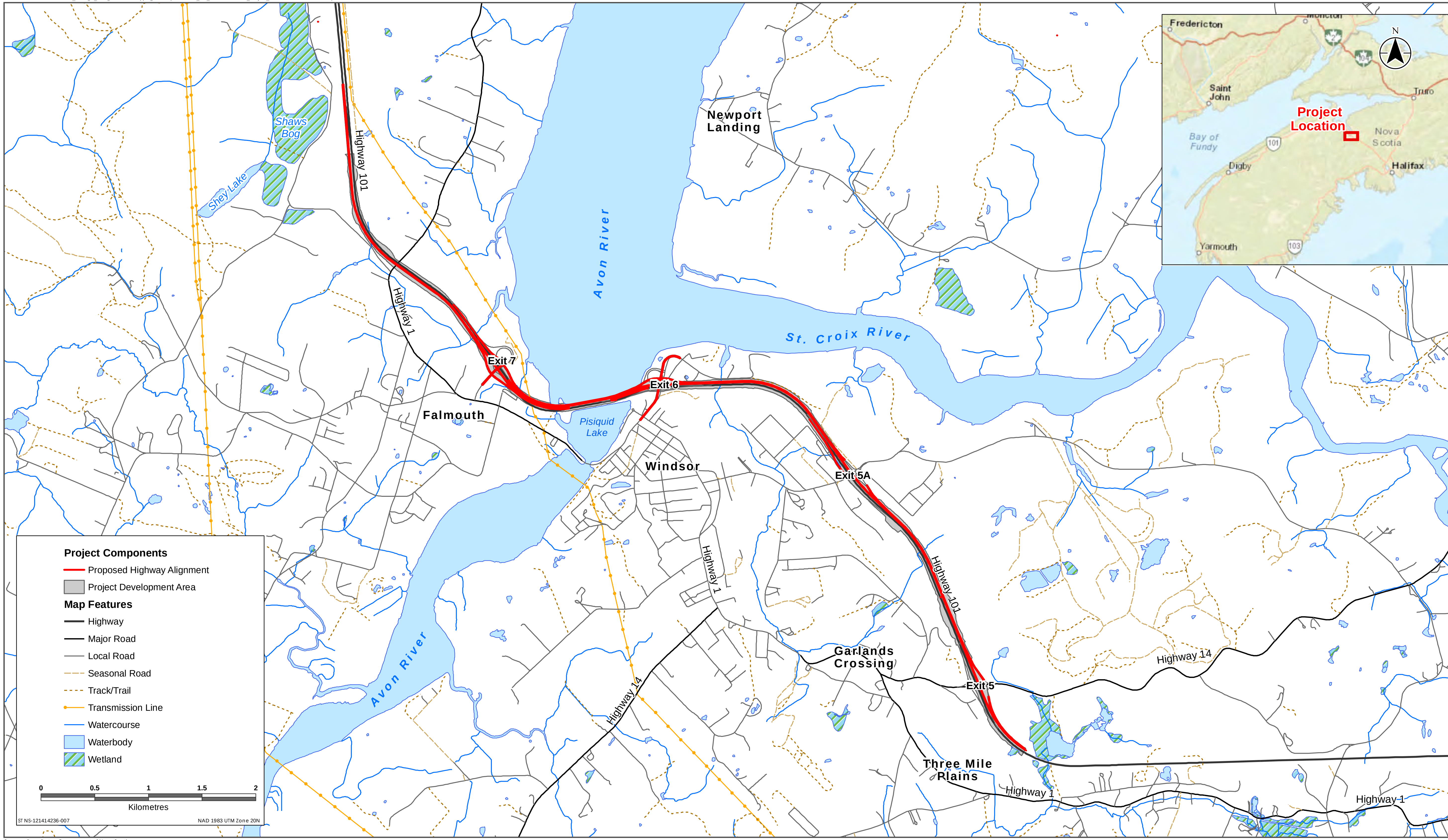

Sources: Base Data - Government of Nova Scotia

Disclaimer: This map is for illustrative purposes to support this Stantec project; questions can be directed to the issuing agency.

Project Location

Stantec

ENVIRONMENTAL ASSESSMENT, HIGHWAY 101 THREE MILE PLAINS TO FALMOUTH

Figure 1.1

An EA for the Project was initiated in 2007 when the Project was subject to federal and provincial EA processes under the superseded *Canadian Environmental Assessment Act* and provincial *Environment Act*. Field studies were conducted in 2007 and 2008 based on regulatory consultation at that time. This EA Registration is based on the studies undertaken in 2007 and 2008, with updated information as applicable where Project details and environmental conditions may have changed, including 2016 field survey results and public engagement activities associated with the formation of a community liaison committee (CLC).

1.2 PURPOSE AND NEED FOR THE UNDERTAKING

The main purpose of a 100 series highway network in Nova Scotia is the safe, convenient and efficient movement of large volumes of people and goods over long distances at high speeds while minimizing negative economic, social and environmental impacts.

Highway 101 is part of the National Highway Core System, and stretches approximately 300 km from the Highway 102 interchange in Bedford to Starrs Road in Yarmouth. It provides a vital link serving the Annapolis Valley area and provides connections to provincial entry points at ferry terminals in both Digby and Yarmouth.

Due to safety and performance concerns during the past twenty years, NSTIR has been preparing plans to complete a four-lane controlled access highway from Bedford to the Coldbrook interchange west of Kentville, a distance of about 91 km. By separating eastbound and westbound travel lanes, the potential for head-on collisions is decreased significantly, thereby decreasing risk of injuries and fatalities associated with these types of accidents. Over the past 10 to 15 years, Highway 101 has been twinned from Highway 102 in Bedford to Three Mile Plains, as well as an approximately 11 km section from west of Falmouth to meet the 3 km pre-existing section of divided highway near the Avonport Exit 9 interchange and Gaspereau River crossing.

The 9.5 km segment of Highway 101 between Three Mile Plains and Falmouth remains the only two-lane undivided segment in what is otherwise a continuous 67 km long four-lane divided highway from Bedford to west of Avonport (Hortonville, Exit 10).

The existing section of highway from Three Mile Plains to Falmouth has an average annual daily traffic (AADT) of approximately 14,250 vehicles per day (vpd), well above the traditional 10,000 vpd trigger for highway twinning.

The relative safety of a section of highway is evaluated by comparing assessment area collision rates to the average collisions rates for all similar highways in the Province. Collision rates are expressed as number of collisions per hundred million vehicle kilometres (HMVK). NSTIR periodically publishes collision statistics that include five-year average collision rates by severity and highway class. Motor Vehicle Collision Rates for Numbered Highways and Sections 2010 to 2014 (NSTIR 2016) indicates that the five-year average collision rate for all '100 Series Full Access Control' highways in Nova Scotia is 52.4 collisions per HMVK.

The five year 2010 to 2014 collision rates for the three Highway 101 sections in the assessment area, as well as the combined rates for the three sections, are included in Table 1.2.1. The overall five-year average collision rate is 34.8 collisions per HMVK.

As shown in Table 1.2.1, 56 collisions were recorded for the relevant section of Highway 101 assessed during the five-year period, including 38 property damage only (PDO) collisions, 16 injury collisions and 2 fatal collisions.

Table 1.2.1 Number of Collisions and Collision Rates for Each Highway Section - 2010 to 2014

Year	AADT	HMVK [1]	Number of Collisions				Collision Rates [3]			
			PDO [2]	Injury	Fatal	Total	PDO	Injury	Fatal	Total
Highway 101 Section 060 (Trunk 14 - Exit 5 to Wentworth Road - Exit 5A; 2.33 km)										
2010	15,060	0.1281	2	3	0	5	15.6	23.4	0.0	39.0
2011	15,030	0.1278	2	1	0	3	15.6	7.8	0.0	23.5
2012	14,220	0.1209	4	0	0	4	33.1	0.0	0.0	33.1
2013	13,430	0.1142	6	1	0	7	52.5	8.8	0.0	61.3
2014	14,680	0.1248	1	2	0	3	8.0	16.0	0.0	24.0
Totals / Averages		0.6159	15	7	0	22	24.4	11.4	0.0	35.7
Highway 101 Section 065 (Wentworth Road - Exit 5A to Nesbitt Street - Exit 6; 2.13 km)										
2010	14,150	0.1100	7	0	1	8	63.6	0	9.1	72.7
2011	14,660	0.1140	2	2	0	4	17.5	17.5	0.0	35.1
2012	14,660	0.1140	1	3	0	4	8.8	26.3	0.0	35.1
2013	13,360	0.1039	1	0	0	1	9.6	0	0.0	9.6
2014	14,760	0.1148	2	0	0	2	17.4	0	0.0	17.4
Totals / Averages		0.5566	13	5	1	19	23.4	9.0	1.8	34.1
Highway 101 Section 070 (Nesbitt Street - Exit 6 to Falmouth Connector - Exit 7; 1.71 km)										
2010	13,720	0.0856	1	1	0	2	11.7	11.7	0.0	23.4
2011	14,620	0.0913	3	0	0	3	32.9	0.0	0.0	32.9
2012	13,630	0.0851	4	1	0	5	47.0	11.8	0.0	58.8
2013	13,420	0.0838	2	0	1	3	23.9	0.0	11.9	35.8
2014	14,410	0.0899	0	2	0	2	0	22.2	0.0	22.2
Totals / Averages		0.4357	10	4	1	15	23.0	9.2	2.3	34.4
Combined Highway 101 Sections 060 to 070 (Trunk 14 – Exit 5 to Falmouth Connector – Exit 7)										
Totals / Averages		1.6082	38	16	2	56	23.6	9.9	1.2	34.8

NOTES:
1. 'HMVK' = Hundred Million Vehicle Kilometers
2. 'PDO' = Property Damage Only

Table 1.2.1 Number of Collisions and Collision Rates for Each Highway Section - 2010 to 2014

Year	AADT	HMVK [1]	Number of Collisions				Collision Rates [3]			
			PDO [2]	Injury	Fatal	Total	PDO	Injury	Fatal	Total
3. Collision rates are 'number of collisions per HMVK'										

Source: *Nova Scotia Motor Vehicle Collision Rates on Numbered Highways 2000 to 2004*; NSTIR

A key purpose and need for the Project is therefore to improve the current level of service and safety performance of the section of highway between Three Mile Plains and Falmouth.

Another key purpose of the Project is to upgrade the current aboiteau at the Avon River in Windsor. A section of the existing highway crosses a causeway and aboiteau (sluice) at the Avon River in Windsor. The causeway and aboiteau act as a dyke and sluice system for agricultural purposes and protect the communities of Windsor and Falmouth from flooding. The aboiteau structure is nearing the end of its design life but will also need to be upgraded to accommodate the highway twinning as well as climate change and fish passage. A portion of Highway 101 at the Avon River causeway, approximately 1,618 ha of protected agricultural marshlands, portions of Windsor and Falmouth, and considerable other public and private infrastructure are already known to be at risk from high storm surges and rising sea levels (van Proosdij 2009, 2013). This Project is therefore also considered a key component of Nova Scotia's plan for climate change adaptation as modification of the dyke/road system is required to protect these assets. Sea levels in the Bay of Fundy, which already has some of the highest tides in the world, are predicted to rise up to 1.93 m over existing levels by 2100 (Webster *et al.* 2011). A recent climate change vulnerability assessment for the Town of Windsor (van Proosdij 2013) and the West Hants Municipal Climate Change Action Plan (Municipality of the District of West Hants 2013) acknowledged the risks associated with sea level rise and storm surges and identified opportunities to help mitigate against these effects. One of the identified opportunities involved improvements to aboiteau drainage capabilities and elevation of the roadbed during twinning of Highway 101 (van Proosdij 2013).

The causeway provides several other benefits including serving as a base for the Windsor & Hantsport Railway (WHRC; operations currently suspended), as well as providing an active transportation (AT) trail for local residents, and planned portions of the provincial *Blue Route* cycling network (Blue Route 2017) and the Trans Canada Trail (Nova Scotia Heath Promotion and Protection 2010).The causeway has created a freshwater reservoir, known as Lake Pisaquid (*aka* Pesaquid), which is part of the landscape of the Town of Windsor and is also used for sport and recreational purposes. Ski Martock also uses the lake to draw water for its snowmaking equipment during the winter ski season. The causeway also provides network linkages for telecommunication and power cables.

The causeway created the conditions for the development of a large salt marsh immediately north of the causeway and the nascent "Newport Marsh" developing on the intertidal bar to the north of the Windsor Marsh. This marsh system is designated as an internationally-significant wetland under the Ramsar Convention (Southern Bight-Minas Basin; Ramsar Sites Information Service 2001), and is part of globally and nationally-significant habitat for birds (Important Bird Area [IBA] of Canada, Southern Bight, Minas Basin, IBA Canada Undated) and the Western Hemisphere Shorebird Reserve Network (Western Hemisphere Shorebird Reserve Network 2009).

In summary, the Project is a priority for the Province of Nova Scotia for the following reasons:

- It will increase safety and comfort for motorists traveling on Highway 101.
- It will protect valuable farmland, communities and critical infrastructure behind the Avon River causeway from storm surges and rising sea level.
- It will upgrade a reduced speed (90 km/h zone) and often congested section at the Avon River causeway to a Controlled Access Freeway Classification with a posted speed limit of 100+km/hour.
- It will complete about 67 km of continuous four-lane divided highway representing about 75% of the Bedford to Coldbrook section of 100 series highway network.
- It will sustain and enhance sport/recreational use, tourism and the adjacent salt marshes.

1.3 IDENTIFICATION OF THE PROPONENT

Name of Undertaking:	Highway 101 Twinning Three Mile Plains to Falmouth
Name of Proponent:	Nova Scotia Transportation and Infrastructure Renewal
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Proponent Executive

Name:	Ms. Bonnie Miles-Dunn
Official Title:	Acting Director, Highway Engineering and Capital Programs

Signature **Date** April 27/17

1.4 REGULATORY CONTEXT

The Project will require environmental assessment in accordance with the provincial *Environmental Assessment Regulations* made pursuant to *the Environment Act*. The Project will be subject to the requirements associated with a Class I registration under the *Environment Assessment Regulations* since it is predicted to "disrupt a total of 2 ha or more of any wetland". A summary of key provincial legislation relevant to the Project is provided below in Table 1.4.1.

Table 1.4.1 Key Provincial Legislation Relevant to the Environmental Assessment

Legislation	Regulating Authority	Relevance
Environment Act and Associated Regulations	Nova Scotia Environment (NSE)	The Project will require EA approval in accordance with the *Environmental Assessment Regulations*. In addition to EA approval, the Project will require other approvals under the *Activities Designation Regulations* of the Act, including Water Approvals to authorize alterations to wetlands and watercourses. Approvals under the *Activities Designation Regulations* are granted by NSE. *Air Quality Regulations* under the Act specify ambient air quality maximum permissible ground level concentrations.
Environmental Goals and Sustainable Prosperity Act (*EGSPA*)	NSE	In 2007, *EGSPA* established specific goals associated with air quality, water quality, renewable energy, ecosystem protection, contaminated sites, solid waste reduction, sustainable purchasing, and energy efficiency building. In particular, goals associated with climate change and air quality improvements (*e.g.*, reduction of greenhouse gas emissions to at least 10% below 1990 levels) and ecosystem protection (*e.g.*, prevention of net loss of wetlands) have implications for Project design and mitigation.
Nova Scotia *Endangered Species Act* (NS *ESA*)	Nova Scotia Department of Natural Resources (NSDNR)	NS *ESA* provides for the protection, designation, recovery and other relevant aspects of conservation of species at risk in the Province, including habitat protection. The Act prohibits killing or disturbing endangered or threatened species, destroying or disturbing its residence (habitat) and destroying or disturbing core habitat. Species assessed by the NS Species at Risk Working Group as endangered threatened, or vulnerable are listed under the NS *ESA* are legally protected.
Special Places Protection Act	Nova Scotia Department of Communities, Culture and Heritage (NSCCH)	This Act provides for the preservation, protection, regulation, exploration, excavation, acquisition and study of archaeological and historical remains and paleontological sites, which are considered important parts of the natural or human heritage of the Province.
Agricultural Marshland Conservation Act	Nova Scotia Department of Agriculture (NSDA)	This Act focuses on conserving the current level of dykelands and limits non-agricultural development on dyked marshlands.

Other provincial regulations, policies and guidelines are discussed throughout this report, where relevant.

The Project is not a designated physical activity under the *Regulations Designating Physical Activities* of the *Canadian Environmental Assessment Act*, 2012 (CEAA 2012), therefore there is no requirement to conduct a federal EA under CEAA 2012.

It is likely that an authorization under Section 35(2)(b) of the *Fisheries Act* will be required for "serious harm" to fish as a result of the infilling of salt marsh habitat that will occur as part of the Avon River causeway. However, since this Project does not occur on federal crown lands, a determination under Section 67 of CEAA 2012 will not be required before DFO exercises their authority under the *Fisheries Act* to grant such an authorization. Therefore, no federal EA is required for the Project.

Transport Canada has determined that authorization under the *Navigation Protection Act* (NPA) will not be required for this Project.

Key federal environmental legislation that applies to the Project is summarized in Table 1.4.2.

Table 1.4.2 Key Federal Legislation Relevant to the Environmental Assessment

Legislation	Regulating Authority	Relevance
Canadian Environmental Protection Act, 1999 (CEPA 1999)	Environment Canada (EC)	CEPA 1999 pertains to pollution prevention and the protection of the environment and human health in order to contribute to sustainable development. Among other items, *CEPA 1999* provides a wide range of tools to manage toxic substances, and other pollution and wastes.
Fisheries Act	Department of Fisheries and Oceans (DFO) EC (administers Section 36, specifically)	The *Fisheries Act* contains provisions for the protection of fish, shellfish, crustaceans, marine mammals and their habitats. Under the *Fisheries Act*, Section 35, no person shall carry on any work, undertaking, or activity that results in serious harm to fish that are part of a commercial, recreational, or Aboriginal (CRA) fishery, or to fish that support such a fishery, unless this activity has been authorized by the Minister of Fisheries and Oceans. Section 36 of the *Fisheries Act* pertains to the prohibition of the deposition of a deleterious substance into waters frequented by fish. Section 20 of the *Fisheries Act* pertains to watercourse crossing designs and provision of fish passage, regulating designs that provide the free passage of fish without harm and maintain a flow of water sufficient to allow the free passage of fish. The Government of Canada is currently undertaking a review of environmental and regulatory processes, including restoring lost protection and introducing modern safeguards to the *Fisheries Act*.
Migratory Birds Convention Act, 1994 (MBCA)	EC	Under the MBCA, it is illegal to kill migratory bird species not listed as game birds or destroy their eggs or young. The Act also prohibits the deposit of oil, oil wastes or any other substance

Table 1.4.2 Key Federal Legislation Relevant to the Environmental Assessment

Legislation	Regulating Authority	Relevance
		harmful to migratory birds in any waters or any area frequented by migratory birds.
Species at Risk Act (SARA)	DFO/EC/Parks Canada	SARA is intended to protect species at risk in Canada and their "critical habitat" (as defined by *SARA*). The main provisions of the Act are scientific assessment and listing of species, species recovery, protection of critical habitat, compensation, permits and enforcement. The Act also provides for development of official recovery plans for species found to be most at risk, and management plans for species of special concern. Under the Act, proponents are required to complete an assessment of the environment and demonstrate that no harm will occur to listed species, their residences or critical habitat or identify adverse effects on specific listed wildlife species and their critical habitat, followed by the identification of mitigation measures to avoid or minimize effects. All activities must be in compliance with SARA. Section 32 of the Act provides a complete list of prohibitions.

Since February 23, 2007, a tri-partite forum consisting of Mi'kmaq, Nova Scotian and Canadian governments has dealt with environmental, economic and social issues related to Aboriginal and Treaty rights in Nova Scotia (see http://novascotia.ca/abor/office/ for further details on the "Made in Nova Scotia Process"). The Nova Scotia Office of Aboriginal Affairs (NSOAA) helps ensure resolution of issues via effective negotiation, consultation, collaboration, and public education. NSTIR has been working with the NSOAA, nearby First Nations Communities, and the Confederation of Mainland Mi'kmaq (CMM) for over a decade on this project and its environmental assessment.

1.5 PROPERTY OWNERSHIP

The majority of land required for the Project is already owned by the Province of Nova Scotia. There may be a requirement to obtain additional right-of-way (RoW) lands in the vicinity of Exit 5 and Exit 7 to allow for lane realignment. Property acquisition is ongoing.

2.0 PROJECT DESCRIPTION

2.1 OVERVIEW OF THE PROJECT

Highway 101 is part of the National Highway System and extends from Bedford to Yarmouth. It is currently twinned from Bedford to Three Mile Plains, and from Falmouth to Avonport; the remainder of the highway is two lanes.

The proposed new lanes will parallel the existing highway on the north side from the end of the twinning east of Exit 5 and will cross over to the south side at Exit 7 to connect with the existing twinning 2 km west of Exit 7. From Exit 5 west through Exit 7 and over Trunk 1, the median will be a cable barrier design. This was chosen to maintain sight lines while allowing for a narrower right-of-way (RoW) width to accommodate property constraints and reduce environmental impact. Through the horizontal curve west of Trunk 1, the RoW will widen to a standard wide median to match into the existing twinning in the area.

The tidal gate structure (aboiteau) in place at the Avon River causeway that protects approximately 1,618 ha of farmlands, several communities and other infrastructure will be upgraded as part of this Project. This new structure will have provisions for fish passage as required by Section 20 of the *Fisheries Act* and may include automatic as well as mechanical operation of tidal gates.

The highway will be realigned at the causeway, to the north of the aboiteau. This change in alignment will improve the geometry of the highway approaching from the east and west along with the addition of auxiliary lanes which will improve the operation of interchange ramps at Exit 6 and Exit 7. This will result in four lanes being added to the existing two lanes across the causeway. The raised elevation of the roadbed will significantly lessen the probability of storm surges and higher sea levels from overtopping the dyke system and flooding farmland, communities and other vulnerable infrastructure.

Underpasses will be replaced and overpasses will be twinned to accommodate the new lanes. The roadbed of the causeway will be expanded to accommodate new lanes. Existing culverts will be extended to accommodate the new lanes.

Parallel to the EA process, NSTIR and NSDA will proceed with a detailed topographic survey, geometric design, detailed design of an upgraded aboiteau and causeway, acquisition of the remaining portions of the RoW, and more detailed environmental design and permitting for watercourse and wetland crossings. Assuming the Project is released from the EA approval process, construction could start later in 2017 and be completed in approximately five years. It is anticipated that the system will be maintained and remain in operation indefinitely.

2.2 PROJECT COMPONENTS

Project components include:

- roadway
- interchanges and grade separated structures
- watercourse crossings
- causeway
- aboiteau upgrading and associated facilities
- access roads
- existing road modifications
- temporary ancillary elements.

2.2.1 Roadway

The existing section of Highway 101 between Three Mile Plains and Falmouth is constructed to a Major Arterial standard with posted speeds varying from 90 to 100 km/hr. When the new lanes are built for the twinning, the highway will be upgraded to a controlled access Freeway classification with a posted speed of 100+ km/hour. Controlled access designation requires that access only be permitted by grade-separated interchanges, which are designed so that vehicles using the interchange ramps have minimal effect on the traffic using the freeway.

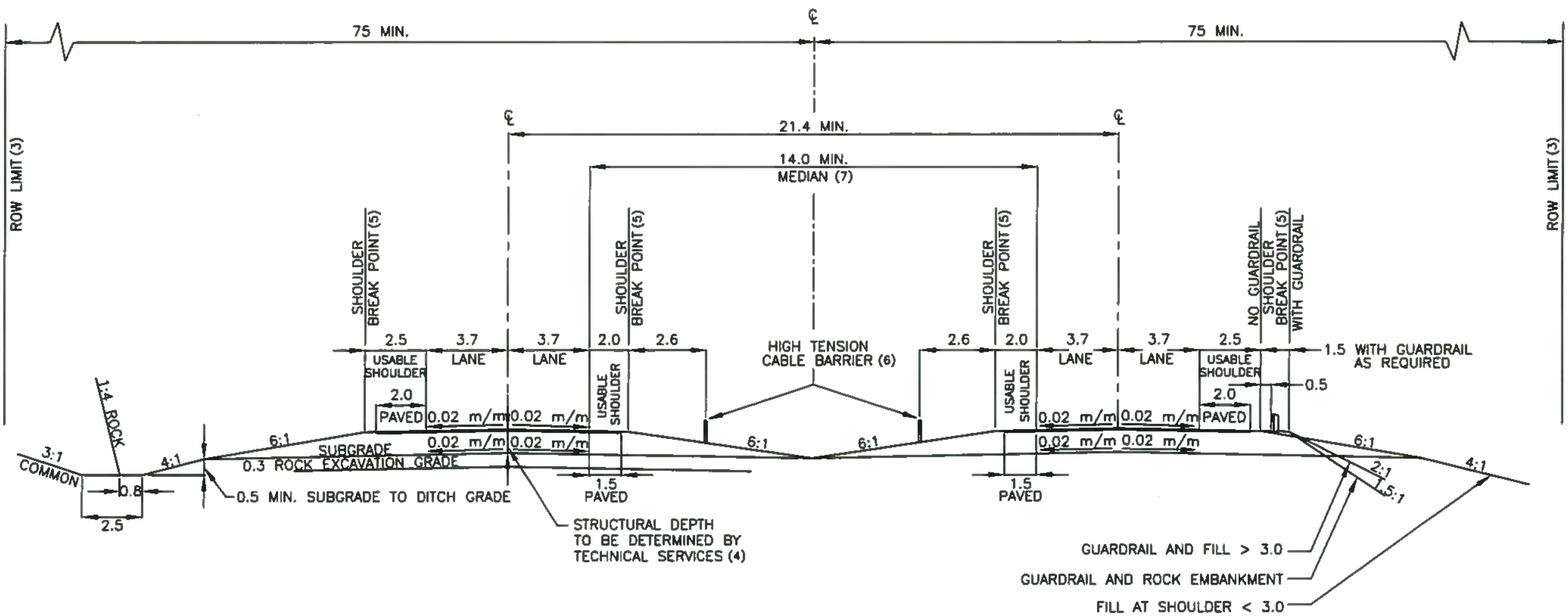
From Exit 5 west through Exit 7 and over Trunk 1 the median between the original lanes and the new twinned lanes is planned to be a freeway cable barrier design (14.0 m, see Figure 2.1). Through the curve west of Trunk 1 (in the vicinity of Exit 7), the highway will widen to a freeway open (22.6 m) vegetated median to match into the existing twinning in the area (refer to Figure 2.2).

Some areas of the existing highway will be reconstructed during this Project. The curve at the west end of the causeway will be rebuilt to meet provincial standards for horizontal geometry. This will allow a consistent speed limit for the Project. In the area of the causeway and near Trunk 14 the existing lanes will be rebuilt at a higher grade. Raising these lanes is needed to meet the requirements for sea level rise, structural clearance and to minimize cut in karst geology (refer to Section 2.4). Final grades are to be determined through the design process.

2.2.2 Interchanges and Grade Separation Structures

All existing interchanges along Highway 101 will be maintained however some changes are necessary to accommodate the new lanes. The Project includes four interchanges (Figure 1.1) and will require construction or modification of grade separation structures at Exits 5, 5A, 6 and 7, as well as two railway locations and Trunk 1, along the alignment. Additional overpass structures will be constructed on the twinning alignment at Exit 5, Exit 5A, railroad locations west of Exit 5A and Exit 7, and at Trunk 1 west of Exit 7. A new underpass structure and new interchange lanes will be required at Exit 6 and the underpass structure at Exit 7 will be modified and new interchange lanes added. The Exit 6 and Exit 7 interchanges will be reconstructed to provide typical “diamond” type interchanges prevalent throughout the Province. The eastbound exit ramp to Wentworth Road at Exit 5A will be reconstructed to provide a diamond ramp to improve safety and operational efficiency.

Figure 2.1



NOTES:

1. ALL DIMENSIONS ARE IN METRES UNLESS OTHERWISE NOTED.
2. DIMENSIONS ARE MEASURED PERPENDICULAR TO CENTERLINE.
3. TO BE ADJUSTED TO ALLOW FOR MINIMUM OF 5.0m BEYOND DAYLIGHT LOCATION OR EXCEPTIONALLY 3.0m MAY BE ACCEPTABLE.
4. THE SUBGRADE WIDTH IS DEPENDENT UPON THE DEPTH OF STRUCTURAL MATERIAL.
5. 0.8m ROUNDING CENTERED ON SHOULDER BREAK POINT IF GUARDRAIL NOT INSTALLED.
6. PLACEMENT OF BARRIER TO BE DETERMINED BASED ON HORIZONTAL GEOMETRY.
7. INSTALL ROUNDED DEPRESSION OR SWALE WITH DRAINAGE TREATMENT AS REQUIRED IN MEDIAN.
8. CABLE BARRIER TO BE BRIFEN SYSTEM MEETING TL-4 OR APPROVED EQUIVALENT.

Manager Highway Planning and Design

Director Highway Engineering Services

Executive Director Highway Engineering and Construction

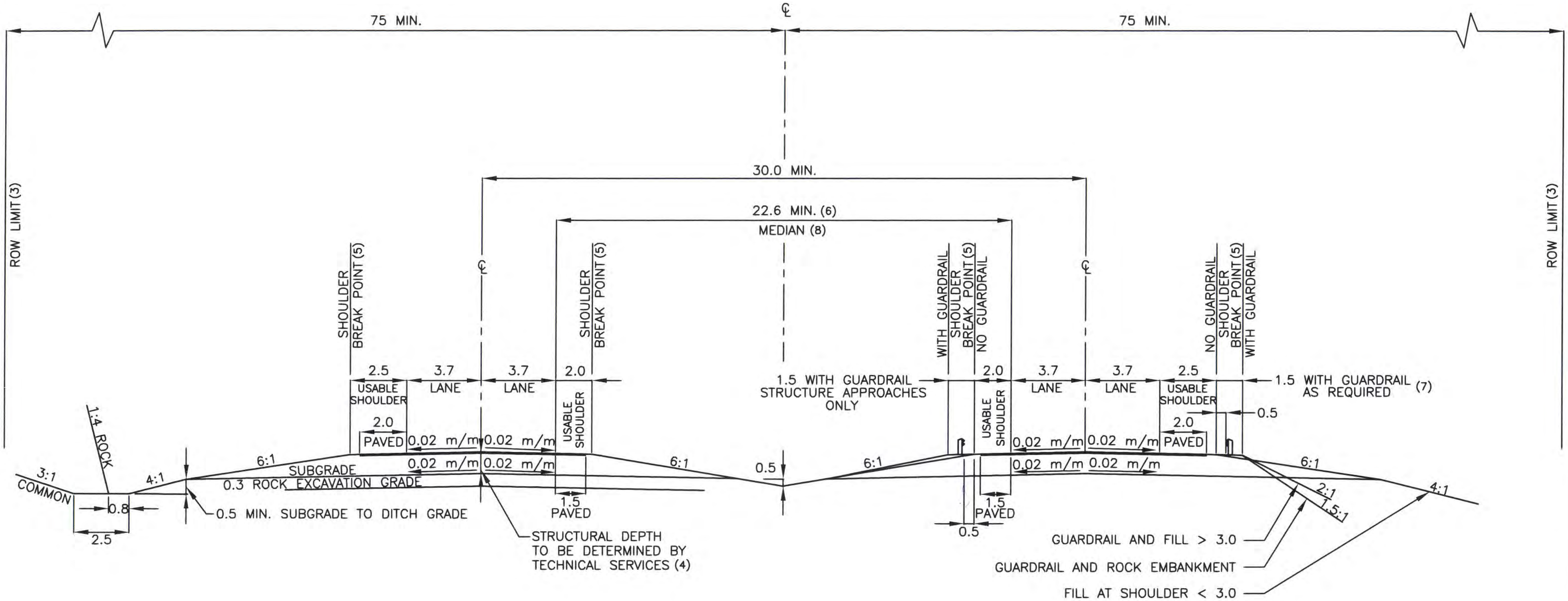
NOVA SCOTIA
Transportation and Infrastructure Renewal

No.	REVISION

Scale : N.T.S.
Drawn by : G.WRIGHT
Checked by : K.BODDY
Date of Plan : SEPT2014
File No. : S-2014-029

STANDARD CROSS SECTION
FREEWAY CABLE BARRIER MEDIAN (A)

Figure 2.2



NOTES:
1. ALL DIMENSIONS ARE IN METRES UNLESS OTHERWISE NOTED.
2. DIMENSIONS ARE MEASURED PERPENDICULAR TO CENTERLINE.
3. TO BE ADJUSTED TO ALLOW FOR MINIMUM OF 5.0m BEYOND DAYLIGHT LOCATION OR EXCEPTIONALLY 3.0m MAY BE ACCEPTABLE.
4. THE SUBGRADE WIDTH IS DEPENDENT UPON THE DEPTH OF STRUCTURAL MATERIAL.
5. 0.8m ROUNDING CENTERED ON SHOULDER BREAK POINT IF GUARDRAIL NOT INSTALLED.
6. APPLICABLE TO SOME TWINNING PROJECTS. WIDER MEDIANS SHOULD BE CONSIDERED FOR GREENFIELD ALIGNMENTS, THROUGH SIDE HILL AREAS, ON CURVES, ETC.
7. IF GUARDRAIL IS INSTALLED THE SIDE SLOPE OF THE STRUCTURAL MATERIAL WILL VARY.
8. INSTALL ROUNDED DEPRESSION OR SWALE WITH DRAINAGE TREATMENT AS REQUIRED IN MEDIAN.

Manager Highway Planning and Design

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NOVA SCOTIA
Transportation and Infrastructure Renewal

No.	REVISION

Scale :	N.T.S.
Drawn by :	G.WRIGHT
Checked by :	K.BODDY
Date of Plan :	NOV–2015
File No. :	S–2015–003

STANDARD CROSS SECTION FREEWAY OPEN MEDIAN (A)

2.2.3 Watercourse Crossings

The causeway at the Avon River will be widened and elevated in conjunction with upgrading of the aboiteau; therefore, a bridge structure is not required at this location. Other watercourse crossing structures will be minor structures or culverts. Adequate hydraulic design considering both present day and future hydraulic conditions will be carried out for new structures. Several existing culverts in nearby roadways and access ramps require consideration during detailed highway design. If these culverts require removal or the drainage pattern is altered considerably, adequate provisions will be made for local drainage by installing additional culverts.

Culverts along the existing highway will require culvert extensions to accommodate the new lanes. Culvert extensions will be conducted as per the criteria presented in Conrad and Jansen (1994), or updates. If a realignment of Bog Road is required, a replacement watercourse crossing will be required. Section 2.3.1.3 contains additional information on watercourse crossing construction.

2.2.4 Causeway

The Project will include an adjusted alignment to cross the Avon River. The existing causeway will be expanded to six lanes. The six-lane configuration is necessary to accommodate safe interchanges for Exit 6 and Exit 7. The new roadway will be designed to be at a higher elevation (approximately 1 m higher) than the existing causeway to account for climate change effects such as sea level rise and storm surges (actual height to be determined as part of detailed design; an RFP is currently under development for public release in Spring 2017).

2.2.5 Aboiteau

A section of the existing highway currently crosses a causeway and aboiteau at the Avon River in Windsor. The current aboiteau, which is owned and operated by the NSDA incorporates two gates (approximately 4.5 m x 6 m) which are automated and monitored by personnel to regulate water levels in Lake Pisiquid. This aboiteau acts as a dyke and sluice system for agricultural purposes and provides flood control for the Town of Windsor, the village of Falmouth and Municipality of West Hants. An upgrade of the aboiteau structure is required as part of the Project, as the current structure is reaching the end of its design-life and is not large enough to accommodate the new lanes and future fresh water flows.

The design and placement of the aboiteau will be developed for:

- fish passage requirements in consultation with DFO
- climate change predictions matching the life of the structure (*e.g.*, sizing for the expected freshwater flow and protection of sea level rise, storm surge and wave runup)
- storm event predictions
- constructability, maintenance and monitoring considerations
- relevant stakeholder interests and concerns related to lake level management.

Operational requirements for the updgraded aboiteau will be fully explored to ensure: limited staff resources are required; provision of a backup system; and flood mitigation precautions for the community.

2.2.6 Access Roads

Temporary or permanent access roads may be required to maintain appropriate access to property during and following construction of the highway. Only one new access road is proposed at this time, to connect the NSDA tide gate facilities to a public road in Falmouth. Temporary roads will adhere to relevant NSTIR standards. Final access road locations are yet to be determined but will be within the Assessment Area considered in this EA.

2.2.7 Secondary Road Modifications

The Project includes modifications to some existing secondary roads to ensure controlled access to the highway from secondary roads. Roads adjacent to the proposed highway or connecting to roads that connect to the highway ramps may require modification to accommodate the new lanes.

There will be new ramp construction. Industrial Drive (a road south of the existing highway at Exit 5A) will become a cul-de-sac to accommodate a new eastbound exit ramp to the Wentworth Road. Additional collaboration with the Town of Windsor is expected at the detailed design stage; this could result in a refined solution.

Bog Road may require a slight realignment to the south and a culvert replacement to accommodate the RoW needed for construction of the highway lanes south of the existing alignment and west of the Trunk 1 highway crossing. It is anticipated that approximately 200 m of the road will require realignment.

2.2.8 Temporary Ancillary Elements

Temporary ancillary elements that may be required for the Project include: material storage areas, temporary access roads, mobile asphalt plants, borrow areas, and disposal sites. The locations of these ancillary structures and sites will be identified as part of the contractors' bid proposals and have not yet been established. The locations and operations of these facilities will be subject to approval by NSTIR and any applicable regulators and will be sited and operated in accordance with NSTIR standards.

Environmental effects, issues and mitigation for ancillary elements are similar to those discussed under the construction and operation activities for the Project. Additional information is provided in Section 2.3.1.5.

2.3 PROJECT ACTIVITIES

This section provides a description of construction and operational activities typical for a 100 series highway.

2.3.1 Construction

Prior to initiating construction, clearing of trees and shrubs will be required to accommodate site preparation activities such as grubbing and grading. Following clearing, construction activities will include the following:

- site preparation to prepare the site for road and structure construction (including access roads and interchanges) such as grubbing and installation of sediment control structures
- roadbed preparation (including access roads and structures) such as blasting, excavation, placement of fill material, and drainage culverts
- installation of watercourse crossing structures
- surfacing and finishing including activities such as paving, line painting, and installation of signs, and guide rail/cable barriers
- development and removal of temporary ancillary structures and facilities.

Additional details of these activities are provided below.

2.3.1.1 Site Preparation

Site preparation includes activities associated with the preparation of the site in anticipation of roadbed construction such as:

- clearing and grubbing
- erosion and sediment control (ESC) measures
- removal or modification of existing buildings.

Clearing and Grubbing

The first phase of major construction activity will be clearing of the proposed alignment. Construction of the two twinning lanes and ramps will require clearing the RoW to a width of approximately 30 m, with the exception of a few areas where greater widths are required to accommodate the interchanges and deep cuts and fills. Where access roads will be constructed, additional clearing may be required. Clearing width will vary depending on the toe of the slope (*i.e.*, 4 m from the toe of slope or top of cut). Limits of clearing will be clearly indicated on the contract drawings and in the field (*i.e.*, surveyed and marked with flagging tape).

The primary environmental concern associated with clearing of the RoW is to limit ground disturbance which may result in erosion and sedimentation of wetlands and watercourses. Harvesting (which is expected to be minimal) will be conducted using conventional harvesting techniques and equipment and in accordance with the NSTIR Standard Specifications (1997 and latest revisions). Trees will be cut to within 0.3 m of the ground. Merchantable timber (minimum butt diameter of 100 mm and a length of 2.5 m) will be de-limbed and removed from the site, while non-salvageable material will be chipped within the RoW and left in place.

In some instances, isolated or ornamental trees, as designated by the Project Engineer, shall be removed and relocated in accordance with NSTIR's Standard Specifications (1997 and latest revisions). Removal will be done by excavating the tree and removing the total tree including stump and roots, limiting damage to the surrounding property.

Clearing activities will be conducted outside of the breeding season for birds (*i.e.*, no clearing between April 1 and August 15), where possible. Where it is not possible to avoid clearing during the bird breeding season, mitigation measures will be undertaken by NSTIR to facilitate compliance with the *Migratory Bird Convention Act*. Where possible, clearing operations will be conducted during winter months on frozen ground to protect the underlying vegetative mat and to reduce erosion and sedimentation of watercourses and wetlands. Hand clearing will be conducted where ground conditions are not suitable for heavy equipment access (*e.g.*, within watercourse and wetland buffer zones).

Grubbing for roadway construction involves the removal of all organic material and unsuitable soil above the underlying soil. It also consists of the removal, disposal and/or salvage of all stumps, roots, downed timber, embedded logs, humus, root mat and topsoil from areas of excavations and embankments or other areas as directed by the Project Engineer. Grubbing is required for all areas where fills are less than 1.5 m or where excavation is planned. Grubbing is usually not required under fills greater than 1.5 m in depth, unless a structure (*e.g.*, bridge, culvert or retaining wall) is to be constructed, or where there is a significant layer of compressible soil that could cause a future settlement problem. To reduce environmental risks associated with erosion and sedimentation, grubbing within 30 m of a watercourse is conducted only after the installation of culverts and required erosion and sediment controls (*e.g.*, sediment fence, settlement ponds, *etc.*).

Bulldozers are typically used to scrape the organic material off the underlying soil and to pile the material. If the grubbed material is to be removed from the site, track-mounted excavators are sometimes used to load the material on to dump-trucks. Where grubbing involves the removal of extensive organic deposits (*i.e.*, peat), the material is usually removed by an excavator and loaded directly to dump-trucks. If the deposit of unsuitable material cannot be removed with a track mounted excavator, a drag-line excavator is often used.

The projected end use of the grubbed material and the method of disposal dictate whether incidental organic materials such as stumps, roots, *etc.* are removed prior to re-use or disposal. Some stumps may be removed from the grubbed material and chipped. Grubbed material may also be used in erosion and sediment control. Where feasible, grubbed soil may also be used to flatten the slopes of embankments along the roadway depending on soil quality and the need for fill at the site. Topsoil will be salvaged for use in the median and on side slopes as per NSTIR's

Standard Specifications (1997 and latest revisions). Other grubbed material is disposed of as indicated in Section 2.3.1.5.

Erosion Prevention Measures

The primary environmental concern during site preparation is to manage ground disturbance to limit erosion and prevent sedimentation of wetlands and watercourses. Erodibility of soils and overburden material depends on terrain, cut slope, grain size and drainage characteristics of the material. In general, the soil material along the slopes of the valleys of the large rivers (*e.g.,* Avon River), are fine textured, and erosion will take place readily unless some means of preventing it is practiced. Several generic measures that can be taken to minimize sedimentation and erosion potential include: fitting the development to the terrain; construction sequencing to minimize soil exposure; retaining existing vegetation as long as possible; vegetation and mulching of grubbed areas; diverting runoff away from denuded (*i.e.*, bare) areas; minimizing length and steepness of slopes; keeping runoff velocities low; properly sizing and protecting drainage ways and outlets; intercepting sediments on site; and inspecting and maintaining control measures. Erosion and consequent siltation due to direct run-off is a concern to dug wells in very close proximity to the alignment (*e.g.*, a few 10s of m) and where direct overland flow of silt occurs. It is also important to prevent uncontrolled erosion to watercourses and wetlands.

A 30 m buffer of undisturbed vegetation will be maintained between the construction area and watercourses until required erosion and sediment controls are in place and watercourse crossing structures are installed. A 5 m buffer will be retained adjacent to wetlands.

Erosion and sediment control will be carried out according to:

- Nova Scotia's Watercourse Alterations Standard (NSE 2015a)
- NSTIR's Standard Specifications (1997 and latest revisions)
- Generic EPP for the Construction of 100 Series Highways (Generic EPP) (NSTPW 2007; see also http://www.gov.ns.ca/tran/enviroservices/enviroErosion.asp)
- National Guide to Erosion and Sediment Control on Roadway Projects (TAC 2005)
- Terms and conditions or government approvals, authorizations, and letter of advice.

NSTIR's work progression schedule will require construction in any work area to be carried out continuously from initiation to completion thereby reducing exposed soil on construction sites. Site-specific Water Control Plans, Erosion Control Plans, and Contingency Plans will be developed for the Project, where appropriate, and will specify the location of specific mitigation measures. These will require approval by NSE under the *Environment Act* Part V Water Approval process prior to culvert installation.

Removal or Modification of Existing Buildings

It is anticipated that the only buildings which would require modification as a result of Project construction are the two buildings owned by NSDA at the aboiteau location. Water and sewer services are from a municipal source therefore no well decommissioning activities are anticipated. Municipal water and sewage services will be properly terminated when buildings are removed. Any required municipal or provincial permits associated with building removal will be obtained by the contractor performing the demolition. Waste from any such removals will be managed in accordance with the provincial Solid Waste-Resource Management Regulations.

2.3.1.2 Roadbed Preparation

Roadbed preparation includes activities associated with construction of the road prior to surfacing and finishing, such as:

- Excavation, blasting and ripping
- Subgrade and grade separation preparation
- Sub-base and base construction
- Grade separation structures
- Ditching and drainage management
- Work progression.

Excavation, Blasting and Ripping

The removal of material for the construction of sub-grade (bottom layer of material) may involve one or more methods of excavation including common excavation, rock excavation, and swamp excavation. Common excavation is the removal of overburden, including till, smaller boulders, and topsoil. Rock excavation is the excavation of rock which is considered to be bedrock or single pieces greater than one cubic metre in size. Cuts in 'soft' rock can be accomplished using ripper blades attached to the back of larger bulldozers, breaking up the rock so that it can be loaded on to trucks with an excavator or loader. This procedure tends to be successful in softer rock such as shales and sandstones, and in areas where the bedrock surface is highly weathered and/or fractured.

Swamp excavation occurs where soil is unsuitable for use as a sub-grade. The soil is either excavated and replaced with a competent fill, or floated over using geogrids or berm construction. This may occur when peat is encountered or when exposed soil has been saturated with water. Excavated soils unsuitable for use as fill or dressing slopes are disposed of at a site approved by the Project Engineer (or potentially salvaged for use in wetland restoration projects). An NSE Approval for wetland alteration will be obtained prior to any disturbance of wetland habitat.

The use of blasting for rock excavation is dependent upon the competency of the rock. Additional concerns include areas that may have acid-generating bedrock (*e.g.*, Meguma Formation with mineralized slates and coal) or Karst and evaporite deposits (*e.g.*, limestone and gypsum) with sinkholes. The contractor will determine whether or not blasting will be required for the construction of the proposed alignment. Wherever practical, rock excavation will be performed by ripping rather than blasting, due to the lower costs involved.

Based on overburden thickness (2-5 m) and lithology (physical character of the rock), blasting is expected to be minor along the alignment. Most of the bedrock is composed of relatively 'soft' siltstone, minor gypsum and limestone which should require generally much less blasting energy compared with harder rock types. Due to the geochemical nature of the bedrock and the hard groundwater associated with the Windsor Group, these bedrock units are not associated with significant acid drainage.

If blasting is necessary, blasting operations will be conducted in accordance with the applicable federal and provincial regulations and guidelines. Blasting in or near watercourses will require approval from DFO, and will be conducted in accordance with the "Guidelines for Use of Explosives in or Near Canadian Fisheries Waters" (Wright and Hopky 1998). Blasting will also be conducted in accordance with the General Blasting Regulations made pursuant to the Nova Scotia *Occupational Health and Safety Act*. The contractor performing the blasting will have a valid Blaster's Licence and will confirm that a pre-blast survey has been conducted prior to blasting.

Subgrade and Grade Separation Preparation

Several factors are considered in the design of the vertical alignment for the highway including subgrade and grade separation preparation. Major cut and fill sections are designed based on factors such as: slope stability; erosion control; silt and runoff control; location and rehabilitation of borrow pits; impacts on groundwater; and impacts on blowing snow. Specific cut and fill information is not available at this stage of the Project, however, it is anticipated that the new alignment will parallel the existing alignment very closely.

Stability of slopes for both cuts and embankments will be considered along the proposed alignment, and connectors. As per NSTIR's Standard Cross Section conservative slopes for cuts and embankments will not generally exceed three horizontal: one vertical; slopes may be steeper in rock, rock fill, and guardrail locations (*e.g.*, 2:1). Cut slopes in soils tend to undergo minor sloughing where high groundwater and freeze-thaw occurs. These are typically repaired using a layer of rockfill to facilitate drainage; however, such analysis is site-specific and depends on the specific soil type, geological features and elevation of the water table.

Subbase and Base Construction

Once the sub-grade or subbase has been brought to final lines, grade and cross sections as shown on plans or as approved by the Engineer, granular material consisting of crushed and screened rock or gravel are applied to the roadway. Normally on 100 Series Highway construction projects, once the subgrade is completed a 300 mm layer of Gravel Type 2 is applied. Then on the ensuing paving contracts, an additional layer of Gravel Type 2 (based on testing of bearing capacity) and additional layer of Gravel Type 2 (if required) and Gravel Type 1 is applied. The gravel provides a free draining layer under the asphalt concrete pavement.

The Project area is underlain by the Windsor Group Bedrock formation. The Windsor Group is highly susceptible to Karst problems (Trescott 1969). Karst topography is known to occur in the area between Exit 5 and 5A and remedial work has been carried out to address an ongoing sinkhole along the existing alignment.

Gypsum and limestone bedrock in the area are easily dissolved by water, and deformed by the weight of overlying sediments; characteristics that make evaporite rocks very prone to sinkhole development. Sinkholes are a potential geological hazard, particularly where structures rest on or near the overlying surface. In areas identified for sinkhole risk, for example, near Exit 5, site-specific analyses including a full geotechnical and/ or geophysical assessment is recommended. The sinkholes near Exit 5 were assessed through reviews of existing geological mapping, historical air photo interpretation, site reconnaissance, Ground Penetrating Radar (GPR) surveys, and geotechnical drilling. Common mitigation measures for sinkhole risk includes reducing potential for further sinkhole development by directing surface drainage away from the area, providing additional soil cover, and remediating existing sinkholes by excavation and stabilization using an engineered soil profile. Ditches may be lined with clay and vegetated to reduce infiltration and promote runoff reduction through evapotranspiration. Although the grade of the new highway will not be increased substantially, it may be raised slightly to provide greater separation from Karst. Construction using local soils will be promoted so as not to increase the infiltration rate. Refer to Section 2.4 for more information on Karst topography and how it is influencing the environmental design for the Project.

Grade Separation Structures

Construction of grade separation structures will begin with the installation of erosion and sediment control measures followed by clearing and grubbing, excavation, and fill placement to prepare a road embankment to the structure, as required. The foundations for abutments will typically be cast-in-place reinforced concrete on either spread footings or piles. The prefabricated girders, either of pre-stressed concrete or steel construction, are then put into place using cranes. The deck is constructed of cast-in-place reinforced concrete; a waterproofing membrane is then applied and the surface is paved to match the specified road elevation.

Ditching and Drainage Management

Ditching, drainage channels and cross culverts will be designed and constructed to avoid erosion issues and divert stormwater away from active work areas. These structures will be constructed where natural drainage and surface runoff is intersected by new roadway construction. The outlets from ditches and drainage channels will be directed away from natural watercourses into areas of dense vegetative growth. Erosion control measures (*i.e.*, erosion control blankets, hydraulic mulches, turf reinforced mats and rip rap will be used to line ditches, swales, and drainage channels to avoid erosion and siltation of down gradient watercourses and wetlands.

Ditching and drainage management will also be considered as a means to mitigate risk of subsidence and sinkholes in areas of Karst topography (*e.g.*, around Exit 5).

Causeway

The construction of new lanes will be accomplished by adding a rock base for the lanes. The rock will be placed adjacent to the existing causeway lanes and holes may be drilled through the rock fill to accommodate release of mud and water that may come up as the road bed settles under the weight of the rock. The rock will be allowed to settle and when the appropriate grade is reached and a solid road bed established, granular materials will be added and the lanes will be paved.

Work Progression

The progression of construction activities is described in Section 3.1 of the Generic EPP to facilitate the orderly progression of work and environmental protection. In any sensitive work area, the time between grubbing/cut/fill activities to stabilization will be no greater than 30 days. Stabilization refers to landscaping, hydroseeding and/or mulching, and includes completion of ditches and shaping of slopes as well as installation/maintenance of temporary and permanent sediment and erosion control structures.

2.3.1.3 Watercourse Crossing Structure Construction

The proposed RoW contains 11 watercourse crossings including the Avon River crossing and a potential crossing that may be required if Bog Road requires realignment work. It is anticipated that these crossings will be accomplished using culverts (the Avon River crossing requires an aboiteau structure). Culvert installations at watercourse crossings are normally accomplished by constructing temporary stream diversions, allowing the culvert to be bedded in the dry (*i.e.*, in the absence of flow) and backfilled prior to conveying the stream through the culvert. To avoid disturbance of fish spawning, incubation, and hatching activities, in-stream work is typically restricted to the period between June 1 and September 30. Watercourse crossings will be constructed in accordance with Watercourse Alterations Standard (NSE 2015a). NSTIR will comply with specific limits, conditions, and restrictions set by NSE and DFO in watercourse alteration approvals. Applicable sediment and erosion control practices and fish passage requirements will be followed.

It is anticipated that an authorization and compensation plan pursuant to Section 35 (2) of the *Fisheries Act* will be required from DFO to offset potential serious harm to commercial, recreational and/or Aboriginal (CRA) fish and fish habitat. NSTIR has already developed a plan in consultation with DFO and NSE that involves one or more habitat banks to offset loss and damage to fish habitat. These banks will provide habitat for the same species affected by this Project and will be monitored for at least five years to comply with the anticipated *Fisheries Act* authorization.

Culverts will be constructed of either cast-in-place concrete or precast concrete and can be either three-sided (open bottom) or four sided. A typical box culvert would have a maximum inside clear span of 3.6 m. Two or more lines of box culverts may be placed side-by-side to create twin or multi-barrel box culvert installations for wider watercourses.

All crossings of watercourses are normally designed to accommodate the 1 in 100 year storm for the local region as defined by data from the Atmospheric Environment Service of Environment and Climate Change Canada. These estimates will incorporate anticipated changes in precipitation due to global warming.

Culvert sizing will be reviewed during highway design but will take into account potential Project-related changes to local drainage patterns through blockage or alteration of existing drainage or creation of drainage patterns. The majority of small watercourses have limited drainage areas and may therefore be susceptible to effects of highway drainage. This assumes that normal standards are used in the design of hydraulic structures, including addressing the high risk for the initiation of an ice or debris jam and the accommodation of increased storm flows due to highway runoff and global warming. Estimates of runoff volumes and design of runoff control features will be made during the final highway design process using standard highway design criteria once the alignment and profile have been finalized.

2.3.1.4 Aboiteau Upgrade

The Avon River crossing will be accomplished by expanding the causeway to accommodate additional lanes (rockfill and surcharging), by positioning slightly north of the existing alignment and upgrading the existing aboiteau. Work on the aboiteau will likely involve a temporary highway detour. The current aboiteau comprises two box culverts. Redesign of the aboiteau will be conducted in consultation with DFO to provide adequate fish passage. A site-specific ECP will be developed prior to construction in consultation with DFO for the aboiteau upgrade. The sequence of the work will be determined based on final design of the structure and timing with respect to other construction activities, although it is likely that this work will occur during the summer when freshwater flows are lower. Timing of construction activities will be discussed with key stakeholders during Project planning. Although design and construction details of the aboiteau upgrade are not known at this time, NSTIR and NSDA will work closely with DFO and stakeholders to address concerns as design proceeds.

2.3.1.5 Surfacing and Finishing

Surfacing and finishing includes activities associated with the completion of the highway prior to commissioning, such as:

- paving
- hydroseeding and other permanent erosion control measures
- signage, lighting, guide rail/cable barrier installation
- highway marking/painting.

Paving

The majority of pavement used in Nova Scotia is the familiar black asphalt concrete. This material is made by mixing petroleum based liquid asphalt with sand and crushed stone (aggregates) in an asphalt plant. The hot mix is easily transported, spread and rolled to provide a smooth surface that can be used almost immediately. Special care must be taken in the design and placement of granular and asphalt pavement layers to minimize wheel track rutting and frost action that may break the pavement and cause pot holes.

Concrete pavement is another type of road surfacing material. The material is made by mixing Portland cement, sand, gravel, and water at a concrete batch plant. The concrete mix material is transported by trucks and placed by a slip forming machine that automatically creates joints complete with steel joint dowels to ensure that adjacent slabs retain their alignment. Concrete must set or cure for several days before it can be opened to traffic. Although it has a higher initial cost than asphalt pavement, concrete pavement is rigid and provides a smooth riding surface which is not subject to rutting and generally resists frost action and pot holes.

Both pavement types require durable crushed stone that will meet NSTIR specifications. Provision of crushed stone will be the responsibility of road construction contractors, who will abide by appropriate pit and quarry regulations. It is expected that stone for pavement mixes will be obtained from existing quarries near the Project area.

Hydroseeding and Other Permanent Erosion Control Measures

Stabilization of the finished soil surface is typically carried out by hydroseeding and covering with straw mulch, hydraulic mulches, erosion control blankets (*e.g.*, slope protection and channel protection) or turf reinforced mats (*e.g.*, permanent channel protection). Hydroseeding will be conducted as soon as possible after completion of the soil preparation, as per NSTIR's Standard Specifications (1997 and latest revisions; Division 7, Section 5). Final dressing of the slopes will be done as areas are completed to enable hydroseeding to be done in stages as work progresses, in accordance with the Work Progression Schedule.

Hydroseeding will not be permitted on hardened or crusted soil. Final dressing of slopes will include removal of materials such as sticks, roots or large rocks; loosening of the top 50 mm of soil; and scarification (or tracking) to minimize runoff velocities.

Hydroseeding will not be performed under windy conditions, or during periods of rainfall or severe drought, on areas covered by standing water, on frozen surfaces or under other adverse conditions, as determined by the Project Engineer.

Signage, Lighting, and Guide Rail/Cable Barrier Installation

Signage, lighting, guide rail, and barriers will be installed once most construction activities have been completed. Signage and lighting installation involves localized disturbances within the finished Project, and will require small amounts of excavation and placement of concrete footings for the erection of the posts and signs. Guide rail installation involves posthole drilling, post installation and attachment of metal guide rail to the posts. As noted above, a cable barrier will be installed in the median between the eastbound and westbound lanes. Environmental protection procedures for signage and barrier installation are included in Section 3.15 of the Generic EPP and include guidance for handling wood preservatives (*i.e.,* waste wood ends should be disposed of through a solid waste facility and not burned). Lighting and reflective devices will also be installed where necessary. Lighting is typically used near intersections and interchanges.

Highway Marking

The painting of pavement markings will also be performed after most construction activities have been completed. Marking, or striping, a highway consists of physically painting yellow and white longitudinal and transverse lines and other symbols and words as required on road surfaces to ensure the traveling public receives direction and guidance. The arrangement of these markings will be in accordance with TAC's Manual of Uniform Traffic Control Devices (TAC 2014) and NSTIR policies and Standard Plans. The products that will be used for highway marking will be approved products that meet NSTIR's Standard Specification (NSTPW 1997 and latest revisions).

2.3.1.6 Temporary Ancillary Elements

Construction includes activities associated with the development and removal of temporary ancillary Project elements, such as:

- Temporary access roads
- borrow areas
- petroleum storage areas
- materials and equipment (transportation, storage and handling)
- construction waste disposal
- mobile asphalt plants.

The exact locations of temporary ancillary elements have not been determined at this time. The following subsections provide information regarding the process for selection of suitable sites. The siting of temporary ancillary elements will avoid wetlands, watercourses, archaeological resources, and Species at Risk and Species of Conservation Concern, to the extent possible. Environmental investigations will be carried out as required in advance of development of temporary ancillary elements outside of the RoW to determine suitability of proposed locations.

Temporary Access Roads

Construction activities will require provision of access to the RoW and to maintain landowner access during construction activities. Existing access roads will be used to the extent possible; however, temporary access roads may be necessary. Temporary access roads will be constructed in accordance with landowner agreements and other construction practices as described in this section.

Borrow Areas

For this Project any new borrow sites located outside the RoW may require further environmental investigation (*e.g.,* archaeological and heritage resources, rare plants). Mitigation, where required, will include avoidance of environmentally sensitive areas and will comply with guidelines for borrow areas described in the Generic EPP (Section 3.11) including the following: NSTIR will approve all borrow sites; pits will be operated in accordance with applicable guidelines, policies, acts, and regulations; an erosion and sediment control plan will be developed by the contractor for review and approval by the Project Engineer; and pits must be left in a neat and safe condition so as to comply with the Pit and Quarry Guidelines.

Petroleum Storage Areas

Specific mitigation measures in regard to storage of hazardous materials during construction are identified in the Generic EPP (Section 3.14) and include the following:

- Permanent storage areas for containers or drums will be clearly marked.
- Storage areas will have appropriate secondary containment.
- If drums are stored on their sides, the drums shall be stored so that the bungs are in the "9 and 3" position, on level ground and prevented from rolling.
- Drum storage areas shall be marked or fenced with temporary fence to avoid impact.
- Day-use quantities can be stored upright or on the side as required, drip pans lined with absorbent pads shall be used beneath taps.
- Machinery will be checked regularly for leaks.
- Storage of petroleum products is not allowed within boundaries for water supply watersheds or designated environmentally sensitive areas. Lubricants, hydraulic fluid, grease, gasoline, diesel or other fuels will not be stored within 30 m of any watercourse.
- Refuelling and equipment maintenance required in the field will not occur within 30 m of a watercourse, drainage ditch, areas with a high water table, private wells, or exposed and shallow bedrock.

These guidelines apply directly to watercourses, but are also considered to be relevant to the protection of groundwater resources, including private wells. The appropriate permits, as set out in the Petroleum Management Regulations, will be obtained for any onsite temporary fuel storage tanks.

Materials and Equipment

Vehicles used in construction typically include cranes, excavators, bulldozers, rollers, trucks, asphalt-concrete pavers, and graders. Most of these vehicles operate on diesel fuel and require some form of daily maintenance. Truck traffic generated by the Project during construction is closely related to the amount of imported fill material required. If asphalt-concrete and concrete plants are not located onsite and/or aggregate must be obtained from offsite sources, the amount of truck traffic on the access roads will increase accordingly. Offsite truck traffic will also consist of hauling various unclassified excavated and other materials to approved disposal sites, and/or the movement of construction equipment to and from the Project site. Trucking operations during the subgrade construction phase will primarily include onsite transportation activities of materials for cut and fill operations. Specific borrow and disposal sites will not be known until they are identified by the construction contractor. All borrow areas and quarry operations will be conducted at approved sites in accordance with applicable laws and regulations.

Vehicles used in base and pavement construction include steel drum rollers, graders, trucks, and asphalt concrete pavers. If the asphalt concrete plant is located onsite and a suitable source of aggregate used for the asphalt concrete and road base construction can be found onsite, truck traffic during this portion of construction will be limited to the delivery of primer, tack coat, asphalt cement and diesel fuel. If the asphalt concrete plant is not located onsite and/or aggregate must be obtained from offsite sources, the amount of truck traffic on the access roads will increase accordingly.

Use of local and collector highways for access to the Project will be subject to applicable Provincial gross vehicle weight maximums and spring weight restrictions.

Material will be stockpiled in such a way as to prevent their erosion and to prevent sedimentation to any adjacent watercourses or wetlands. The runoff from stockpiled material will be managed using standard sediment and erosion control practices and will be directed to a settling basin to be maintained in accordance with NSTIR Standard Specifications. Non-salvageable erosion control materials will also be properly disposed of when no longer needed or damaged (*e.g.*, silt fences).

Construction Waste Disposal

The most desirable use of material excavated from the RoW during construction is use within the RoW (*e.g.*, buried in the toe of the slope), assuming it conforms to NSTIR standards. Disposal of waste materials from the construction of the proposed undertaking will be in accordance with NSTIR's Standard Specifications (1997 and latest revisions) for highway construction and any provisions included in site-specific contracts. The current specifications for clearing and grubbing do not include any specific criteria for the selection of waste disposal sites. Disposal sites will be located by the contractor and must be approved by NSTIR. Existing approved construction and demolition debris disposal sites may be used for disposal outside the RoW.

Non-salvageable material from the clearing operations, such as limbs and non-merchantable timber, are typically chipped within the RoW and left in place except within buffer zones for watercourses and wetlands. Occasionally, large items which cannot be easily chipped (*i.e.*, stumps) are buried on adjacent land. Excavated organics overburden and rock must be disposed of where their use as fill material is impractical. Management and disposal of potential acid generating bedrock, if encountered, will be conducted in compliance with the Sulphide Bearing Material Disposal Regulations.

Mobile Asphalt Plants

A mobile asphalt plant will be required for the manufacture of hot mix paving asphalt. Nearby off-site quarries, may be used as temporary locations to reduce the haulage distance. Permits are required for the operation of the asphalt plant, specifically an Industrial Approval under the Activities Designation Regulations, and if required registration of petroleum storage tanks under the Petroleum Management Regulations. Asphalt plants will be operated in accordance with applicable regulations and appropriate mitigation will be applied (Section 3.17 of the Generic EPP). The Canadian Construction Association's (CCA) Environmental Best Practices Guide for Hot-Mix Asphalt Plants (CCA 2004) will also be adhered to.

The location of an asphalt plant is chosen by the contractor prior to construction and must be approved by the Project Engineer. The plant and its components will be in compliance with ASTM D995-95b (Standard Specification for Mixing Plants for Hot-Mixed, Hot-Laid Bituminous Paving Mixtures) (ASTM 2002) and the contract documents.

2.3.2 Operation and Maintenance

Operation and maintenance activities for the Project include:

- highway operation
- aboiteau operation
- infrastructure maintenance
- winter maintenance
- vegetation management.

2.3.2.1 Highway Operation

The twinned highway will operate as a four-lane divided freeway with a posted speed limit of at least 100 km/h. Traffic volumes are not expected to increase as a result of the twinning Project; however, the level of safety and performance of the transportation network will improve as a result of the Project.

2.3.2.2 Aboiteau Operation

The upgraded aboiteau will operate similarly to the current causeway aboiteau whereby gates will open to allow freshwater to drain during the falling tide and close when the tide is rising. Lake levels will continue to be maintained at targeted heights through the year with the objective of providing fish passage, flood control for the Town of Windsor and Municipality of West Hants, and keeping agricultural lands drained. In particular, the gates will be opened to lower lake levels in advance of predicted storm events. Lake levels will also continue to be altered to allow for maintenance of the aboiteau and to facilitate fish passage. The number of gate openings (which reduces lake levels) will continue to be typically increased during the spring, particularly May, to allow fish passage during the spawning period.

2.3.2.3 Infrastructure Maintenance

General highway maintenance activities retain roadways at a reasonable level of service, comfort and safety and typically take place during the summer months. The repair of the asphalt concrete surface may include excavation or removal of the existing pavement and subgrade, patching and leveling, grading and gravelling, surface treatment and asphalt concrete overlays. Disruption to the public from these repairs would be temporary and infrequent in nature.

Periodic maintenance of roadway drainage systems may be required. This may involve the replacement or repair of culverts and re-establishment of the drainage ditches.

Other highway maintenance activities include shoulder grading, localized pavement repair, bridge maintenance and line repainting. Disruption to the public from these repairs will be temporary and infrequent in nature.

2.3.2.4 Winter Maintenance

Winter highway operations activities generally include snow removal and ice control to reduce traffic disruptions and safety hazards. Snow removal includes plowing services provided by NSTIR or contracted out.

Road ice is controlled by the application of salt and sand. Salt is applied to roads to retain clear driving lanes within a reasonable time after a storm. Sand is applied to roads surfaces to provide traction on snow-packed or icy roads.

NSTIR has implemented several initiatives to help manage the use of road salts. These initiatives include:

- construction of several additional salt/sand storage structures to increase covered storage capacity
- installation of road weather information system (RWIS) sites
- new winter maintenance standards to provide a consistent and measurable level of service for ice and snow removal to all areas of Nova Scotia
- upgrading of salt spread truck fleet through the installation of computerized salt controls, infrared pavement temperature sensors, and retrofitting of some trucks with pre-wetting capability.

Pre-wetting operations involve the application of a sodium chloride (NaCl) brine solution to the road salts just prior to application on the highway. Pre-wetting is carried out in an effort to reduce the loss of road salts applied to highways due to wind and traffic disturbance.

Further reductions in road salts can be realized if placed just prior to a storm event. This is usually referred to as "anti-icing" as opposed to "de-icing".

In accordance with Environment Canada's Code of Practice for the Environmental Management of Road Salt, NSTIR has developed a Salt Management Plan (SMP). The SMP provides a mechanism through which NSTIR can commit to implementing best management practices while fulfilling its obligation to providing safe, efficient, and cost effective roadway systems.

2.3.2.5 Vegetation Management

Regrowth of vegetation within the RoW may interfere with the lines of sight required for safe use of the highway. Clearing along the RoW is part of NSTIR's regular maintenance to maintain sight lines and may involve both manual and mechanized cutting. Vegetation management may also include use of species that require minimal management in the Project environment.

Vegetation management techniques will be employed where feasible to promote sustainable growth along the highway. If herbicide application is required for the control of noxious weeds, they will be used only under the guidance of NSTIR's Integrated Roadside Vegetation Maintenance (IRVM) program and NSE pesticide application approvals and specifically not be applied under any of the following legislated conditions:

- within a 30 m buffer zone of any watercourse
- within any distance of any watercourse prescribed on a product label
- within 60 m of a protected water supply.

2.3.3 Decommissioning

The highway is planned to operate in perpetuity and will be maintained as necessary for an indefinite period of time. Decommissioning, if required in the future, will be undertaken in compliance with relevant laws, regulations and guidelines current at that time.

2.4 ENVIRONMENTAL DESIGN CONSIDERATIONS

In addition to designing the Project with the intent to reduce effects on the biophysical environment (*e.g.*, reducing the PDA to the extent feasible and incorporating fish passage for watercourse crossings), there are other environmental factors that are being considering during Project design including:

- climate change considerations (*e.g.*, sea level rise, flooding)
- geological formations (*e.g.*, Karst topography)
- morphodynamics of the Avon River estuary
- commercial, recreational and aboriginal (CRA) fisheries in the Avon estuary, Lake Pisiquid and the lower Avon River.

Climate Change Considerations

A portion of Highway 101 at the Avon River causeway, approximately 1,618 ha of protected agricultural marshlands, local communities, and considerable other public and private infrastructure are already known to be at risk from high storm surges and rising sea levels (van Proosdij 2008, 2013). Climate change adaptation planning for this region requires the protection of existing key assets and infrastructure and incorporation of climate change planning for future developments (including the proposed Project).

Although specific estimates vary, sea levels in the Bay of Fundy are predicted to rise up to 0.79 m by 2055 (Greenburg *et al.* 2012) and up to 1.93 m by 2100 (Webster *et al.* 2011). A recent assessment for the nearby Town of Hantsport (the nearest Canadian Hydrographic Service [CHS] tide prediction site) predicts a mean value of total sea level rise to be an increase of 0.33 m by 2050 and 0.90 m by 2100 (Daigle 2016). One of the main risks to communities such as the Town of Windsor are storm surges which could combine with high tide cycles to lead to flooding and erosion (van Proosdij 2013). A recent climate change vulnerability assessment for the Town of Windsor acknowledged the risks associated with sea level rise and storm surges and identified opportunities to help mitigate against these effects (van Proosdij 2013). Potential for flooding and overtopping was identified as a concern for low elevation spots on the causeway and the ramps at Exist 6 were considered too low in elevation to allow for safe evacuation during flood conditions (van Proosdij 2013). Recommendations relative to the Project include using a 1:100 year storm return period for high value areas (*i.e.*, developed areas) (1.13 m) assuming the predicted 2055 sea level rise estimate and using a 1:10 year storm return period (0.85 m) in primarily agricultural land. Another recommendation was to raise the elevation of the roadbed to prevent overtopping (van Proosdij 2013). NSTIR is in the process of engaging a consultant to recommend an optimum height and aboiteau discharge capacity as well as a detailed design to ensure a climate-ready structure.

Karst Topography

The Project area is underlain by the Windsor Group Bedrock formation. The Windsor Group is highly susceptible to Karst problems (Trescott 1969). Karst is known to occur in the area between Exit 5 and 5A and remedial work has been carried out to address an ongoing sinkhole along the existing alignment. Gypsum and limestone bedrock in the area is easily dissolved by water, and deformed by the weight of overlying sediments; characteristics that make evaporite rocks very prone to sinkhole development. Sinkholes are a potential geological hazard, particularly where structures rest on or near the overlying surface.

It is very difficult to predict when or precisely where a sinkhole will occur. Potential impacts are also difficult to predict as they depend upon the size of the feature, thickness of overburden and competency of the bedrock. In areas identified for sinkhole risk, for example, near Exit 5, site-specific analyses including a full geotechnical and/ or geophysical assessment is recommended. The sinkholes near Exit 5 were assessed through reviews of existing geological mapping, historical air photo interpretation, site reconnaissance, Ground Penetrating Radar (GPR) surveys, and geotechnical drilling.

Common mitigation measures for sinkhole risk includes reducing potential for further sinkhole development by directing surface drainage away from the area (*e.g.*, through ditching, drainage channels and cross culvert design), providing additional soil cover, and remediating existing sinkholes by excavation and stabilization using an engineered soil profile.

Morphodynamics of the Avon River Estuary

The construction of the Avon River tidal gate and causeway between 1968 and 1971 facilitated rapid sedimentation and formation of a tidal flat which has evolved into substantial salt marsh habitat. The morphodynamics of the Avon River estuary have been studied for several years and the salt marsh and downstream intertidal habitats continue to be very dynamic systems (van Proosdij and Bowron 2017). Design at the causeway and tidal gate structure and construction methods will incorporate learnings to date on the morphodynamics of the Avon River estuary to reduce adverse effects such as scour and erosion of salt marsh.

In recognition of ongoing changes to the estuary and predicted Project impacts associated with twinning and causeway expansion, NSTIR commissioned a monitoring plan to collect and analyze data before and after the twinning of Highway 101 (see van Proosdij and Bowron 2017). This work builds on previous research and monitoring activities conducted by St. Mary's University between 2002 and 2007 (van Proosdij 2005; van Proosdij *et al.* 2006; van Proosdij and Baker 2007). Baseline surveys will occur in Summer/Fall 2017 and post-construction monitoring for at least five years after completion of the new causeway-aboiteau system. These monitoring studies will help document: changes in surface elevation; changes in the location, stability and capacity of tidal channel networks; changes in the amount of vegetated marsh and mudflat habitat conditions; and changes in vegetation community structure and productivity (van Proosdij and Bowron 2017). More information on environmental design considerations for the causeway and aboiteau is contained in Section 5.3.

CRA Fisheries in the Avon River Estuary, Lake Pisiquid, and lower Avon River

NSTIR has also recently commissioned a baseline assessment of commercial, recreational and aboriginal (CRA) fisheries in the Avon River, Lake Pisiquid and lower Avon River. Beginning in April 2017, Darren Porter, local commercial fisherman, and investigators from Acadia University, Sipekne'katik First Nation, and the Mi'kmaw Conservation Group (MCG) will document fish passage through the existing aboiteau in 2017 and 2018, catalog the local, historical and traditional knowledge of CRA fishers, quantify the abundance and timing of species migrations in and near the causeway, and contrast the results of both fisheries-independent (government-academic) and commercial fisheries surveys. This baseline data will inform the engineering design for an upgraded aboiteau and facilitate future monitoring of the selected fish passage measures following completion of construction activities.

2.5 ENVIRONMENTAL MANAGEMENT

NSTIR is committed to the construction and maintenance of highways in a manner that is protective of the environment and has prepared an environmental protection plan (EPP) to communicate this commitment to NSTIR staff, contractors, regulatory agencies and the public: the Generic EPP for the Construction of 100 Series Highways (NSTPW 2007, currently in revision). This Generic EPP provides an overview of items of special consideration in highway construction and provides detailed environmental protection measures, monitoring plans and contingency plans for general highway construction activities. This Generic EPP is publicly available on NSTIR's website:
http://www.gov.ns.ca/tran/enviroservices/epp100series/generic%20epp_july%202007.pdf.

The Generic EPP is referred to throughout this environmental assessment document as it contains important best management practices (BMPs) for key environmental interactions which can occur during highway construction. The NSTIR Salt Management Plan, as described in Section 2.3.2.2 will also apply to this Project.

Contractors hired by NSTIR for highway construction are expected to comply with requirements in the Generic EPP as well as the Terms and Conditions of government approvals/authorizations and environmental control plans (ECPs) that they develop as part of construction tenders and contracts or during construction as the site conditions change or in response to unplanned events (*e.g.*, storms, accidents, and new technologies and equipment). The contractor's ECP will also include contingency plans and contractor awareness training in order to provide an overview of generic requirements and highlights of specific items of concern for the Project including identification and avoidance of species at risk, critical habitat, and archaeological and heritage resources. Where considered appropriate, this environmental assessment document highlights specific items to be incorporated in contractor awareness training for the Project as well as contractor ECPs.

Emergency situations involving the accidental release of hazardous materials to the environment, discovery of historic resources, and other unplanned events, will follow the contingency and emergency response procedures provided in contractor ECPs, Section 5 of the Generic EPP, and Volume 4 of NSTIR's Health, Safety and Environmental Program.

Environmental protection procedures and measures will be observed and employed throughout the life of the proposed Project, as outlined in NSTIR Standard Specifications. NSTIR will be responsible for installation, maintenance, and inspection and monitoring of environmental protection control measures during the operation and maintenance phase.

2.5.1 Inspection and Monitoring

To confirm compliance with environmental standards and regulations, regular inspections and monitoring will be performed by the contractor. NSTIR's Project Engineer and Environmental Services Section staff will also conduct periodic inspections of construction sites and environmental control measures. Improperly installed or damaged environmental controls will be corrected in accordance with the Generic EPP, Standard Specifications, contract requirements and/or manufacturers requirements.

NSTIR will establish an environmental compliance monitoring (ECM) program to ensure that all regulatory requirements and commitments are being met. ECM can be divided into two elements: regulatory environmental surveillance; and self-regulatory environmental compliance monitoring. Regulatory environmental surveillance is carried out by regulatory authorities. Self-regulatory environmental compliance monitoring is that which NSTIR undertakes to monitor its own activities against internal and external environmental standards. Self-regulatory ECM overlaps with regulatory environmental surveillance where the external standards which are being monitored are regulatory in nature. However, self-regulatory ECM is a much broader concept and is an important tool for the implementation of mitigation, particularly where government regulations are vague or non-existent. Self-regulatory ECM can involve:

- monitoring of all environmentally-sensitive activities to ensure compliance with internal and external non-regulatory environmental standards
- coordination of communication with regulatory authorities
- provision of on-site environmental advice to project personnel.

The principal mechanism for ECM will be the Generic EPP, which provides the practical framework for the implementation of the environmental requirements of the Project. The EPP will also provide a common reference document against which compliance can be judged by both regulatory authorities and NSTIR.

Environmental effects monitoring (EEM) involves taking repetitive measurements of environmental variables over time to detect changes caused by external influences directly or indirectly attributable to a specific human activity or development. EEM is generally undertaken by NSTIR and its contractors to:

- improve environmental understanding of cause and effect relationships
- provide an early warning of undesirable change in the environment
- verify earlier predictions of impacts and effectiveness of mitigative measures.

The EEM recommendation program will be incorporated into the contractors' ECPs and will be updated as required, as information regarding the predicted impacts and effectiveness of mitigative measures is collected.

Where habitat restoration is undertaken, monitoring programs will be implemented.

More information on proposed monitoring programs is provided in Section 5; a summary of monitoring commitments is included in Section 8.2.

2.5.2 Compensation Programs

2.5.2.1 Compensation for Land Acquisition

NSTIR's land acquisition and compensation policy will generally follow the guidelines developed under the Nova Scotia *Expropriation Act*. Property expropriation under the Act, however, only occurs when negotiations between individual property owners and/or their legal representatives fail in reaching a fair and equitable settlement.

Once the final design and location of the proposed undertaking has been determined, the process of land acquisition begins. Normal practice is to determine the local market value in accordance with recognized real estate appraisal practices for properties directly impacted and those which may be injuriously affected as appropriate. Acquisition and Disposal Officers will contact property owners to negotiate a mutually acceptable settlement. If negotiations fail, the property is formally expropriated and the claim is scheduled to be heard by the provincial Expropriation Board.

The majority of the RoW for this Project has already been secured by NSTIR although additional acquisition requirements will be confirmed through detailed design.

2.5.2.2 Compensation for Lost Habitat

Under the federal *Fisheries Act* and Fisheries Protection Policy Statement (DFO 2013a), serious harm to commercial, recreational or Aboriginal (CRA) fishery species requires authorization from DFO and an offsetting plan to compensate for lost habitat. It is anticipated that Project construction associated with the expansion of the causeway at the Avon River will potentially result in serious harm to CRA fishery species and therefore require an authorization from DFO and habitat compensation to offset this serious harm.

Construction activities will also result in loss of wetland habitat (refer to Section 5.5) which will require authorization from NSE and a habitat compensation program to achieve no net loss of wetland habitat.

In anticipation of fish habitat and wetland compensation requirements for Highway 101 Twinning, NSTIR initially developed three large salt marsh compensation projects (habitat banks) that collectively restore more than 70 ha at Cheverie Creek, Walton River and St. Croix River. The St. Croix River High Salt Marsh Project has been accepted by NSE as a "consolidated compensation project" for all of the anticipated wetland compensation requirements of twinning between St. Croix and Yarmouth. To date, NSTIR have used the St. Croix Habitat Bank for 16 wetland alterations and *Fisheries Act* authorizations around the Province. This bank still has aproximately 1.3 ha of "habitat credits" available for future applications for wetland and fish habitat compensation. The other two banks, Cheverie and Walton, have since been closed with no available credits.

The St. Croix River High Salt Marsh Project involved the restoration of high salt marsh and floodplain wetlands that were altered or lost by dyking in the 1950s by Agriculture Canada and the NSDA (under the former *Maritime Marshland Reclamation Act*). Removal of dyke segments from all four quadrants of the highway crossing and an obstructing culvert in the southeast quadrant restored natural tidal flow and fish passage to 18.1 ha of former and existing wetlands. The Project was completed in August 2009, and monitoring and adaptive management continued for five years after construction (*i.e.*, to 2014 at St. Croix and a nearby Reference Marsh site).

Re-construction of Exit 7 (Falmouth) as part of this Project will also yield some additional options for on-site wetland compensation. A small (1-2 ha) portion of dyked land between the Highway and the Avon Estuary will no longer be accessible for dyke maintenance and farm operations. Similar to St. Croix, NSTIR would remove portions of the dyke to restore former salt marsh with an added benefit of wave/storm protection for adjacent infrastructure. Further details on this opportunity will become available once Project design is finalized.

In specific recognition of the direct and indirect impacts of the Project on the globally-significant salt marsh adjacent to the Avon River (Windsor) causeway, NSTIR has committed to restoring another former salt marsh in the upper Minas Basin, along the Salmon and North Rivers in Truro. Like the Avon and St. Croix systems, this system also supports populations of the endangered inner Bay of Fundy Atlantic salmon as well as other sea-running fish common in the Windsor area (*e.g.*, Gaspereau, sea trout, striped bass, shad, smelt and eel). Renewal of tidal flushing to former dykelands will restore more than 50 ha of former salt marsh and tidal channels. Design work has begun and baseline habitat studies will commence in Summer 2017.

2.6 PROJECT SCHEDULE

Detailed design is scheduled to be completed in 2018 and some construction could be initiated in the fall of 2017 (*e.g.*, clearing). Following EA approval, NSTIR and NSDA will initiate or complete detailed field survey, geometric design, detailed design of an upgraded aboiteau-causeway system, RoW acquisition, and the provincial and federal environmental approvals processes for watercourse and wetland alterations.

In general, construction activities will be scheduled to avoid potential interactions with Valued Components (VCs) during sensitive periods (*i.e.*, breeding periods) where recommended as specific mitigation measures; recommended as general protection practices; or to comply with specific required permits and conditions. For example, instream work at watercourses will generally be limited to the period from June 1 through September 30, as per Nova Scotia Water Approvals and DFO authorizations to avoid fish migration and periods of higher precipitation and runoff potential.

It is anticipated that construction will take approximately five years. Operation of the highway will occur indefinitely with no plans for decommissioning.

3.0 STAKEHOLDER CONSULTATION AND ABORIGINAL ENGAGEMENT

3.1 OVERVIEW

While highway projects are typically undertaken to improve transportation infrastructure and public safety, it is important to consider the needs, concerns and benefits of the public to be served by the Project as well as area residents who may be affected by Project activities. Key issues identified by the public are subsequently considered during the environmental assessment and design processes and, where possible, economically and technically feasible approaches can be taken to address concerns.

3.2 REGULATORY CONSULTATION

Several provincial and federal regulatory agencies have been engaged over the planning cycle thus far for the Project. In July 2007, when it was assumed that an EA could be required under the former CEAA, NSTIR met with representatives from regulatory agencies with a potential interest in the Project; these included the CEA Agency, DFO, Environment Canada, Transport Canada, NSE, and Health Canada, to discuss the proposed scope of assessment and potential issues of concern. Although the federal EA process was not formally initiated, regulatory agencies agreed to participate in the EA process on an informal basis, providing technical and regulatory advice on scope of assessment, survey protocols and mitigation/compensation, until such time they were formally engaged.

In September 2009, NSTIR met with representatives of NSEt, CEA Agency, and DFO to discuss a joint harmonized process for the environmental assessment of this phase of the Highway 101 Twinning Project (Phase 4). The Project was subsequently put on hold before an EA report was filed for review.

Since then, NSTIR has had ongoing discussions with the Town of Windsor about the Project, primarily with the Town Engineer about the Project and highway access from existing ramps in the Town.

In 2013, a working group involving representatives from NSTIR, NSDA, NSE, the Town of Windsor, Municipality of West Hants, NS Emergency Management Office, and a subject matter expert from St. Mary's University, Dr. Danika van Proosdij, convened a workshop to discuss a vulnerability assessment and analysis of options for climate change adaption for the Tregothic Marsh Body (van Proosdij 2013). The Project was discussed at length in terms of how it may be designed to help to mitigate local flooding risks associated with climate change.

In May 2016, NSTIR and Stantec met with NSE, Nova Scotia Office of Aboriginal Affairs, NSNR and DFO to reintroduce the Project and EA process, with the understanding that only a provincial EA process would now be required under the regulatory regime. At this meeting, government department representatives discussed expectations for new data and reuse of original draft EA data. This input was used to scope the current scope of work reflected in this EA report.

3.3 ABORIGINAL ENGAGEMENT

NSTIR commissioned CMM Environmental Services in 2004 to conduct a Mi'kmaq Knowledge Study (MKS) for the Highway 101 Twinning Project from St. Croix to Greenwood (Mi'kmaq Environmental Services 2004) which includes the Three Mile Plains to Falmouth twinning. The MKS predominantly involved archival research and interviews on current Mi'kmaq land and resource occurring within "living memory" and addressed current Mi'kmaq land and resource use sites, and plants of significance to Mi'kmaw communities. Information on plants of significance to Mi'kmaq was collected through random sampling of the vegetation along the existing highway corridor. An updated MEKS was commissioned in 2016 (see below). The MEKS (November 2016) describes baseline conditions for current use of lands and resources for traditional purposes including land and resource use sites, plants of significance to Mi'kmaq, and Mi'kmaw communities in the area. A copy of the 2016 MEKS is included as Appendix F to this report. A summary of findings is provided in Section 5.7.4.2.

Aboriginal consultation for the Project was initiated in April 2008. Between 2008 and 2016 there has been ongoing correspondence between NSTIR and the Kwilmu'kw Maw'klusuaqn Negotiation Office (KMNO) with NSTIR providing updates on various highway planning projects including this Project. In 2016 a Project update was provided to the KMNO, Millbrook First Nation, and Sipekne'katik First Nation. At that time, a written response had been received from the Sipekne'katik First Nation requesting protection of fish and fish habitat and the overall ecosystem, as well a request that work cease and Sipekne'katik be notified in writing should archaeological deposits or human remains be unearthed during construction. These comments were noted to not preclude present and future use and did not preclude reference to Aboriginal and Treaty Rights.

In March 2017, NSTIR sent a copy of the updated MEKS as well as a Project update to the KMKNO, Millbrook First Nation, and Sipekne'katik First Nation, seeking information on any concerns including details on any asserted Mi'kmaq rights that could be adversely affected by the Project. As of April 10, 2017 no response had been received.

3.4 PUBLIC CONSULTATION

As a means of gathering public input on the proposed Highway 101 twinning, NSTIR held a Public Open House in December of 2001. NSDA has also convened meetings for stakeholders interested in the levels of Lake Pisiquid which involved a tour of the existing aboiteau and culminated in an informational report (NSDA 2015), as well as Marsh Body meetings. Although not initiated by NSTIR and NSDA, additional input for this EA Report was obtained from meeting notes from a public meeting organized by the Minas Basin Working Group of the Bay of Fundy

Ecosystem Partnership (BoFEP) Public Meeting in December 2004 to discuss the future fate of the Avon River causeway and potential effects of the proposed Highway 101.

In September 2016, NSTIR contracted Beyond Attitude Consulting Inc. to develop an advisory body for NSTIR and NSDA to better plan and renew Highway 101. Early establishment of a Community Liaison Committee (CLC) and a dedicated website is intended to provide an avenue for engagement and the exchange of information about the Project to interested individuals and local stakeholders. The Project website (www.hwy101windsor.ca) went live on November 1, 2016, and the first CLC meeting was held on January 30, 2017.

Details on previous meetings as well as the current CLC process are provided below.

3.4.1 NSTIR Public Open House and Presentations, 2001-2004

NSTIR held a public consultation open house for the proposed Phase 3 and Phase 4 twinning project from Ellershouse to Avonport on May 30, 2001 at the Hants County Exhibition Grounds in Windsor. The purpose of the open house was to allow NSTIR to present information on the project and obtain feedback from the public on the proposed functional design and/or construction of the project. Potentially impacted landowners were contacted and representatives from the Town of Windsor were briefed prior to the open house. A project fact sheet and a project map were posted in several public locations and advertisements were placed in the Chronicle Herald and Hants Journal prior to the session. At the open house, large project maps were on display and NSTIR staff was present to answer questions and discuss concerns. Guests were encouraged to complete a comment form. Approximately 110 people attended the session; 49 people completed comment forms.

In 2001, the proposed design for the twinning project involved elimination of the interchange ramps at Nesbitt Street (Exit 6). This is no longer part of the functional design; Exit 6 will remain intact. Approximately 45% of respondents indicated that the proposed highway would affect their property or business, with approximately 95% of those respondents indicating a negative effect. However, at least 14 of the 22 reported negative effects were related to access issues associated with loss of existing interchanges within the project areas. In the present functional design access will be maintained (*e.g.*, Exit 6 will not be eliminated), and therefore these concerns have been addressed in the current design.

A minority (22%) of respondents used Highway 101 in the area for commuting; most were considered users for local business and personal destinations.

When asked what benefits would be realized from completing the twinning of Highway 101 from Ellershouse to Avonport, the most common response was improved safety/fewer accidents. Other common responses included improved traffic flow, increased tourist traffic, increased property values and increased residential/industrial development. Reported concerns with respect to the proposed twinning (excluding access points) included increased population and growth and reduced scenic value as the most common concerns. Overall, the feedback on the proposed twinning was favorable, particularly in consideration of the elimination of access concerns.

Based on the feedback received at the public meeting, the proposed design was amended to retain and enhance Exit 6 in the current design. Further presentations were made by NSTIR to the Town of Windsor Council in May of 2004 to present the proposed twinning plans and tentative scheduling.

3.4.2 Minas Basin Working Group of the Bay of Fundy Ecosystem Partnership (BoFEP) Public Meetings, 2002-2004

In 2002 the Minas Basin Working Group (MBWG) held several community forums around the Minas Basin (the Basin) to discuss the approach to work towards sustainable management of resources and activities around the Basin. At one of the forums a discussion group identified the future fate of the Avon River causeway over the Avon River as an issue of potential concern. There were some questions regarding whether the causeway would be expanded or removed and it was decided that more information was needed about past and potential effects of the causeway. A public forum at which information could be shared and planning options could be presented by NSTIR was recommended by the group.

In late 2004, recognizing that community discussions were ongoing around the future fate of the Avon River causeway and the potential effects of the proposed Highway 101 twinning, the MBWG and the Avon River Coalition hosted a meeting in Windsor for December 2, 2004 for government, academia, special interest groups and residents to discuss issues and concerns associated with the expansion of the Avon River causeway on Highway 101. A representative of NSTIR's Environmental Services participated in the discussions. Other participants included representatives of the Minas Basin and Avon River groups, concerned residents, individuals from provincial departments including Agriculture and Transportation and the federal CEA Agency as well as a mediator. The discussion centered on the implications of the Avon River causeway and concerns expressed ranged from impacts on agricultural lands, broadened fish passage capacities and socio-economic implications of changes to the causeway. Fish passage at the Avon River and Pisiquid Lake emerged as a primary topic in a discussion that included a suggestion for causeway removal and a counter of the socio-economic and biological benefits associated with the freshwater component of the system. A discussion of whether fish passage may be accommodated without removal of the causeway was also discussed.

There were concerns expressed from regional farmers regarding potential effects on agriculture if the causeway were to be removed. Concerns included significant land loss and impacts to agriculture due to flooding that would result from the elimination of the causeway.

A resident of the Falmouth-Windsor area since the 1940s noted that sedimentation issues began in the 1950s preceding causeway construction by several years but coinciding with construction of a nearby power dam. It was noted that the entire watershed has undergone changes and that in this dynamic system change is ongoing and has been since the time of the establishment of the dykes by Acadians some three hundred years ago. It was noted that the sediment balance is not always equally distributed and build up and subsequent erosion are not always predictable. Sediment accumulation in absence of similar barriers in other areas of Minas Basin was noted.

Salt marsh development was attributed to the presence of the causeway but was noted as a potential positive in consideration of significant salt marsh losses (80%-90%) in other areas of the Bay of Fundy. It was noted that the salt marsh was very productive as marsh habitat but that it is the mudflats that support the invertebrates that the shorebirds feed upon.

Fish passage alternatives were discussed and a partial opening of the causeway was suggested; however it was noted that this could result in significant erosion and would also be likely to produce ice jams that would lead to flooding during spring runoff. The effectiveness of the current passage provided to fish through the bottom opening gates at 9.8 m below the surface was questioned. It was noted that a difference of 1.2 m on either side seemed to impede fish crossings at other barriers that fish would wait for appropriate water levels and velocities to cross. It was noted that various species have different migration periods that may need to be considered when determining duration of gate openings.

When an inquiry was made regarding the crossing alternatives being considered for the twinning, it was noted that causeway removal was not being considered. One individual noted that the Avon River should be returned to its former state to accommodate re-establishment of past fish species. In response, it was suggested that the development of the lake and associated walking trails, as well as the freshwater source for snowmaking were parts of the overall system that should be considered. The Lake Pisaquid boat, canoe and kayak clubs were also noted as positive aspects of the freshwater component of the causeway area. It was noted that the freshwater side of the causeway would be flooded including the downtown area if the causeway were removed.

A question was raised regarding potential effects of the introduction of salt water to the system on stream bank vegetation and other species and what potential impacts on erosion may be. The (18.6 year) tidal cycle was noted to be currently at a low point of the cycle and that future tidal ranges would likely be higher making consideration of sea level rise important. It was also noted that the causeway was higher than the dykes, and therefore provided better flood protection.

3.4.3 Community Liaison Committee

A CLC was formed to be an advisory body to the Project Team, and to provide advice on the Project, particularly regarding potential effects of the Project to the community. The first meeting of the CLC was held on January 30, 2017 at the West Hants Municipal Council Chambers. The purpose of the meeting was to have the member meet each other and the Project Team and to have an orientation to the Committee and to the Project.

During the meeting, there were questions asked about the aboiteau as well as concerns expressed about fish passage through a redesigned aboiteau. Concerns were raised regarding the quality of baseline fish count data and the inadequacy of fish passage provided through the existing aboiteau. In response, the Project Team indicated that the design of the upgraded aboiteau will meet DFO requirements for fish passage, including passage for all fish species likely to be using the Avon system.

To further address concerns, since the CLC meeting, NSTIR has commissioned a 2-year study led by Darren Porter, commercial fisherman, and Dr. Trevor Avery, Acadia University professor, to obtain quantitative data on commercial, recreational, and Aboriginal (CRA) fish species in the Avon Estuary, Lake Pisiquid and lower Avon River. Beginning in April 2017, the study leads and members of the Sipkne'katik First Nation, Acadia University staff and students, and the Mi'kmaw Conservation Group (MCG) will document fish passage through the current aboiteau, catalog the local, historical and traditional knowledge of CRA fishers, quantify the abundance and timing of species migrations in and near the causeway, and contrast the results of both fisheries-independent (government/academic) and commercial fisheries surveys.

Concern was raised regarding the importance of maintaining recreational use of Lake Pisiquid when designing the fish passage solution. Additional concerns regarding Lake Pisiquid included the concern about infilling and lack of oxygen, noting that many areas of the lake have become too shallow or weedy for boats, and the potential effects to the canoe club.

Questions were raised about the plans for railroad and concern that money had to be spent to accommodate the railbed even though the railbed is inactive.

The CLC will meet regularly during planning and construction of the Project and serve as a forum for information exchange between NSTIR, NSDA and interested stakeholders.

3.5 SUMMARY OF QUESTIONS AND CONCERNS RAISED DURING ENGAGEMENT

In general, there is overall support for the twinning of Highway 101 in recognition of improved safety and service performance. The majority of questions and concerns that have been raised during regulatory, Aboriginal and public engagement on the Project primarily pertain to the current existence and expansion of the causeway at Avon River, and in particular, potential effects on fish (*e.g.*, fish passage), fishing, and fish/wetland habitat. As noted above, there are also various stakeholders that have an interest in maintaining or improving current benefits that the causeway provides (*e.g.*, flood control, socio-economic use of Lake Pisiquid). These issues and concerns have been taken into consideration in this EA Report and ongoing Project design. NSTIR and NSDA will continue to work with regulatory, Aboriginal and public interests in optimizing Project design and implementation.

4.0 ENVIRONMENTAL ASSESSMENT SCOPE AND METHODS

4.1 SCOPE OF THE ASSESSMENT

4.1.1 Scope

The scope of the Project includes those Project components described in Section 2 and summarized in Table 4.1.1 for construction and operations and maintenance activities. There are no plans for decommissioning within the planning horizon therefore decommissioning/abandonment was not considered to be applicable to the scope.

Table 4.1.1 Description of Project Activities and Physical Works

Project Phase	
Activity Category	**Project Activities and Physical Works**
Construction	
Site Preparation	Includes all Project-related activities associated with preparing the RoW for access and road construction. Activities include: • clearing and grubbing • removal or modification of existing buildings • erosion and sediment control (ESC) measures
Roadbed Preparation	Includes all Project-related activities that are associated with roadbed preparation. Activities include: • blasting • excavation • placement of fill • grading • ditching and drainage management • grade separation structure construction
Watercourse Crossing Structure Construction	Includes all Project-related activities required to install the watercourse crossing structures. Activities include: • site preparation • stream diversion (if applicable) • installation • site restoration
Aboiteau and Causeway Upgrading	Includes Project-related activities that are associated with upgrading of the current aboiteau at the Avon River crossing and upgrading of the causeway to prevent flooding of dykelands. Activities to be defined as part of detailed engineering studies but will involve • salt marsh infilling • water management planning • road, rail and trail reinstatement

Table 4.1.1 Description of Project Activities and Physical Works

Project Phase	
Activity Category	**Project Activities and Physical Works**
Surfacing and Finishing	Includes all Project-related activities that are associated with surfacing and finishing. Activities include: • paving • hydroseeding and other permanent erosion control measures • signage, lighting and guide rail/cable barrier installation • highway marking/painting
Operation and Maintenance	
Project Presence and Operation	Includes all Project-related aspects that will be present for the life of the Project, including: • presence of the highway • presence of vehicle traffic • presence and operation of the aboiteau and causeway
Infrastructure Maintenance	Includes all Project-related activities that are required to maintain the Project infrastructure, including: • pavement maintenance • shoulder maintenance • watercourse crossing structure maintenance • highway marking/painting • signage, lighting, and guide rail/cable barrier maintenance
Winter Maintenance	Includes all Project-Related activities that are required for the safe operation of the Project during adverse winter weather conditions including: • salting • sanding • plowing
Vegetation Management	Includes: • mowing, vegetation removal, and planting
Decommissioning and Abandonment	
No plans for decommissioning identified within the planning horizon (lifespan of the facility)	N/A

4.1.2 Valued Component (VC) Identification

An important part of the assessment process is the early identification of Valued Components (VCs) upon which the assessment can be focused for a meaningful and effective evaluation. VCs are broad components of the biophysical and socio-economic environments that, if altered by the Project, may be of concern to regulatory agencies, the Mi'kmaq of Nova Scotia, scientists, and/or the general public. The selection of VCs was carried out in consideration of:

- a previous Terms of Reference which had been prepared for the Project in 2007 in consultation with federal and provincial government departments for a federal

Environmental Screening (no longer applicable) and Class I Nova Scotia Registration document
- issues raised by regulatory agencies, the Mi'kmaq, key stakeholders, and the public (refer to Section 3)
- existing environmental conditions in the area and interconnections between the VCs and the biophysical and socio-economic environment
- experience and lessons learned from other highway projects
- the professional judgment of the Study Team.

Table 4.1.2 Selected Valued Components

Valued Component	Factors To Be Considered
Atmospheric Environment	• Air quality • Sound quality (noise and vibration) • Climate • Global climate change (GHG Emissions)
Groundwater	• Bedrock, surficial geology and soils • Groundwater quality and quantity • Water supply source
Aquatic Environment	• Fish and fish habitat • Aquatic species of special conservation concern
Vegetation	• Terrestrial vascular plants • Dominant plant communities • Terrestrial plant species of special conservation concern
Wetlands	• Wetlands function and area • Use of wetlands by wildlife
Wildlife and Wildlife Habitat	• Wildlife (including migratory birds) presence/absence • Wildlife habitat • Wildlife species of special conservation concern
Land Use	• Agricultural (including dyke system), recreational, residential, industrial, or commercial use of land (existing and anticipated land use) • Identified current use of lands and resources for traditional purposes by Aboriginal persons
Archaeological and Heritage Resources	• Structures, sites, or things of historical, paleontological, archaeological, or architectural significance

4.2 ENVIRONMENTAL ASSESSMENT METHODS

The EA methods for the Project have been developed to meet the regulatory requirements of a Class I Registration under the Nova Scotia *Environment Act* and Environmental Assessment Regulations.

This report focuses the assessment on environmental components of greatest concern to the public, other stakeholders, Mi'kmaq of Nova Scotia, regulators and those identified through professional judgement. In general, the assessment:

- is focused on issues of greatest concern;
- addresses regulatory requirements;
- addresses issues raised by the public and stakeholders;
- integrates engineering design and mitigation and monitoring programs into a comprehensive environmental management planning process; and
- concludes with an assessment of residual environmental effects.

The EA method for the Project includes an evaluation of the potential environmental effects of each phase (construction, operation and maintenance) as well as accidents and malfunctions, with regard to VCs. Project-related effects are assessed within the context of temporal and spatial boundaries established for the assessment.

The following sections describe the process used to evaluate each of the VCs. Environmental assessments of each VC are presented in Section 5.

4.2.1 Boundaries

Spatial and temporal boundaries include those areas within which, and periods during which, the VCs are likely to interact with, or be influenced by, the Project. Environmental effects are evaluated within spatial and temporal boundaries. The spatial and temporal boundaries may vary among VCs, depending on the nature of potential environmental effects.

Spatial and temporal boundaries are developed for each VC in consideration of:

- timing/scheduling of activities for Project phases of construction and operation
- known natural variations of each VC
- information gathered on current and traditional land and resource use
- the time required for recovery from an environmental effect.

The Project Development Area (PDA) is defined as the footprint of physical disturbance that will occur as a result of Project construction and operation activities. The PDA remains the same for all VCs. The Assessment Area, which extends beyond the PDA and is the area within which environmental effects may extend, may vary from VC to VC. The Assessment Area is specifically defined for each VC in Section 5. In some cases, the VC analysis also distinguishes a separate Field Survey Area which falls within the Assessment Area.

Temporal boundaries identify when an environmental effect may occur. The temporal boundaries are based on the timing and duration of Project activities and the nature of the interactions with each individual VC.

The temporal boundaries considered for this assessment include the construction and operation of the Project. Decommissioning is not envisioned at this time and would be undertaken in consideration of requirements and regulations in place at that time; decommissioning is not being carried forward in the assessment. This EA assesses potential effects of the Project throughout the year. Temporal boundaries also address other temporal issues such as seasonal sensitivities (*e.g.*, bird breeding, migration). Spatial boundaries for the assessment vary according to the VC and are defined in Section 5.

4.2.2 Significance Determination

Each VC includes a threshold criteria or standard for determining the significance of the environmental effect, beyond which a residual environmental effect is considered significant (an unacceptable change). The threshold for significance is defined within each VC and is defined based on information obtained in issues scoping, available information on the state and characteristics of the VC, existing standard or regulations, and professional judgement. In particular, regulatory standards are used, where appropriate, to determine thresholds. Where regulatory standards are not available, other key factors such as the sustainability of biological populations, and rarity of species and critical habitats, have been used as indicators of significance. Significance for environmental effects is predicted after application of mitigation (*i.e.*, residual effects).

4.2.3 Description of Existing Conditions

Existing (baseline) conditions are described for each VC to characterize the setting for the Project, support an understanding of the receiving environment, and provide sufficient context for the effects assessment. The description is restricted to a discussion of the status and characteristics of the VC within the boundaries established for the assessment. This section includes a brief summary of field surveys and additional data analysis, as applicable to the VC.

4.2.4 Assessment of Project-Related Environmental Effects

The assessment of Project-related environmental effects follows a sequence where potential interactions between each VC and the Project are first identified, and where such interactions may exist, a more detailed assessment of those effects is completed. Effects are analyzed qualitatively, and, where possible, quantitatively, using existing knowledge, professional judgment and other analytical tools, where appropriate and applicable. Where existing knowledge indicates that an interaction is not likely to result in an effect, certain issues may not warrant further analysis.

The specific steps in the assessment of potential environmental effects include:

- identification of environmental effects pathways (*i.e.*, identification of the means by which the Project could result in an environmental effect on the VC);
- description of the mitigation measures proposed to reduce or eliminate potential environmental effects, including industry standards, best management practices (BMPs), compensation/habitat offsetting projects, and environmental protection measures that NSTIR will implement;
- identification of residual environmental effects (those that remain after mitigation and control measures are applied); and
- determination of significance of the residual effects.

A determination of the significance of residual Project-related effects is included for each VC. Following the determination of significance, follow-up and monitoring measures are recommended, where required, to verify environmental effects predictions or to assess the effectiveness of proposed mitigation measures. Effects from accidents and malfunctions are assessed separately in Section 7.

5.0 ENVIRONMENTAL IMPACT ASSESSMENT

5.1 ATMOSPHERIC ENVIRONMENT

The atmospheric environment is the component of the environment that comprises the layer of air near the earth's surface to a height of approximately 10 km. The atmospheric environment is characterized in three ways for this assessment:

- air quality, which is characterized by the chemical and physical properties of the air in the lower atmosphere, including gaseous and particulate air contaminants;
- sound quality, which is characterized by the type, character, frequency, intensity, and duration of sound pressure levels or noise (unwanted sound) in the outdoor environment; and
- climate, which is characterized by long-term trends in temperature, precipitation, sea level rise, and wind.

The atmospheric environment has been selected as a VC due to the nature of potential environmental effects of the Project on the local airshed, such as air contaminant releases and sound emissions, as a result of Project activities. The atmospheric environment has intrinsic importance to the health and well-being of humans, wildlife, vegetation, and other biota. The atmospheric environment is also an important pathway for the transport and eventual deposition of air contaminants to the freshwater, terrestrial and human environments.

In consideration of the relatively limited scale of the Project, as defined in the Project Description (Section 2), the potential environmental effects of the Project on local climate are expected to be nominal. For example, microclimate issues such as cold air pooling along elevated sections of the Project and the potential for local crop damage are not expected to be a concern due to the relatively limited scale of the Project (*i.e.*, 9.5 km of two-lane highway, and associated infrastructure) and because the Project is not expected to traverse any agricultural areas that would be sensitive to cold air pooling (*i.e.*, crops). Microclimate issues therefore will not be considered further in this assessment. Global climate change will be addressed in the context of Project-related changes in greenhouse gas (GHG) emissions.

5.1.1 Regulatory and Policy Setting

Air Quality

For the purposes of this EA, the Project-related air contaminants of interest consist of total suspended particulate matter (TSP) (including dust), particulate matter less than 10 microns (PM10), particulate matter less than 2.5 microns ($PM_{2.5}$), sulphur dioxide (SO_2), nitrogen dioxides (NO_2), and carbon monoxide (CO), and oxidants – ozone (O_3).

The Government of Nova Scotia has established Air Quality Regulations, under the Nova Scotia *Environment Act* (Table 5.1.1). In addition to the provincial regulations, Canada has set an ambient air quality standard for fine particulate matter over two time averaging periods (Table 5.1.1).

Table 5.1.1 Summary of Regulations Pertaining to Ambient Air Quality in Nova Scotia

Contaminant	Averaging Period	Regulatory Threshold (µg/m³)	
		Federal[1]	Provincial[5]
Total Suspended Particulate (TSP)	24-hour	-	120
	Annual	-	70
Particulate Matter Less than 10 microns (PM_{10})	24-hour	-	-
Particulate Matter Less than 2.5 microns ($PM_{2.5}$)	24-hour[2]	28 (2015) 27 (2020)	-
	Annual[3]	10 (2015) 8.8 (2020)	-
Sulphur Dioxide (SO_2)	1-hour	-	900
	24-hour	-	300
	Annual	-	60
Nitrogen Dioxide (NO_2)	1-hour	-	400
	Annual	-	100
Carbon Monoxide (CO)	1-hour	-	34,600
	8-hour	-	12,700
Ozone (O_3)	1-hour	-	160
	8-hour[4]	135 (2015) 133 (2020)	-

Notes:

1 Canadian Council of Ministers of the Environment Canada-Wide Standards for $PM_{2.5}$.
2 3-year average of the annual 98th percentile of the daily 24-hour average concentrations.
3 3-year average of the annual average concentrations.
4 3-year average of the annual 4th highest daily maximum 8-hour average concentrations.
5 Nova Scotia Air Quality Regulations (N.S. Reg. 179/2014).

Ground-level ozone is not emitted directly, but rather formed by secondary photochemical reaction between nitrogen oxides (NO_X) and VOCs in the atmosphere in the presence of strong sunlight. Although it is not expected that ground-level ozone levels in the Assessment Area will change substantially as a result of Project activities, it is useful to consider this contaminant in the assessment of existing conditions, since ozone is often considered an indicator of ambient air quality conditions in the environment. Therefore, ground-level ozone will be considered in this assessment solely as it pertains to the characterization of existing conditions in the Assessment Area.

Acoustic Environment

For sound levels, the province of Nova Scotia has published a noise guideline, "Guideline for Environmental Noise Measurement and Assessment" (NSDOE 1989). This guideline includes noise criteria for different periods of the day (day, evening and night) and requires that the measurement duration be a minimum of two continuous hours of data in each time period for the data to be representative. The Nova Scotia noise guidelines are presented in Table 5.1.2. Although not explicitly stated, these values are interpreted to represent hourly averages measured at the property boundary of sensitive receptors (*e.g.*, residential properties, schools, retirement homes, medical facilities, places of spiritual significance). It is noted in the guidelines that "transportation" is "excluded from the guideline" (NSDOE 1989). These limits are adopted in this assessment, as in previous highway environmental studies, in lieu of regulatory limits or a formal noise policy of NSTIR.

Table 5.1.2 NSE Noise Guidelines

Averaging Time Period	NSE Noise Guideline (dBA)
Day (7:00 to 19:00)	65
Evening (19:00 to 23:00)	60
Night (23:00 to 7:00)	55

GHG Emissions

There are currently no air quality standards or guidelines for GHG concentrations in ambient air (provincial or federal). Nova Scotia enacted the *Environmental Goals and Sustainable Prosperity Act* in 2007 that commits to supporting and enabling energy efficiency, sustainable transportation options, increased renewable energy and enhanced use of natural gas to displace oil and coal. The Act includes renewable energy targets, improved energy efficiency in building codes and GHG reduction targets. The GHG related targets include the following.

- Nova Scotia will work with other levels of government on national emissions standards for greenhouse gases and air pollutants from new motor vehicles.
- Greenhouse gas emissions are to be, by 2020, at least 10% below the levels that were emitted in 1990.

The Government of Nova Scotia has published two guidance documents for considering climate change during EA and project development: the "Guide to Considering Climate Change in Environmental Assessments in Nova Scotia" (NSE 2011a); and the "Guide to Considering Climate Change in Project Development in Nova Scotia" (NSE 2011b). The federal government has also developed a GHG assessment method which is based on guidance from the Federal-Provincial-Territorial Committee on Climate Change and Environmental Assessment, "Incorporating Climate Change Considerations in Environmental Assessment: General Guidance for Practitioners" (Federal-Provincial-Territorial Committee on Climate Change and

Environmental Assessment 2003) (the Climate Change General Guidance document). The GHG assessment presented here follows the general guidance specified in these documents.

5.1.2 Boundaries

The assessment of potential environmental effects on atmospheric environment encompasses two spatial boundaries: the Project Development Area (PDA) and the Assessment Area. The PDA (*i.e.,* footprint of physical disturbance) is defined in Section 4.2.1. The potential environmental effects of Project-related activities on air quality and the acoustic environment are generally not expected to extend beyond approximately 300 m from the median between the existing lanes and new twinned lanes. This 300 m range generally provides for sufficient dispersion of emissions and dissipation of noise generated from Project-related activities, such as heavy equipment operation and vehicle traffic. The spatial boundaries for the characterization of potential environmental effects of Project activities on air quality and sound quality are therefore identified as the zone extending to approximately 300 m from the median.

Potential effects related to GHG emissions on climate change are, by definition, global in nature.

The temporal boundaries for the assessment of potential environmental effects for each key aspect of the atmospheric environment include periods of construction and subsequent operation and maintenance phases of the Project in perpetuity. Residential areas are the most sensitive receptors for noise impacts at night. In residential areas, noise levels are usually dominated during the day by traffic, property maintenance and recreational activities. At night, local traffic is greatly reduced so that noise from the nearest arterial roads and industry may be the most dominant perceived source. Other temporal issues include seasonal considerations when residents may be engaged in a greater number of outdoor activities and potentially subject to a greater amount of noise and dust.

5.1.3 Significance Definition

A **significant residual adverse environmental effect of the Project on air quality** is one that, after mitigation has been considered, causes the maximum Project-related emissions of the air contaminants of interest (those described in Section 5.1.1) to exceed the Nova Scotia *Air Quality Regulations* for TSP, NO_2, SO_2, and CO, and the Canada Ambient Air Quality Standard for $PM_{2.5}$.

A **significant residual adverse environmental effect of the Project on the acoustic environment** is one that, after mitigation has been considered, causes either of the following to occur:

- a noticeable change in noise level (approximately 5 dBA) which results in exceedance of the NSE Noise Guidelines;
- a noticeable change in noise level (approximately 5 dBA) above existing noise levels in areas where the guideline levels are already exceeded; or
- a change in noise level of approximately 10 dBA above existing noise levels in areas where the guideline levels are not exceeded.

It is assumed that a noise level exceedance at a sensitive receiver would be frequent and persistent to result in a significant adverse change in sound quality.

Provincial guidance documents for assessing climate change (refer to Section 5.1.1) do not provide guidance on the determination of significance for GHG; therefore this assessment is based on guidance from the Federal-Provincial-Territorial Committee on Climate Change and Environmental Assessment, "Incorporating Climate Change Considerations in Environmental Assessment: General Guidance for Practitioners" (Federal-Provincial-Territorial Committee on Climate Change and Environmental Assessment 2003) (the Guidelines).

The Guidelines do not provide guidance on determination of significance for GHGs; instead, it focuses on increasing attention to Project GHG emissions and consideration of less emission-intensive ways to develop projects. For this assessment, emitter levels are used to determine if a GHG Management Plan is required under the Guidelines.

As identified in the Guidelines, "…the contribution of an individual project to climate change cannot be measured". As the effect on climate change from the contribution of a single project cannot be accurately measured or attributed, it is not reasonable to conclude a significant adverse residual effect on atmospheric GHG concentrations or climate change from a single project's GHG emissions.

5.1.4 Description of Existing Conditions

The existing atmospheric environment is described in the following section in the context of air quality, climate, greenhouse gases and the acoustic environment.

5.1.4.1 Methods

Air Quality

The Assessment Area and Nova Scotia in general, have good air quality due to the combination of maritime climate, providing good dispersion of air contaminants, and relatively small population and industrial bases (NSDOE 1998). The ambient air quality also benefits from the infusion of relatively clean polar and arctic air masses. Occasionally, however, long-range transport of air masses from central Canada or the eastern seaboard may transport contaminants into the area, causing poorer air quality.

NSE and Environment and Climate Change Canada, through the National Pollutant Surveillance Program (NAPS), operate a network of ambient air monitoring stations within the province to measure ambient concentrations of various air contaminants. The 2014 monitoring data from the Halifax and Aylesford Mountain monitoring stations (*i.e.* the closest monitoring stations to the Project that monitor the air contaminants of interest to this Project) are discussed in Section 5.1.4.2 to provide context with regard to regional ambient air quality. From the selected air contaminants listed in Section 5.1.1, particulate matter less than 2.5 microns in diameter ($PM_{2.5}$), carbon monoxide (CO), sulphur dioxide, (SO_2), nitrogen dioxide (NO_2), and ozone (O_3) are monitored at the Halifax monitoring station. Ambient concentrations of ground level O_3, $PM_{2.5}$ and NO_2 are a monitored at the Aylesford Mountain monitoring stations. Ambient concentrations of VOCs and PAHs are not monitored in Nova Scotia.

Acoustic Environment

The existing ambient sound levels in and surrounding the area would be expected to be typical of rural ambient levels, as well as the existing industrial activities in the area, road traffic, and any natural background sounds (*e.g.*, wind).

Noise is measured as sound pressure levels (SPL) in decibels (dB). These measurements are conventionally expressed on the A weighted scale (denoted as dBA), as it emphasizes the frequencies of highest sensitivity to the human ear. Humans are exposed to a broad range of sound pressure levels, which are represented on a logarithmic scale. A level of 0 dBA is the least perceptible sound by a human. A change in 3 dBA represents a physical doubling of the SPL but is barely perceptible as a change, whereas most people clearly notice a change of 5 dBA and perceive a change of 10 dBA as a doubling of the sound level. Typically, conversation occurs in the range of 50 to 60 dBA. Loud equipment and trucks passing on a busy road can create noise levels above 85 dBA. Very quiet environments, such as still rural or suburban nights, typically fall below 40 dBA.

To characterize the existing acoustic environment in the Assessment Area, sound pressure level monitoring was conducted in October 2007 (with supplementary monitoring in 2009), using Type 1 integrating sound level meters (Larson Davis models 820 and 824). These instruments average the energy level of sound over a selected period of time and express this as L_{eq} in dBA. Equivalent sound pressure levels, L_{eq}, are the steady state sound levels that would produce the same amount of energy as the fluctuating sound actually occurring over a specific amount of time. Each measurement session comprised 1 minute L_{eq} readings and the monitoring was conducted over a 24-hour period at each noise receptor location to establish the variation over time for the ambient sound pressure levels. One-minute measurements were then used to calculate hourly L_{eq} values, which is the most common averaging period for the expression of L_{eq}. The collected data are representative of the existing conditions and include contributions from traffic and any other substantive sources of noise near the monitoring locations, including those that are natural (*e.g.*, wind in trees, animals, *etc.*).

Climate

Climate is the statistical average (*i.e.*, mean and variability) of meteorological and weather conditions of a region over a defined period of time. Climate is characterized by various weather elements such as air pressure, precipitation, temperature, humidity, sunshine, cloudiness, wind and fog (Environment Canada 2014a).

Current climatic conditions are typically represented by the most recent 30 year period, for which the Government of Canada has developed statistical summaries, referred to as climate normals. The closest Government of Canada weather station, with available historical data (1981-2010), to the Assessment Area is the Windsor and Greenwood weather locations. Data collected at these stations was used to characterize existing climatic conditions in the Assessment Area (refer to Section 5.1.4.2).

Greenhouse Gases

An understanding of the existing provincial, national and global GHG emissions is required to place Project-related GHG emissions in context. Provincial and national GHG emissions were obtained from the Environment and Climate Change Canada's (ECCC) National Inventory Report for 1990–2014 (ECCC 2016a). Emissions from Transport, within the Energy Sector, were also reviewed. Global GHG emissions were acquired from the World Resources Institute (refer to Section 5.1.4.2).

5.1.4.2 Summary of Existing Conditions

Air Quality

There are very few industrial sources of emissions located near the Assessment Area including Annapolis Valley Ready Mix Ltd. (concrete supplier) located on Park Drive in the Town of Windsor just west of Exit 5A, and CKF (Canadian Keys Fibre Company), a manufacturer of pulp and foam products, located in Hantsport, NS. The CKF facility is located approximately 10 km north of Falmouth. Emissions from consumer products such as home heating systems and motor vehicles, as well as air contaminants transported to the region by prevailing winds, are also likely to be predominant contributors to ambient air contaminant concentrations in the Assessment Area.

Based on the 2014 NAPS data (ECCC 2014) the following general observations can be made regarding the existing air quality in the Assessment Area.

- The monthly average 24-hour concentration of particulate matter less than 2.5 microns ($PM_{2.5}$) in diameter at the Halifax monitoring station ranged from 3 to 7 µg/m^3 and from 4 and 8 µg/m^3 at the Aylesford Mountain monitoring station. These values fall well below the current 24-hour Canada Wide Standard for $PM_{2.5}$(28 µg/m^3).
- The monthly average 1-hour and 8-hour concentrations of carbon monoxide at the Halifax monitoring station ranged from 344 µg/m^3 to 460 µg/m^3. These values were below the 1-hour and 8-hour Nova Scotia Air Quality Regulations for CO (34,600 and 12,700 µg/m^3 respectively). CO is not monitored at the Aylesford monitoring station.
- The monthly average 1-hour concentration of nitrogen dioxide at the Aylesford monitoring station was 1.88 µg/m^3, well below the 1-hour Nova Scotia Air Quality Regulations for NO_2 of 400 µg/m^3. There is no Nova Scotia standard for the 24-hour time averaging period.
- The monthly average 1-hour and 24-hour concentrations of sulphur dioxide at the Halifax monitoring station ranged from 2.6 µg/m^3 to 7.86 µg/m^3, well below the 1-hour and 24-hour Nova Scotia Air Quality Regulations of 900 µg/m^3 and 300 µg/m^3, respectively. SO_2 is not monitored at the Aylesford monitoring site.

- The monthly average 1-hour and 24-hour concentrations of ozone for the Aylesford monitoring station range from 53 µg/m^3 to 82 µg/m^3. These values fall well below the 1-hour and 8-hour Nova Scotia Air Quality Regulations for Ozone (provide the values).

A summary of estimated emissions of criteria air contaminants (CACs) in Nova Scotia for 2014 is presented in Table 5.1.3. These emissions include those from industrial, non-industrial, mobile, incineration, miscellaneous and open sources in Nova Scotia, as reported to the NPRI (ECCC 2016b). These emission summaries represent the latest information available.

Table 5.1.3 2014 Air Pollutant Emissions for Nova Scotia

Contaminant	2014 Emissions (tonnes/year)
Total Suspended Particulate Matter (TSP)	370,029
Particulate Matter less than 10 microns (PM_{10})	101,500
Particulate Matter less than 2.5 microns ($PM_{2.5}$)	30,373
Sulphur Oxides (SOx as SO_2)	75,486
Nitrogen Oxides (NOx as NO_2)	72,432
Carbon Monoxide (CO)	172,631
Volatile Organic Compounds (VOCs)	42,296

Source: ECCC 2016b

Acoustic Environment

A description of land uses in the Assessment Area is provided in Section 5.7. Aside from residential and commercial land uses (including the Super 8 Motel between Exits 5 and 5A) there are no particularly noise sensitive receptors along the alignment.

As discussed in Section 5.1.5, sound pressure level monitoring was conducted in 2007 and 2009 to characterize the existing acoustic environment surrounding the Assessment Area. Seven noise receptor locations were selected based on their proximity to the proposed RoW and they are considered representative of the greatest potential adverse environmental effects of the Project on sound quality. The locations of the noise receptors are presented in Figure 5.1.

A summary of the 1-hour Leq values for all eight monitoring locations is provided in Table 5.1.4. Monitoring locations 1, 3, 4 and 5 were sampled on October 14, 2007 and locations 2, 5A, 6, and 7 were sampled on October 15, 2007. Site 6 was re-measured on April 15, 2009 due to data recovery issues with the original data set for that location. Measurements that exceed the NSE Noise Guideline are shown in bold.

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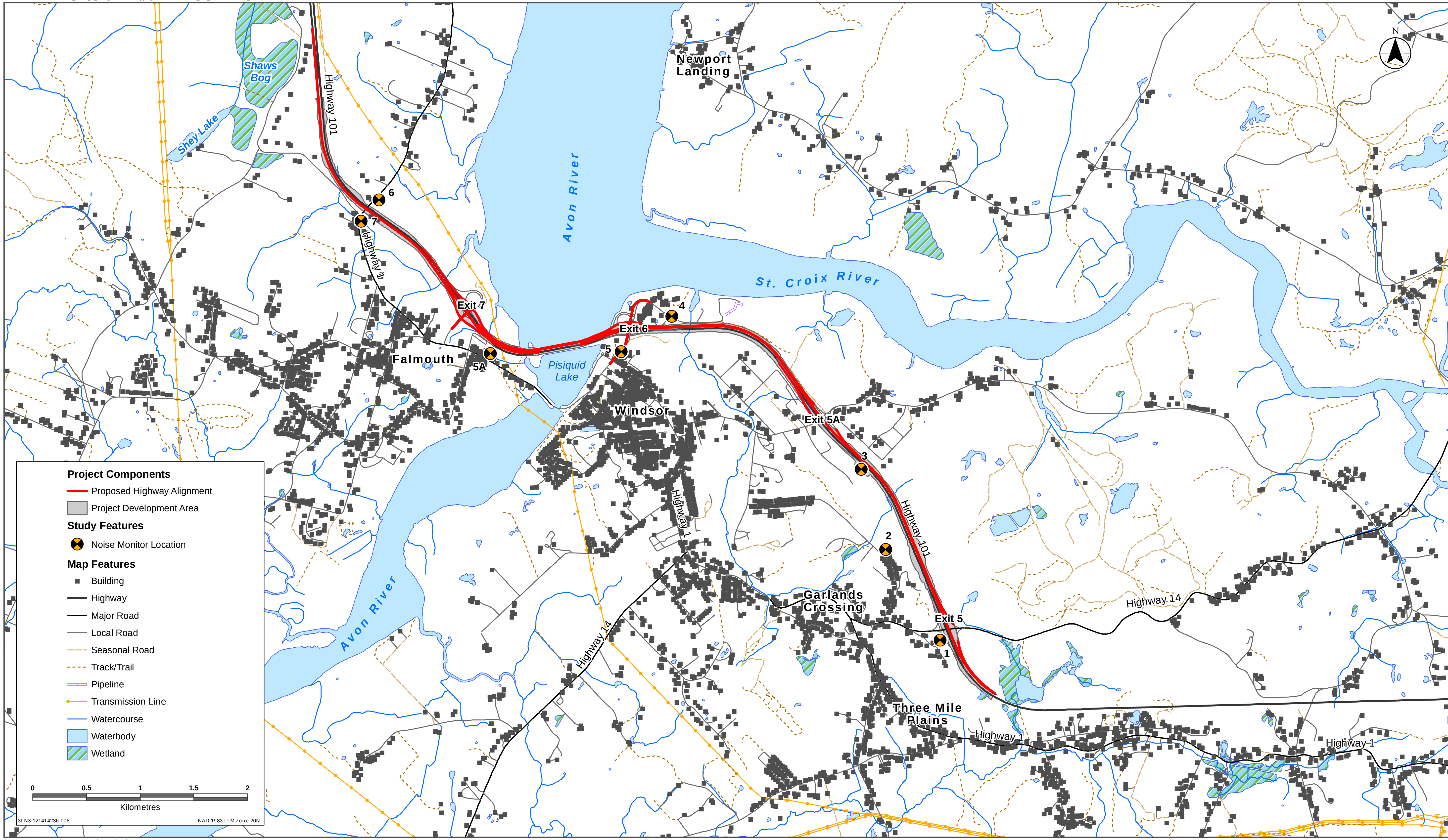

Sources: Base Data - Government of Nova Scotia

Disclaimer: This map is for illustrative purposes to support this Stantec project; questions can be directed to the issuing agency.

Baseline Noise Monitoring Locations

Stantec

ENVIRONMENTAL ASSESSMENT, HIGHWAY 101 THREE MILE PLAINS TO FALMOUTH

Figure 5.1

Table 5.1.4 2007 Baseline Noise Monitoring Results - Hourly Leq

Time of Day	Monitoring Location								NSE Noise Guideline
	1	2	3	4	5A	5	6*	7	
10:00	60.5	-	-	-	-	-	-	-	65
11:00	61.6	50.2	64.8	-	-	-	53.2	-	65
12:00	61.7	52.4	**66.4**	57.3	60.5	60.9	55.3	-	65
13:00	63.2	51.7	**66.3**	57.7	63.0	61.7	53	60.0	65
14:00	62.8	52.7	**68.6**	52.5	**66.4**	63.9	54.6	60.1	65
15:00	61.7	52.3	**68.2**	56.3	64.2	**71.2**	54	60.2	65
16:00	60.0	51.2	**67.6**	57.3	**65.7**	**68.1**	55	60.7	65
17:00	61.6	52.2	**68.0**	57.7	59.7	**66.5**	55.8	60.6	65
18:00	61.0	51.5	**67.3**	57.3	62.4	**66.7**	56.8	59.1	65
19:00	60.4	50.9	**65.8**	58.1	**66.2**	**63.4**	55.6	58.2	60
20:00	58.8	52.5	**64.9**	56.2	**60.9**	**65.0**	54.9	56.8	60
21:00	57.5	50.4	**63.2**	53.3	57.2	**62.2**	53.7	55.0	60
22:00	56.9	51.2	**61.5**	51.0	65.0	**60.3**	54.1	54.2	60
23:00	55.5	50.5	**60.2**	50.2	61.1	**62.8**	49.5	52.0	55
0:00	54.5	49.5	**57.3**	48.5	49.3	**57.7**	49.4	49.2	55
1:00	53.6	50.6	**57.7**	48.1	49.8	49.4	51.2	49.6	55
2:00	53.9	50.2	**58.1**	49.4	48.9	50.8	52.2	50.1	55
3:00	54.9	50.7	**57.9**	49.3	50.0	51.5	50.4	49.4	55
4:00	**55.4**	50.3	**59.7**	52.6	52.0	53.3	52.1	52.6	55
5:00	**58.6**	50.1	**63.5**	55.2	**56.0**	**59.1**	**55.4**	54.9	55
6:00	**60.9**	52.7	**66.2**	**58.0**	**60.7**	**64.9**	**56.1**	**59.1**	55
7:00	61.4	53.6	**68.1**	60.5	61.8	**67.7**	55	61.1	65
8:00	61.4	53.0	**68.1**	61.4	**67.6**	**67.4**	56.5	61.3	65
9:00	60.6	53.6	**67.0**	59.7	64.7	**66.1**	59.8	60.4	65
10:00	61.5	52.8	**67.2**	60.6	**66.5**	**67.4**	55.8	60.8	65
11:00	-	52.7	**66.4**	59.1	61.6	58.6	**-**	60.7	65
12:00	-	-	-	-	-	-	-	60.4	65

Baseline exceedances of NSE Noise Guidelines are bolded.
*Data collected in 2009.

The baseline noise monitoring study raw data can be found in Appendix A.

Monitoring locations 1, 3, 5A, and 5 demonstrate effects of the existing highway. All of these locations exhibited sound pressure levels that are above the NSE Noise Guidelines during all or some portion of the evening and night time periods (shown in bold in Table 5.1.4). The sound pressure levels logged for locations 3 and 5 were above the NSE Noise Guidelines over the majority of the 24-hour sampling period. Site 3 is located closest to the highway (approximately 40 m from the existing highway alignment). Locations 2, 4, 6 and 7 were observed to be quieter sites and within the Noise Guidelines for all portions of the day, evening and night time periods for the most part.

Climate

The Assessment Area is located in the central-west portion of Nova Scotia. The closest complete weather station is that at Greenwood, NS. The Town of Windsor contains a smaller weather station.

A summary of the Climate Normals (1981 – 2010) for the Windsor weather station and the Greenwood weather station (for wind statistics only) (Environment Canada, 1982; Government of Canada 2016) is presented in Table 5.1.5 and discussed below.

Table 5.1.5 Summary of Climate Normals for the Assessment Area, Windsor and Greenwood, NS

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Temperature Normals for Windsor, NS (1981 - 2010)													
Daily Average (°C)	-5.5	-4.4	-0.6	5.3	11.3	16.2	19.9	19.5	15.2	9.4	4.2	-1.6	7.4
Daily Maximum (°C)	-1	0.2	4	10.1	17.1	22.1	25.5	25.1	20.6	14.2	8	2.4	12.4
Daily Minimum (°C)	-9.9	-9.1	-5.2	0.4	5.5	10.3	14.2	13.9	9.8	4.6	0.3	-5.6	2.4
Precipitation Normals for Windsor, NS (1981- 2010)													
Rainfall (mm)	71.9	54.6	83.2	88.6	93.7	82.8	83.9	76.3	105.6	108.8	127	84	1060.2
Snowfall (cm)	75.2	52.6	42.9	14.7	1.6	0	0	0	0	0	16.6	45.7	249.4
Precipitation (mm)	147.1	107.2	126.1	103.3	95.3	82.8	83.9	76.3	105.6	108.8	143.6	129.7	1309.6
Wind Normals for Greenwood, NS (1981 – 2010)													
Most Frequent Direction	W	W	W	W	W	W	W	W	W	W	W	W	W
Maximum Gust Speed (km/h)	161	188	161	130	122	101	93	108	129	161	126	161	188
Direction of Maximum Gust	SE	SW	SE	S	W	W	NW	S	S	S	W	E	SW
Days with Winds >= 52 km/h	4.1	2.8	3.3	2.7	1.3	1	0.4	0.6	0.8	1.3	3.5	4.4	26.1
Days with Winds >= 63 km/h	1.5	1.1	1.4	0.7	0.3	0.2	0	0.1	0.2	0.3	1.3	1.8	9
Wind Speeds for Greenwood, NS (1981 - 2010) (km/hr)													
Average Speed (All Directions)	16.5	16.1	16.3	15.9	14	12.5	11.5	10.9	11.7	13.5	15.2	16.4	14.2

Based on the climate normals described in Table 5.1.5, January is the coldest month in the Assessment Area, recording a minimum of -9.9 ºC, and July and August are the warmest with maximum temperatures of 25.5 ºC and 25.1ºC respectively. The average annual precipitation at the Windsor weather station is 1310 mm, of which approximately 81% is in the form of rain.

The average annual wind speed reported at the Greenwood weather station was approximately 14.2 km/h. The maximum wind speeds occur in January with average speeds of 16.5 km/h and the minimum speeds occur in August at an average of 10.9 km/h. The average monthly wind speeds in the Assessment Area are higher in the winter than in the summer.

Greenhouse Gases

The provincial, national and global GHG emissions for 2005 through to 2014 (the most recent available) are presented in Table 5.1.6.

Table 5.1.6 Global, National and Provincial GHG Emissions (kt CO2e), 2005–2014

Region	2005	2009	2010	2011	2012	2013	2014
Global[1]	38,696,545	40,956,547	42,669,718	43,816,734	44,815,500	NA	NA
Canada	749,000	699,000	707,000	709,000	715,000	726,000	732,000
Nova Scotia	24,000	21,000	20,700	21,400	19,600	18,300	17,000

Notes:
NA = not available.
Years 2005, 2009, 2010, 2011, 2012, 2013, 2014 are presented as these are the data provided in the most recent national inventory report (ECCC 2016a).
1 Includes countries that report GHG emissions.

Source: ECCC 2016a, WRI 2016

In 2014, Canada's contribution to global GHG emissions (based on the most recent data available - 2012 data) was 1.6%. Nova Scotia's contribution to the national total was approximately 2.3% in 2014 and to the global total, approximately 0.04%.

In 2014, the Energy Sector (stationary combustion, transport and fugitive emission sources) represented the majority of Canada's GHG emissions at 81% (594,000 kt CO_{2e}) (excludes Land Use). The Industrial Process and Product Use, Agriculture, and Waste Sectors represented the remaining 7%, 8% and 4%, respectively. The Transport Sector represented approximately 34% (203 kt CO_{2e}) of the Energy Sector, with Road Transportation making up 69% (140 kt CO_{2e}) of the Transport emissions (ECCC 2016a).

5.1.5 Potential Environmental Effects and Project-Related Interactions

Activities and components could potentially interact with the atmospheric environment to result in adverse effects on air quality and increased levels of greenhouse gas emissions and noise levels. In consideration of these potential interactions, the assessment of Project-related environmental effects on the atmospheric environment is therefore focused on the following potential environmental effects:

- change in air quality;
- change in acoustic environment; and
- change in greenhouse gases.

5.1.5.1 Change in Air Quality

Construction

During all construction activities, the operation of heavy equipment, such as earth movers, excavators, dump trucks and graders will affect air quality including emissions of particulate matter (dust) as well as the emission of combustion gases and small amounts of particulate matter from the combustion of fuel in construction equipment.

Dust will be generated during site preparation, sub-grade development, and construction of temporary ancillary elements. Grubbing generally creates few dust problems since the exposed soil is usually moist, and the grubbed areas are seldom left exposed for extended periods. Handling of fill material, dumping, grading, compaction, pouring of footings and bridge/overpass piers, are potential sources of airborne dust that may affect air quality in the immediate vicinity of the Project.

Until the roadway is paved, the movement of construction vehicles on unpaved roadway sections, access roads, and construction/laydown areas may generate airborne dust, especially where these vehicles cross from the exposed area to a paved roadway. This type of dust is typically confined to the immediate vicinity of the Project site, and transported up to a distance of approximately 300 m from the point of origin.

Equipment used in highway construction activities are typically powered by diesel engines. The combustion gases released from the operation of such equipment include sulphur dioxide (SO_2), carbon monoxide (CO) and nitrogen oxides (NO_x), as well as particulate matter (PM). The number and distribution of the equipment during typical construction practices will allow for sufficient dispersion of these emissions to prevent significant impact on local air quality during most atmospheric conditions.

The paving of the roadway will result in emissions of TSP, CO, NO_2, SO_2, VOCs and PAHs through the operation of a mobile asphalt plant (if used by contractor) and associated paving equipment.

Operation and Maintenance

Interactions between the Project and air quality during all phases of operation and maintenance will occur on a localized basis, primarily as a result of the emissions of combustion gases (including greenhouse gases) along the roadway. The Project is not intended to increase traffic in the area but rather to facilitate the movement of existing traffic. As such, no additional interactions with air quality are expected from the Project presence, on an airshed basis.

During all maintenance activities, there will be operation of heavy equipment (possibly including paint striping equipment, vegetation control equipment, earthmovers, winter maintenance equipment and excavation and grading equipment). There is potential for environmental effects from dust generated due to some of the maintenance activities and from road salt application during winter, as well as the emissions of combustion gases, including selected air contaminants, from the equipment.

5.1.5.2 Change in Acoustic Environment

Construction

Sound quality will be affected by construction activities for the Project. Temporary changes in sound pressure levels will occur due to activities such as blasting (if required), earth moving, and the operation of heavy equipment associated with site preparation, structure construction, roadbed preparation and the development of facilities. Changes in sound quality due to construction are generally of shorter duration and more localized than changes expected during highway operation.

Operation and Maintenance

Interactions between the operation and maintenance of the Project and sound quality will occur due to increased sound pressure levels from vehicle traffic and maintenance equipment on the Project route. The sound emissions from vehicle engines and tires on the road may be perceptible to occupants of nearby residences and commercial developments. Winter maintenance activities (such as snow plowing) and vegetation control activities will also create sound emissions. These maintenance activities are typically short-lived and infrequent in nature, while vehicle traffic associated with Project presence will persist in perpetuity.

5.1.5.3 Change in GHG Emissions

Construction

Emissions of GHGs from heavy construction equipment (*e.g.*, trucks, front-end loaders, pavers, and other equipment) will occur from the operation of internal combustion engines, which are typically diesel-fueled. The removal of carbon sequestered in soil and vegetation within the Assessment Area as part of Project may lead to small changes in the net balance of GHG in the local area.

Operation and Maintenance

Project presence is not expected to result in increased vehicle traffic but rather facilitate the movement of existing traffic. No incremental interactions with global climate change are therefore expected from road traffic during operation.

During Project maintenance, the operation of mowing and vegetation control equipment and heavy equipment (possibly including paint striping equipment, earthmovers, and excavation and grading equipment) will result in the release of GHG emissions as a result of the combustion of fossil fuels.

5.1.6 Mitigation

Mitigation measures to be implemented to reduce potential effects on existing ambient air quality, reduce sound emissions, and reduce emissions of GHGs during construction and operation and maintenance are presented in Table 5.1.7.

Table 5.1.7 Mitigation for Atmospheric Environment

<table>
<tr><th>Effect</th><th>Phase</th><th>Mitigation</th></tr>
<tr><td rowspan="2">Change in Air Quality</td><td>Construction</td><td rowspan="2">• Follow Generic EPP (Section 3.13) including application of dust suppressants, where feasible, follow equipment maintenance schedules, preserving natural vegetation where possible
• Reduce activities that generate large quantities of dust during high winds</td></tr>
<tr><td>Operation and Maintenance</td></tr>
<tr><td rowspan="2">Change in Sound Quality</td><td>Construction</td><td rowspan="2">• Follow Generic EPP (Section 3.13) including notification, muffling devices, machines in good working order, minimization of idling, and time of day restrictions (daytime)
• Use noise controls where possible (e.g., mufflers)</td></tr>
<tr><td>Operation and Maintenance</td></tr>
<tr><td rowspan="2">Change in GHG Emissions</td><td>Construction</td><td rowspan="2">• Environmental awareness sessions to reduce vehicle idling
• Follow equipment maintenance schedules</td></tr>
<tr><td>Operation and Maintenance</td></tr>
</table>

5.1.7 Residual Environmental Effects and Significance Determination

The assessment of residual environmental effects considers residual effects on atmospheric environment after the general mitigation measures, as provided above, have been implemented.

5.1.7.1 Change in Air Quality

Construction

Air quality may be affected during construction due to emissions associated with the operation of heavy equipment.

Dust will primarily be generated during construction from site preparation and sub-grade development activities, such as clearing, grubbing, grading and leveling. The grubbing operation as part of the Project should result in relatively few dust events since the exposed soil is expected to be moist, and the grubbed areas are not expected to be left exposed for extended periods. The handling of fill material, dumping, grading and compaction are potential sources of airborne dust that may affect nearby receptors. Until the roadway and watercourse crossing structure decks are paved, the movement of construction vehicles on unpaved roadway sections, access roads, and construction/laydown areas may generate airborne dust (suspended particulate matter), especially where these vehicles cross from the exposed area to a paved roadway.

All dust is expected to be generally confined to the immediate vicinity of the construction activity, and could be transported up to a distance of approximately 300 m or less from the point of origin. Dust emissions are expected to be short-lived, and will be reduced by following the Generic EPP (Section 3.13). Among the mitigation suggested in these documents are dust suppression measures, such as the application of water during periods of heavy activity and/or during dry or windy periods to reduce generation and transport of airborne dust.

The emissions of combustion gases from heavy construction equipment (*e.g.*, trucks, front-end loaders, pavers, and other equipment) will occur from the operation of internal combustion engines, which are typically diesel-fueled.

Table 5.1.8 summarizes the emissions estimates associated with typical construction equipment (*e.g.*, pavers, rollers, trucks, asphalt plant) to be used during Project construction.

Table 5.1.8 Total Estimated Construction Emission Estimates for the Project

Emissions	Project Construction Totals (tonnes)	Nova Scotia 2014 Totals (tonnes)
TPM	1.31	370,029
PM_{10}	0.46	101,500
$PM_{2.5}$	0.33	30,373
NO_x	5.65	72,432
CO	12.5	172,631
SO_2	2.72	75,432
VOC	0.37	42,296
PAH	0.22	NA

Sources: ECCC 2016b; US EPA 2002; US EPA 2004

Emission factors and methodologies published by the US EPA for non-road diesel vehicles (US EPA 2002) were used to estimate the emissions of selected air contaminants from the paving portion of the construction phase. Since most vehicles used during construction are powered with heavy-duty diesel engines with approximately similar engine displacements, it was assumed that the proportion of heavy-duty vehicles per km of highway construction would remain constant for all phases of construction.

Emissions associated with asphalt plant operation (if required), including emissions of PAHs, were estimated using published emission factors (US EPA 2004) and assuming an asphalt tonnage requirement of 3,500 tonnes/km of two lane highway, with approximately 9.5 km of twinned lanes and related infrastructure (*e.g.*, realignment of existing lanes, ramps, auxiliary lanes).

In consideration of the emissions estimates presented in Table 5.1.8, contaminant emissions during construction represent a very small fraction of comparable provincial emissions.

The number and distribution of heavy equipment during typical construction practices are not expected to result in substantive emissions to the local air shed and would not influence ambient air quality during most atmospheric conditions. The use of properly maintained vehicles and equipment during construction and adherence to the Generic EPP (Section 3.12) will reduce Project-related construction air emissions. The magnitude, frequency and duration of the construction activities are such that the applicable ambient air quality standards and objectives are unlikely to be exceeded.

In consideration of the potential environmental effects of the Project-related activities during construction, the proposed mitigation, and the significance definition, residual environmental effects of the construction of the Project on air quality are predicted to be not significant.

Operation and Maintenance

Air quality will be affected during operation due to air emissions from vehicle traffic and maintenance equipment including combustion gases and particulate matter. However, the Project will not cause an increase in vehicle traffic in the Assessment Area (and resulting air emissions), but rather is intended to facilitate existing traffic volumes and improve overall traffic flows.

The magnitude, frequency and duration of the maintenance activities and related emissions are very unlikely to result in an exceedance of applicable ambient air quality standards or objectives within the Assessment Area. The use of properly maintained vehicles and equipment, and adherence to the EPP will help to mitigate any potential emissions from maintenance equipment during the operation and maintenance phase.

In consideration of the potential environmental effects of the Project-related activities during operation and maintenance, the proposed mitigation, and the significance definition, residual environmental effects of the operation and maintenance of the Project on air quality are predicted to be not significant.

5.1.7.2 Change in Acoustic Environment

Construction

Construction equipment will cause sound pressure levels along the road, within 50 m or so, to approach 85 dBA during peak passes, and levels of 60 to 70 dBA averaged over each active working hour. These levels will decrease with distance to approximately background levels within 1 to 2 km, and likely not to be perceptible at 5 km. Certain equipment may exceed these levels, but it would be anticipated that this is very rare. Table 5.1.9 provides the sound pressure levels at a distance of 15 m, of various typical pieces of construction equipment.

Table 5.1.9 Typical Construction Equipment Sound Pressure Levels

Equipment Powered by Internal Combustion Engines	Sound Pressure Level (dBA at 15 m)
Roller	85
Front loader	80
Backhoe	80
Excavator	85
Bulldozer	85
Scraper, grader	85
Paver	85
Pick-up truck	55
Concrete mixer truck	85
Concrete pump truck	82
Crane	85
Pump	81
Generator	82
Generator (<25KVA, VMS signs)	70
Compressor (air)	80
Pneumatic Tools	85
Jackhammer	89
Blasting	94

Source: United States Department of Transportation, Federal Highway Administration (FHWA) 2006

To reduce the sound pressure levels at the nearest residents, a combination of mitigation measures will be employed, as described in the Generic EPP (Section 3.13 and Table 5.1.6) including notification of construction activities to landowners; use of muffling devices on equipment; keeping machines in good working order (*i.e.*, regularly maintained); minimization of idling; and time of day working restrictions. Any complaints received will be investigated promptly and addressed as required. After mitigation is applied the sound pressure levels during construction may still occasionally exceed 65 dBA (especially at those residences where existing sound levels exceed the Guideline); however, any exceedances are not likely to be frequent at any one residence.

Blasting may be required as part of the construction activities and could produce elevated sound pressure levels at the nearest residences, on a very short term and intermittent basis. Blasting, if required, will be conducted in accordance with the Generic EPP (Section 3.13) and the Project-specific EMP, as well as other applicable guidelines.

Occasional noise sources such as the dumping of rock may be louder than the working machinery (>125 dBA at the source) (*e.g.*, tailgate slamming during dumping). However, these high sound levels attenuate quickly due to their impulsive nature (*i.e.*, short duration).

In general, mitigation measures may not bring levels to within the Guidelines at all times, especially for those areas that already experience higher noise levels due to the operation of the existing highway. Actual construction noise levels are expected to be lower than the maximum predicted most of the time, as construction activities will be moving locations and will not always be at the nearest point to any particular sensitive receptor. Therefore, there may be instances where a noticeable change in noise levels result in an exceedance of the Guidelines or, for areas where the Guidelines are already exceeded, a noticeable change above existing noise levels. These levels, however, are not expected to be sustained over a long period or on a frequent basis.

In consideration of the potential environmental effects of the Project-related activities during construction, the proposed mitigation, and the significance definition, residual environmental effects of the construction of the Project on sound quality are predicted to be not significant.

Operation and Maintenance

Motor vehicle and maintenance equipment traffic on the Project route will result in increased sound levels at nearby receivers, as the sound from vehicle engines and tires on the road may be perceptible to occupants of nearby residences.

The assessment of change in sound quality for the Project is based on predicted sound pressure levels generated by the Federal Highway Administration (FHWA) Traffic Noise Model. The information pertaining to existing traffic volumes was used in the model included approximately 14,000 vehicles per day. The results are based on worst case scenarios (*i.e.*, highest noise estimates) which involved taking 10% of the daily traffic as the worst case 1-hour and assuming that the worst case hour would occur during the daytime.

The model predictions for traffic levels at varying distances from the highway, based on the FHWA model predictions for the Project, are presented in Table 5.1.10.

Table 5.1.10 Summary of Results from the Traffic Noise Model

Receiver Location - Distance from Center of Highway (median between eastbound and westbound lanes) (m)	Predicted Worst Case 1-hour L_{eq} (dBA) (Daytime)
10	74
20	68
40	62
50	60
75	57
100	54
150	50
200	48
250	46
300	45

At approximately 40 m from the centerline of the highway, based on existing traffic volumes, Project predicted sound pressure levels are below the NSE Noise Guideline of 65 dBA, for the daytime period. Currently the only buildings within a 40 m radius from the centerline of the existing highway are the two provincial government buildings associated with the causeway; noise monitoring location 3 is also within 40 m. As evident in the baseline noise monitoring results (refer to Table 5.1.4), site 3 exhibits effects from the existing highway and a noticeable change in noise level (approximately 5 dBA) above existing noise levels is not predicted. As shown in Table 5.1.9, with increasing distance from the centerline of the highway sound pressure levels continue to decrease.

Due to the alignment of the Project, sound pressures resulting from the operation of the Project at site 5 and 5A will likely decrease, as the highway will move slightly north. At noise monitoring sites 4 and 7, sound pressure levels related to the operation of the Project will likely increase slightly as the twinning of the highway will result in the westbound and eastbound lanes, respectfully, being positioned closer to these sites. These monitoring sites are located between 100 and 120 m from the edge of the proposed new lanes. Based on the results presented in Table 5.1.10 a noticeable change in sound levels resulting in an exceedance of the NSE Noise Guidelines is not expected.

Infrastructure maintenance activities will typically be restricted to daylight hours, and will be of relatively short duration. Events of elevated sound pressure due to maintenance activities are not expected to affect any one receiver for a prolonged period of time or during nighttime hours. Adherence to the Generic EPP (Section 3.13), including the use of mufflers when appropriate on maintenance equipment and following regular maintenance schedules, will help to mitigate the effects of maintenance activities on sound quality in the Assessment Area.

In consideration of the potential environmental effects of the Project-related activities during operation and maintenance, the proposed mitigation, and the significance definition, residual environmental effects of the operation and maintenance of the Project on the acoustic environment are predicted to be not significant.

5.1.7.3 Change in GHG Emissions

Construction

Emissions of GHGs will result from the operation of heavy construction equipment (*e.g.*, trucks, front-end loaders, pavers, and other equipment) during the construction phase of the Project. Table 5.1.11 summarizes the GHG emissions estimate associated with typical construction equipment (*e.g.*, pavers, rollers, trucks, asphalt plant) to be used during Project construction and comparative provincial GHG emissions for 2014 (also refer to Table 5.1.7).

Table 5.1.11 Total Estimated GHG Emissions for Project Construction

	Project Construction Totals (tonnes)	Nova Scotia 2014 Totals (tonnes)
GHGs (CO_2eq)	780.87	17,000,000

The estimated GHG emissions from Project construction represent 0.005% of the provincial 2014 emissions and 0.0001% of the national emissions.

The removal of carbon sequestration sources such as forested areas during construction may also lead to changes in the net balance of stored carbon in the local area. Carbon sequestration is usually presented in terms of the tonnes of carbon stored per year in a given forested area. Carbon is incorporated into the physical structure of trees and plants through photosynthesis, which sequesters CO_2 from the air. An estimation of the removed carbon sequestration within the Assessment Area was completed based on the forested areas removed and their respective carbon sequestration potentials using methodologies developed by the United States Energy Information Administration (US EIA 2000) and Environment Canada (Gray 1995).

The estimated loss in carbon sequestration potential as a result of the construction of the Project is presented in Table 5.1.12.

Table 5.1.12 Estimated Loss of Carbon Sequestration due to the Project

Loss in Area of Carbon Sequestration Sources Resulting from Project (Hectares)	Loss of Carbon Sequestration in Assessment Area (tonnes CO_2/year)	Estimated Provincial Greenhouse Gas Emissions for 2014 (ECCC 2016a) (tonnes CO_2-equivalent/year)
0.339	2	17,000,000

Carbon sink calculations were limited to forested areas or areas with general tree cover, due to the lack of standardized procedures for determining carbon sequestration by other sinks, such as agricultural land and water bodies. The area of forest or tree cover removed, as presented in Table 5.1.12, was determined using habitat type classification based on NSDNR land cover data (refer to Figure 5.9 and Table 5.6.1).

The estimated GHG emissions and carbon sequestration lost due to Project construction is negligible when compared to GHG emissions in the province and nationally. The carbon sequestration loss could be offset by GHG emission reductions from improvements in vehicle traffic flow as a result of twinning the highway and facilitating the movement existing traffic volumes.

GHG emissions during construction will be temporary, short in duration and small in magnitude and will be mitigated as described in the Generic EPP (Section 3.13) and Table 5.1.7.

Operation and Maintenance

Project operation is not expected to result in increased vehicle traffic but rather facilitate the movement of existing traffic and negligible interactions with global climate change are expected.

GHG emissions during maintenance will be temporary, short in duration, and small in magnitude. GHG considerations during maintenance will be managed as described for the construction phase.

5.1.8 Monitoring and Follow-up

Should complaints of excessive noise or airborne dust be received, the root causes of these complaints will be determined by NSTIR, and corrective action will be taken if warranted. Should it be determined to be necessary to identify the source or extent of such problems, ambient monitoring of dust or noise will be conducted, as appropriate.

5.2 GROUNDWATER RESOURCES

Groundwater resources has been selected as a VC due to potential Project-related effects on groundwater that could be used for potable purposes. Groundwater provides a potable water supply to approximately half of the total population of Nova Scotia, and to all of the un-serviced residences adjacent to the proposed highway alignment. The potential for the disruption or contamination of the groundwater drinking supply for nearby residents therefore requires assessment.

5.2.1 Regulatory and Policy Setting

Provincial regulations and standards that relate to groundwater resources are described below.

- *Water Resources Protection Act*: This Act was developed to protect water resources in Nova Scotia.
- Well Construction Regulations, in accordance with sections 66 and 110 of the Nova Scotia *Environment Act*: These regulations stipulate requirements for proper water supply well construction, testing and abandonment.
- Nova Scotia Groundwater under the Direct Influence (GUDI) Standards (NSE 2012): This standard applies to Municipal Groundwater Supplies and outlines the methods used to assess and remediate wells that interact directly or indirectly with surface water.
- Nova Scotia Source Water Protection Planning, in accordance with section 106 of the Nova Scotia *Environment Act*: In areas that have been formally designated as a Protected Water Area, municipalities and/or utilities can develop regulations with the aim of protecting source water quality. This regulation can limit activities within designated watersheds, or well field protection areas, and can require monitoring of specific activities within these protected areas.

The following federal guidelines also apply to the protection of groundwater resources:

- Canadian Environmental Quality Guidelines (CCME 2007); and
- Guidelines for Canadian Drinking Water Quality (Health Canada 2014).

5.2.2 Boundaries

The assessment of potential environmental effects on groundwater resources encompasses the following spatial boundaries: the Project Development Area (PDA) and the Assessment Area. The PDA (*i.e.,* footprint of physical disturbance) is defined in Section 4.2.1. The Assessment Area for groundwater resources is the maximum area within which environmental effects related to the Project can be predicted or measured with a reasonable degree of accuracy and confidence, and encompasses the likely zone of influence on groundwater resources. For groundwater resources the zone of influence is based on a combination of the type and locations of the known aquifers, aquifer hydraulic properties, expected groundwater flow directions, and the distance between the RoW and water supply wells that may be affected by Project activities. The Assessment Area for groundwater resources is therefore an area extending 500 m from the PDA, which conservatively accounts for the various zones of influence.

With respect to temporal boundaries, most physical and chemical effects on groundwater resources are likely to be temporary and to occur during the construction phase. However, if a deep road cut is necessary, a permanent drop in elevation of the local groundwater table in the vicinity of the road cut could occur. Residual effects from road de-icing materials could occur throughout the operation phase of the Project, and potential effects due to an accidental spill could occur in all phases of the Project.

5.2.3 Significance Definition

A **significant adverse residual environmental effect on groundwater resources** is defined as one in which the Project causes one or more of the following:

- yield from an otherwise adequate well supply decreases to the point where it is inadequate for intended use;
- the quality of groundwater from an otherwise adequate well supply that meet guidelines deteriorates to the point where it becomes non-potable or cannot meet the Guidelines for Canadian Drinking Water Quality (Health Canada 2014); and/or
- the aquifer is physically or chemically altered to the extent that interaction with local surface water results in stream flow or chemistry changes that adversely affect surface water supply.

5.2.4 Description of Existing Conditions

5.2.4.1 Methods

Background information on groundwater was obtained from published resource materials, maps and hydrogeological databases including:

- topographical and air photo mapping along the highway route
- Nova Scotia Groundwater Atlas (NSDNR 2016a) which includes:
  - NS Well Log Database (1960 to present)
  - NS Pumping Test Database (1975 to present)
- Surficial Geology Map (Stea and Fowler 1979)
- Bedrock Geology Map (Keppie 2000)
- Discussions with officials at the Town of Windsor and the Municipality of West Hants

No field reconnaissance was completed as part of this assessment. Since this preliminary assessment identifies areas of potential concern (*i.e.*, areas likely containing potable wells; see Figure 5.4), a residential well water survey will be conducted within 300 m of the centreline prior to construction (refer to Section 4.2.3 of the Generic EPP).

5.2.4.2 Summary of Existing Conditions

5.2.4.2.1 Topography and Drainage

The Project alignment generally follows the current Highway 101 alignment at elevations ranging from 10 m above sea level (mASL) at the Avon River to approximately 40 mASL near both the eastern and western ends of the alignment. The Assessment Area is located entirely within the physiographic zone of the Hants-Colchester Lowland which is characterized by relief of gently rolling low land which is generally less than approximately 60 mASL with common swamps and peat bogs (Trescott 1969). Drainage in the Assessment Area generally drains through streams and watercourses into the Avon River or its tributaries including the St. Croix River. At the location of the Project, the Avon River is considered an estuary with a tidal range of approximately 12 m. Water flowing in the Avon River discharges into the Bay of Fundy.

5.2.4.2.2 Surficial Geology

Overburden within 500 m of the proposed PDA consists mainly of Quaternary silty till ground moraine deposits (Lawrencetown Till), which is compact and derived from both local and distant sources, and generally ranges from 3 to 30 m thick (Stea *et al*. 1992). This till sheet was initially laid down by major ice sheets advancing across the area from northwest to southeast. Other non-glacial Holocene surficial deposits within 500 m of the PDA include organic, alluvial and marine deposits along the banks of the Avon River, as indicated on Figure 5.2.

The soils along the alignment fall predominantly into three soil associations: Queens, Acadia, and Stewiacke series. The Queens series is till derived, and comprises the soil over the majority of the Assessment Area. It is a reddish-brown clay loam derived from till where the parent material was reddish-brown shale and mudstone. Both the Stewiacke and Acadia series are soils developed from water-deposited materials. The Stewiacke series is reddish-brown silty clay loam deposits in estuaries reworked by tidal waters, and the Acadia series is reddish-brown sandy loam material deposited along river courses (Cann *et al*. 1954).

Erodibility of soils and overburden material is dependent on terrain, cut slope, grain size and drainage characteristics of the material. In general, the soil material along the slopes of the valleys of the large rivers (*e.g.,* Avon River), are fine textured, and erosion will take place readily if not controlled. In upland areas, erosion is most prevalent on long or steeper slopes from which the forest cover has been removed (Cann *et al*. 1954). Additional soil erodibility information will be gathered during the detailed design phase. Where areas of high erosion potential are identified, specific erosion and sediment controls plans will be developed.

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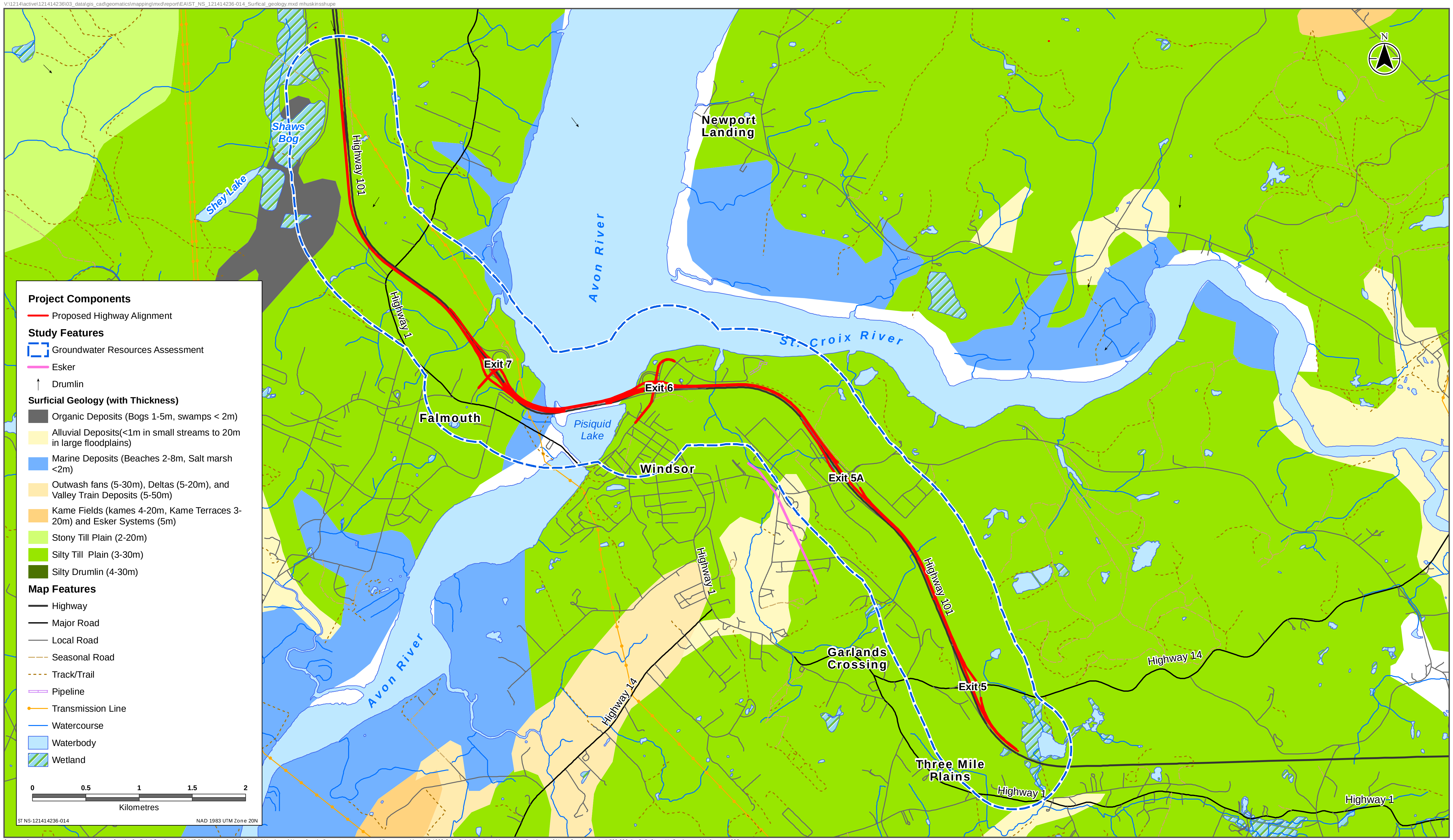

Sources: Base Data - Government of Nova Scotia, Surficial Geology - DP ME 36, Version 2, 2006, Digital Version of Nova Scotia Department of Natural Resources Map ME 1992-3, Surficial Geology Map of the Province of Nova Scotia, scale 1:500 000, by R. R. Stea, H. Conley and Y. Brown, 1992

Disclaimer: This map is for illustrative purposes to support this Stantec project; questions can be directed to the issuing agency.

Surficial Geology

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ENVIRONMENTAL ASSESSMENT, HIGHWAY 101 THREE MILE PLAINS TO FALMOUTH

Figure 5.2

5.2.4.2.3 Bedrock Geology

Based on the geological mapping by Keppie (2000), the Assessment Area is underlain by sedimentary bedrock of the Windsor Group, as indicated on Figure 5.3. The Windsor Group consists of Early Carboniferous-aged sedimentary rocks of the White Quarry, Stewiacke, Carrols Corner, Macumber, Gays River, Murphy Road, Pesaquid, Green Oaks, Wentworth Station, Miller Creek, MacDonald Road and Elderbank Formations, which are composed of anhydrite, gypsum, salt, siltstone, and marine limestone and dolostone. The Horton Group consists of Late Devonian to Early Carboniferous-aged sedimentary rocks and is undifferentiated in the mapping within the 500 m buffer.

Due to the geochemical nature of the bedrock and the hard groundwater associated with the Windsor Group, these bedrock units are not associated with significant acid drainage. However, due to dissolution of gypsum and anhydrite beds, the Windsor Group is highly susceptible to karstification (Trescott 1969). The Windsor Group is composed of mostly marine deposits derived from intermittent salt water flooding in an ancient sea. As the sea was cut off, the salt water became shallower and evaporite bedrock was formed as the dissolved salts became concentrated and began to precipitate out. The salts were then covered with fine silts, later to be flooded again.

One of the first salts to precipitate is calcium sulphate in the form of anhydrite. Anhydrite hydrated in the presence of water becomes gypsum and may expand by up to 44% by volume. The change from anhydrite to gypsum causes the evaporite beds to become softer and distorted.

Gypsum bedrock in the area is easily dissolved by water, and deformed by the weight of overlying sediments; these characteristics make evaporite rocks very prone to sinkhole development. Sinkholes are a subsidence feature that are generally cone or funnel shaped depressions and occur in loose surficial material that thinly covers thick beds of limestone, gypsum, or anhydrite. These are potential geological hazards, particularly where structures rest on or near the overlying surface. This karst/evaporite topography is known to occur in the area between Exit 5 and 5A and remedial work has been carried out to address ongoing sinkholes along the existing alignment. If sinkholes are found to be within the Assessment Area, the potential impact of the sinkhole would depend on the size of the feature, thickness of the overburden, hydrogeological connectivity and competency of the bedrock. Unlike other areas, sinkholes near Exit 5 have been full of water and not open voids.

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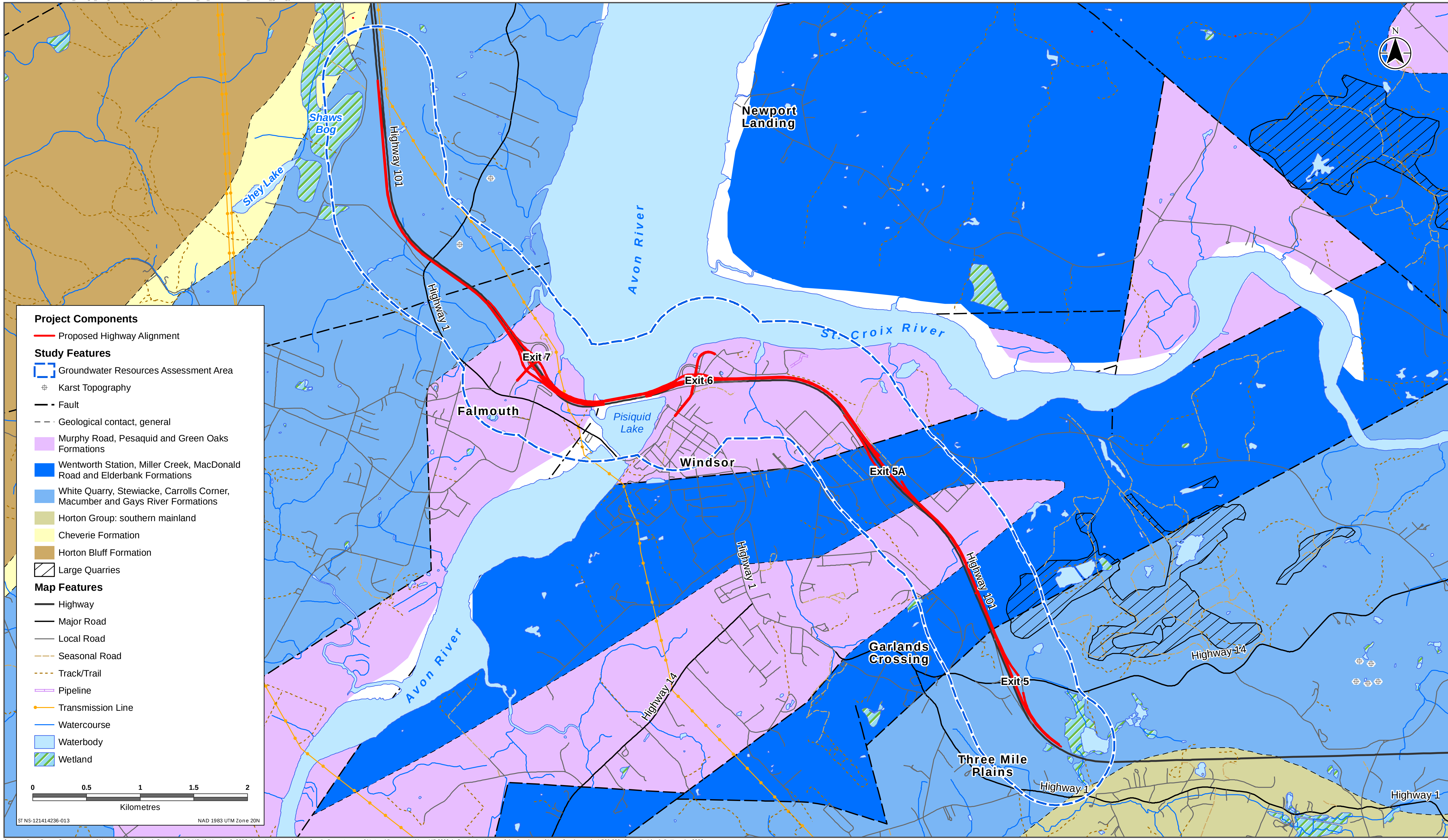

Sources: Base Data - Government of Nova Scotia, Bedrock Geology - DP ME 43, Version 2, 2006, Digital Version of Nova Scotia Department of Natural Resources Map ME 2000-1, Geological Map of the Province of Nova Scotia, scale 1:500 000, Compiled by J. D. Keppie, 2000

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Bedrock Geology

Stantec

ENVIRONMENTAL ASSESSMENT, HIGHWAY 101 THREE MILE PLAINS TO FALMOUTH

Figure 5.3

5.2.4.2.4 Hydrogeology

Surficial Materials

The hydrogeology and hydraulic properties of the various unconsolidated surficial materials underlying and within the Assessment Area are presented below in order of age and occurrence below ground surface. The capacity of each unit to store and transmit groundwater to wells and the relative potential for impact from construction of a highway alignment is discussed.

Organic Deposits

Organic deposits of peat, gyttja (sedimentary peat consisting primarily of plankton and other plant and animal residues) and clay are identified by surficial geology mapping approximately 100 m west of the most western 500 m of the alignment. These deposits have a very high hydraulic conductivity; however water supply wells are generally not constructed in organic deposits due to the very poor quality of the groundwater.

Marine Deposits

Marine deposits of gravel, sand, silt and clay are identified by surficial geology mapping along a small portion (*i.e.*, approximately 3%) of the Assessment Area where the RoW crosses the Avon River. The majority of the marine deposits in the vicinity of the Assessment Area are fine grained with permeable layers confined to joints and thin sandy stringers and lenses (Trescott 1969). These marine deposits within 500 m of the alignment occur within an area serviced by municipal water and therefore domestic wells are not likely constructed in this unit.

Alluvial Deposits

Alluvial deposits of gravel, sand and mud are identified by surficial geology mapping approximately 300 m west of Exit 5. These alluvial deposits are typically very productive aquifers. However, the alluvial deposits within 500 m of the alignment occur within an area serviced by municipal water and therefore domestic wells are not likely constructed in this unit.

Lawrencetown Till

Stony, gritty clay and silt glacial till deposits of various depths typically underlies the majority (*i.e.*, approximately 97%) of the proposed alignment. This unit typically has a low hydraulic conductivity in the order of 10^{-5} to 10^{-6} cm/sec; however, properly constructed dug wells may yield and store sufficient water for domestic supplies.

The NSE Pumping Test Database (retrieved September 2016) does not include any pumping test data from the Lawrencetown till within Hants County.

Windsor Group Bedrock

Windsor Group bedrock underlies 100% of the proposed PDA. The units of the Windsor Group comprise gypsum, anhydrite, limestone, dolostone, salt, and siltstone (often termed evaporites that generate the characteristic sinkhole features of karst topography).

Based on five pumping tests in Hants County (Table 5.2.1), wells completed in Windsor Group bedrock have an average transmissivity of 19.1 m^2/day, and a typical well yield ranging from 19.1 to 294.6 m^3/day, averaging 85.1 m^3/day.

Table 5.2.1 Summary of Water Well Pumping Test Information in the Windsor Group for Hants County

	Well Depth (m)	Well Diameter (mm)	Water Level (m)	Pumping Rate (m^3/d)	Transmissivity (m^2/d)	Specific Capacity (m^3/d/m)	Safe Yield (m^3/d)
Maximum	62.0	203.2	26.5	399.3	64.0	36.5	294.6
Minimum	27.7	152.4	5.4	93.6	2.8	7.4	19.1
Mean	43.2	163.8	11.9	230.7	19.1	17.2	149.6
Median	37.8	152.4	7.3	245.4	9.7	13.1	85.1

Source: NSE Pumping Test Inventory 1973-2016

Existing Water Wells

The NSE Well Logs Database only contains records of logs submitted to NSE that have been digitized, and the database is incomplete. Based on a query of the database, a total of 38 dug and drilled wells fall within the Assessment Area. One of the known limitations of the database is the spatial coordinates (geo-referencing) of some of the wells. Thus, the number, location, and construction of wells present and in use within the PDA cannot be verified without a field investigation. A review of satellite imagery indicates there are approximately 22 structures outside of the Municipal Water Supply Service Area (Figure 5.4) that likely have a private well for water supply.

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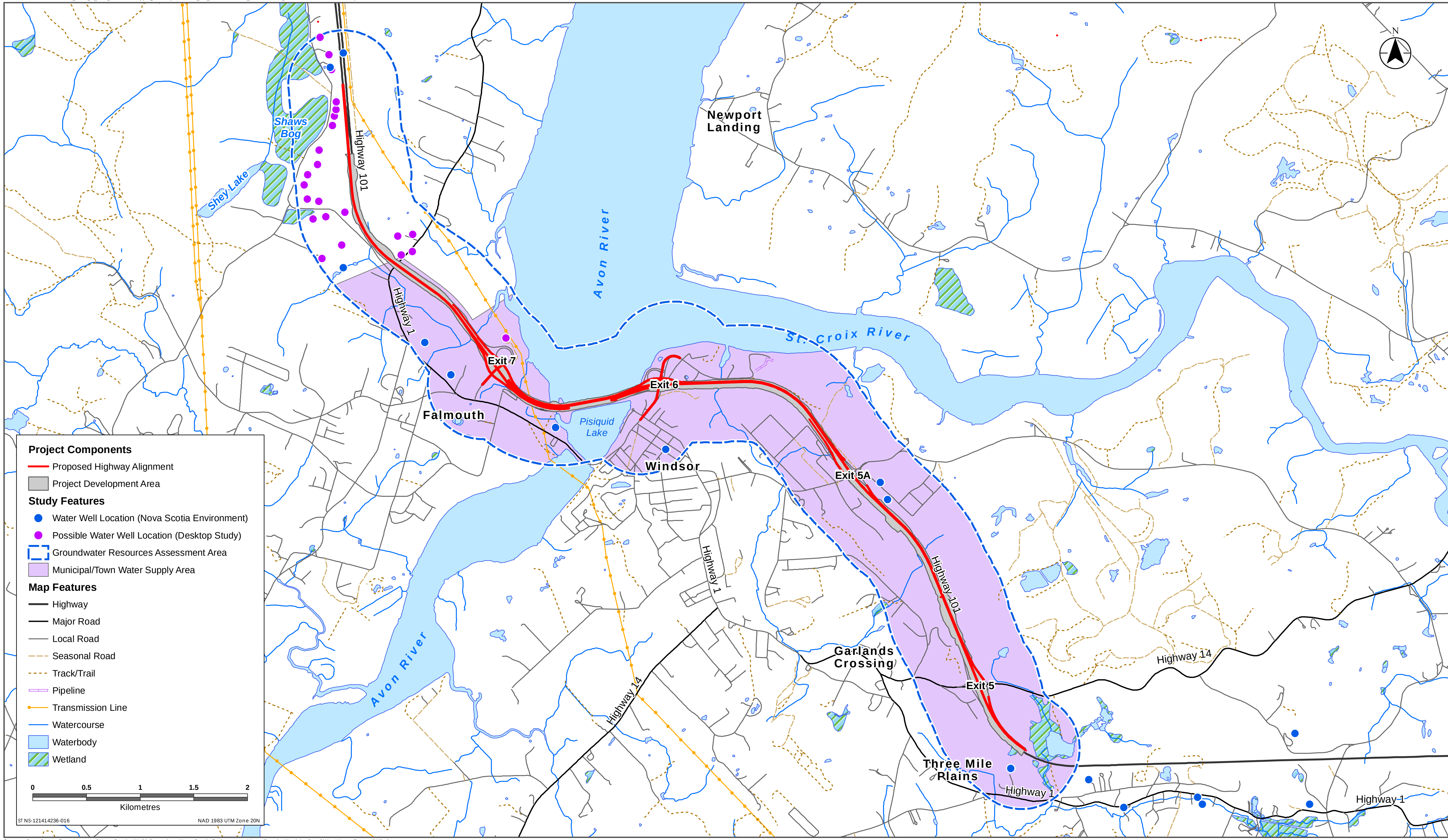

Sources: Base Data - Government of Nova Scotia, Well information - Nova Scotia Environment, Water Supply- Municipality of West Hants, Town of Windsor

Disclaimer: This map is for illustrative purposes to support this Stantec project; questions can be directed to the issuing agency.

Groundwater Resources and Municipal/Town Water Supply Service Area

Stantec

ENVIRONMENTAL ASSESSMENT, HIGHWAY 101 THREE MILE PLAINS TO FALMOUTH

Figure 5.4

Municipal Wells

No municipal water supply wells are identified within the Assessment Area. The water supply for the Town of Windsor comes from Mill Lake (NSE 2009, 2014a). The Mill Lakes Watershed (protected water area) is approximately 7.5 km south of this Project. The water supply for the Village of Falmouth comes from French Mill Brook (NSE 2009, 2014a). The French Mill Brook Watershed (protected water area) is approximately 3.5 km to the west of this Project. These water supplies are not a concern with respect to the Project based on separation distance. Areas serviced by the municipal water of Windsor and Falmouth in the Assessment Area include all areas west and east of the alignment from Exit 5 to the overpass of Highway 1, and on the east and north side of the alignment from Exit 5A to Exit 7 (Figure 5.4).

Dug Domestic Wells

The NSE Well Logs Database indicates eight dug wells within the Assessment Area (summarized in Table 5.2.2). However, only one dug well along Bog Road is outside of the Municipal Water Supply Service Area. It is expected that the remaining wells within the Municipal Water Supply Service Area are no longer used. The single dug well is 4.57 m deep, an unreported static water level, and a yield of 9.08 L/min. Dug wells are typically constructed by backhoe or excavator, are usually 4.5 to 6.5 m in depth, and generally provide sufficient water for single family needs. Depending on location, topography, and permeability of the overburden, some wells experience seasonal loss of water due to annual water table fluctuations.

Table 5.2.2 Summary of Dug Well Information

	Well Depth (m)	Casing Length (m)	Diameter (mm)	Est., Yield (L/min)	Static Water Level (m)
Maximum	9.4	9.9	2514.6	204.3	4.9
Minimum	4.6	4.6	914.4	9.1	0.8
Mean	6.1	6.5	1234.4	110.8	2.4
Median	6.1	6.1	914.4	113.5	2.4
Number	7	6	5	5	5

Source: NSE Well Logs Database 1920-2015

Drilled Domestic Wells

The NSE Well Logs Database indicates 30 drilled wells within the 500 m buffer of the PDA, summarized in Table 5.2.3. Only two of these are located outside of the Municipal Water Supply Service Area along Bog Road. These two wells have depths ranging from 42.63 m to 48.72 m, static water levels ranging from 12.18 m to 27.4 m, and yields ranging from 45.4 L/min to 68.1 L/min. it is assumed the other wells within the Municipal Water Supply Service Area are not used.

Table 5.2.3 Summary of Drilled Well Information

	Well Depth (m)	Casing Length (m)	Diameter (mm)	Est., Yield (L/min)	Static Water Level (m)
Maximum	182.7	57.3	203.2	272.4	27.4
Minimum	15.2	6.1	101.6	4.5	1.8
Mean	64.5	29.6	154.1	92.7	11.9
Median	54.2	28.6	152.4	45.4	10.7
Number	30	26	26	26	19

Source: NSE Well Logs Database 1920-2015

Water Quality

Water quality within the till above Windsor Group bedrock is expected to be poor with concentrations of sulphate hardness ranging from 300 to 600 mg/L (Trescott 1969). According to the Guidelines for Canadian Drinking Water Quality the aesthetic criteria for sulphate and total dissolved solids (measure of all inorganic solids dissolved in water) are 500 mg/L (Health Canada 2014). However, in areas where the overburden is thick and recharge of the till is from surface runoff, the sulphate content of shallow groundwater can be low and therefore potable water in these areas can be of good quality (Trescott 1969). Depending on age, location and construction method, dug wells are highly prone to coliform bacteria and road salt impact.

Groundwater quality from the Windsor Group is often of very poor quality as the unit is strongly influenced by gypsum and anhydrite, making the water highly calcium sulphate rich with hardness ranging from 1,400 to 1,600 mg/L.

5.2.5 Potential Environmental Effects and Project-Related Interactions

Activities and components could potentially interact with groundwater resources resulting in a change to groundwater quality and quantity. In consideration of these potential interactions, the assessment of Project-related environmental effects on groundwater resources is focused on the following potential environmental effect:

- change in groundwater quality and quantity.

5.2.5.1 Change in Groundwater Quality and Quantity

Construction

Construction activities that have the potential to affect groundwater quality and/or groundwater quantity include:

- clearing, and grubbing of vegetation during site preparation;

- blasting and major excavations associated with roadbed preparation and site preparation for watercourse crossing structures;
- excavations associated with roadbed preparation and site preparation for watercourse crossing structures (especially in areas with Karst/evaporite deposits);
- surfacing and finishing of paved surfaces which involve the application and mixing of asphalt; and
- ancillary elements, including temporary access roads and borrow areas.

The clearing, grubbing, and stripping of vegetation may lead to increased surface runoff, since there is no vegetation to intercept precipitation or impede the flow of water. Surface runoff from cleared and grubbed areas typically contains sediments. Shallow springs and wells, which are more susceptible to direct surface water influence, could experience an increase in turbidity if exposed to runoff. Increasing the amount of surface runoff reduces the amount of infiltration into the ground, thereby decreasing the amount of groundwater recharge.

Blasting activities are commonly the cause of complaint from well owners. The major complaints of changes in well water quality include increased turbidity, dis-coloured water, and nitrate and/or coliform contamination due to damage of casing seals. The major complaints for changes in well water production capacity include loss of quantity production, air in water and/or water lines, damage to pump, and damage to the well screen or borehole. However, it is anticipated that blasting would be minimal for this Project, if required.

Major excavations associated with cuts have the potential to affect groundwater quantity and/or quality in nearby or down-gradient shallow water wells and may cause localized changes in groundwater flow directions. Typical complaints are temporary increases in turbidity and decreased yield or “dry” wells due to a lowering in the water table. Exposure of evaporite deposits may also lead to alterations of groundwater flow and well water quality (rain is normally acidic in nature and can accelerate the dissolution of limestone and gypsum (evaporites) and other natural minerals within the bedrock and overlying till/soils.

Runoff during paving operation may contain dissolved hydrocarbons. At least part of this runoff will infiltrate the ground, introducing dissolved contaminants into the groundwater flow system. Vibrations from equipment have also been reported to environmentally affect water wells in close proximity, generally resulting in temporary increases in turbidity. Accidental releases of hazardous materials (*e.g.*, hydrocarbons) during construction can degrade the chemical quality of downgradient water supplies.

Operation and Maintenance

Operation of the highway has the potential to affect groundwater quality and/or quantity by:

- reducing groundwater recharge due to the increase in impervious surface area;
- altering local groundwater quality due to dissolved contaminants in runoff from the highway or from accidental spills;
- lowering of the water table due to ditching, cutting, and grading; and
- altering shallow groundwater flow patterns due to changes in surface drainage patterns.

Impervious materials, such as asphalt, prevent the infiltration of precipitation into the ground, thereby reducing the amount of groundwater recharge. Similarly, ditching and cutting modify local drainage patterns, thereby reducing groundwater recharge and potentially resulting in a local lowering of the water table, as well as altering shallow groundwater flow patterns.

Runoff from roads and highways, as well as from paving operation during infrastructure maintenance may contain contaminants such as lubricants, coolants, vehicle deposits, and road salt. Some runoff may infiltrate into the ground, introducing dissolved contaminants into the groundwater system. In addition, accidental releases of hazardous materials (*e.g.,* hydrocarbons) from vehicular crashes or other unforeseen events can degrade the chemical quality of downgradient water supplies. The normally acidic runoff will dissolve underlying evaporite deposits and alter groundwater flow rates and pathways.

During winter, salt is used by NSTIR on road surfaces to aid in melting snow, and to provide clear road conditions. Road salt can enter into the environment (surface water, groundwater, and soil) through application of these salts. As road salt is applied directly to the road surface, its potential to affect the groundwater system is considered to be substantially higher than other potential contaminants whose origins are vehicle-related.

Vibrations from equipment during operation and maintenance have also been reported to affect water wells in close proximity to highways, generally resulting in temporary increases in turbidity.

Since NSTIR primarily uses mechanical means to maintain vegetation control, ongoing maintenance of vegetation is not expected to affect groundwater quality. However, the removal of vegetation will reduce the amount of precipitation that is intercepted, thereby increasing runoff. This could result in a local reduction in groundwater recharge and a lowering of the water table. In this case, this effect is likely to be negligible since much of the area is already cleared due to previous developments.

5.2.6 Mitigation

Mitigation measures to be implemented to reduce potential effects on groundwater quality and quantity during pre-construction, construction, and operation and maintenance are presented in Table 5.2.4.

Table 5.2.4 Mitigation for Groundwater Resources

Effect	Phase	Mitigation
Change in Groundwater Quality and Quantity	Construction	• Pre-construction well survey • Pre-blast surveys (if required) • Ripping instead of blasting where practical near residential areas • Erosion and sediment control measures to reduce surface runoff • Minimize extent of clearing • Remedial action as necessary to restore damaged wells and provide temporary potable water as needed • Follow Generic EPP and site-specific pill Contingency Plan)
	Operation and Maintenance	• Drainage and, if blasting, vibration controls • Follow Generic EPP and site-specific spill contingency plan • Remedial action as necessary to restore damaged wells and provide temporary potable water as needed • Limit use of herbicides for vegetation management to the extent practical • Follow NSTIR Salt Management Plan

5.2.7 Residual Environmental Effects and Significance Determination

The assessment of residual environmental effects considers effects on groundwater resources after the general mitigation measures, as provided above, have been implemented.

5.2.7.1 Construction

During Project construction, several activities could result in a change in groundwater quality and quantity. These include grubbing and stripping of vegetation during site preparation; erosion from denuded areas; major excavations associated with roadbed preparation; site preparation for watercourse crossing structures; surfacing and finishing of paved surfaces which involve the application and mixing of asphalt; and ancillary elements.

Clearing, grubbing, and stripping activities associated with site preparations will decrease interception of precipitation by vegetation and increase runoff in these areas, which would result in a reduction of groundwater recharge (*e.g.,* a decrease in groundwater quantity) and an increase in water turbidity within shallow wells and springs.

Erosion from grubbed and stripped areas is generally only a concern to shallow dug wells and springs in very close proximity to the RoW (*e.g.*, a few tens of metres) and where direct overland flow of silt occurs. Environmental effects to surface watercourses and aquatic environments (Section 5.3) by uncontrolled erosion are a more important concern.

Erosion control measures will be in place to manage runoff from the construction areas. These measures are described in Section 2.3.1.1 and Section 3.2 of the Generic EPP; site specific ECPs will also be developed and will include erosion control measures. As these erosion control measures also slow the transport of surface runoff, they will also increase the potential for localized infiltration to groundwater.

Blasting (if required) can cause environmental effects in adjacent wells ranging from minor temporary turbidity to rare complete collapse of the well. The severity of the environmental effect is proportional to distance, physical and seismic properties of the bedrock being excavated, age and construction method of the well, well yield, and blast magnitude. It is expected that blasting, if required, would be minimal. Several properties with potential onsite wells have been identified within the Assessment Area. Pre-blast well surveys will be conducted on wells within 300 m of planned blast locations. Major excavations through tills could lead to a drop in groundwater table elevations in proximity to the cut. The degree of water level lowering will be proportional to the depth of the cut below the natural water level table, the distance between the well and the cut, and the hydraulic properties of the overburden materials (*i.e.*, larger and faster decline in higher permeability media). Dug wells near the edge of a cut could suffer sufficient water level decline to become dry, while drilled wells are not likely to be adversely affected. Ripping will be used preferentially over blasting, when practical, near residential areas.

Runoff from paving areas may contain dissolved hydrocarbons, and vibration from equipment may cause temporary increases in turbidity in adjacent wells. However, the concentration of dissolved hydrocarbons in any runoff from these areas is expected to be at trace levels. Proper staging of the paving (*e.g.*, dry weather application, drainage controls as required, paving of the roadway in sections) and vibration controls will minimize any potential environmental effects.

A contingency plan will be implemented to provide an interim water supply to consumers in areas that experience adverse Project-related effects in water quality or quantity during construction, and operation and maintenance phases of the Project. Well repair and/or replacement, including deepening of existing wells and drilling new wells, which are permanently damaged will be undertaken.

5.2.7.2 Operation and Maintenance

Once the highway has been constructed, there will be a permanent decrease in the amount of infiltration to groundwater as runoff is directed to adjacent ditches and drainage structures; however, as the surface extent of the highway within any one watershed is substantially less than the total watershed area, the magnitude of this effect will be imperceptible to groundwater users.

ECCC completed an assessment of road salt under CEPA. Recognizing that a total ban of road salt could potentially compromise human safety, the focus of road salt risk management is an implementation of measures that optimize winter road maintenance practices to promote road safety while minimizing potential environmental effects (Environment Canada and Health Canada 2001). Therefore, ECCC has categorized road salt as a Track 2 substance, requiring Life-Cycle Management.

NSTIR has a Salt Management Plan which specifies application rates and designates vulnerable areas to be used to maximize the efficiency of salting and sanding. The drainage of salt laden runoff away from residences and their wells along ditching will likely mitigate this potential environmental effect on any nearby residential wells. A change in groundwater quality may occur with the presence of the Project. However, adherence to the Salt Management Plan will ensure the changes in groundwater quality would likely be at levels that are indiscernible from natural variation. Furthermore, as indicated in Section 5.2.4, most residences in the Assessment Area are serviced by a municipal water supply and therefore drinking water would not be affected by the application of road salt for the Project.

Dissolved contaminants such as lubricants, coolants, and vehicle deposits may also be present in runoff from the highways, and subsequently may infiltrate into the ground and reach the groundwater. However, the concentrations of these contaminants are expected to be very low relative to road salt. The effect of these other dissolved contaminants on the groundwater quality will be imperceptible to groundwater users.

Routine infrastructure maintenance may potentially interact with groundwater. Runoff from paving areas may contain dissolved hydrocarbons, and vibration from equipment may cause temporary increases in turbidity in adjacent wells. However, the concentration of dissolved hydrocarbons in any runoff from these areas is expected to be at trace levels. Proper staging of the paving (*e.g.*, dry weather application, drainage controls as required, paving of the roadway in sections) and vibration controls will minimize any potential environmental effects. The likelihood of an environmental effect on groundwater resources from runoff and vibration environmental effects during resurfacing activities is considered to be very low.

NSTIR primarily uses mechanical means to maintain vegetation control; herbicide use is rrestricted under certain conditions (refer to Section 2.3.25). Since the use of herbicides is not anticipated, the ongoing maintenance of vegetation is not expected to affect groundwater quality.

A contingency plan will be implemented to provide temporary water to consumers in the area that experience Project-related adverse effects in water quality or quantity during the operation and maintenance of the Project. Repairs and replacement of any wells that are permanently damaged by the Project will be decided on a case-by-case basis, pending the nature of the adverse environmental effect and its relation to the Project.

5.2.8 Monitoring and Follow-up

Several domestic water supply wells are likely located within 500 m Assessment Area, although as indicated in Section 5.2.4, most of these occur within a Municipal Water Supply Service Area.

As per Section 4.2.3 of the Generic EPP, NSTIR will complete a detailed standardized survey of wells within 300 m of the centreline of the new alignment prior to construction. This would include the type of water supply and its age, conditions and known history based on property and survey information obtained during sample collections. Water samples will be collected by an independent contractor and analysed for pH, general chemistry and metals (RCAp plus metals), as well as fecal and total coliform counts as per NSE guidelines for sampling domestic wells. The number of wells to be inventoried and the monitoring boundary will be determined through consultation with NSE and the well-log database. Should samples indicate the presence of fecal coliform or concentrations of other parameters in excess of Canadian Drinking Water Standards, NSTIR's Project Engineer will immediately notify the landowner(s).

In the event that any residential wells are found within 300 m of any significant blasting excavation areas (*e.g.*, road cut or quarry), or if dug wells are located within 50 m of a major (> 5 m) overburden cut, these wells will be inspected (measuring depth, yield and water level in dug wells), and sampled for baseline water quality (RCAp-MS and bacteria) by the contractor. Where several drilled wells are present within the proposed 300 m blast monitoring radius, selected representative proximal wells will be inspected, baseline sampled, and closely monitored during the construction phase.

Because water levels may change slowly over time in tight glacial till aquifers, follow-up water level monitoring is recommended for shallow dug wells located close to major overburden cuts along the alignment. Natural seasonal variation in water levels will be considered in the evaluation of effects. The suggested duration of any post-construction monitoring would be the lesser of two years of quarterly monitoring, or stabilization of water level and chemical indicators in wells of concern.

The extent and frequency of well monitoring post-construction and during the operation phase will be determined once the pre-construction data has been assessed or following receipt of landowner complaints.

5.3 AQUATIC ENVIRONMENT

The aquatic environment was selected as a VC because of the importance of the aquatic environment as an ecosystem component and the associated regulatory protection. The aquatic environment is socially and culturally important to the people of Nova Scotia for the fisheries it supports. In the context of the aquatic environment VC, the following definitions apply:

Fish, as defined by the *Fisheries Act,* includes: (a) parts of fish; (b) shellfish, crustaceans, marine animals and any parts of shellfish, crustaceans or marine animals; and (c) the eggs, sperm, spawn, larvae, spat and juvenile stages of fish, shellfish, crustaceans and marine animals.

Fish habitat is defined by the *Fisheries Act* as spawning grounds and any other areas, including nursery, rearing, food supply and migration areas, on which fish depend directly or indirectly in order to carry out their life processes. Fish habitat includes physical (*e.g.*, substrate, temperature, flow velocity and volumes, water depth), chemical (*e.g*., dissolved oxygen, pH, nutrients) and biological (*e.g*., fish, benthic invertebrates, plankton, aquatic plants) attributes of the environment that are required by fish to carry out life cycle processes (*e.g.,* spawning, rearing, feeding, overwintering, migration).

Sediment dynamics refers to the movement of sediment in response to various conditions such as water velocity, mixing and ice movement.

The aquatic environment VC is inherently linked to the Vegetation and Wetlands VCs (Sections 5.4 and 5.5) through riparian vegetation and wetlands. The aquatic environment VC is also linked to the Land Use VC (Section 5.7) through the recreational fishery and traditional Aboriginal use.

5.3.1 Regulatory and Policy Setting

Fish and fish habitat are protected through federal and provincial legislation. Key federal and provincial acts and regulations that apply to the Project with respect to fish and fish habitat in Nova Scotia include:

- the *Fisheries Act* (R.S.C., 1985, c.F-14)
- the *Species at Risk Act*
- the Nova Scotia *Endangered Species Act*
- *Nova Scotia Activities Designation Regulations*.

These key acts and regulations are supported by federal, provincial, and non-governmental policies and guidelines; including:

- the Fisheries Protection Policy Statement (DFO 2013a);
- Watercourse Alterations Standard (NSE 2015a); and
- Canadian Council of Ministers of the Environment (CCME) Water Quality Guidelines for the Protection of Aquatic Life (CCME 1999).

Fish species of conservation interest (SOCI) are defined for this assessment as those species that are:

- listed under the NS ESA or the federal SARA as being either *endangered, threatened, vulnerable,* or of *special concern* (*i.e*., Species at Risk or “SAR”);
- not yet listed under provincial or federal legislations, but identified by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) as being either *endangered, threatened,* or of *special concern;*
- listed by the NSDNR to be *at risk, may be at risk,* or *sensitive* to human activities or natural events; and/or
- ranked as *S1, S2,* or *S3* by the Atlantic Canada Conservation Data Centre (AC CDC).

5.3.1.1 Fisheries Act

Fish habitat is protected under the federal *Fisheries Act*. On November 25, 2013, the *Jobs, Growth and Prosperity Act* came into force which resulted in changes to several sections of the *Fisheries Act*, most notably section 35 that defines serious harm to fish and their habitat. An updated Fisheries Protection Policy Statement (DFO 2013a) was released, replacing the previous Fish Habitat Policy. The amendments in Section 35 of the *Fisheries Act* adopt "serious harm to fish" replacing "harmful alteration, disruption or destruction (HADD), of fish habitat". The updated Fisheries Protection Policy Statement interprets "serious harm" to commercial, recreational or Aboriginal (CRA) fishery species as:

- *the death of fish;*
- *a permanent alteration to fish habitat of a spatial scale, duration or intensity that limits or diminishes the ability of fish to use such habitats as spawning grounds, or as nursery, rearing, or food supply areas, or as a migration corridor, or any other area in order to carry out one or more of their life processes; and*
- *the destruction of fish habitat of a spatial scale, duration, or intensity that fish can no longer rely upon such habitats for use as spawning grounds, or as nursery, rearing, or food supply areas, or as a migration corridor, or any other area in order to carry out one or more of their life processes.*

With the recent amendments, the requirement under the Act to gain authorization applies only where a project results in "serious harm" to a CRA fishery. An alteration of fish habitat must be deemed to be permanent to be of regulatory consequence under the Act.

Table 5.3.1 outlines the relevant requirements for NSTIR under the federal *Fisheries Act* and regulations.

Table 5.3.1 Relevant Directives under the *Fisheries Act*

Regulations	Nature of Directive	Relevance to NSTIR	Federal Authority
Section 20	Regulate fishway designs that provide the free passage of fish without harm and maintain a flow of water sufficient to allow the free passage of fish.	Watercourse crossing designs and provision of fish passage.	DFO
Section 35(1)	Provide protection of fish and fish habitat.	Watercourse crossing designs.	DFO
Section 35(2)	Permit authorizations for the serious harm to fish that could occur directly or indirectly through the destruction of fish habitat.	Permit *Fisheries Act* authorizations for the serious harm to fish, if required.	DFO

Table 5.3.1 Relevant Directives under the *Fisheries Act*

Regulations	Nature of Directive	Relevance to NSTIR	Federal Authority
Section 36	Implement mitigation as per guidelines to prevent introduction of deleterious substances into fish bearing waters.	All heavy equipment work within watercourse buffers (30 m) and the need to prevent erosion and sedimentation of watercourses, or fuel spills from reaching watercourses.	DFO/ECCC

5.3.1.2 *Endangered Species Act and Species at Risk Act*

Provincially, species listed as *extirpated*, *endangered*, *threatened* or of *special concern* are formally protected under the Nova Scotia *Endangered Species Act* (NS ESA). Federally, species listed on Schedule 1 as *extirpated*, *endangered* or *threatened* are formally protected under the Federal *Species at Risk Act* (SARA). Species at risk (SAR) are formally protected through prohibitions on killing, harassing or capturing a listed species, unless otherwise approved through a ministerial order (*i.e.*, license or permit). Habitat critical to the survival of SAR is also protected, through prohibitions on destruction or alteration.

5.3.1.3 Nova Scotia *Activities Designation Regulations* – Watercourse Alteration

Provincial regulations applicable to fish habitat protection include the Nova Scotia *Activities Designation Regulations* made under section 66 of the *Environment Act*. The objective of the Watercourse Alteration Program is to protect aquatic habitat from unmitigated works in or near watercourses and wetlands. The *Activities Designation Regulations* enable NSE to issue either an approval (stipulating project-specific mitigation), or a notification to the department, indicating that the work is to be carried out in accordance with the Nova Scotia Watercourse Alterations Standard. A Water Approval for watercourse alteration is required before:

- the physical modification of the bed or banks of a watercourse; or
- the modification of flow of water (*i.e.,* diversion or pumping).

5.3.2 Boundaries

The assessment of potential effects on the aquatic environment encompasses the following spatial boundaries: the Project Development Area (PDA) and the Assessment Area. The PDA (*i.e.,* footprint of physical disturbance) is defined in Section 4.2.1. The Assessment Area includes sufficient upstream and downstream freshwater habitat at all crossings to evaluate anticipated measurable Project-related environmental effects to the St. Croix Watershed and tributaries of the Avon River (refer to Figure 5.5). This Assessment Area was selected to encompass all areas with potential to have direct and indirect loss of fish habitat under normal conditions that could cause serious harm to fish and where environmental effects are reasonably expected to occur and are measurable with a high degree of confidence.

The temporal boundaries for the assessment of the Project's effects on the aquatic environment are the periods of construction, and operation and maintenance of the Project. Most potential Project-related environmental effects on the aquatic environment will begin and peak during construction, and diminish during operation and maintenance. Other temporal considerations for assessment include critical life stages for fish such as spawning and migration seasons.

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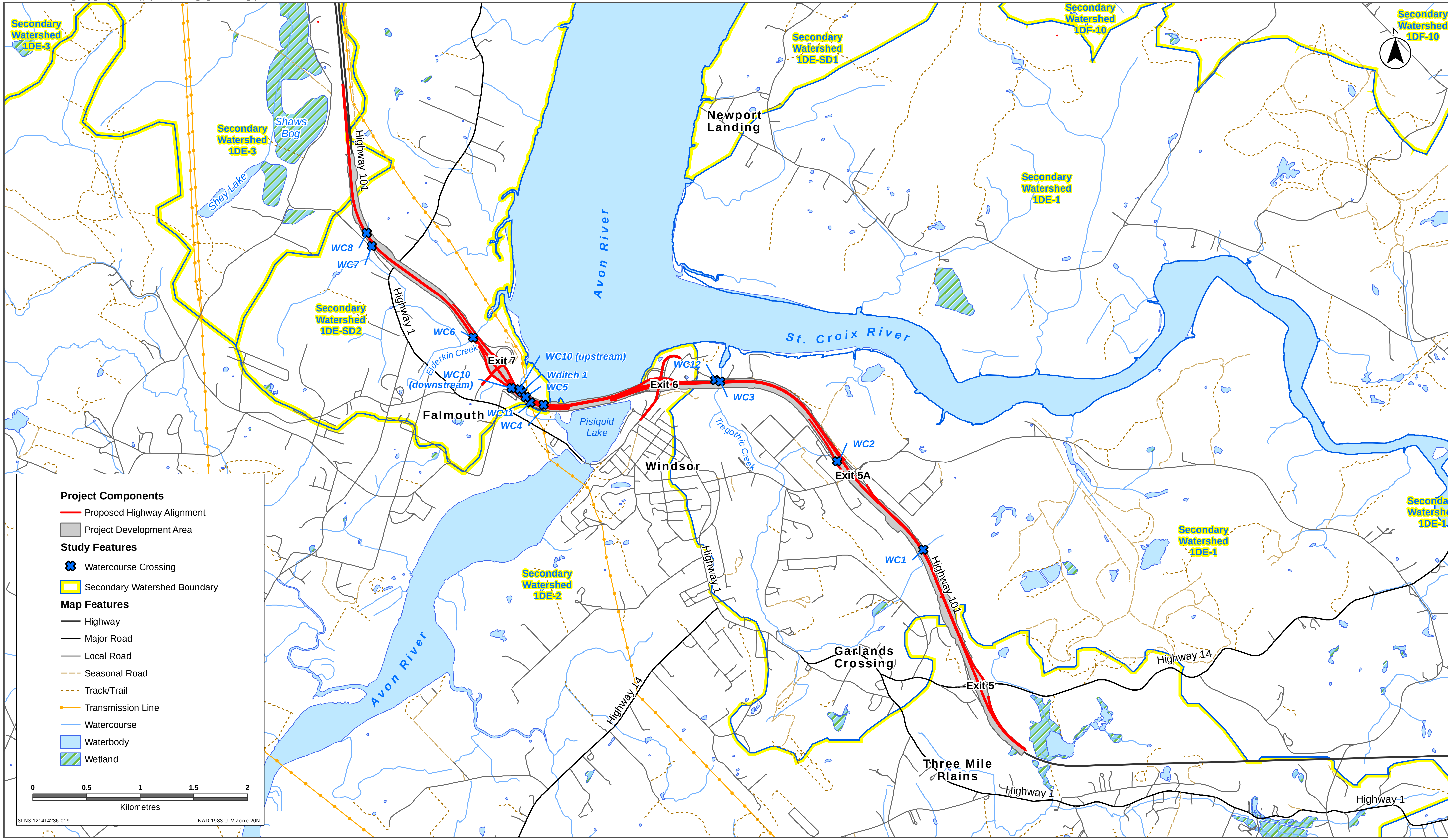

Sources: Base Data - Government of Nova Scotia, Watershed - Nova Scotia Environment

Disclaimer: This map is for illustrative purposes to support this Stantec project; questions can be directed to the issuing agency.

Aquatic Resources

Stantec

ENVIRONMENTAL ASSESSMENT, HIGHWAY 101 THREE MILE PLAINS TO FALMOUTH

Figure 5.5

5.3.3 Significance Definition

A **significant adverse residual environmental effect on the aquatic environment** is defined as a Project-related environmental effect that:

- results in the likelihood of fish mortality, after mitigation measures are implemented, that reduces the productivity and sustainability of a CRA fishery and cannot be offset, thereby indicating residual serious harm to fish;
- results in the likelihood of mortality of an aquatic Species at Risk, after mitigation measures are implemented, that jeopardizes the achievement of self-sustaining population objectives or recovery goals for listed species; or
- results in the permanent alteration or destruction of fish habitat and is of a spatial scale, duration, or intensity that limits or diminishes the ability of CRA or SAR aquatic species to use or rely upon such habitats for spawning, nursery, rearing, food, migration, or to carry out one or more other life processes affecting the productivity and sustainability of a CRA fishery, if the results of this change in fish habitat cannot be mitigated or offset.

5.3.4 Description of Existing Conditions

An EA for this Project was initiated in 2007. A desktop review and aquatic field surveys were conducted in 2007 and 2008 based on regulatory consultation.

The description of existing conditions for the aquatic environment is based on the work undertaken in 2007 and 2008 with updated information (including 2016 aquatic survey results) as applicable where Project details and environmental conditions have changed (Table 5.3.2).

5.3.4.1 Methods

5.3.4.1.1 Fish

Fish were not sampled because the Project falls within an area known to support a population of SARA-listed species; the Atlantic salmon, inner Bay of Fundy (iBoF) Population (DFO 2013b). These waters are protected under the SARA as potential Atlantic salmon spawning grounds and fish sampling is therefore restricted.

The *Fisheries Act* requires the identification of fisheries waters and their fish habitat during environmental assessments of aquatic systems. While fish sampling helps to confirm viable fisheries species or fish that support these fisheries and their habitat in an area and can provide updated species information to DFO, fish habitat of these species can be identified without sampling fish. Given the extensive existing information from existing reports for the watershed, the characterization of fish species in the watershed consisted of a desktop review with no sampling.

5.3.4.1.2 Fish Habitat

2007 Methods

In 2007, a review of existing 1:10,000 maps and aerial photographs of the Assessment Area was completed and nine proposed watercourse (WC) crossings (WC1 to WC9) were sampled in the field, including the Avon River crossing (WC9) (refer to Figures 5.5 and 5.6). Field investigations were conducted during the summer and early fall of 2007. Stream characteristics and potential fish habitat were assessed upstream and downstream of the proposed watercourse crossings along the RoW where habitat was accessible. For some sites, the upstream area of the proposed crossing to be assessed was a paved, multi-lane highway. In these cases, the upstream section of the stream reach was a culvert which was excluded from the habitat survey due to lack of access. Several of the watercourse crossings were small, intermittent streams that became dry channels either shortly upstream or downstream of the proposed crossings.

Habitat assessments and benthic invertebrate samples were completed at seven of the nine identified watercourse crossings during the 2007 summer sampling season. Benthic invertebrates were not collected at WC4 or WC9. WC4 was dry during the summer sampling, and WC9 (Avon River) was not accessible for benthic invertebrate sampling (see Section 5.3.4.2, Benthic Invertebrates). Habitat surveys and benthic invertebrate samples conducted in 2007 were completed based on an internal Jacques Whitford sampling protocol and the Environment Canada CABIN (Canadian Aquatic Biomonitoring Network) protocol (Reynoldson *et al.* 2007). Benthic invertebrates were identified to the family level (Bousfield 1958, Scott 1967, Gilhen 1974, Pennack 1978, Clarke 1981, Peckarsky *et al.* 1990, Merritt and Cummins 1996 and Barbour *et al.* 1999) and enumerated by SpryTech Biological Services.

2016 Methods

In 2016, information gathered during the 2007 surveys was reviewed, along with more recently collected Lidar data provided by NSTIR. Aquatic field surveys were conducted between July 11 and 14, 2016. Previously identified watercourses (WC1 to WC9) were revisited and the following physical parameters were evaluated at the crossing location: slope, flow, channel width, and channel depth. At the request of DFO, the downstream extent of WC2 and WC7 was reassessed and characterized using transects. WC7 is associated with the proposed realignment of Bog Road and is included in the summary of watercourses.

In addition to these watercourses, Lidar data suggested the potential presence of four additional watercourses within the Assessment Area (WC10 to WC13). Stantec confirmed the presence of three of these watercourses (WC10 to WC12) and completed physical and fish habitat characterizations.

Stantec also assessed an agricultural drainage ditch (Ditch 1) found to contain fish. This ditch was not assessed in 2007, nor was it identified during the desktop review. Habitat in this drainage ditch was assessed and the ditch was characterized using transects.

For each watercourse, crossing characteristics were collected using transects placed at the following locations, where possible:

- 100 m upstream of the watercourse crossing (Transect 1)
- 50 m upstream of the watercourse crossing (Transect 2)
- the watercourse crossing (Transect 3)
- 100 m downstream of the watercourse crossing (Transect 4)
- 200 m downstream of the watercourse crossing (Transect 5)
- 300 m downstream of the watercourse crossing (Transect 6).

Transect placement was adjusted when necessary, typically due to the presence of the existing highway. For example, if the transect location would have been in a culvert, this transect was placed at the next available portion of the stream instead (either upstream or downstream). This occurred most often with Transect 3 (the crossing location). Where a watercourse did not completely extend through the assessment corridor, transects were placed at 50 or 100 m intervals to adequately characterize the watercourse. Although several transects were placed on each watercourse, only those transects that were within the PDA boundaries were used to characterize the watercourse. Data collected from each transect included, but was not limited to, the following:

- channel width
- wetted width
- water depth at 0.25, 0.50 and 0.75 of wetted width
- velocity at evenly spaced stations across one transect (corridor centre line)
- abiotic water column measures (temperature, conductivity, pH, turbidity, dissolved oxygen);
- substrate composition
- bank description, including height, slope and stability
- functional in-water and riparian cover type and abundance
- photographs facing upstream, downstream, at left bank and at right bank.

Fish habitat assessments were conducted using Stantec's internal protocols along the surveyed reach. This habitat assessment procedure was based on differentiating habitat units (runs, riffles, pools), and recording channel characteristics, cover types and abundance and channel stability for each unit. Biotic features of interest (*e.g.*, molluscs, algae, aquatic plants, *etc.*) were also noted if encountered.

Table 5.3.2 summarizes the 2007 and 2016 watercourse assessment work.

Table 5.3.2 Summary of Watercourse Assessments in 2007 and 2016

Watercourse	2007			2016				
	Assessed	Benthic Invertebrate Sampling	Water Chemistry	Confirmed[1]	Assessed	Transects Collected	Water Chemistry	Notes
WC1	✓	✓	✓	✓		at crossing		
WC2	✓	✓	✓	✓		at crossing 100 m DS 200 m DS 300 m DS	✓	DFO requested additional information downstream of this crossing
WC3	✓	✓	✓	✓		at crossing		
WC4	dry			✓	✓	at crossing	✓	
WC5	✓	✓	✓	✓		at crossing		
WC6	✓	✓	✓	✓		at crossing		
WC7 Bog Road Crossing	✓	✓	✓	✓		at crossing 100 m DS 200 m DS 300 m DS	✓	DFO requested additional information downstream of this crossing
WC8	✓	✓	✓	✓		at crossing		
WC9 Avon River Crossing	✓		✓			none (unsafe)		
WC10					✓	100 m US 50 m US at crossing 100 m DS 300 m DS	✓	Identified through Lidar survey

Table 5.3.2 Summary of Watercourse Assessments in 2007 and 2016

Watercourse	2007			2016				
	Assessed	Benthic Invertebrate Sampling	Water Chemistry	Confirmed[1]	Assessed	Transects Collected	Water Chemistry	Notes
WC11					✓	at crossing 100 m DS 200 m DS 300 m DS	✓	Identified through Lidar survey
WC12					✓	one transect collected in wet portion of stream on north side of existing highway	✓	Identified through Lidar survey
WC13					no visible channel	none		Identified through Lidar survey
Ditch 1[2]					✓	100 US 50 US 0 US	✓	Was not identified through Lidar survey and was not previously assessed; does not cross RoW

Notes: US-upstream; DS-downstream;

[1]During 2016 surveys, the slope, flow, channel width, and channel depth were confirmed at all previously assessed crossing locations.

5.3.4.2 Summary of Existing Conditions

5.3.4.2.1 Fish

The results of the desktop study confirmed the potential presence of several species in the watershed that could be affected by the Project. The desktop study yielded fish data for the Avon and St. Croix rivers, as well as the Avon River estuary and Pisiquid Lake (Table 5.3.3). Fish species considered to have the potential to be present in the Avon River, Avon River estuary, St. Croix River, and Pisiquid Lake, have the potential to inhabit the watercourses of this Project.

Data gathered from reports prepared by the Acadia Centre for Estuarine Research (ACER) (Daborn and Brylinsky 2004) and DFO (Gibson *et al*. 2003) confirmed the potential presence of 25 fish species (Table 5.3.3). Unidentified species of chub were also reported. The likelihood of these species inhabiting watercourses in the Assessment Area depends on various factors, including availability of appropriate habitat, salinity, and water quality (*e.g.*, dissolved oxygen, pH). Table 5.3.3 identifies fish species that could potentially inhabit watercourses that intersect the PDA.

Local fishers, academia, environmental groups and Mi'kmaw have collaborated to develop a two-year study proposal to obtain additional baseline data on commercial, recreational and Aboriginal (CRA) fisheries species in the Avon River estuary, Lake Pisiquid and lower Avon River. Beginning in April 2017, this study will document fish passage through the current aboiteau, catalog the local, historical and traditional knowledge of CRA fishers, quantify the abundance and timing of species migrations in and near the causeway, and contrast the results of both fisheries-independent (government/academic) and commercial fisheries surveys.

Additional details for this study are provided in Section 3.4.4 and 5.3.8.

Table 5.3.3 Fish with Potential to Inhabit Watercourses in the PDA

Common Name	Scientific Name	Family	*SARA* Rank[1]	NS ESA Rank[2]	COSEWIC Rank[1,3]	NSDNR General Species Rank[3]	AC CDC Rank[3]	SOCI
Alewife	*Alosa pseudoharengus*	Clupeidae	-	-	-	Sensitive	S4	Yes
American Eel	*Anguilla rostrata*	Anguillidae	-	-	Threatened	Secure	S5	Yes
American Shad	*Alosa sapidissima*	Clupeidae	-	-	-	Secure	S5	
Atlantic Salmon (Inner Bay of Fundy Pop.)	*Salmo salar*	Salmonidae	Endangered (Schedule 1)	-	Endangered	May Be At Risk	S2	Yes
Atlantic Silverside	*Menidia menidia*	Atherinopsidae	-	-	-	-	-	
Atlantic Sturgeon	*Acipenser oxyrinchus*	Acipenseridae	-	-	Threatened	May Be At Risk	S1?	Yes
Atlantic Tomcod	*Microgadus tomcod*	Gadidae	-	-	-	Secure	S5	
Banded Killifish (Mainland Pop.)	*Fundulus diaphanus*	Cyprinodontidae	-	-	Not at Risk	Secure	S5	
Blueback Herring	*Alosa aestivalis*	Clupeidae	Not at Risk	-	Not at Risk	Secure	S5	
Brook Trout	*Salvelinus fontinalis*	Salmonidae	-	-	-	Sensitive	S4	Yes
Dogfish (Atlantic Pop.)	*Squalus acanthias*	Squalidae	-	-	Special Concern	-	-	
Fourspine Stickleback	*Apeltes quadracus*	Gasterosteidae	-	-	-	Sensitive	S5	Yes
Lake Chub	*Couesius plumbeus*	Cyprinidae	-	-	-	Secure	S5	
Mummichog	*Fundulus heteroclitus*	Cyprinodontidae	-	-	-	Secure	S5	
Ninespine Stickleback	*Pungitius pungitius*	Gasterosteidae	-	-	-	Secure	S5	
Northern Redbelly Dace	*Phoxinus eos*	Cyprinidae	-	-	-	Secure	S5	
Rainbow Smelt	*Osmerus mordax*	Osmeridae	-	-	-	Secure	S5	
Smallmouth Bass	*Micropterus dolomieu*	Centrarchidae	-	-	-	Exotic	SNA	
Smooth Flounder	*Liopsetta putnami*	Pleuronectidae	-	-	-	-	-	
Striped Bass (Bay of Fundy Pop.)	*Morone saxatilis*	Percichthyidae	-	-	Endangered	May Be At Risk	S1B	Yes
Threespine Stickleback	*Gasterosteus aculeatus*	Gasterosteidae	-	-	-	Secure	S5	
White Perch	*Morone americana*	Moronidae	-	-	-	Secure	S4	
White Sucker	*Catostomus commersonii*	Catostomidae	-	-	-	Secure	S5	
Winter Flounder	*Pseudopleuronectes americanus*	Pleuronectidae	-	-	-	-	-	
Yellow Perch	*Perca flavescens*	Percidae	-	-	-	Secure	S5	

Notes:

1 Species At Risk Public Registry. 2016. Accessed September 9, 2016. Available online at: http://www.sararegistry.gc.ca/

2 Nova Scotia *Endangered Species Act*.1999. Accessed August 19, 2016. Available online at http://www.novascotia.ca/natr/wildlife/biodiversity/

3 Atlantic Canada Conservation Data Centre, 2016. Accessed August 19, 2016. Available online at http://www.accdc.com/en/ranks.html

"-" = No data.

Atlantic Canada Conservation Data Centre

S1 = Critically imperiled in the province because of extreme rarity (often 5 or fewer occurrences). May be especially vulnerable to extirpation.

S2 = Imperiled in the province because of rarity due to very restricted range, very few populations (6 to 20 occurrences or few remaining individuals). May be vulnerable to extirpation due to rarity or other factors.

S3 = Vulnerable - Vulnerable in the province due to a restricted range, relatively few populations (often 80 or fewer).

S4 = Uncommon but not rare; some cause for long-term concern due to declines or other factors (80+ occurrences).

S5 = Common, widespread, and abundant in the province.

Species of Conservation Interest

Legal protection for SOCI is limited to species listed under Schedule 1 of SARA and those species listed under the NS ESA (as described in Section 5.3.1.2). SOCI fish species (Table 5.3.3) potentially present in the watershed encompassing the Project area include alewife, American eel, Atlantic salmon (iBoF population), Atlantic sturgeon, brook trout, fourspine stickleback and striped bass (Bay of Fundy population). Atlantic salmon (iBoF population) are listed under SARA as endangered. Species descriptions and a discussion on historical trends of the iBoF population of Atlantic salmon are provided below.

Species Descriptions

Atlantic salmon and brook trout are both members of the salmon family (Salmonidae). Both species are anadromous (spawn in freshwater, return to sea as adults), but both species are also known to have purely freshwater populations. Freshwater spawning requirements of both species are typically gravel-bottom riffle areas (*i.e.,* highly oxygenated) above or below pools within river or stream complexes (Scott and Crossman 1998). Trout tend to prefer headwater streams with strong spring water flow. Brook trout are listed as *sensitive* by NSDNR and have been recorded in the St. Croix River (Gibson *et al.* 2003). They were considered known or potentially occurring within the Avon River estuary (Daborn and Brylinsky 2004).

Atlantic salmon are the focus of much attention in the iBoF rivers, where the species is listed as *endangered* under COSEWIC and SARA. Historical trends of Atlantic salmon in the iBoF rivers are discussed in greater detail below. Atlantic salmon typically use gravel beds close to pools in well-oxygenated areas as spawning habitat, while lakes can be used as staging and resting areas (Scott and Crossman 1998). The low flow conditions and silt substrate dominating the watercourse crossings in the Assessment Area would not be considered favourable salmonid habitat (see Section 5.3.4.2.2).

American eels are a member of the Anguillidae family and have been recorded within the Avon and St. Croix rivers, and the Avon River estuary (Daborn and Brylinsky 2004). The species is catadromous (lives in fresh water, spawns in salt water) and can be found in lakes, streams, rivers and estuaries, depending on the life-cycle stage of the individuals. The American eel is designated as *threatened* by COSEWIC. While it is not currently listed under SARA, it is likely that the species may be listed in the future. The largest declines in eel populations are in the Great Lakes and in Atlantic (US) coastal rivers with prominent dams and heavy pollution. Populations in Nova Scotia are not currently at risk and are designated as *secure* by NSDNR and as *S5* by AC CDC.

Herring are part of the Clupeidae family and are primarily marine fishes, although some species are anadromous (Scott and Crossman 1998). Members of the herring family that have been recorded for the Avon River and St. Croix River include alewife, American shad and blueback herring; all three species are anadromous. Alewife are a SOCI, listed as *sensitive* by NSDNR and *S4* by AC CDC. Locally, alewife and blueback herring are also known as gaspereau. This group of species enters fresh water to spawn in lakes and quiet stretches of rivers above the influence of the tide, although blueback herring will spawn in brackish water as well. Alewife typically spawn over gravel or sandy bottoms (Scott and Crossman 1998). No herring species were caught during DFO's 2000/2002 survey of the Avon and St. Croix rivers (Gibson *et al.* 2003). All three species were determined to be known or potentially occurring within the Avon River estuary, while alewife and blueback herring specifically were recorded for Pisiquid Lake and the Lower Avon River during the ACER assessment (Daborn and Brylinsky 2004). NSDA has worked with DFO staff to alter the aboiteau opening and closing times to facilitate runs into the Avon River during the spring. Abundant gaspereau runs are common and support a small recreational and commercial fishery near the WC9 site and in the lower Avon River/Pisiquid Lake.

Yellow perch are a member of the perch family (Percidae), and can inhabit brackish or fresh water lakes and tributary rivers. Yellow perch are an adaptable species, able to survive a wide temperature range and utilize a wide variety of habitats (lakes, ponds, or quiet rivers). They prefer mud or sand and gravel bottoms and like clear water.

Smallmouth bass is a member of the sunfish (Centrarchidae) family, while striped bass and white perch represent the temperate bass family (Moronidae). Smallmouth bass typically inhabit freshwater lakes and will use sandy, gravel or rocky bottomed lakes and rivers for spawning (Scott and Crossman 1998). Striped bass occur in coastal waters but also have a freshwater life-cycle phase. They are listed as *endangered* by COSEWIC, may be *at risk* by NSDNR and *S1* by the AC CDC (however, they are actively fished in many Nova Scotia Bay of Fundy rivers). White perch are often found in brackish or freshwater lakes and ponds close to the sea. They thrive in a variety of habitats but prefer warm waters in the summer (> 24°C) and have no known preference for spawning substrate (Scott and Crossman 1998). None of these species were found in the DFO 2000/2002 survey (Gibson *et al.* 2003) but were recorded in various areas within the ACER assessment study area (Daborn and Brylinsky 2004).

The stickleback family (Gasterosteidae) includes multiple species (ninespine, fourspine and threespine) that have all been recorded for the iBoF waters within the Assessment Area. Both threespine and ninespine species inhabit salt, brackish, and fresh water. The fourspine stickleback is typically considered marine, and all three species tend to occur in shallow areas (Scott and Crossman 1998). Fourspine stickleback is listed as *sensitive* by NSDNR. Sticklebacks are tolerant of a range of water conditions (*e.g.*, salinity) and can be found in shallow, turbid waters not considered favourable by other species. Sticklebacks were not identified to species level but were confirmed in the St. Croix River (Gibson *et al.* 2003). All three species were found in the Pisiquid Lake and Lower Avon River areas while only threespine and ninespine sticklebacks were considered known or potentially occurring in the Avon River estuary (Daborn and Brylinsky 2004). These species have the potential to inhabit WC9.

In addition to sticklebacks, a variety of small-bodied fishes were recorded in the DFO and ACER reports, including minnows (Cyprinidae family; Northern redbelly dace, lake chub, unidentified chub), killifish/mummichog (Cyprinodontidae family) and suckers, which can also grow to be quite large (Catostomidae family; white sucker). All of these species are common throughout

Nova Scotia, and can be found in a variety of habitats throughout streams, rivers and lakes. The Northern redbelly dace, a freshwater species, may be best adapted to the shallow, silt-dominated conditions found in the freshwater streams throughout the Project area (*i.e.,* not including the estuarine environments at WC3 and WC9), as it is known to prefer quiet waters over a bottom of finely divided brown detritus or silt (Scott and Crossman 1998). Members of the killifish family (including mummichog) also inhabit freshwater shallows, but move freely into brackish water and even sea water as well (Scott and Crossman 1998). Killifish and particularly mummichogs have the potential to inhabit the estuarine sites (WC3 and WC9) among the identified watercourses, as well as the freshwater sites. Mummichogs are known to commonly occur in salt marsh flats, estuaries, and tidal areas, especially where there is submerged or emergent vegetation (Scott and Crossman 1998).

Rainbow smelt (Osmeridae family), Atlantic sturgeon (Acipenseridae family) and tomcod (Gadidae family) are anadromous species recorded as known or potentially present within the Avon River estuary (Daborn and Brylinsky 2004). Marine and brackish fish species also recorded in this area include dogfish (Squalidae family), smooth and winter flounder (Pleuronectidae family) and Atlantic silversides (Atherinopsidae family) (Daborn and Brylinsky 2004).

Historical Trends for iBoF Atlantic Salmon

Atlantic salmon (iBoF) were harvested commercially within the Bay of Fundy from the 1800s until the closure of the commercial fishery in 1985. A growing body of evidence suggests that the rapid decline in numbers of iBoF Atlantic salmon is due to low marine survival rather than an inability to spawn and live successfully in freshwater rivers and streams. The reasons for the salmon's low marine survival rates are not fully known, but may be due to ecological changes in freshwater habitat caused by forestry, agriculture and road development. Tidal barriers such as dykes, dams and causeways placed at the mouths of rivers and streams may also be a factor, along with commercial salmon farms, which can attract predators and parasites, alter habitat, and obstruct migration (DFO 2010a). While access to spawning and rearing habitat declined over the past two hundred years, it does not correspond with the collapse over the previous couple of decades (COSEWIC 2006a). Although not directly targeted, iBoF Atlantic salmon are still susceptible to angling in non-salmon recreational angling fisheries (*e.g.*, brook trout, striped bass, and smallmouth bass fisheries) despite closures to recreational salmon angling in the iBoF region (DFO 2016a).

Inner Bay of Fundy Atlantic salmon are currently listed as *endangered* by COSEWIC and the federal SARA. In 2012, DFO reviewed and evaluated the available iBoF salmon data to identify important marine and estuarine habitat needed to complete all life-history stages (DFO 2013). Barriers exist on at least 25 major rivers around the Bay of Fundy and in the iBoF; causeway-dam type barriers on the Petitcodiac, Shepody, Avon, Great Village, Chignois and Parrsboro rivers are among the most substantial (Amiro *et al.* 2008). These barriers have caused or are thought to have caused a wide range of ecological effects on the rivers and their estuaries (Wells 1999).

Fish population studies carried out by the Acadia Centre for Estuarine Research (ACER) in 2003 within the Assessment Area found a lack of systematic fish survey data for the Avon River estuary area (Daborn and Brylinsky 2004). However, historical recreational fishery data indicate that salmon were once supported by the Avon River (National Recovery Team 2002; Isaacman 2005; COSEWIC 2006). Assessment data of iBoF rivers from 2010-2014 did not identify the presence of Atlantic salmon in the Avon River (DFO 2016a). The release of adult salmon into the St. Croix River were reported during the 2010-2014 Live Gene Bank program, which is a captive rearing program designed to minimize the loss of genetic diversity, so that the populations can be restored when conditions become favourable for their survival in the wild (O'Reilly and Harvie 2010).

The Recovery Strategy for iBoF salmon does not currently identify the Avon River (or any of the rivers flowing into the Avon River embayment) as containing freshwater critical habitat (DFO 2010a). Thus, the Avon River estuary, and the estuaries of the rivers flowing into it, are not being considered as containing estuarine critical habitat in the forthcoming amended Recovery Strategy (DFO 2016b). However, the Avon River estuary is near the Gaspereau River, which has been identified as containing freshwater critical habitat and for which estuarine critical habitat is being considered. Adult Atlantic salmon are known to stray into adjacent rivers when they are trying to find their natal river (Jonsson *et al.* 2003).

5.3.4.2.2 Fish Habitat

This section includes water quality data gathered in 2007 and 2016, a summary of the results from the benthic invertebrate sampling program conducted in 2007, and results of watercourse assessments conducted in 2007 and 2016.

Data collected during the watercourse assessments including photographs of each site are presented in Appendix B.

Water Quality

Water quality measurements were collected in 2007 and 2016 (Table 5.3.4). Water temperatures measured during habitat assessments in 2007 (*i.e.*, WC1 to WC8) were within the typical range that will support aquatic life at that time of year (< 22 ˚C) for most of the watercourses, except for WC1 (31.2 ˚C). In 2016, temperature was measured in seven watercourses (WC2, WC4, WC7, WC10, WC11, WC12 and Ditch 1). Only three of these watercourses (WC2, WC7 and WC11) had a water temperature < 22 °C. WC10 and WC12 were 25.1 °C and 25.9 °C, respectively. Ditch 1 and WC4 had temperatures exceeding 30 °C (Ditch 1 = 31 °C; WC4 = 34.9 °C).

The CCME Guidelines for the Protection of Freshwater Aquatic Life recommends pH values in the range of 6.5 to 9 as suitable for all life stages of aquatic life. Of the sites sampled in 2007 and 2016, most were slightly basic (pH readings between 7 and 8). The only site with a pH below the CCME guideline was WC4 (pH of 5.7 in 2016).

The CCME guideline for dissolved oxygen states a minimum acceptable dissolved oxygen concentration of 9.5 mg/L for early life stages for cold-water biota, and 6.5 mg/L for other life stages. Dissolved oxygen recorded in 2007 and 2016 ranged from 2.36 mg/L to 15.6 mg/L with an average of 6.7 mg/L. In 2007, six of the nine measured watercourses met the minimum guideline of 6.5 mg/L, and none met the guideline of 9.5 mg/L for early life stages. In 2016, three of the seven measured watercourses met the minimum guideline of 6.5 mg/L and one met the 9.5 mg/L guideline (Ditch 1). The major sources of dissolved oxygen in water are atmospheric oxygen and photosynthesis of primary producers. Other variables that influence these levels include surface and water velocity, channel roughness, hydraulic gradient, sediment texture and porosity, daily water temperature fluctuation, and the consumptive oxygen demand of the substrate (CCME 1999).

Table 5.3.4 Water Quality Results

Project Site ID	Date Sampled	Watercourse Name	Air Temp. (°C)	Water Temp. (°C)	Conductivity (µS/cm)	DO (%)	DO (mg/L)	pH	TDS (g/L)	TDS (ppm)	Salinity (ppt)
Ditch 1	July 13, 2016		-	31	1657	21*	15.6	7.11	-	790	0.8
WC1	July 19. 2007		33	31.2	1499	98.8	7.29	7.26	0.974	-	-
WC2	July 19. 2007		25	20.35	207	100.9	9.1	7.87	0.134	-	-
WC2	July 11, 2016		-	19	806	93	8.6	7.3	-	54.6	0.4
WC3	July 19. 2007	Tregothic Creek	22	20.97	31800	97.6	7.77	7.43	20.65	-	-
WC4	July 12, 2016		-	34.9	1.2	63	4.5	5.7	-	>2000	0
WC5	July 20, 2007		20	20.5	2226	30	2.36	7.4	1.2 (lab)	-	-
WC6	July 20, 2007	Elderkin Creek	18	20.53	1703	79.2	7.09	7.59	1.108	-	-
WC7	July 20, 2007		-	21.71	474	65.9	5.76	7.57	0.307	-	-
WC7	July 11, 2016		-	16.6	266	80	7.8	7	-	879	0.1
WC8	July 20, 2007		25	19.02	2885	71.2	6.55	7.48	1.876	-	-
WC9	December 17, 2007	Avon River	-4	-0.35	32400	65.1	7.26	7.26	N/Av	-	-
WC10	July 13, 2016		-	25.1	15.2	47	3.7	6.61	-	753	0
WC11	July 12, 2016		-	17.7	1	46	4.4	7.18	-	60.3	0
WC12	July 14, 2016		-	25.9	3	34	2.9	6.88	-	1070	0

Notes: “-“ means that no data were collected
*Data anomaly

Benthic Invertebrates

Benthic invertebrates were collected in the summer of 2007. The ratio of the sum of three pollution-sensitive orders of macroinvertebrates present in streams of Ephemeroptera (mayflies) Plecoptera (stoneflies), and Trichoptera (caddisflies) to the total number of invertebrate species (EPT Ratio) is a commonly used water quality assessment index. Samples were sent to SpryTech Biological Services for processing and the calculation of EPT ratios, species diversity and total abundance (Table 1, Appendix B).

The invertebrate population was dominated by high numbers of molluscs. Oligochaetes and Hemiptera were also common. Chironomids, amphipods, dragonfly nymphs and beetles contributed to the rest of the species composition. No stonefly nymphs (Plecoptera) were found. Mayflies (Ephemeroptera) were found only at WC5 and WC6 and caddisflies (Trichoptera) were found at sites WC5 and WC8 (two individuals at each site). High mollusc diversity can indicate clean water with low levels of organics. WC1, WC2, WC7 and WC8 had diverse mollusc populations. The EPT ratios were consistently low. This is a reflection of the low numbers of these taxa (*i.e.,* mayflies, stoneflies, caddisflies) found throughout the Assessment Area. These results are consistent with low flow, stagnant watercourses with high silt levels, as observed in the majority of the watercourse crossings within the PDA.

Habitat Assessment Results

Many of the watercourses assessed were small, shallow and had little or no flow. When considered in combination with the dominant substrate type (*i.e.,* fines), these sites do not provide desirable habitat for salmonids.

Substrate in most of the watercourses was predominantly composed of fine material (*i.e.,* silt and clay) and sand (refer to photographs in Appendix B). Water in the Avon River (WC9) was too cloudy to see the bottom, but it is likely that the substrate at this site is composed of fine mud with some cobble and boulders. The banks of the impoundment (Pisiquid Lake) are composed of material that ranges from fines to boulder-sized substrate (Photographs 25 to 27, Appendix B).

Two of the watercourses were estuarine environments: WC3 (Tregothic Creek) and WC9 (Avon River). Estuarine environments fill and empty with changes in sea level and have variable mixtures of fresh and salt water. Both watercourses have tidal gate structures (aboiteaux) at or near the proposed crossings that restrict tidal flushing and protect upgradient lands from flooding (Photographs 7 and 26, Appendix B). WC6 (Elderkin Creek) also has an estuarine portion, but the sampling location was located upstream of the aboiteau (~300 m downstream of the highway crossing; Photograph 17, Appendix B). Historically (pre-dyking), all of the watercourses were once connected to the Avon or St. Croix River estuaries. Estuaries and associated salt marshes are typically considered very rich environments in which nutrients can be supplied from freshwater and marine sources as well as recycled from the sea bed; this in turn supports a broad range of estuarine-tolerant organisms, including benthic invertebrates, fishes, plants and birds.

Ten of the thirteen crossings (WC1, WC2, WC4, WC5, WC7, WC8, WC10, WC11, WC12, and Ditch 1) could potentially support small-bodied species tolerant of fresh water (*i.e.,* non-estuarine species), low oxygen, low-flow conditions in the summer, and a silt-dominated substrate. Species that may tolerate this type of habitat include: sticklebacks, redbelly dace and perhaps American eel. Several of these watercourses ran through active pasture and contained evidence of disturbance from grazing cattle (*i.e.*, WC4, WC5, WC10, and Ditch 1).

Two of the thirteen sites sampled (WC3 and WC6) were substantially larger bodies of water with run areas of higher flow than that observed at the other crossings (Photographs 7 to 9 and 16 to 18, Appendix B). These two estuarine sites offer more diverse habitat than observed at other watercourses in the assessment area. Both sites had water depth and flow conditions that were heavily dependent on tidal levels. The substrate recorded at these sites (silt) is not the preferred habitat type of salmonids. However, other estuarine fish species may be supported, such as larger-bodied and migratory species tolerant of the brackish, turbid conditions and sandy-silt substrate. Species with the potential to tolerate this type of habitat may include yellow perch, white perch, some herring, American eel as well as the smaller-bodied sticklebacks and mummichog.

The Avon River Estuary

The existing highway currently crosses a causeway and aboiteau at the Avon River. The current aboiteau is owned and operated by the NSDA (refer to Section 2.5.5) and acts as a dyke and sluice system to maintain agricultural land upstream and provide flood control. The two gates are operated by an automated system with staff oversight regulating water levels in Lake Pisiquid. An upgraded aboiteau structure is planned for this crossing. The following commentary on the Avon River estuary and its intertidal morphology is based on a review conducted by Dr. Graham Daborn (Acadia Centre for Estuarine Research) in 2008 for an earlier draft version of this EA report and has been updated to reflect more recent research findings as applicable.

Like all estuaries, the Avon River estuary responds dynamically to its tributaries and the neighbouring marine environment. Changes to its tributaries that influence the input of fresh water include the construction of dams for water storage and hydroelectricity, land reclamation (*e.g.*, dyke construction), and water removal for irrigation. Changes at the seaward end may result from natural cycles in tidal movements, sea level rise, storms, and shoreline modifications that affect patterns of sediment erosion and deposition.

Tidal range in the Minas Basin, the receiving environment for the Avon River, averages 12 m, with extreme tides exceeding 16 m, but because of the increasing bed level, the actual tidal range in the Avon River diminishes with distance towards the head of the estuary. At Hantsport, the largest predicted tides are approximately 15.6 m, and the smallest (neap) tides about 8.2 m (van Proosdij and Baker 2007); upstream of Hantsport, however, the actual maximum tidal range falls to < 10 m (Amos and Joice 1977) because of the increased level of the river bed. At the mouth of the Avon River estuary the time of flood and ebb tides tends to be almost equal, especially on neap tides, but on spring tides a marked asymmetry develops, with the flood tide filling the estuary in approximately four hours, while the ebb tide is extended to as much as 8.5 hours (Lambiase 1980a). This rapid filling of the estuary is accompanied by a tidal bore up to 15 cm in height that moves upstream at a rate of 1 m/sec.

The greater velocities on the flood than the ebb tides mean that sediments may be resuspended from the bottom or the shore during the flood tide which then settle in a more landward location at high water; this results in a common pattern of estuarine circulation that, in warm months at least, tends to push sediments toward the head of the estuary (Allen 1982; Wells 1995; Dyer 1995). In the Avon River, however, ice formation and movements in winter have the effect of remobilizing intertidal sediments, often moving them seaward again (Daborn 1997; Partridge 2000). The random location of ice blocks in late winter may be significant factors determining the migration of the major estuary channels, and therefore the local patterns of erosion and deposition of sediments (Gordon and Desplanque 1983; Desplanque and Mossman 1998; Daborn *et al.* 2003; van Proosdij and Baker 2007).

At low tide, water often remains only in the deeper channels, representing the freshwater outflow from three major tributaries: the Avon, St. Croix and Kennetcook Rivers, with inputs from several smaller streams. Because of the large tidal range, and relatively small freshwater input, the water in the estuary is generally vertically mixed, such that salinity and temperature values are usually uniform throughout the water column. Salinity varies seasonally with variations in freshwater input, but is generally about 30 ppt at the mouth of the estuary (Amos and Joice 1977; Lambiase 1980b), diminishing to about 28 ppt in the vicinity of the Avon River causeway and the mouth of the St. Croix River estuary (Daborn *et al.* 2003).

Suspended sediment concentrations reflect the vigorous vertical mixing occurring in the water column, the increasing proportion of finer sediments towards the head of the estuary, and the increasing tidal asymmetry that tends to move coarser sediments toward the head of the estuary during the warmer seasons. Near high water, concentrations range from about 4 mg/L at the mouth of the estuary (Amos and Joice 1977; Amos and Alföldi 1979) to more than 350 mg/L near Windsor, and > 500 mg/L in waters advancing onto the Windsor marsh (Daborn *et al.* 2003).

Construction of the Avon River causeway between 1968 and 1970 affected the hydrodynamics and sediment transport processes, resulting in rapid accumulation of fine sediments in the 1970s and 80s and creating a tidal flat which rapidly evolved into a highly productive salt marsh (van Proosdij and Bowron 2017).

An extensive analysis by van Proosdij and Baker (2007) of the changes in morphometry and dynamics of the Avon River estuary has shown that the major sediment accumulation directly attributable to construction of the Avon River causeway is restricted to within 1 to 2 km of the causeway. Immediately downstream of the causeway, less than 6.8 m of sediment has accumulated over an intertidal bar that appears to have been present since 1858. Although this 'Windsor Bar' remained unvegetated until the 1990s, it has now been converted into a very productive salt marsh by the growth of marsh cordgrass (*Spartina alterniflora*) (Daborn *et al.*

2003; van Proosdij and Bowron 2017), and acts as significant protection for the causeway against wave action. A second bar (termed the Newport Bar) has formed another 1 km downstream of the causeway, and is also currently beginning to evolve into a new salt marsh; however, although some 7 m of sediment have accumulated to form this bar, the cross-sectional area at this point in the estuary is only reduced by about 13%, because the adjacent main channel has deepened to compensate for the initial reduction in cross section (van Proosdij and Baker 2007).

Sediments have not settled significantly much beyond these bars; apparent accumulations of sediments further down the estuary have been the result of local changes in erosion and deposition patterns associated with migration and sometimes deepening of the major channel(s) within the estuary (van Proosdij and Baker 2007; van Proosdij and Bowron 2017). Although there is no evidence for significant permanent accumulations of sediment over more distant parts of the Avon River estuary, there have been changes to the cross-sectional area of the Avon River and the St. Croix River. Construction of the causeway caused an immediate reduction in the tidal prism, but the estuary has slowly compensated for this by increases in depth, particularly in the St. Croix River. Although it was believed that the Avon River estuary appeared to have established a new equilibrium state over most of its reach (van Proosdij and Baker 2007), since approximately 2012 marked infilling within the main salt marsh channels and a shift to a ramped marsh platform suggest the marsh/mudflat system is still adjusting to a new equilibrium state (van Proosdij and Bowron 2017). Ongoing research on the morphodynamics of the marsh and tidal channel system downstream of the causeway will provide further insight on how this system is evolving (refer to Section 5.3.8).

5.3.5 Potential Environmental Effects and Project-Related Interactions

The Project is expected to interact with the aquatic environment during Project construction, and operation and maintenance. Key potential issues are identified in consideration of DFO's Pathway of Effects diagrams (DFO 2014). These diagrams describe mechanisms through which projects near water could have an effect on the aquatic environment. In particular, 'Pathways of Effects' for vegetation clearing (DFO 2010b), fish passage issues (DFO 2010c), placement of material or structures in water (DFO 2010d), use of explosives (DFO 2010e), use of industrial equipment (DFO 2010f), and addition or removal of aquatic vegetation (DFO 2010g) were reviewed as being potentially relevant to the assessment of effects associated with Project construction, and operation and maintenance. In consideration of these potential interactions, the assessment of Project-related environmental effects on the aquatic environment is focused on the following environmental effect:

- change in fish habitat quality and use.

A change in fish habitat includes consideration of physical (*e.g.*, change in water temperature, change in habitat structure and cover), biological (*e.g.*, change in food supply) and chemical (change in nutrient or contaminant concentrations) changes to the watercourse, which could in turn result in behavioral and/or physiological changes in fish and their ability to carry out life-cycle processes affecting the sustainability of CRA and/or SOCI fish species.

5.3.5.1 Change in Fish Habitat Quality and Use

Construction

Project-related construction activities will affect the aquatic environment. The most substantive interaction is the loss (or change) of habitat from the installation of watercourse crossings (including causeway expansion and upgrading of the existing aboiteau), culvert installation and extension, as well as the potential erosion and sedimentation.

The upgrading of the aboiteau structure is required as part of the Project. Design of the upgraded aboiteau will be carried out by an experienced team of consulting engineers and scientists and involve consultation with DFO (refer to Section 2.3.1.4). The Avon River crossing will be accomplished by expanding the causeway to accommodate additional lanes and sea-level rise (rockfill and surcharging), by realigning slightly north of the existing alignment, and ensuring linkage of the upgraded aboiteau/causeway to adjacent portions of the agricultural dyke system. If the existing aboiteau cannot be refurbished and is considered to have reached "end of life", it may be replaced. Although design and construction details of the aboiteau-causeway are not known at this time, NSTIR and NSDA will work closely with DFO and other stakeholders to address concerns as design proceeds. Key project objectives are to maintain water management capacity and the current fish passage standard, and make improvements based on expertise and design options.

Expanding the width of the causeway is unlikely to have a detectable effect on the processes in the estuary, other than the loss of a small fraction of the salt marsh. The salt marsh acts as a barrier to water flow in the estuary; this barrier will not effectively change by converting a portion of it into a highway. The major change in tidal prism has already occurred with building of the original causeway, and incremental changes associated with its widening will be lost in the relatively larger signal to which the estuary is continuing to respond. Post-construction monitoring of the Windsor Bar and adjacent mudflats will be carried-out to quantify physical, chemical and biological features following the recommendations of van Proosdij and Bowron (2017) (see Section 5.3.8).

Site preparation, especially clearing, has the potential to decrease the abundance of riparian vegetation along watercourses. Removing vegetation near streambanks removes shaded habitat, alters food supply and may increase bank erosion and increase suspended sediment concentrations and nutrient concentrations in the watercourse (DFO 2010b). The loss of stream shading may result in increased stream temperatures during the summer months (Teti 1998). With increased water temperature, there is also a potential for decreased dissolved oxygen for fish and other aquatic life (DFO 2010b). As a result of reduced riparian vegetation, the diversity and abundance of the aquatic food supply may change through the reduction of invertebrates and their food sources (DFO 2010b). Soil may be mobilized by equipment working near watercourses which may cause sediment to enter the watercourses and alter ecological conditions such as water quality and stream habitat. Sediment entering watercourses may reduce visibility affecting predator or prey awareness or, if concentrations of sediment are high enough, damage gill structures (DFO 2010b, c).

Erosion and sedimentation can occur whenever soil is exposed. Sedimentation (increased sediment load in stream water and deposition in downstream sediments) is perhaps the most common environmental effect of construction activities on the aquatic environment. Fish eggs and larvae have been shown to be the most sensitive to increased sedimentation through the reduction of water flow and oxygen to eggs (DFO 2000; Baxter and Hauer 2000; Sedell *et al*. 1990). The potential direct environmental effects of sedimentation on fish include the following:

- first-level behavioural responses, usually temporary, and not resulting in a change in health;
- minor physiological influences where the fish may avoid exposure but there may be environmental effects to health due to exposure or reduction in food supply;
- physiological changes due to long-term exposure affecting life stages or feeding; and
- environmental effects on eggs and larvae which cannot avoid areas of exposure.

Sedimentation of surface water can degrade surface water quality (*e.g*., oxygen levels, light penetration, water temperature, and water chemistry) leading to changes in primary production and food availability (DFO 2010d). Sediment can transport contaminants and/or nutrients which can degrade water quality. Additional nutrients can lead to a eutrophic system in which oxygen is limited, driving fish from preferred habitat and/or resulting in mortality (DFO 2010d). Bacteria levels can also be affected by changes in sediment loading within a system. Other potential environmental effects on surface water quality that may occur during construction include increases in total suspended sediments (*i.e.,* increased turbidity), a change in hydrologic conditions, and changes in pH from runoff. These changes in surface water quality can lead to effects on the benthic invertebrate community, in addition to potential physical effects resulting from sedimentation.

Changes in pH resulting from runoff can also have a direct effect on fish in watercourses already experiencing acidification. Salmonid species in particular (*e.g*., brook trout and Atlantic salmon) are sensitive to pH changes throughout their life history, including during egg incubation and larval hatching.

Watercourse crossings have the potential to alter fish habitat directly through changes in streambed material at the crossing location or downstream as a result of increased sediment loads. Depending upon the type of structure, watercourse beds and banks may be disturbed during the installation of culverts. Fish movement could be impaired or fish may be displaced during culvert installation as well as following installation if the culvert is not properly placed or measured (*i.e*., sufficient depth and flow). If altered, the stream must be remediated to natural conditions. Flow alterations must be kept short and reversible (*i.e*., restored to the pre-alteration flow rate). Culverts will be designed to meet NSE and DFO requirements.

American eels are known to spawn in the marine environment and salmonid species spawn in spring or fall. Constructing the watercourse crossings outside the spawning periods and within DFO's lower biological risk period of June 1 to September 30 is anticipated to reduce effects on spawning salmonids and their offspring (note that nearly all of the tributary watercourses in the PDA/Assessment Area are currently classified as poor habitat for salmonids based on water temperature, bottom substrate, agricultural runoff, and/or urban development). Creek chub, fourspine and ninespine stickleback spawn during the summer months, when Project activities could potentially interact with spawning. The summer spawners that may be present in the Assessment Area are batch spawners which spawn multiple times in a spawning season and their spawn have short incubation periods of approximately two weeks (McMahon 1982; Holm *et al*. 2009). The spawning periods for fish that may be present in the Assessment Area are shown in Table 5.3.5.

Table 5.3.5 Summary of Spawning Times for Species that may be Present in the Assessment Area

Scientific Name	Common Name	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec
Alosa pseudharengus	Alewife												
Salmo salar	Atlantic salmon												
Anguilla rostrata	American eel					1			2	2			
Alosa sapidissima	American shad												
Ameiurus nebulosus	Brown bullhead												
Salvelinus fontinalus	Brook trout												
Salmo trutta	Brown trout												
Cyprinids	Dace, Shiners, Chubs												
Gasterosteus aculeatus	Threespine stickleback												
Apeltes quadracus	Fourspine stickleback												
Pungitius pungitius	Ninespine stickleback												
Micropterus dolomieu	Smallmouth bass												
Morone saxatilis	Striped bass												
Osmerus mordax	Rainbow Smelt												
Catostomus commersoni	White sucker												
Perca flavescens	Yellow perch												
Morone americana	White perch												
Fundulus diaphanus	Banded killifish												
Fundulus heteroclitus	Mummichog												

1 Upstream Migration of immature fish
2 Downstream migration of mature spawners
Spawning
Eggs/Sacfry in substrate
Source: Scott and Crossman 1998, COSEWIC 2005, COSEWIC 2006a, COSEWIC 2006b.

Noise from construction activities may result in habitat avoidance by fish. The handling of asphalt, concrete, hydrocarbon and hazardous materials in the vicinity of watercourse crossings during the construction phase of the new highway lanes could potentially affect the aquatic environment through exposure to contaminating substances.

Blasting (although unlikely required) can have physical and chemical environmental effects on the aquatic environment. Shock waves and vibrations from blasting can damage fish swim bladders and rupture internal organs, and may kill or damage fish eggs or alevins (DFO 2010e). Blasting can cause re-suspension of sediments, bank failure and resultant sedimentation and habitat avoidance. Nitrogen-based explosives can affect aquatic life through direct toxicity of the compounds, reducing dissolved oxygen during nitrification and providing nutrients for aquatic plants (DFO 2010e).

Operation and Maintenance

Various operation and maintenance activities can result in increased sediment entry into watercourses, including ditching for improved runoff water flow, vegetation control and watercourse crossing repairs and maintenance. An increase in sediment entering the watercourses can affect the aquatic environment. Accumulation of debris or erosion can lead to loss of fish passage within watercourse crossings. The sudden release of blockages can result in increased sediment levels and an associated decrease in water quality.

The operation and maintenance of the additional lanes for Highway 101 is unlikely to have any further detectable effect on sediment dynamics near the causeway.

Freshwater aquatic species such as fish have preferred temperature ranges; if temperatures exceed these ranges (*e.g.,* from pavement runoff and removal of riparian vegetation), additional stress is put on that species (DFO 2010b; Sauter *et al.* 2001). The first flush of spring runoff may also contain traces of various substances including automotive fluids, road salt, dust, metals or polycyclic aromatic hydrocarbons (PAHs) that can result in contamination of surface water.

During operation, vegetation will be mechanically maintained along the roadways. The use of equipment within 30 m of watercourse crossings for vegetation control may result in increased suspended sediment concentrations and the physical alteration of watercourse habitats and adverse effects to fish (DFO 2010f). Direct conduits to the watercourse may be created from equipment rutting; these ruts may create a pathway for sediment or contaminants to enter the watercourse. The alteration of bed and banks may reduce fish habitat quality and the suitability for life processes (DFO 2010b).

Winter maintenance activities such as salting and/or sanding highways during winter months can lead to increased sedimentation in surface water in relation to sanding, and changes in salinity of surface water in relation to salting. The spring melt may present the greatest potential for environmental effects on surface water quality. Refer to Section 2.3.2.4 for additional information on the NSTIR Salt Management Plan.

5.3.6 Mitigation

The following documents will be used for each stage of the Project, as applicable:

- Generic EPP for the Construction of 100 Series Highways (NSTPW 2007)
- NSE Nova Scotia Watercourse Alteration Standard (NSE 2015a)
- NSE Guide to Altering Watercourses (NSE 2015b)
- Guidelines for the design of fish passage for culverts in Nova Scotia (DFO 2015).

The design of the aboiteau will be developed for:

- fish passage requirements (in consultation with DFO)
- climate change predictions matching the life of the structure (*e.g.*, sizing for the expected freshwater flow and protection of sea level rise, storm surge and wave runup)
- storm event predictions
- constructability, maintenance and monitoring considerations
- relevant stakeholder interests and concerns related to lake level management.

Table 5.3.6 outlines specific mitigation measures that will be implemented, where practical, to reduce the environmental effects of the Project on the aquatic environment during construction and operation and maintenance.

Table 5.3.6 Mitigation

Effect	Phase	Mitigation
Change in Fish and Fish Habitat	Construction	• Erosion and sediment control (ESC) measures (Section 2.3.1) will be implemented • Follow Guidelines for the use of Explosives in or Near Canadian Fisheries Waters (Wright and Hopky 1998) • A NSE Water Approval for watercourse alteration will be obtained for all watercourse crossings and conditions of the Water Approval will be met • An authorization under the *Fisheries Act* will be obtained as required and conditions of the authorization will be met • A Certified Watercourse Alteration Installer will carry out or directly supervise watercourse crossings • Structure sizing should be equal to or greater than existing structures (and meet DFO guidelines for fish passage and NSE requirements for 100-year storm events) • A fish habitat offsetting plan will be developed and implemented if it is determined that there is a serious harm to CRA fisheries

Table 5.3.6 Mitigation

Effect	Phase	Mitigation
		• In-stream work and/or disturbance will be minimized, where possible • Stream crossings will be assessed for erosion, with areas of erosion stabilized • No washing, fuelling or maintenance of vehicles or equipment in the vicinity of a watercourse or wetland without secondary containment • No storage of chemicals or Petroleum Oils Lubricants (POLs) within 30 m of a watercourse or wetland • Heavy machinery use during clearing will be kept a minimum of 10 m from the watercourse banks • A limited disturbance buffer zone of 30 m from watercourses will be maintained, where possible • Instream construction will be limited to the lower biological risk period between June 1 – September 30, when feasible • Fish passage will be maintained for all species that use the watercourses for life-cycle purposes • Fish rescues will be carried out before in-water work occurs during watercourse crossings
	Operation and Maintenance	• Preferential use of mechanical vegetation control with limited use of herbicides (no pesticides). Herbicides are used only under the guidance of NSTIR's Integrated Roadside Vegetation Maintenance (IRVM) program • Follow NSTIR Salt Management Plan • Operations of the aboiteau will be in accordance with the operations manual to ensure ongoing fish passage and compliance with approval terms and conditions

5.3.7 Residual Environmental Effects and Significance Determination

Residual Project-related environmental effects on the aquatic environment (*i.e.*, effects remaining after the application of mitigation measures) may occur during initial site preparation, construction of watercourse crossings and installation/upgrade of watercourse structures (*e.g.*, aboiteau), and vegetation control during operations and ongoing maintenance (including winter maintenance). These environmental effects will occur once during construction and periodically during operation as needed for road and structure maintenance and vegetation control.

5.3.7.1 Change in Fish and Fish Habitat

Construction

Prior to initiating construction of watercourse crossings, permitting applications for work in or around watercourses will be submitted to NSE and DFO, as applicable. A Request for Review will be completed and submitted to DFO for the construction of watercourse crossings. If DFO determines that the Project may result in "serious harm" to the CRA fisheries, a *Fisheries Act* Authorization and offsetting plan will be submitted for review and acceptance prior to construction.

All watercourse crossings will be sized and designed to ensure watercourse flow and, in fish-bearing streams, to allow fish passage as per the criteria detailed in the DFO Guidelines for the design of fish passage for culverts in Nova Scotia (2015) and the DFO Practitioner's Guide to Fish Passage (2007). The final designs of the watercourse crossing structures will be submitted for review to DFO under section 20 of the *Fisheries Act*.

All watercourse crossing structures will be installed in compliance with the conditions set in the NSE Water Approval and following mitigation outlined in the site-specific ECPs developed by the contractor prior to construction. Specifically, NSTIR will work with NSE and DFO to ensure that the upgraded aboiteau, new culverts and culvert extensions or upgrades installed in fish-bearing streams will not obstruct fish passage, are designed for peak flows, and maintain natural stream conditions (*e.g.,* width, habitat).

In-stream work will be conducted to avoid sensitive biological periods such as brook trout spawning and egg incubation times. In general, in-stream work will be conducted between June 1 and September 30, where possible. During the summer, low water flow makes in-stream work easier and erosion more manageable. Where possible, the installation of watercourse crossings will be done in the dry, using dam and pump procedures or channel diversion and following applicable guidelines. In either case, fish will be removed from the area of planned construction activities prior to construction. This will be accomplished by enclosing the construction area with fine-mesh nets and removing the fish using DFO approved methods (*e.g.*, seine nets). Direct mortality of some fish can be expected at low rates consistent with those typical for the use of seine nets. Water pump intakes, used during dam and pump procedure, will be screened in compliance with the DFO *Freshwater Intake End-of-Pipe Fish Screen Guideline* (DFO 1995).

Subject to regulatory approval, in-stream work may be conducted outside of the June 1 - September 30 period when seasonal weather conditions permit (*i.e.*, where there will be a relatively low environmental effect on sensitive life stages), when work must be completed prior to the onset of winter conditions, or where the advantages of completing the work (*e.g.*, sediment control structures) prior to winter conditions justifies late season work. In the event of in-stream work outside of the June 1 to September 30 season, a Division I approval will be required and DFO will be consulted and appropriate authorizations will be obtained. Any in-stream work completed after September 30 will require monitoring during the work period, and inspection of sediment control mitigation during periods of the visible overland flow of water (*e.g.*, heavy rain or thaw events).

In the event of late season work (*e.g.*, after September 30 and with regulatory approval) stabilization of exposed soils within the Work Area will be completed as follows (and/or as directed by NSE or DFO):

- within 5 days of disturbance within 30 m of a watercourse (using mulch or another approved late season stabilization material), or prior to any forecasted storm event and/or the onset of frozen ground conditions; or
- within 30 days of disturbance beyond 30 m of a watercourse, or prior to any forecasted storm event and/or the onset of frozen ground conditions, when possible.

Should blasting be required during construction in or near a watercourse, authorization will be required from DFO for the use of explosives. Blasting will be conducted in accordance with the Generic EPP and *Guidelines for the use of Explosives in or Near Canadian Fisheries Waters* (Wright and Hopky 1998), and in compliance with the requirements of DFO's authorization.

Habitat avoidance by fish as a result of Project-related noise (from all construction activities) would be temporary. It is assumed that fish would begin re-populating the affected area immediately upon cessation of noise generating activities.

Watercourse crossings will be installed according to the conditions of the NSE Water Approval to reduce potential for introduction to surface waters of contaminants or suspended sediments at levels that exceed the CCME Guidelines. The potential for environmental effects to the aquatic environment through direct disturbance at a site will be reduced by limiting the area accessed and situating temporary ancillary elements at least 30 m from the watercourse.

Throughout the period of highway construction, ESC measures will be installed and maintained. To reduce erosion and sedimentation, clearing will be limited within 30 m of the watercourse, to the extent possible. Sufficient vegetation must be allowed to grow along the bank of the watercourse to maintain bank stability. Heavy machinery used during clearing will be kept a minimum of 10 m from the watercourse banks. Esc employed during construction, and operation and maintenance phases will be designed and maintained in accordance with Section 3.2 of the Generic EPP and Standard Specifications, and the terms and conditions of Water Approvals and the NSE Watercourse Alteration Standards.

Soil loss from slopes may occur even with ESC measures. To prevent this soil from entering watercourses, further mitigation measures, including vegetated buffer strips, silt fences, filter berms and sediment traps will be implemented to intercept sediments. During construction, steep highway embankments could lead to sediment entering the watercourses, but the use of standard ESC measures should adequately mitigate the effects of sediment laden runoff on nearby surface water sources of watercourses. Any watercourses having steep banks should have an augmented level of ESC.

During construction, monitoring will occur directly following major rain events. Total suspended solids (TSS) vary substantially in the Avon River estuary and other tidally influenced areas; therefore, it may not be appropriate to apply the CCME guidelines to the three estuarine sites in this Project; WC3 (Tregothic Creek), WC6 (Elderkin Creek) and WC9 (Avon River).

Increases in watercourse nutrient levels from hydroseeding would be temporary as the applications are infrequent and these nutrient forms are readily flushed away (nitrates), absorbed by sediments (phosphates) or taken up by plants and microbial communities.

Construction on the causeway in the Avon River estuary area will include laying rock fill, allowing settling time, laying additional rock fill as required for stability and grade, adding granular fill and then paving. Salt marsh habitat (Wetland 4, see Section 5.5), which can also provide fish habitat, will be permanently altered under the new roadway footprint. Erosion and sedimentation issues along the causeway are not anticipated to be of significance given the extremely high suspended sediment levels in the Avon River estuary (exceeding 500 mg/l). However, if feasible, NSTIR will install a turbidity curtain during construction to reduce off-site sediment transport, otherwise, ESC measures will be implemented to minimize any increase in sedimentation due to construction activities.

Storage of hazardous materials will not occur within 30 m of watercourses. Fuel storage and designated fuelling areas will be located at least 30 m from watercourses and wetlands. Refuelling and equipment maintenance required in the field will not be undertaken within 30 m of a watercourse or wetland. Wastewater from washing equipment will not be released into the watercourse.

In consideration of the potential environmental effects of the Project-related activities during construction, and the proposed mitigation (including offsetting for serious harm), residual environmental effects of the construction of the Project on the aquatic environment are predicted to be not significant.

Operation and Maintenance

The watercourse crossing structures will be inspected, cleaned and repaired on a regular basis, as required, to maintain normal water flows. Maintenance will be conducted according to the requirements specified in the NSE Water Approval including clearing of culverts and maintenance of erosion control measures. The aboiteau structure will be maintained and monitored as required to demonstrate effective functioning for flood control and fish passage.

Adherence to the NSTIR Salt Management Plan and winter maintenance guidelines in the Generic EPP will reduce the environmental effects to the aquatic environment, as the guidelines specify application rates and designate vulnerable areas. Detailed protection measures outlined in Section 3 of the Generic EPP and Standard Specifications will help to reduce the potential environmental effects to the aquatic environment resulting from maintenance activities. Ditching will end a minimum of 30 m from watercourses where possible, and will be directed into the surrounding vegetation to allow filtering of sediment prior to water entering the watercourse.

Mechanical clearing will primarily be used for vegetation control during highway operation on the RoW (*e.g.,* road shoulders and interchanges). NSTIR does not use any pesticides other than herbicides. Herbicides are used only under the guidance of the department's Integrated Roadside Vegetation Maintenance (IRVM) program and NSE pesticide application approvals and specifically not be applied under any of the following legislated conditions:

- within a 30 m buffer zone of any watercourse;
- within any distance of any watercourse prescribed on a product label; and
- within 60 m of a protected water supply.

In consideration of the potential environmental effects of the Project-related activities during operation and maintenance, and the proposed mitigation, residual environmental effects of Project operation and maintenance on aquatic environment are predicted to be not significant.

5.3.8 Monitoring and Follow-up

In response to issues raised during consultation and engagement for the Project to supplement existing baseline information on fish species, NSTIR has commissioned a study by local fisher Darren Porter, Sipkne'katik First Nation, Acadia University, and the MCG to obtain up-to-date baseline data on CRA fish species in the Avon River estuary, Lake Pisiquid and lower Avon River, document fish passage through the current aboiteau, catalog the local, historical and traditional knowledge of CRA fishers, quantify the abundance and timing of species migrations in and near the causeway, and contrast the results of both fisheries-independent (government/academic) and commercial fisheries surveys. The results of this study will be used to supplement existing baseline data such as that presented in this EA Report.

Monitoring during construction will promote and confirm application of applicable environmental protection and permitting requirements for work in and adjacent to watercourses and successful implementation of remedial actions where necessary. Monitoring will consist of the following core elements at each watercourse, as applicable:

- regular inspection of all ESC measures to confirm effectiveness;
- monitoring of TSS when precipitation events result in the visible overland flow of water; and
- inspection of hazardous materials storage areas (including possible sediment generating materials).

The location and frequency of observations will be determined in consultation with NSE and DFO through their respective permitting and authorization processes where required.

In recognition of ongoing changes to the Avon River estuary and predicted Project impacts associated with twinning and causeway expansion, NSTIR has commissioned a salt marsh monitoring plan to collect and analyze data before and after the twinning of Highway 101 (see van Proosdij and Bowron 2017). Additional baseline surveys (pre-construction) will occur in Summer/Fall 2017 and post-construction monitoring for at least five years after completion of the upgraded causeway-aboiteau system. These monitoring studies will help document: changes in surface elevation; changes in the location, stability and capacity of tidal channel networks; changes in the amount of vegetated marsh and mudflat habitat conditions; and changes in vegetation community structure and productivity (van Proosdij and Bowron 2017).

A post-construction monitoring program will be also developed in consultation with DFO, local fishermen and the MCG to assess fish and fish habitat along the RoW and downstream. Specifically, the program will evaluate the stability of the channel and the ability to provide fish passage at fish bearing crossings, including at the upgraded aboiteau.

As noted earlier, post-restoration monitoring has already been completed to offset unavoidable loss or damage to fish and wetland habitat. Five hectares of habitat credits have been withdrawn from the St. Croix River High Salt Marsh Habitat Bank to account for freshwater and salt marsh wetland habitat compensation required for this Project (see Section 2.5.2).

5.4 VEGETATION

Vegetation was selected as a VC because of the potential for interactions between Project activities and vegetation, particularly plants that are considered as Species of Conservation Interest (SOCI) and their habitats. SOCI provide a gauge of the effects of a project on the vegetated environment due to the sensitivity of many of these plants to disturbance, and because of the intrinsic value of these plants and their habitats (vegetation communities) for biodiversity. SOCI are often associated with rare or unusual microsites and habitats which develop in areas supporting unique combinations of soil, geology, topography, microclimate, and/or disturbance regimes. These include habitats such as old growth forest, Karst topography, cliffs, rich intervales, and certain types of wetlands. These habitats often provide areas for rare species of plants and animals and contribute to the overall habitat diversity of a particular area. The rarity of the habitat type can result in the concentration of plants or animals dependent on relatively small areas. The vegetation VC is closely linked to other VCs, including Wetlands (Section 5.5), Wildlife and Wildlife Habitat (Section 5.6) and Land Use (Section 5.7).

5.4.1 Regulatory and Policy Setting

SOCI, as defined in this report, refer to plant species that are:

- listed under the Nova Scotia *Endangered Species Act* (NS ESA) or the federal *Species at Risk Act* (SARA) as either *endangered*, *threatened*, *vulnerable*, or of *special concern* (*i.e.*, Species at Risk or "SAR");
- not yet listed under provincial or federal legislations, but identified by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) as either *endangered*, *threatened*, or of *special concern*;

- listed by the Nova Scotia Department of Natural Resources (NSDNR 2014) as *at risk*, *may be at risk*, or *sensitive* to human activities or natural events; or
- ranked as *S1*, *S2*, or *S3* by the Atlantic Canada Conservation Data Center (AC CDC 2014).

There are regulations under the provincial *Forest Act*, the *Wilderness Areas Protection Act* and the *Wildlife Act* that provide protection for some vegetation communities, either directly or indirectly. The regulatory framework relevant to the potential effects on vegetation focuses specifically on SAR.

Plant species that are protected federally under SARA are listed in Schedule 1 of the Act. The purpose of SARA is to protect SAR and their critical habitat. SARA is administered by Environment and Climate Change Canada (ECCC), Parks Canada and DFO. Those species listed as *endangered* or t*hreatened* in Schedule 2 or 3 of SARA may also be considered as SAR, pending regulatory consultation.

Certain plant species are also protected under the NS ESA. Species identified as seriously at risk of extinction or extirpation in Nova Scotia are identified by a provincial status assessment process through the Nova Scotia Endangered Species Working Group. Once identified, they are protected under the NS ESA. The conservation and recovery of species assessed and legally listed under the NS ESA is coordinated by the Wildlife Division of the NSDNR. There is also a provincial General Status assessment process that serves as a first alert tool for identifying species in the province that are potentially at risk. Under this process, species are assigned to categories that designate their population status in Nova Scotia, including *secure, sensitive*, *may be at risk*, and *at risk*. Although species assessed under this process are not granted legislative protection, the presence of species ranked as *sensitive, may be at risk*, and *at risk* is an indication of concern by provincial regulators, as are those ranked as *S1, S2*, or *S3* by the AC CDC. The occurrence of rare plant species within wetlands is also of concern with respect to provincial wetland policy and the permitting process.

5.4.2 Boundaries

The assessment of potential environmental effects on vegetation encompasses the following spatial boundaries: the Project Development Area (PDA) and the Assessment Area. The PDA (*i.e.,* footprint of physical disturbance) is defined in Section 4.2.1. The Assessment Area for vegetation is presented on Figure 5.6 as the Terrestrial Field Survey Area, and is defined as the area encompassed within a 30 m buffer of the PDA. This represents the area in which field surveys were conducted; although the significance of residual environmental effects is considered within a larger context. Portions of the Assessment Area that were not visited in the field include those associated with connector roads to Upper Water St. and Colonial Road at Exit 6, and a fenced off active pasture and adjacent coastal features on the north side of the existing highway between the Avon River causeway and Exit 7.

The temporal boundaries for the assessment of the potential environmental effects of the Project on vegetation include the duration of construction, and operation and maintenance of the

Project in perpetuity. Temporal boundaries consider that rare plants or habitats are non-mobile and may be present at a particular location on a continuous basis.

5.4.3 Significance Definition

A **significant residual adverse environmental effect on vegetation** is one that, after mitigation has been considered, results in a non-permitted contravention of any of the prohibitions stated in sections 32-36 of the federal SARA, or in contravention of any of the prohibitions stated in section 3 of the NS ESA; or threatens the long-term sustainability of a plant species within the Central Lowlands Ecodistrict (630).

Sources: Base Data - Government of Nova Scotia
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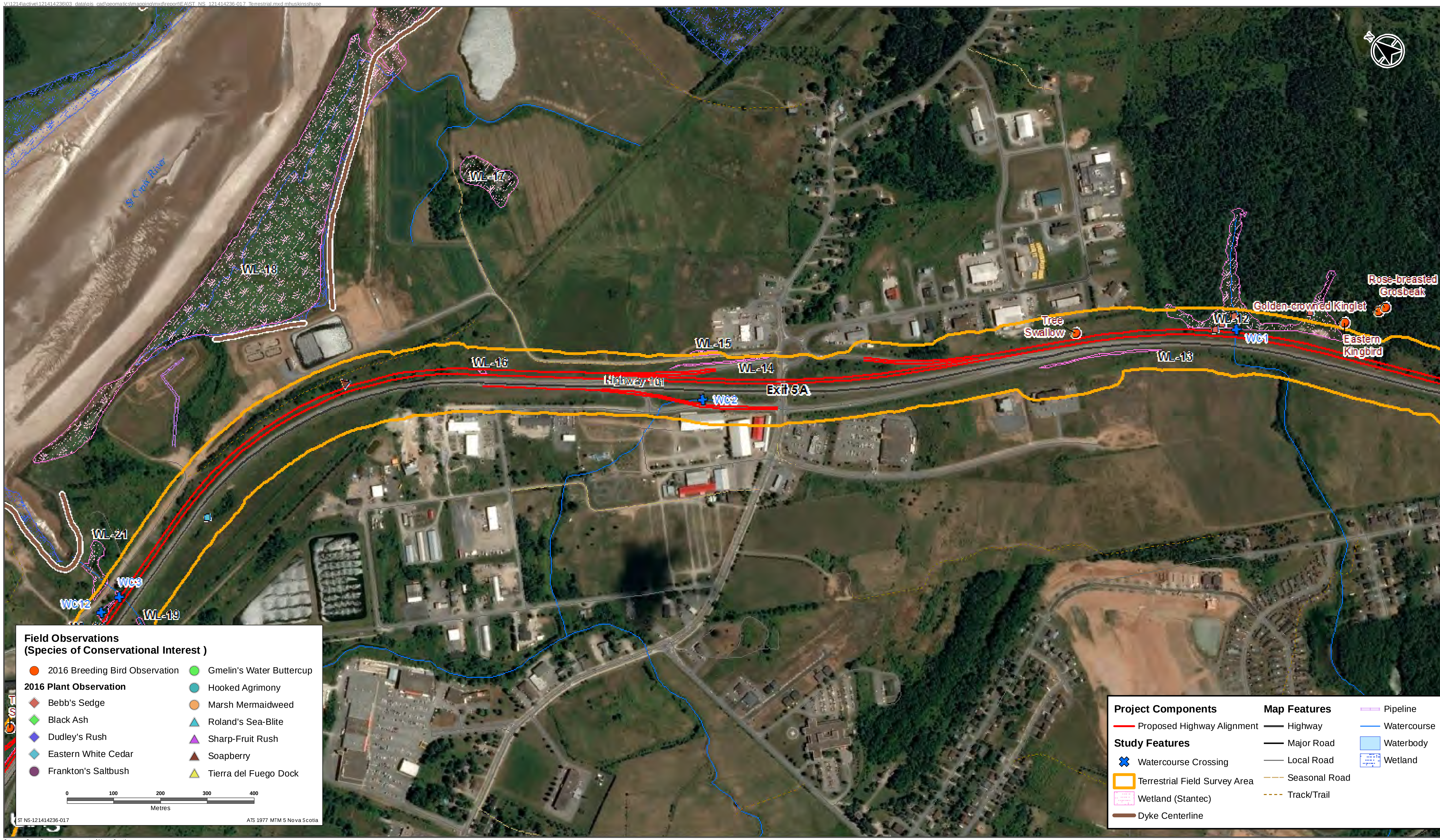
Disclaimer: This map is for illustrative purposes to support this project; questions can be directed to the issuing agency.

Biophysical Features

Stantec

ENVIRONMENTAL ASSESSMENT, HIGHWAY 101 THREE MILE PLAINS TO FALMOUTH

Figure 5.6
Map 1



Sources: Base Data - Government of Nova Scotia
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Biophysical Features

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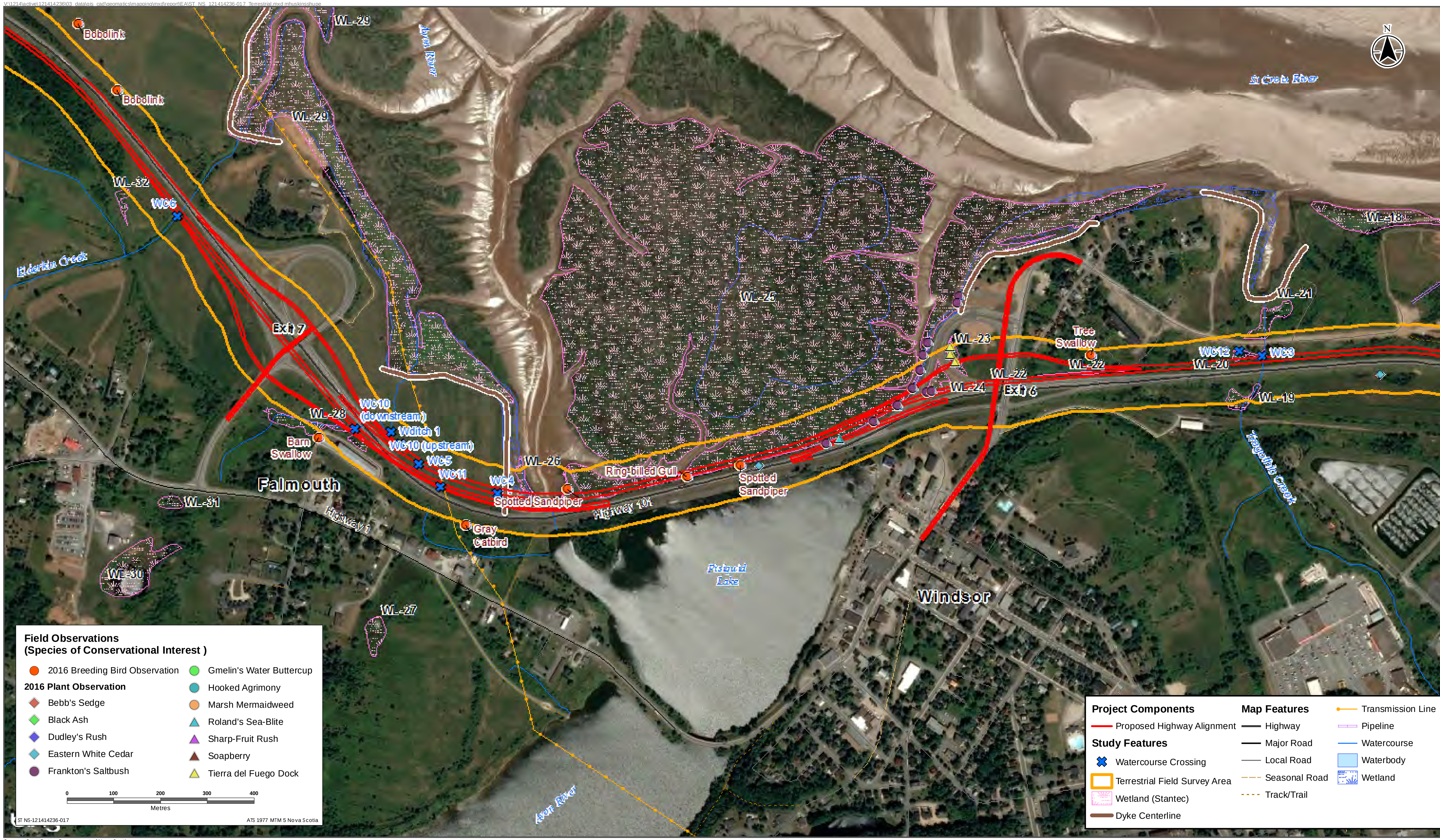
ENVIRONMENTAL ASSESSMENT, HIGHWAY 101 THREE MILE PLAINS TO FALMOUTH

Figure 5.6
Map 2



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Biophysical Features

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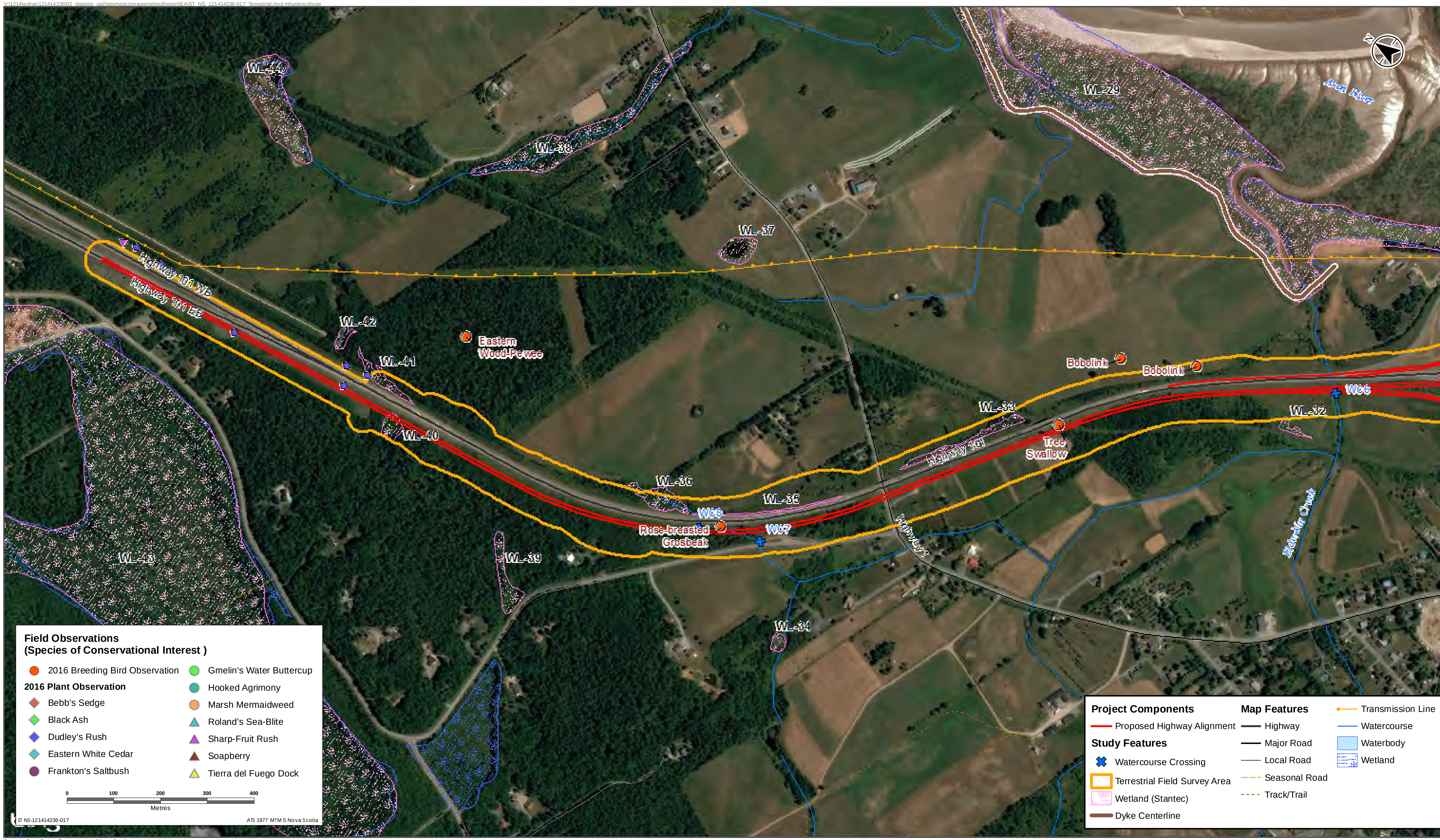
ENVIRONMENTAL ASSESSMENT, HIGHWAY 101 THREE MILE PLAINS TO FALMOUTH

Figure 5.6
Map 3



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Biophysical Features

Stantec

ENVIRONMENTAL ASSESSMENT, HIGHWAY 101 THREE MILE PLAINS TO FALMOUTH

Figure 5.6
Map 4

5.4.4 Description of Existing Conditions

5.4.4.1 Methods

Desktop Information Sources

Baseline vegetation data used to describe existing conditions within the Assessment Area include the following sources:

- AC CDC records of SOCI within 10 km of the Project (AC CDC 2016a)
- NSDNR forest data (NSDNR 2016b)
- NSDNR wetland data (NSDNR 2016c).

These data, along with data previously collected in 2007 and 2008, were used in planning field surveys, analyzing field-collected data, and determining the potential presence of SOCI.

Field Surveys

Information on vegetation conditions within the Assessment Area was obtained during field surveys conducted in 2007, 2008 and 2016. Field surveys were conducted to document the presence of plant SOCI, including vascular and non-vascular taxa, and their habitats. Additional information on the methods used during these surveys is provided below.

Field surveys were conducted in the Assessment Area and adjacent areas in 2007 and 2008 in support of a federal-provincial EA process for the Project that was subsequently cancelled due to changing federal legislation and uncertainty around funding. During this time, an inventory of vascular plants was compiled by experienced botanists during June 15 to 16 and August 7 to 9, 2007. A follow-up survey was conducted in September 2008 to obtain additional information on a rare graminoid, Bebb's sedge (*Carex bebbii*). This survey focused on obtaining information on the local distribution and abundance of this species, particularly in areas outside of the Project RoW.

More recent surveys for vascular plants were conducted June 28 and 30; July 19 to 21, 25 and 29; and September 9, 2016. Surveys were not conducted throughout the entire extent of the Assessment Area in 2016, but focused on verifying existing records of SOCI recorded during 2007-2008, documenting additional SOCI within portions of the Assessment Area not covered during previous surveys, and re-visiting areas with relatively high potential to support SOCI. The locations of plant SOCI were recorded during these surveys along with information on their abundance and habitat association.

Areas with relatively high likelihood of supporting vascular plant SOCI were most intensively investigated during the field surveys, including wetlands, riparian habitats, mature forest, and areas of karst topography. However, all habitats were surveyed with the exception of active residential, commercial, and agricultural properties. All species of vascular plant encountered during the surveys were identified and their population status in Nova Scotia was determined through a review of the designations provided by NSDNR (2014), AC CDC (AC CDC 2014), the Committee on the Status of Endangered Wildlife in Canada (COSEWIC 2016), SARA, and the NS ESA.

A survey for non-vascular plant SOCI was also conducted in 2016 by Tom Neily. This survey was conducted September 2, 2016 and focused on areas of relatively mature forest with potential for epiphytic cyanolichens, and areas of exposed gypsum for ground inhabiting lichens. No areas within the Assessment Area were identified by the provincial government as having relatively high potential to support boreal felt lichen (NSE 2010). Incidental bryophyte observations were also made during this survey.

5.4.4.2 Summary of Existing Conditions

5.4.4.2.1 Environmental Setting

The Assessment Area falls within the Central Lowlands Ecodistrict (630) of the Valley and Central Lowlands Ecoregion, as described by Neily *et al*. (2003). This ecoregion is distinguished by lowlands that are sheltered from coastal climatic influences, and it is characterized as having warmer summers and milder winters than elsewhere in the province (Neily *et al*. 2003). Most of the ecodistrict is fairly level with hummocky to undulating topography, and elevations seldom exceed 90 m above sea level (Neily *et al*. 2003). The climate is conducive to farming and the area has been extensively used for dairy and beef production, and for forage and cereal crops (Neily *et al*. 2003). The ecodistrict is underlain by Carboniferous shale, limestone, sandstone and gypsum. Karst topography is common on areas underlain by gypsum such as is found in proximity to the Assessment Area. Most of the ecodistrict has fine textured soils comprised of loams, silts and clays that have been derived from the underlying Carboniferous rock; and soil drainage has been restricted in many areas because of glacial compaction of the fine textured material (Neily *et al*. 2003). As is characteristic of the larger ecoregion, the forests of this ecodistrict are predominantly softwood, but stands of tolerant upland hardwood are found on a few well-drained sites. Yellow birch (*Betula alleghaniensis*) grows in association with red spruce (*Picea rubens*) on the well- drained hummocks, along with occasional occurrences of American beech (*Fagus grandifolia*), sugar maple (*Acer saccharum*) and eastern hemlock (*Tsuga canadensis*) (Neily *et al*. 2003). Red spruce with scattered eastern white pine (*Pinus strobus*) and hemlock may occur on the better drained sites, particularly on relatively steep slopes near watercourses. Black spruce (*Picea mariana*) forests and scattered white pine occur on imperfectly drained soils within the ecodistrict (Neily *et al*. 2003).

The Assessment Area is located in a highly disturbed landscape. Most of the area has been heavily disturbed as a result of agricultural activity, residential and commercial development, gypsum quarrying and linear corridor development. NSDNR land cover data indicate that approximately 69% of the Assessment Area is comprised of anthropogenic habitats, including existing transportation infrastructure, agricultural land, and urban developments (see Section 5.6 (Wildlife and Wildlife Habitat) for data on the abundance of land cover classes within the Assessment Area). These highly disturbed and anthropogenic cover types are dominated by a variety of native and non-native weedy herbaceous plants. The character of forest and wetlands within the Assessment Area has been highly influenced by disturbance and other stressors.

Data indicate that approximately 24% of the Assessment Area is forested, but the structure and composition of these forests has been highly influenced by past human activities and non-native species. Areas of relatively undisturbed forest occur at the eastern and western ends of the Assessment Area and are comprised of immature – mature hardwood and mixed wood forests. These stands all appear to be either second growth forest or white spruce (*Picea glauca*) dominated stands that have developed on abandoned agricultural land or gypsum spoil piles. Non-native tree species comprise an important component of forested areas throughout much of the Assessment Area. English hawthorn (*Crataegus monogyna*) is abundant at the margins of forest stands at the southern end of the Assessment Area while English oak (*Quercus robar*) is prominent at the northern end. Several small copses of black locust (*Robinia pseudoacacia*) are present near residential areas and Manitoba maple (*Acer negundo*) is abundant in the central portion of the Assessment Area near roadways. Only one area of Karst topography was encountered within the boundaries of the Assessment Area - several small pits and exposed gypsum boulders were observed within a forest stand at the eastern end of the Assessment Area between Wetlands 2 and 3.

Wetlands are common within the Assessment Area, representing approximately 5% of its area. Most wetland habitat in the Assessment Area has been altered by human activities or has developed as a result of human activity. The large salt marsh located adjacent to the Avon River causeway is notable in that it has established over the last five decades in response to hydrological changes resulting from construction of the causeway. Several other occurrences of brackish marsh occur near the coast and in association with watercourses that feed into the Avon River estuary. Freshwater marshes are relatively abundant within the Assessment Area where they occur in association with low-lying basins and ditches. Treed and tall-shrub dominated wetlands are also present but are relatively scarce as a result of the influence of clearing activities and other anthropogenic disturbances. Additional information on the vegetative character of wetland types present in the Assessment Area is provided in Section 5.5 (Wetlands).

5.4.4.2.2 Plant Species of Conservation Interest

AC CDC records indicate that at least 70 vascular plant SOCI have been recorded in the vicinity of the Project (AC CDC 2016a). These species are associated with a variety of habitat conditions, including wetlands, deciduous forests, intervales, coastal features, and open and disturbed areas such as pastures or roadsides. Many of the plant SOCI are calciphytes and relatively undisturbed areas with karst topography have particularly high potential to support SOCI, including ram's-head lady's-slipper (*Cypripedium arietinum*), yellow lady's-slipper (*Cypripedium parviflorum*), eastern leatherwood (*Dirca palustris*), northern wild comfrey (*Cynoglossum virginianum*), and round-leaved liverleaf (*Hepatica nobilis*). The timing of the surveys conducted in June and July 2016 would have been sufficient to identify the majority of SOCI that have been historically recorded in the vicinity of the Project. Many of these SOCI would have been flowering or in fruit at the time of the surveys (*e.g.*, pubescent sedge (*Carex hirtifolia*)) and others are identifiable throughout the growing season (eastern white cedar (*Thuja occidentalis*)). Although some of the SOCI would be most easily recognizable in spring (yellow lady's-slipper (*Cypripedium parviflorum*), most maintain aboveground vegetative features that would allow for their identification at other times of the growing season. The September 2016 survey focused on those areas of the Assessment Area with potential to provide habitat for species which are best identified later in growing season. Particular attention was given to salt marsh habitats during the September survey because AC CDC data indicate that seablite (*Suaeda spp*.) SOCI have been recorded in the vicinity of the Project, and the seeds that are required for proper identification of this genus are not available until late summer or fall. Several freshwater wetlands were also visited during the September survey to search for other taxa that are best identified late in the growing season (*e.g.*, purple-veined willowherb (*Epilobium coloratum*)). AC CDC data indicate that two SAR have been recorded in the vicinity of the Project: ram's-head lady's-slipper and eastern white cedar. Although eastern white cedar is easily identifiable year-round, ram's-head lady's-slipper is most easily identified when in flower during from late May to early June (although its leaves remain above ground for a longer period of time). A list of vascular plant SOCI recorded within 10 km from the center of the Assessment Area, along with information on their habitat associations and phenology is provided in Appendix C.

A total of 465 vascular plant taxa were recorded during the 2007 and 2016 field surveys (Appendix C). Plant species richness is relatively high within the Assessment Area for several reasons, including the presence of large numbers of non-native species, a moderate diversity of habitat types, and high soil fertility. Approximately a third of the plant species recorded during field surveys are non-native; this abundance is attributable to the influence of human activities within the area, including those related to agriculture, highway infrastructure, residential and commercial development.

Sixteen of the species recorded during field surveys in support of the Project are SOCI (Table 5.4.1). Ten of these SOCI were recorded during 2007 surveys and twelve were encountered in 2016. Of the species recorded during field surveys, two are SAR: Black Ash (*Fraxinus nigra*) and eastern white cedar (*Thuja occidentalis*). The provincial population of one species, Roland's sea-blite (*Suaeda rolandii*) is considered as *may be at risk*, while that of five species is considered *sensitive*: Bebb's sedge, fan-leaved hawthorn (*Crataegus flabellata*), purple-veined willowherb, big-leaved marsh-elder (*Iva frutescens*), and soapberry (*Shepherdia canadensis*). Although the remaining species are considered by NSDNR to have *secure* populations, they have been assigned ranks of *S3* or *S3S4*, indicating that they may be considered *vulnerable* to apparently *secure* within the province but are of long-term concern due to declines or some other factors (AC CDC 2016b). These species include: hooked agrimony (*Agrimonia gryposepala*), Frankton's saltbush (*Atriplex franktonii*), sharp-fruit rush (*Juncus acuminatus*), Dudley's rush (*Juncus dudleyi*), Loesel's twayblade (*Liparis loeselii*), marsh mermaidweed (*Proserpinaca palustris*), Gmelin's water buttercup (*Ranunculus gmelinii*), and Tierra del Fuego dock (*Rumex fueginus*). Additional information on the local distribution, abundance, and habitat associations of these species is provided below. None of the species encountered are listed under the federal SARA.

Table 5.4.1 Plant Species of Conservation Interest Recorded during Field Surveys

Common Name	Scientific Name	ACCDC S-Rank	NSDNR General Status Rank	NS ESA Designation	Observed in 2007?	Observed in 2016?
Hooked Agrimony	*Agrimonia gryposepala*	S3	Secure			x
Frankton's Saltbush	*Atriplex franktonii*	S3S4	Secure		x	x
Bebb's Sedge	*Carex bebbii*	S2	Sensitive		x	x
Fan-leaved Hawthorn	*Crataegus flabellata*	SNR	Sensitive		x	
Purple-veined Willowherb	*Epilobium coloratum*	S2?	Sensitive		x	
Black Ash	*Fraxinus nigra*	S1S2	At Risk	Threatened	x	x
Big-leaved Marsh-elder	*Iva frutescens*	S2	Sensitive		x	
Sharp-Fruit Rush	*Juncus acuminatus*	S3S4	Secure			x
Dudley's Rush	*Juncus dudleyi*	S3	Secure			x
Loesel's Twayblade	*Liparis loeselii*	S3S4	Secure		x	
Marsh Mermaidweed	*Proserpinaca palustris*	S3	Secure			x
Gmelin's Water Buttercup	*Ranunculus gmelinii*	S3	Secure			x
Tierra del Fuego Dock	*Rumex fueginus*	S3S4	Secure		x	x
Soapberry	*Shepherdia canadensis*	S2S3	Sensitive		x	x
Roland's Sea-Blite	*Suaeda rolandii*	S1?	May Be At Risk			x
Eastern White Cedar	*Thuja occidentalis*	S1	At Risk	Vulnerable	x	x

Hooked Agrimony

Hooked agrimony is a perennial herb that has been recorded in association with thickets, the margins of rich woods, intervales, and slopes of the province (Zinck 1998). Several hundred of these plants were observed in 2016 within the open woods and forest edges on the south side of Highway 101 near Exit 5; one occurrence was also recorded in the same area on the north side of the highway (Figure 5.6). AC CDC (2016a) data indicate that there are 14 other records for this species within 10 km from the Project.

Frankton's Saltbush

Frankton's saltbush is a halophytic forb that is typically found in salt marshes, brackish marshes and along seashores (Zinck 1998). This species was observed in the large salt marsh that is located adjacent to the Avon River causeway (Wetland 25, Figure 5.6) during both 2007 and 2016 surveys. Hundreds of plants occurred along the transition zone between the salt marsh and the causeway within this wetland. Specimens of what are likely Frankton's saltbush were also observed along the edge of Wetland 24 (Figure 5.6) during a 2016 field survey (fruiting specimens were not present during this visit, as would be required for identification confirmation). AC CDC (2016a) data do not indicate any other records for this species within 10 km from the Project.

Bebb's Sedge

Bebb's sedge was recorded at several locations at the southern end of the Assessment Area between Exits 5 and 5A during 2007 and 2016 surveys (Figure 5.6). The majority of the records were associated with mapped wetlands (including Wetlands 8, 9, 10 and 12) and another occurrence was found in association with an imperfectly drained area near Exit 5. This species prefers poorly drained alkaline or circumneutral soils, and does not tolerate heavy shade. All of the areas which were found to support Bebb's sedge had been disturbed from past highway construction and or gypsum quarrying.

In an effort to better understand the local distribution of this species in and around the Assessment Area, a survey of the local abundance of this species was conducted in September 2008. Survey effort focused on properties between Exits 5 and 5A along the eastern side of the existing highway, including the proposed RoW and adjacent lands. On the western side of the proposed Project, the search was limited to the highway ditch. Survey efforts focused on the diversity of habitats in which Bebb's sedge is known to reside, which include open wetlands, gravelly lakeshores, stream banks, swales, meadows, forest seeps, and other poorly drained soils (Zinck 1998; Hinds 2000; FNA 2003). In addition to areas within the Project RoW, these habitats were searched on nearby properties owned and operated by the Fundy Gypsum Company which are located immediately east of the proposed Project, and to which permission had been granted for survey activities. Approximately 155 Bebb's sedge plants, distributed among six general localities, were found during these surveys. Individuals were encountered along the edges of marshes, ponds, and their associated drainages. Many of these areas were dominated by cattails (*Typha spp.*) and were found within areas which had been highly disturbed by human activities. Within these habitats, Bebb's sedge was encountered in open areas which provided abundant light and that were moderately saturated. Although roadside ditches on either side of Highway 101 provide similar environmental conditions, Bebb's sedge was not found here. Although many pockets of small marsh and wet meadow were encountered throughout the quarry property, Bebb's sedge was only found at a small percentage of these. In addition to these records, AC CDC (2016a) data indicate that Bebb's sedge has been recorded at a number of other locations within 10 km of the Project, including near Windsor, Mantua, Newport Station, Meander River, and Brooklyn.

Fan-leaved Hawthorn

Fan-leaved hawthorn is a shrub or small tree that has been recorded in association with hedgerows and thickets (Zinck 1998). This species is known from scattered localities within the province (Munro *et al*. 2014) and was recorded during vascular plant surveys in 2007, but spatial coordinates are not available. AC CDC (2016a) data do not indicate any other records for this species within 10 km from the Project and it is unknown whether the 2007 record was confirmed.

Purple-veined Willowherb

Purple-veined willowherb is scattered throughout the province where it is found in association with low ground and seepy soils (Munro *et al*. 2014). Although this species flowers during the summer months, its seeds are required for proper identification and are often not available until early fall. This species was recorded during vascular plant surveys in 2007 but spatial coordinates are not available. Although not confirmed during 2016 field surveys, unidentified *Epilobium* specimens were encountered during field visits in June and July (*i.e.*, some could not be reliably identified to their species epithet because of a lack of mature material), and this species has potential to occur within the Assessment Area in association with wetlands and other seepy areas. AC CDC (2016a) data do not indicate any records for this species within 10 km from the Project, and efforts to identify this species during a September 2016 survey were unsuccessful. It is currently not known if this species occurs within the Assessment Area or if the 2007 record was confirmed.

Black Ash

Black ash is typically found on poorly drained sites such as damp woods and swamps (Zinck 1998). Although immature trees are scattered throughout the province, mature specimens are rare and account for only 12 of the estimated 1,000 black ash known in the province (NSDNR 2013). Black ashes are slow growing, poor competitors, and are prone to fungal infections. They are very susceptible to the emerald ash borer, a non-native insect which is currently colonizing central North America and is expected to eventually reach Nova Scotia and result in heavy mortality of this species. Four black ash trees were found during the field survey; all of which are located to the north of the Assessment Area near Exit 5 (Figure 5.6). These trees were found in association with a low-lying area and were observed to have diameter-at-breast-heights (dbh) of approximately 12, 15, 19, and 20 cm during a 2016 site visit. AC CDC (2016a) data do not indicate any records for this species within 10 km of the Project. Black ash were also recorded at this location during the 2007 surveys.

Big-leaved Marsh-elder

Big-leaved marsh-elder is associated with disturbed and elevated areas around salt marshes (Munro *et al*. 2014). This species can tolerate occasional flooding by seawater and extended periods of flooding in freshwater but it grows best on fairly dry sites. Its tolerance for salt provides this species with a competitive edge in the transitional zones between salt marsh and upland habitats. Marsh-elder was found growing on the toe of slope of the westbound entry ramp of Exit 6 at the edge of a small marsh in 2007. The plant was growing in the sand and gravel fill near the base of the road embankment at the point where the embankment abutted a small brackish marsh. The marsh was formerly the upper portion of a salt marsh that was isolated by the construction of Highway 101 and the Exit 6 west bound entry ramp. The marsh ranges from freshwater marsh at the higher elevated eastern end to brackish marsh at the lower elevation western end, and the marsh elder was found near the western end of the wetland. A search for big-leaved marsh-elder was conducted in 2016 at the location where it was previously recorded, but no records for this species were obtained during that time and the area has been recently disturbed by human activities. AC CDC (2016a) data indicate that this species has been recorded at one other location (*i.e.*, near Centre Burlington) within 10 km from the Project.

Sharp-fruit Rush

Sharp-fruit rush is known to be scattered throughout the province in association with sand and mud flats, clay soils as in sterile meadows or ditches (Munro *et al*. 2014). This species was observed growing in a ditch at the northern end of the Project in September 2016 (Figure 5.6). AC CDC (2016a) data do not indicate any records for this species within 10 km from the Project.

Dudley's Rush

Dudley's rush is considered to be a habitat generalist and it is known to be scattered throughout the province, including within Annapolis, Hants, and Lunenburg counties (Munro *et al*. 2014). Approximately 43 clumps of this species were observed at seven locations within highway ditches at the northern end of the Project during 2016 surveys (Figure 5.6). AC CDC (2016a) data indicate that this species has been recorded at two other locations (*i.e.*, near Mantua and Herbert River) within 10 km from the Project.

Loesel's Twayblade

Loesel's twayblade occurs in a variety of habitats including bogs, peaty meadows, wet ditches, cobbly lake shores, the edges of ponds and bogs and behind coastal barrier beaches (Zinck 1998). This species was recorded in 2007 in association with Wetlands 9 and 10 which consist of small anthropogenic wetlands composed of open water wetland, freshwater marsh and tall shrub swamp. This species was not found in this area during 2016 surveys and AC CDC (2016a) data do not indicate any records for this species within 10 km from the Project.

Marsh Mermaidweed

Marsh mermaidweed is scattered throughout the province where it is often abundant in association with boggy swales, savannas, wet marshes, and the edges of streams (Zinck 1998). In 2016, this species was observed at the eastern end of the Assessment Area in association with the shallow waters of Wetland 1 (Figure 5.6), where it was abundant. AC CDC (2016a) data indicate that there are eight other records for this species within 10 km from the Project.

Gmelin's Water Buttercup

Gmelin's water buttercup is a small forb that is found in marshes and it is often abundant where it occurs in association with slow-flowing streams, ditches, shallow pools, and ponds in relatively alkaline areas; as well as in shallow water in swamps and sometimes on sandy shores or in dried-up ditches (Zinck 1998). In 2016, this species was observed in association with the edges of Wetlands 2 and 3 (Figure 5.6), where it was growing at the edge of marsh and tall shrub habitats. AC CDC (2016a) data indicate that there are nine other records for this species within 10 km from the Project.

Tierra del Fuego Dock

Tierra del Fuego dock is an annual or biennial forb of salt marshes and barachois that is scattered around the coast of Nova Scotia where it is found in open organic microsites (Munro *et al*. 2014). This species was observed within Wetland 23 during both 2007 and 2016 surveys (Figure 5.6). Within this wetland, it was observed growing in the exposed organic mat of a marsh that would be flooded early in the growing season and exposed later in the summer. This habitat would be characterized as presenting relatively low levels of competition with other plants. Approximately 200 plants were found growing on the exposed mud in 2007 but 2016 surveys indicated that the population was comprised of approximately 22 plants. The species composition of the vegetation surrounding the pond suggests that it may be slightly brackish, which may be a result of road salt application during the winter months. AC CDC (2016a) data do not indicate any records for this species within 10 km from the Project.

Soapberry

Soapberry is a low nitrogen-fixing shrub that is typically associated with gypsum talus slopes and coastal headlands (Zinc 1998). This species was found within the Assessment Area during both 2007 and 2016 surveys where it was growing on heavily disturbed sites occupied by grasses and forbs; particularly on gypsum quarry spoil piles or on road cuts of Highway 101. The distribution of soapberry within the Assessment Area was largely confined to the southern end of the route near Exit 5 where approximately 51 plants were observed in 2016. One large patch of soapberry was also found on the steep embankment of an old railroad spur located between Exits 5A and 6, just north of the existing railroad line. Although surveys for this species in 2016 were restricted to the Assessment Area, 2007 surveys extended into adjacent areas where this species was encountered at the southern end of the route. The 2007 surveys found that approximately 93% of the local population encountered was located outside of the proposed RoW on gypsum quarry spoil piles. AC CDC (2016a) data obtained indicate that there are 72 records for this species within 10 km from the Project.

Roland's Sea-blite

Little is currently known about Roland's sea-blite in Nova Scotia, but it has been recorded in salt marshes and saline soils at several places within the province (Munro *et al*. 2014). During surveys in September 2016, Roland's sea-blite were observed within the large salt marsh along the Avon River causeway (*i.e.*, Wetland 25, Figure 5.6). Because of the difficulty in identifying members of the *Suaeda* genus and the abundance of the more common white sea-blite (*Suaeda maritima ssp. maritima*) in the same area, an inventory of the abundance and distribution of this species within the Assessment Area was not obtained. However, this species may be relatively common along the Avon River causeway and AC CDC (2016a) data indicate that this species has been recorded in the vicinity of the Project near Sweets Corner.

Eastern White Cedar

Two eastern white cedars were found growing on the side of Highway 101: one on the north side of the Avon River causeway and another on the south side near the Town of Windsor (Figure 5.6). Both native and introduced populations of eastern white cedar are present in Nova Scotia. Native populations are typically found growing around the margins of lakes, in swamps and in old fields; but this species is also a popular ornamental tree that is grown throughout much of the province (Zinck 1998). The populations found in the Annapolis Valley, Digby County and Cumberland County are thought to be native while other populations are believed to be introduced. Given the location and habitat in which the eastern white cedars were found during field surveys, it is likely that they have escaped from cultivation and are of non-native stock. AC CDC (2016a) data include two other records for this species within 10 km of the Project.

Non-vascular Plants

The Windsor area is known to support exceptional habitat for rare lichens. Ground-inhabiting species such as woodland owl lichen (*Solorina saccata),* soil tarpaper lichen *(Collema tenax), scaly pelt lichen (Peltigera lepidophora)* and moss shingles lichen (*Fuscopannaria praetermissa)* have all been observed on gypsum outcrops and sinkholes and in abandoned quarries and complement a rich diversity of rare vascular plant and bryophyte calciphiles known to occur in the general area. AC CDC records indicate that 20 non-vascular SOCI have been recorded within 10 km from the Project, including seven lichens and 13 bryophytes (AC CDC 2016a). None of the non-vascular plants that have been recorded in the vicinity of the Project are designated SAR under either the federal SARA or the NS ESA. A list of non-vascular plant SOCI recorded within 10 km from the center of the Assessment Area is provided in Appendix C, Table C.3.

Field surveys did not identify any non-vascular SOCI in the Assessment Area. A small site of exposed gypsum sinkholes near Exit 5 was identified during previous survey work as potential habitat but was not found to provide habitat for any lichen species of interest. Only scattered exposed gypsum was observed and the area’s habitat quality has likely been degraded by its proximity to the highway. Drive-by observations did not identify the presence of other habitat for epiphytic or ground inhabiting lichens. A list of non-vascular species recorded during the surveys is available in Appendix C, Table C.4.

5.4.5 Potential Environmental Effects and Project-Related Interactions

Activities and components could potentially interact with vegetation and result in changes to SOCI populations, and vegetation communities. The assessment of Project-related environmental effects on vegetation is therefore focused on the following potential effect:

- change in SOCI.

5.4.5.1 Change in SOCI

Construction

Construction activities could potentially interact with vegetation and result in changes to plant SOCI populations and their habitats through direct or indirect interactions. The measurable parameter for these effects would be changes to vascular plant or lichen SOCI (number of individuals or populations). Direct interactions with SOCI could occur as a result of physical disturbance whereas indirect effects may occur where there is potential for hydrological modifications to their habitat (*e.g.*, wetlands), or sedimentation and erosion occurs in areas with SOCI. The most substantive and likely interactions are a change in habitat quantity or quality and possible loss of SOCI as a result of site preparation activities and the construction of watercourse crossing structures.

Site preparation activities have the highest potential to directly or indirectly interact with vegetation, including plant SOCI. Vegetation located within the PDA will be removed during the construction phase of the Project. In particular, clearing and grubbing during site preparation will directly remove vegetation and has potential to result in a permanent loss of SOCI individuals. A number of indirect effects can also result from these site preparation activities. Clearing of forested areas can change the quality of the habitat along the edge of the PDA as a result of increased side lighting or drying, which may enable more light-tolerant and disturbance-tolerant species to penetrate. Off-road and off RoW activity also have potential to disturb vegetation habitat and cause direct mortality of vascular plants. This may occur when vehicles are accessing the work site along tertiary roads, by the gradual widening of the thoroughfare, as well as through non-motorized activity in undisturbed areas adjacent to the RoW.

The Project will require the installation of culverts and bridges. Improper installation of watercourse crossings can alter aquatic or wetland habitat on which some plant species are dependent. Improperly installed crossings can result in flooding or extensive erosion. Construction activities also have potential to introduce sediment or silt into wetlands, watercourses, and surface water in the Assessment Area. This has potential to cause adverse effects to SOCI.

Operation and Maintenance

Several activities related to the operation and maintenance of the Project could affect vegetation. In particular, maintenance of the Project infrastructure and vegetation management initiatives can adversely affect SOCI.

During winter, salt is used by NSTIR on road surfaces to aid in melting snow, and to provide clear road conditions. Road salt can enter into the environment (surface water, groundwater and soil) through storage and application of these salts. The highest concentrations are usually associated with winter and spring thaws. Environment Canada (2001) cites a number of studies attributing vegetation damage and changes in plant community composition to road salt application. Road salt applications can damage plants located immediately adjacent to highways and increase the salinity of soils. The effects of road salt are generally observed within 10 m of the edge of the road, although salt related injuries have been detected at distances of up to 80 m from the road. Damage to vegetation includes osmotic (*i.e.*, concentration induced dehydration) injuries as well as direct chloride ion toxicity. Salt deposited on soils can adversely affect plant growth by changing the structure of soil (development of salt crusts) or reducing soil fertility (replacement of calcium and potassium ions by sodium ions). In some areas between 5 and 10% of trees within 30 m of highways have salt damage (Transportation Research Board 1991). Although road salt applications may be generally considered to have an adverse effect on vegetation, some plant SOCI found in the area are associated with saline conditions (*e.g.*, Frankton's saltbush, Tierra del Fuego dock) and have potential to benefit from this application in areas where they may not otherwise occur.

Vegetation management will occur during the operation and maintenance phase and could affect SOCI populations if they become established in the RoW after construction. However, SOCI that would tend to populate the RoW during operation would typically be associated with disturbed or early-successional vegetation communities (*e.g.*, Bebb's sedge) and their long-term presence may therefore benefit from periodic vegetation management initiatives. These plants have potential to be adversely affected by herbicides if they are used for vegetation maintenance.

As part of infrastructure maintenance, ditching may be required to improve water flow, reduce erosion, and/or to deter excessive vegetative growth. The release of sediment into wetlands could have a detrimental effect on the survivability of SOCI in these areas. Some rare species may colonize ditches (*e.g.*, Bebb's sedge) and could be lost when ditches are periodically cleaned out. The effects of infrastructure maintenance on wetlands are also discussed in Section 5.5.

5.4.6 Mitigation

Mitigation to reduce the environmental effects of the Project on vegetation are identified in Table 5.4.2. Standard mitigation and measures identified in Sections 5.3, 5.5, and 5.6 to reduce effects on aquatic resources, wetlands, and wildlife and wildlife habitat will also act to reduce effects on vegetation. The use of some mitigation will be determined on a site-by-site basis in consideration of local concerns and conditions. Locations for site-specific mitigation will be outlined in the ECP following detailed design and in consultation with the appropriate regulatory authorities in consideration of the following criteria:

- rarity, status, or function of SOCI under consideration
- ecology of SOCI under consideration
- location of SOCI relative to the RoW
- alternatives to current design
- temporary or permanent mitigation
- public or landowner support (*e.g.*, existing use/ownership).

Table 5.4.2 Mitigation for Vegetation

Effect	Phase	Mitigation
Change in SOCI and their habitats	Construction	• Project design will reduce area to be cleared, where feasible • Limit Project-related off road activity • Follow Generic EPP • Employee environmental awareness training • Follow Watercourse and Wetland Alterations permit conditions • Erosion control measures • Proper installation of culverts to prevent flooding or draining of wetlands • Flagging and avoidance of plant SOCI outside PDA but within the RoW • Develop mitigation plans for unavoidable effects on SOCI in consultation with regulators. Mitigation may include salvage and translocation of SOCI. • Use snow fencing and signage in areas of SOCI to protect plant occurrences near disturbance activities • All equipment must arrive at the site clean and free of soil or vegetative debris. Equipment will be inspected by the Environmental Inspector(s), or designate.
	Operation and Maintenance	• Follow Generic EPP • Employee environmental awareness training • Follow NSTIR Salt Management Plan • Apply drainage controls • Follow NSTIR Integrated Roadside Vegetation Management Manual • Restrict the general application of herbicide near SOCI and in wetlands. Spot spraying, wicking, mowing, or hand-picking are acceptable measures for integrated vegetation management in these areas.

5.4.7 Residual Environmental Effects and Significance Determination

5.4.7.1 Change in SOCI

Construction

Clearing and grubbing for site preparation of the highway PDA will be the most important adverse effect of the Project on vegetation. Eight of the 16 plant SOCI which have been recorded during field surveys conducted in support of the Project will be directly affected by clearing and grubbing: hooked agrimony, Frankton's saltbush, Bebb's sedge, Dudley's rush, Tierra del Fuego dock, soapberry, Roland's sea-blite, and eastern white cedar (Table 5.4.3). The remainder of the species are not known to occur within or immediately adjacent to the PDA so are unlikely to be affected during site preparation.

Table 5.4.3 Effects on Plant SOCI during Site Preparation

Common Name	Scientific Name	Within PDA?	Effects from Site Preparation
Hooked Agrimony	*Agrimonia gryposepala*	Yes	One record of approximately 10 plants is within the PDA, all other individuals encountered are outside the PDA.
Frankton's Saltbush	*Atriplex franktonii*	Yes	Populations within Wetlands 24 and 25 will be directly disturbed.
Bebb's Sedge	*Carex bebbii*	Yes	Several occurrences are within or immediately adjacent to the PDA but the majority of the local population is outside the Project footprint.
Fan-leaved Hawthorn	*Crataegus flabellata*	unknown	Unknown; information on the location and abundance of this species within the PDA is unavailable, but it may not occur within the Assessment Area.
Purple-veined Willowherb	*Epilobium coloratum*	unknowna	Unknown; information on the location and abundance of this species within the PDA is unavailable, but it may not occur within the Assessment Area.
Black Ash	*Fraxinus nigra*	No	None expected; all individuals encountered are outside the PDA
Big-leaved Marsh-elder	*Iva frutescens*	No	No populations known within the Assessment Area.
Sharp-Fruit Rush	*Juncus acuminatus*	No	Individuals encountered are outside the PDA.
Dudley's Rush	*Juncus dudleyi*	Yes	Two occurrences are within the PDA but the majority of the local population is outside the Project footprint.
Loesel's Twayblade	*Liparis loeselii*	No	No populations known within the PDA
Marsh Mermaidweed	*Proserpinaca palustris*	No	No populations known within the PDA
Gmelin's Water Buttercup	*Ranunculus gmelinii*	No	None expected; all individuals encountered are outside the PDA.
Tierra del Fuego Dock	*Rumex fueginus*	Yes	A portion of the population within Wetland 23 will be directly disturbed.

Table 5.4.3 Effects on Plant SOCI during Site Preparation

Common Name	Scientific Name	Within PDA?	Effects from Site Preparation
Soapberry	*Shepherdia canadensis*	Yes	Three occurrences are within or immediately adjacent to the PDA but the majority of the local population is outside the Project footprint.
Roland's Sea-Blite	*Suaeda rolandii*	Yes	The population along the edge of Wetland 25 will be directly disturbed as a result of twining of the Avon River causeway
Eastern White Cedar	*Thuja occidentalis*	Yes	Both individuals encountered are within the PDA and will be directly disturbed but this effect is not considered ecologically important because specimens encountered are likely of non-native stock.

Frankton's saltbush occurs along the margins of Wetlands 24 and 25, which are expected to be directly disturbed by Project activities. The largest population of this species is found at the transition zone between the Avon River causeway and the adjacent salt marsh (*i.e.*, Wetland 25). This area will be lost as a result of construction of the roadbed for the new lane. Although there are no practical mitigative measures that could be used to prevent the loss of this population, this population has established in this location within the last few decades (*i.e.*, the salt marsh has formed following construction of the causeway) and it is likely that other populations are located nearby that could help to reestablish the population along the base of the new roadbed following Project construction.

Recent (*i.e.*, 2016) information on the distribution and abundance of Bebb's sedge within the PDA indicate that approximately 29 plants will be directly disturbed by Project construction. However, survey data indicate that this species is also located within surrounding areas and its local population is not likely to be substantially reduced by Project construction. For example, approximately 36 plants observed within the Assessment Area during 2016 are outside the PDA (*i.e.*, > 50% of the populations within the Assessment Area). The 2008 survey found that approximately 149 plants were found to be distributed amongst four general areas outside a previous estimated PDA for the Project; the greatest abundance was found in association with a small pond and area of tall rush marsh connected via small drainages. Although surveys were not completed for Bebb's sedge outside the Field Study Area in 2016, it is likely that the population encountered outside the PDA in 2008 is still present. Construction activities within the RoW may result in the direct mortality of individuals or may indirectly affect populations if activities result in hydrological, chemical, and/or biological changes to their habitat. The proposed Project is unlikely to adversely affect the portion of the Bebb's sedge population surveyed outside of the Assessment Area (*i.e.*, on old quarry lands) as these are located uphill of the Project and are therefore removed from the major influence of stressors related to Project construction, operation, and maintenance.

Two Dudley's rush records, comprised of approximately seven and three clumps each, are within the boundaries of the PDA. Although these occurrences will likely be directly disturbed during Project construction, activities are unlikely to have an important effect on the local abundance of this species. In particular, approximately 77% of the local population encountered during field surveys (*i.e.*, approximately 33 clumps) is located outside of the PDA. Because this species was only encountered in ditches, it has potential to colonize additional roadside habitats created by the Project.

A small population of Tierra del Fuego dock is known to occur within Wetland 23. Data collected in 2016 indicate that approximately 13 of the 22 plants located within this wetland are within the PDA, and are therefore likely to be directly disturbed. Construction activities may also indirectly affect the remaining portion of the population if they result in hydrological, chemical, and/or biological changes to the wetland.

Of the approximately 52 soapberry plants observed in 2016, data suggest that about 16 are located within the PDA and will be directly disturbed by Project activities, including one plant on the steep embankment of an old railroad spur located between Exits 5A and 6, and 15 near the southern end of the Assessment Area. Survey data from 2007 indicate that large numbers of soapberry were encountered on spoil piles on the adjacent Fundy Gypsum site. In particular, approximately 290 plants were located in this area during surveys. Because only a small portion of the spoil pile habitat was investigated and soapberry was found wherever open grass covered gypsum spoil was present, it is likely more abundant in the area than data indicate. Project construction is therefore unlikely to have to have an important influence on the local population of this species and no species-specific mitigation measures have been identified.

Roland's sea-blite was found at the transition zone between the Avon River causeway and the adjacent salt marsh (*i.e.*, Wetland 25). This area will be lost as a result of construction of the roadbed for the new lanes. Although there are no practical mitigation measures that could be used to prevent the loss of plants in this area, this population has established in this location within the last few decades (*i.e.*, this salt marsh has formed following construction of the causeway) and it is likely that this species occurs in other nearby areas that could help to reestablish the population along the base of the new roadbed following Project construction.

Project construction is likely to result in the direct disturbance of both eastern white cedars that were encountered on the roadside shoulder of Highway 101. However, both occurrences are likely introduced cultivars and therefore not protected under the NS ESA. No species-specific mitigation has been recommended for these occurrences. In the absence of Project construction, the cedars are unlikely to survive along the highway edge because of the stressful nature of the site on which they are growing and periodic maintenance activities (*i.e.*, vegetation clearing) associated with the current infrastructure.

Several additional plant SOCI have been recorded during surveys in support of the Project for which recent spatial data on their distribution and abundance is not available, including fan-leaved hawthorn, purple-veined willowherb, and Loesel's twayblade. Loesel's twayblade was observed in association with Wetlands 9 and 10 during 2007 surveys, both of which intersect with the PDA and are expected to be directly disturbed by Project activities. Although these areas continue to provide potential habitat for this species, 2016 survey efforts could not re-locate this species in or adjacent to Wetlands 9 and 10 and this population may no longer occur in the area. Although fan-leaved hawthorn and purple-veined willowherb were both noted during 2007 surveys, information on the distribution and abundance of these species within the Assessment Area is not available (*i.e.*, these species were not identified in 2016 surveys and no spatial data is available for the 2007 records), and they may not occur within the PDA.

Culvert installation can adversely affect the hydrology of wetlands resulting in changes in plant species composition in wetlands. A number of wetlands within the PDA provide habitat for plant SOCI, including Wetland 9 (Bebb's sedge), Wetland 10 (Bebb's sedge), Wetland 12 (Bebb's sedge), Wetland 23 (Tierra del Fuego Dock), Wetland 24 (Frankton's saltbush), and Wetland 25 (Frankton's saltbush and Roland's sea-blite). Wetland 25 is unlikely to be affected by improper culvert placement since water levels in this wetland is dictated by the tide; and Wetlands 9, 10, 23, and 24 do not receive inputs and do not drain directly into culverts. Wetland 12 does drain under the existing highway through a culvert on its western side and has potential to be adversely affected by improper culvert placing or sizing. Particular attention will be given to the proper sizing and installation of this culvert as well as the placement of infill in this wetland in order to maintain existing hydrological conditions.

In consideration of the potential environmental effects of Project-related activities during construction, and the proposed mitigation, residual environmental effects of the construction of the Project on SOCI or their habitat are predicted to be not significant. In particular, construction activities are unlikely to result in a non-permitted contravention of any of the prohibitions stated in sections 32-36 of the federal SARA or the prohibitions stated in section 3 of the NS ESA; or threaten the long-term sustainability of a plant species within the Central Lowlands Ecodistrict. However, the level of confidence associated with this determination is reduced as a result of a lack of information on the distribution and abundance of some SOCI within the region, particularly Roland's sea-blite.

Operation and Maintenance

Although winter maintenance (*i.e.*, road salt applications) and vegetation management have potential to adversely affect vegetation, Project operation and maintenance are not likely to have an important effect on plant SOCI.

Road salt applications can adversely affect salt sensitive plants growing near the edge of the RoW. The overall salt loading will be minimized by following the NSTIR Salt Management Plan, which specifies application rates. Mitigation measures include following the Generic EPP, applying drainage controls, employee environmental awareness training prior to commencement of operation activities (*e.g.,* salt and sand application during winter), and increased vigilance and inspection of permanent erosion and sediment control structures, particularly in areas identified as being sensitive (*e.g.,* wetlands).

Vegetation management will consist primarily of mechanical control of vegetation. Use of herbicides may be considered where undesirable species persist but these applications would be in accordance with applicable legislation and in consideration of sensitive areas. Regular mowing will occur on the shoulder of the road and occasional mowing of the RoW will occur on an as needed basis to control the growth of trees and tall shrubs. Some plant SOCI found in the Assessment Area could colonize the cleared RoW and ditches; including soapberry, Bebb's sedge, sharp-fruit rush, and Dudley's rush.

Soapberry was found growing on the cleared RoW of the existing highway at a number of locations and was found in large numbers on gypsum spoil piles indicating that it is well adapted to growing on nutrient poor mineral soils. It is likely that this species will colonize well drained portions of the cleared RoW where soils poor in nitrogen but rich in calcium are found. This species is a nitrogen fixer and produces fairly dense patches of low shrub cover that are typically less than 1 m in height, making it an ideal species to revegetate the cleared portions of the RoW.

Bebb's sedge prefers moist calcareous soils and has been found at several locations between Exits 5 and 5A. It is possible that this species will colonize wet habitats such as ditches along the cleared RoW. As noted above, only mechanical cutting will be carried out during routine ditch maintenance activities (no broadcast spraying of herbicides) in these areas. As part of infrastructure maintenance, ditching may be required to improve water flow, reduce erosion and/or to deter excessive vegetative growth. The release of sediment into wetlands during Project maintenance could have a detrimental effect on the survivability of any Bebb's sedges that establish during the operation and maintenance phase of the Project.

Sharp-fruit rush and Dudley's rush were both recorded within ditches at the northern end of the Project and may be disturbed during roadside maintenance activities. However, because these species are associated with disturbed or early-successional vegetation communities their long-term presence may therefore benefit from periodic vegetation management initiatives.

In consideration of the potential environmental effects of Project-related activities during operation and maintenance and the proposed mitigation, residual environmental effects of the operation and maintenance of the Project on SOCI and their habitat are predicted to be not significant. In particular, Project operation and maintenance are unlikely to result in a non-permitted contravention of any of the prohibitions stated in sections 32-36 of the federal SARA or the prohibitions stated in section 3 of the NS ESA; or threaten the long-term sustainability of a plant species within the Central Lowlands Ecodistrict.

5.4.8 Monitoring and Follow-up

Of the plant SOCI that have potential to be adversely affected by Project construction, Roland's sea-blite may be considered to be of greatest conservation concern. This species is ranked as *may be at risk* by NSDNR (2014) and as *S1?* by the AC CDC (2014), indicating that its population may be regarded as critically imperiled in the province because of extreme rarity (often 5 or fewer occurrences) or because of some factor. However, there is considerable uncertainty regarding its status (AC CDC 2016b). Members of the genus *Suaeda* can be difficult to identify to species and this is likely to be an important contributor to the current lack of knowledge regarding Roland's sea-blite. It is recommended that a follow-up survey be conducted to obtain better information on the occurrence of this species within the region. Surveys would focus on portions of Wetland 25 that are outside the Field Study Area as well as within other salt marsh habitat in the vicinity of the Project, and would occur when Roland's sea-blite has mature fruit (*e.g.*, September). Results would be used to help determine the importance of Project residual effects, to help identify the need for species-specific mitigation measures (*e.g.*, collecting seed within the PDA and distributing this post-construction), and / or monitoring requirements (*e.g.*, of colonization post-construction) in consultation with provincial regulators. Incidental observations of other plant SOCI associated with salt marsh habitats (*e.g.*, Frankton's saltbush and Tierra del Fuego dock) may also be recorded during the survey.

5.5 WETLANDS

Wetlands have been selected as a VC because of the potential for interactions between Project activities and wetland habitat. Wetlands have environmental, aesthetic, recreational, and socio-economic value to the people of Nova Scotia. They provide habitat for plant and animal species, many of which depend on wetland habitats for their survival. Hydrological functions of wetlands include erosion and flood control, contaminant reduction, and groundwater recharge and discharge. Wetlands support various forms of recreational activity, as well as subsistence production, such as harvesting of wildlife and plants, and commercial production, such as cranberry bogs, forestry, and peat extraction. They are also subject to federal and provincial legislation, regulations and policies that require delineation and conservation. Related VCs include Vegetation (Section 5.4) and Wildlife and Wildlife Habitat (Section 5.6).

5.5.1 Regulatory and Policy Setting

Wetlands in Nova Scotia are protected by the Nova Scotia *Environment Act*, where “wetland” is defined as:

> *“…land commonly referred to as a marsh, swamp, fen or bog that either periodically or permanently has a water table at, near or above the land's surface or that is saturated with water, and sustains aquatic processes as indicated by the presence of poorly-drained soils, hydrophytic vegetation and biological activities adapted to wet conditions.”*

The Nova Scotia Wetland Conservation Policy (NSE 2011c) provides context to legislation, regulations and operational policies designed to protect and guide management of wetlands in Nova Scotia. Most importantly, the policy establishes a specific goal of no loss of Wetlands of Special Significance (WSS) and no net loss in area and function for other wetlands. Government will not support or approve alterations proposed for a WSS or any alterations that pose a substantial risk to a WSS, except those that are required to maintain, restore, or enhance a WSS; or alterations deemed to provide necessary public function (NSE 2011c). The government considers the following to be WSS:

- all salt marshes;
- wetlands that are within or partially within a designated Ramsar site per the Ramsar Convention; Provincial Wildlife Management Area (Crown and Provincial lands only), Provincial Park, Nature Reserve, Wilderness Area or lands owned or legally protected by non-government charitable conservation land trusts;
- intact or restored wetlands that are project sites under the North American Waterfowl Management Plan and secured for conservation through the Nova Scotia Eastern Habitat Joint Venture;
- wetlands known to support at-risk species as designated under SARA or the NS ESA; and
- wetlands in designated protected water areas as described within Section 106 of the *Environment Act*.

Projects with the potential to alter a wetland (*e.g.*, filling, draining, flooding or excavating), including direct and indirect effects, typically require a Water Approval (for wetland alteration) from NSE, pursuant to the *Activities Designation Regulations*, prior to starting the work. However, an approval is not required in all cases, including for wetlands that are less than 100 m^2 in size, wetlands within agricultural and roadside drainage ditches, and wetlands constructed specifically for wastewater or storm water treatment (NSE 2011c). Wetlands within agricultural marsh bodies are also exempt under the *Agricultural Marshland Conservation Act*. If alterations to a wetland exceed two hectares in area, a project is also subject to registration under the *Environmental Assessment Regulations*.

Applications for a NSE Water Approval for wetland alteration must be supported with details of the unavoidable nature of the proposed wetland alterations, the measures to reduce or compensate for wetland alteration, and the character and function of wetlands to be affected. These applications are evaluated in the context of the mitigation sequence comprised of avoidance, minimization and compensation. Loss of wetland habitat, either through direct or indirect project effects, requires compensation to replace the wetland functions lost as a result of the wetland alterations. In this respect, area is used as a surrogate for function, and compensation is required as a ratio of the area lost.

Wetland conservation federally is directed by the Federal Policy on Wetland Conservation (Environment Canada 1991) which sets a conservation goal of no net loss of wetland function. This policy is applied to federal land or federal programs in areas where wetland loss has reached critical levels, but is not applicable to the Project as no federal lands will be crossed by the new highway lanes.

5.5.2 Boundaries

The assessment of potential effects on wetlands encompasses the following spatial boundaries: the Project Development Area (PDA); the Field Survey Area and the Assessment Area. The PDA (*i.e.,* footprint of physical disturbance) is defined in Section 4.2.1. The Assessment Area is the area within 500 m of the PDA. The Assessment Area encompasses the "Field Survey Area" as presented on Figure 5.6 (*i.e.* the PDA plus a 30 m buffer). The Assessment Area represents the extent within which known or potential wetlands were identified, although field surveys were limited to accessible portions of the Field Survey Area. Portions of the Field Survey Area that were not visited in the field include those associated with connector roads to Upper Water St. and Colonial Road at Exit 6, and a fenced off active pasture and adjacent coastal features on the north side of the existing highway between the Avon River causeway and Exit 7.

The temporal boundaries for the assessment of the potential effects of the Project on wetlands include the duration of construction, and operation and maintenance of the Project in perpetuity. Temporal boundaries consider that wetlands are a semi-permanent landscape feature and may interact with the Project year-round.

5.5.3 Significance Definition

This assessment considers residual effects on wetlands (*i.e.*, after mitigation is implemented). A **significant adverse residual environmental effect on wetlands** is defined as:

- one that results in an unauthorized permanent net loss of wetland area; or
- one that results in a loss of WSS.

5.5.4 Description of Existing Conditions

5.5.4.1 Methods

Areas within accessible portions of the Field Survey Area that meet the definition of a wetland as outlined by Nova Scotia's *Environment Act* were delineated in the field following principles outlined by the US Army Corps of Engineers (1987). Delineations were conducted June 28 and 30; July 19 to 21, 25 and 29; and September 9, 2016. Reference to provincial wetland mapping (NSDNR 2016c) and air photos were used to extrapolate partially delineated wetland boundaries. Additional wetlands within the Assessment Area (*i.e.*, which did not intersect the Field Survey Area) were identified using 1:10,000 aerial imagery and reference to provincial wetland mapping in 2007. The marine edge of salt marshes boundaries was determined with reference to aerial imagery; those areas which were un-vegetated and which are likely to be flooded at depths of > 2m were not considered wetland habitat. As a result, large tidal channels were not included within mapped salt marsh boundaries, but small tidal channels and pools were included within the delineations.

Wetlands were classified according to the Canadian Wetland Classification System (NWWG 1997). This system classifies wetlands to three levels: class, form/subform, and type. The wetland class places a wetland into one of five categories based on the overall nature of the wetland environment, such as whether the wetland soils are primarily mineral or organic (*i.e.*, peat), their association with groundwater, and whether or not they are dominated by woody plants over 1 m in height. Wetland classes include bog, fen, swamp, marsh, and shallow water. Form and subform indicate the physical morphology and hydrological characteristics of the wetland. Wetland type distinguishes wetland communities based on one of eight groups of dominant vegetation (NWWG 1997). Only information on class and dominant vegetation type were obtained for wetlands identified through desktop assessment.

Information on the functional characteristics of wetlands in accessible portions of the Field Survey Area was obtained during field surveys following the NovaWET method (NSE 2011d). These assessments were only conducted for wetlands that intersect the PDA and for which alteration applications were considered likely to be required. Although the NovaWET method consists of a field component and a desktop component, the approach focused on collecting information that is obtained through site visits, such as dominant species and the potential for the wetland to provide habitat for SAR or other SOCI. Functional assessments were primarily conducted during wetland delineation surveys; but results of the breeding bird surveys were also reviewed to obtain information on habitat functions for wildlife SAR and other SOCI. Data collected during the surveys were used to determine whether the wetlands provided key hydrogeological, water quality and wildlife-related functions, as well as their social value. Functional assessments were completed for 16 wetlands / wetland portions during field surveys. Additional information on wetland functions was obtained through reference to the wetland evaluations conducted in support of the Project in June and September, 2007. These wetland surveys collected a variety of information including the type of wetland and a description of its hydrology, a description of the wetland habitat types present in the wetland, inventories of vascular plants, birds, mammals, reptiles and amphibians present in the wetland, evidence of anthropogenic use and disturbance.

5.5.4.2 Summary of Existing Conditions

5.5.4.2.1 Wetland Classification and Character

A total of 44 known or potential wetlands were identified within the Assessment Area through a combination of field surveys and desktop assessment (Table 5.5.1, Figure 5.6). The boundaries of 27 of these wetlands were delineated in the field. Three were identified through a combination of field delineation and desktop assessment, and 14 were identified through desktop review only. Marshes are the most common wetland class in the Assessment Area, but shrub and tree-dominated swamps are also present, as are occurrences of shallow water wetland (Table 5.5.1). Additional information on the character and functions of the wetlands within the Assessment Area is provided below and in Appendix D.

Table 5.5.1 Wetlands identified in the Assessment Area

Wetland Class (type)	Field Survey Area[1]		Assessment Area[2]	
	Number	Area (ha)	Number	Area (ha)
Marsh	17	1.6	19	2.9
Marsh (Brackish)	4	0.4	4	0.7
Marsh (Salt marsh)	2	4.2	4	65.6
Marsh / Shallow Water	1	0.1	6	10.9
Marsh / Swamp	3	1.2	3	2.2
Marsh / Swamp / Shallow Water	0	0.0	1	1.3
Shallow Water	0	0.0	1	0.7
Swamp	1	0.3	6	22.9

Table 5.5.1 Wetlands identified in the Assessment Area

Wetland Class (type)	Field Survey Area[1]		Assessment Area[2]	
	Number	Area (ha)	Number	Area (ha)
Total	28	7.8	44	107.2

[1]Only wetlands within accessible portions of the Field Survey Area were field surveyed; wetland boundaries identified through desktop assessment have not been confirmed.
[2]Data for the Assessment Area is inclusive of the Field Survey Area.

Marshes

Marshes are wetlands that are periodically inundated by standing or slow flowing water that fluctuates daily, seasonally, or annually as a result of tides, flooding, evapotranspiration, groundwater recharge, or seepage losses (NWWG 1997). During drier periods, declining water levels may expose areas of matted vegetation or mud flats. The surface waters are typically rich in nutrients and the substrate is usually mineral material although well-decomposed peat may occasionally be present (NWWG 1997). Marshes typically display zones or surface patterns consisting of pools or channels interspersed with patches of emergent vegetation, bordering wet meadows and peripheral bands of shrubs or trees. Marshes are relatively abundant within the Assessment Area and represent the most common wetland class encountered during field surveys. Freshwater, brackish, and salt marsh are present within the Assessment Area (Table 5.5.1).

Salt marshes are vegetated wetlands that are regularly flooded by tidal water, or influenced by salt spray or seepage, and the water and/or soil is saline or brackish (NSE 2014b). Salt and brackish marshes are considered highly productive wetlands that provide many important environmental, societal and economic functions and services; they are also considered WSS under the provincial wetland conservation policy (NSE 2011c). Several salt marshes are present in the Assessment Area in association with the Avon River estuary. The largest of these, Wetland 25, is located immediately adjacent to the Avon River causeway. Vegetation within this wetland, and nearby Wetland 26, is dominated by smooth cord grass (*Spartina alterniflora*) but a number of halophytic forbs and graminoids were also observed along the edge of the salt marsh and the causeway, including sea-blite (*Suaeda sp.*), saltmeadow cord grass (*Spartina patens*), orache (*Atriplex spp.*), seaside goldenrod (*Solidago sempervirens*), and seaside plantain (*Plantago maritima*). Several other wetlands were encountered during field surveys that are influenced by tidal waters, including Wetlands 19, 20, 21, and 24 (these, as well as Wetland 26, are located within incorporated marsh bodies and are exempt from provincial wetland approvals). Wetlands 19, 20, and 21 are brackish marshes that occur along a common freshwater watercourse, Tregothic Creek, but are separated by rail and road developments (including the existing Highway 101 and Colonial Road) and are inundated at high tide. Vegetation within these wetlands varies, with some areas being more indicative of freshwater conditions and others reflecting influence by brackish waters. Graminoids are dominant with patches of cattail (*Typha spp.*), prairie cord grass (*Spartina pectinata*), creeping bent grass

(*Agrostis stolonifera*), bulrush (*Schoenoplectus spp*.), and reed canary grass (*Phalaris arundinacea*) being prominent, along with scattered forbs such as hedge false bindweed (*Calystegia sepium*). Wetland 24 is unique in that it is separated from the coast by the on and off ramps for Exit 6, but its vegetative composition strongly reflects saline conditions and it is likely maintained by seawater infiltration through the road beds during high tide. Black-grass rush (*Juncus gerardii*) was the dominant species within this wetland but saltmeadow cord grass was also abundant in patches.

Freshwater marshes encountered during field surveys typically occurred in basins, and many were anthropogenic in character, found in association with roadside ditches, agricultural fields, and other disturbed areas. Marshes were typically dominated by graminoids, with cattail (*Typha angustifolia, T. latifolia*, and / or *T. x glauca*) being particularly common, in addition to species more characteristic of wet meadow habitat. Other graminoids and forbs that were common within the freshwater marshes of the Field Survey Area include soft rush (*Juncus effusus*), bedstraw (*Galium sp*.), sedges (*e.g.*, *Carex nigra, C. pseudocyperus, C. scoparia*), spotted jewelweed (*Impatiens capensis*), creeping bent grass, black-grass rush, sensitive fern (*Onoclea sensibilis*), and creeping buttercup (*Ranunculus repens*). Scattered shrubs were also sometimes present within and along the margins of the freshwater marshes, including red osier dogwood (*Cornus sericea*). Freshwater marshes encountered during field surveys were observed to have average water depths of less than 15 cm during the growing season (most were dry at the time of visitation but would be flooded earlier in the growing season and following precipitation events), and classify as shallow marshes (NSE 2014b).

Swamps

The swamp wetland class is represented within nine of the wetlands identified within the Assessment Area, including three within the Field Survey Area (Table 5.5.1). Swamps are mineral wetlands or peatlands and their water table is generally at or near the surface of the swamp, with standing water or water flowing slowly through pools or channels often present (NWWG 1997). There is internal water movement from the margin of the swamp or from other sources of mineral enriched waters. If peat is present, it consists mainly of well-decomposed wood, underlain at times by sedge peat. The vegetation typically consists of a dense cover of trees or shrubs, herbs and some mosses (NWWG 1997). Both basin and slope swamps were encountered during field surveys. Basin swamps (*e.g.*, portions of Wetlands 12, 40, and 41) are a subform of flat swamp that occur in topographically defined basins with relatively well-defined edges and their water is primarily derived by local surface runoff and groundwater inputs (NWWG 1997). Slope swamps (*e.g.*, Wetland 36) occur on sloped surface, on mineral or peaty soils and surface channels may be either absent or present (NWWG 1997).

Vegetation types encountered within swamps during field surveys include tree and tall-shrub shrub-dominated communities. Hardwood treed and mixed treed swamp habitat was encountered within Wetlands 40 and 41, respectively. Hardwood treed swamps are distinguished from mixed treed swamps by a greater dominance of broadleaf species in the overstory (*i.e.*, >75% canopy cover) but they are often similar, with red maple being particularly abundant. Other species observed in the overstory include white ash (*Fraxinus americana*), balsam fir (*Abies balsamea*), and spruce (*Picea sp*.). Both of the treed swamps have well-developed shrub strata dominated by speckled alder (*Alnus incana*), with lesser amounts of willow (*Salix sp*.) and regenerating trees. Peatmoss (*Sphagnum spp*.) cover was low to moderate and herbaceous vegetation was comprised of a mixture of forbs and graminoids, including sensitive fern (*Onoclea sensibilis*), creeping buttercup, dwarf red raspberry (*Rubus pubescens*) and sedges (*Carex spp*.). Tall shrub swamps were encountered within Wetland 12 and Wetland 36. Willows formed an important component of tall shrub strata for both of these wetlands but speckled alder was dominant within Wetland 36. Both swamps had a well-developed herbaceous layer comprised of a variety of forbs and graminoids, including soft rush, spotted jewelweed (*Impatiens capensis*), bluejoint reed grass (*Calamagrostis canadensis*), and field horsetail (*Equisetum arvense*).

Shallow Water

Shallow water wetlands have standing or flowing water that is <2 m deep during mid-summer but their hydrological character is quite varied. Water levels with shallow water wetlands may be seasonally stable, permanently flooded, or intermittently exposed during droughts, low flows, or intertidal periods (NWWG 1997). Although they typically occupy the transitional areas between wetlands that are saturated or seasonal wet and permanent deep water bodies, those encountered during the field surveys occupied flooded basin that occurred in association with marshes. Those encountered during field surveys were somewhat anthropogenic in character, associated with a large wetland complex at the site of a former gypsum quarry (Wetland 1), a small basin in a regenerating area off an old road near Exit 5 (Wetland 10), and a basin within a forested swamp that appears to have resulted from historic excavations (Wetland 42). The vegetation community within these shallow water wetlands was varied but supported floating leaved aquatics, including duckweed (*Lemna sp*.), lesser bladderwort (*Utricularia minor*), water-shield (*Brasenia schreberi*), aquatic algae, and emergent graminoids such as American burreed (*Sparganium americanum*) and sedge.

5.5.4.2.2 Wetland Functions and Values

A general overview of wetland functions and values that are known or suspected of being provided within the Assessment Area is provided in the following sections with a focus on those wetlands that occur within the Field Survey Area. A summary of wetland functions for each of the field assessed wetlands / wetland portions are provided in Appendix D (these assessments were only conducted for wetlands that intersect the PDA and for which alteration applications are likely to be required).

Wildlife-Related Functions

Wetlands within the Assessment Area provide habitat for a variety of wildlife, such as wetland-associated passerines and amphibians. Coastal marshes (*e.g*., Wetland 25/26) and freshwater marshes with open shallow water components (*e.g*., Wetlands 1 and 10) also provide important habitat for waterfowl or other waterbirds (*i.e.,* ducks, herons, geese, or shorebirds); but, the ability of other freshwater marshes and swamps within the Field Survey Area to provide this function is limited by a general lack of open water features. The large salt marsh and associated mudflats within the Avon River Estuary (*i.e*., Wetland 25/26) is known to be particularly important for migratory shorebirds during late summer and early fall (see Section 5.6, Wildlife and Wildlife Habitat). Wetlands with open water features also have relatively high potential to provide habitat for mammals that are highly dependent on aquatic environments (*e.g*., muskrat, beaver).

None of the wetlands are known to provide breeding habitat for Species at Risk (SAR) but eastern wood-pewee (*Contopus virens*, *vulnerable* under the NS ESA) was recorded in the general vicinity of Wetlands 2, 3 and 41 during the breeding season; and several are associated with other bird Species of Conservation Interest (SOCI). Bird SOCI recorded during the breeding season in association with wetland habitats include spotted sandpiper (*Actitis macularius*, *S3S4B*) in Wetland 25; eastern kingbird (*Tyrannus tyrannus*, S3S4B) in Wetland 10; and solitary sandpiper (*Tringa solitaria, S1?B,S4S5M*) in Wetland 10. Other bird SOCI that are rare breeders but relatively common migrants were observed in association with the Avon River Estuary (Wetland 25/26) during migration season, including greater yellowlegs (*Tringa melanoleuca, S3B,S5M*), semipalmated sandpiper (*Calidris pusilla, S3M*), Least Sandpiper (*Calidris minutilla, S1B,S5M*), and semipalmated plover (*Charadrius semipalmatus, S1S2B,S5M*). Tree swallow (*Tachycineta bicolor, sensitive*) and barn swallow (*Hirundo rustica*, *endangered* under the NS ESA) were also observed in association with this wetland outside the breeding season. A number of wetlands within the Field Survey Area provide habitat for plant SOCI, including for Bebb's sedge (*Carex bebbii*, S2) in Wetlands 9, 10, and 12; Frankton's Saltbush (*Atriplex franktonii, S3S4*) in Wetlands 24 and 25; and Roland's sea-blite (*Suaeda rolandii, S1?*) in Wetland 25.

Few wetlands within the Assessment Area would provide fish habitat. The majority of wetland encountered during field surveys would not be sufficiently inundated to support fish, or is not connected to a permanent waterbody or watercourse where fish may be present. Of exception, the coastal marshes located in association with the Avon River estuary (*e.g*., Wetland 25/26), or along watercourses that are connected to this feature (*e.g*., Wetlands 19, 20, and 21) may be considered relatively important for fish habitat. Open water features associated with the large wetland complex located at the southern end of the Assessment Area (*i.e.,* Wetland 1) is associated with the waters of Meadow Pond, which are regularly stocked and serve as an important area for recreational fishing.

None of the wetlands within the Field Survey Area were considered to have a particularly high diversity of plant communities or to support plant communities that have been identified as being particularly unique or rare within the province. In particular, none were observed to support calcareous fen, black ash, cedar swamp, or wild rice marsh; communities which are identified under NovaWET as unique or rare plant communities within Nova Scotia (NSE 2011d). However, two eastern white cedars saplings were encountered on the upland shoulder of the existing highway and black ash are present outside the Field Survey Area. Furthermore, the vegetative communities within the wetlands did not suggest that any were particularly nutrient-rich or nutrient-poor, as may be respectively observed in areas with calcareous or acidic substrates.

Wetland Hydrology and Non-Wildlife Functions

An overview of the results of the wetland functional assessments as they relate to hydrological condition, water quality, groundwater interactions, shoreline stabilization and integrity, and community use is provided below. A summary of the results for individually assessed wetlands (or portions thereof) is provided in Appendix D.

Hydrological Condition and Integrity

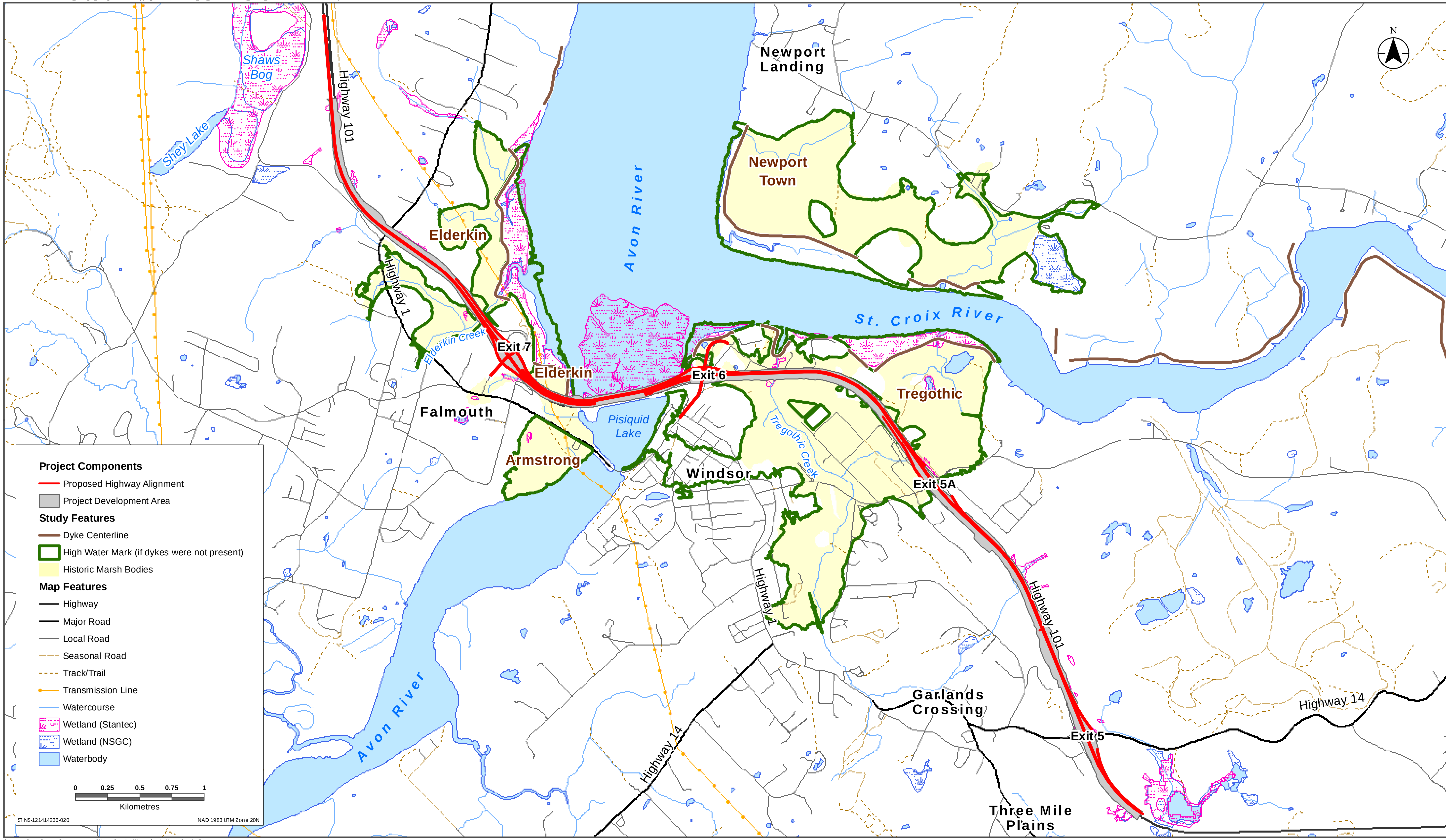
- The hydrological condition of the majority of the assessed wetlands has been altered by human activities as described below.
  - Many of the wetlands within the Field Survey Area are located adjacent to the existing Highway 101 (*e.g.,* Wetlands 2, 3, 4, 5, 6, 12, 13, 14, 22, 23, 24, 28, 33, 35, 40, and 41) and their hydrological character would be influenced by storm water drainage and ditching along this feature. Some of these have formed as a result of these influences (*e.g.,* Wetlands 4, 5, 6, 13, 14, 22, 33, 35, and a component of 41) and are essentially roadside ditches that have been created for the purpose of storm water management. An approval from NSE is not required to alter wetlands that are created specifically for wastewater or storm water treatment (NSE 2011c).
  - Construction of the existing highway and other roadways have influenced the hydrological character of coastal wetlands. Wetlands 19, 20, and 21 are brackish marshes that occur along a common freshwater watercourse (Tregothic Creek) but are separated by rail and road developments (including the existing Highway 101 and Colonial Road). Although culverts provide connectivity, the presence of the surrounding rail/roadways (and aboiteau) may restrict the passage of both freshwater inputs and tidal waters. Wetland 24 has been separated from the coast by the on and off ramps for Exit 6 and now appears to be maintained by seawater infiltration through the road beds during high tide. Although the hydrology of Wetland 25/26 is primarily tidal, an aboiteau (sluice) at the Avon River influences the timing and magnitude of freshwater inputs, and prevents coastal waters from reaching further inland.

- The hydrological character of some other wetlands is maintained (at least in part) by historic disturbances. For example, Wetlands 8, 9, and 10 are associated with an old road in an area that has supported gypsum quarrying activities and their hydrological character reflects the influence of past disturbances on the re-contouring of the lands and resulting patterns of surface water flow.
- Some of the wetlands (*e.g.*, Wetlands 16, 20, 22, and 28) are within the boundaries of agricultural marsh bodies (Figure 5.7). A permit from NSE is not required to alter wetlands that are designated as marshlands under the *Agricultural Marshland Conservation Act* as agricultural land (NSE 2011c).

- Two of the wetlands (*i.e.*, Wetlands 12 and 36) were identified as headwater wetlands and are therefore potentially important for maintaining stream flow. Wetland 12 is the source of a mapped watercourse that flows to the south via a culvert under the existing highway. Similarly, Wetland 36 serves as the headwaters for a mapped watercourse which drains through a ditch (*i.e.,* Wetland 35) before passing under the highway through a culvert (and eventually to Elderkin Creek/aboiteau). Wetland 28 is also located along a mapped watercourse and may be moderately important for maintaining stream flow, but its importance as such is lessened by its relatively low position in the watershed. Although Wetlands 19, 20, and 21 occur along Tregothic Creek, they were not considered to be important for maintaining its flow because of their small size and character (*e.g.,* they are partly maintained by tidal influences through the Tregothic aboiteau).
- Shallow water wetland occurrences and many of the marshes were considered to have a medium to high ability to detain surface water. The ability of swamps to detain surface water was more limited, although there was evidence in some of the swamps (*e.g.*, sparsely-vegetated concave surfaces, blackened leaves) that water collects locally following high precipitation or surface water runoff events.

Water Quality

- Coastal Wetlands 18, 25, 26 and 29 are flooded with saltwater with variable amounts of freshwater released from the Avon River aboiteau and St. Croix River, which in turn are heavily laden with sediments and may also carry nutrient inputs from upstream sources (*i.e.*, agricultural lands). Evidence of sedimentation or excess nutrient loading / contamination within other assessed wetlands was limited, but those located immediately adjacent to roadways or other human infrastructure may receive elevated inputs because of disturbances and activities in these areas.
- Many of the assessed wetlands have potential to improve water quality (*e.g.*, by having capacity to filter excess sediments or nutrients) and were considered potentially important for contributing to water quality in downstream resources. Wetlands that were considered important for maintaining stream flow (*e.g.*, Wetlands 12, 35, and 36) were considered to have greater potential to provide this function, as were those that supported dense vegetation and received surface water runoff from human anthropogenic features (*e.g.*, Wetlands 2, 3, 19, 20, 28, 40, and 41).



Sources: Base Data - Government of Nova Scotia, Watershed - Nova Scotia Environment

Disclaimer: This map is for illustrative purposes to support this Stantec project; questions can be directed to the issuing agency.

Wetlands and Designated Marshlands

Stantec

ENVIRONMENTAL ASSESSMENT, HIGHWAY 101 THREE MILE PLAINS TO FALMOUTH

Figure 5.7

Groundwater Interactions

- None of the wetlands were considered to likely serve as groundwater recharge sites; but the surrounding topography, land use, wetland soils, expected hydroperiod, and inlet/outlet configuration indicated that many are likely to serve as groundwater discharge sites.

Shoreline Stabilization and Integrity

- The majority of wetlands within the Assessment Area are not associated with open water bodies or watercourses and therefore do not have potential to contribute to the function of shoreline stabilization. Of exception, coastal marshes (*e.g*., Wetland 25/26) and wetlands located along watercourses (*e.g.,* Wetland 19, 20, 21) may contribute to this function.

Community Use / Value

- Of the wetlands within the Assessment Area, Wetlands 1 and 25/26 are identified as being relatively important for community use. Wetland 1 is associated with Meadow Pond, which is regularly stocked and serves as an important area for recreational fishing. Wetland 25/26 is a large salt marsh located along the Avon River causeway and has important aesthetic value, being visible from several vantage points (including a live camera; see http://www.novascotiawebcams.com/en/webcams/windsor-salt-marsh/). This wetland may also be considered relatively important for recreational purposes (*e.g*., bird watching), recreational and commercial fishing, and for education.
- Wetland 25/26 is also part of a registered Ramsar Wetland Site (Southern Bight – Minas Basin) and is included within the Bay of Fundy Hemispheric Shorebird Reserve, declared under the Western Hemisphere Shorebird Reserve Network. None of the remaining wetlands are known to be part of any protected area such as a national or provincial park, national wildlife area, federal migratory bird sanctuary, ecological reserve, provincial wildlife management area, wildlife refuge, or game sanctuary.

5.5.5 Potential Environmental Effects and Project-Related Interactions

Project activities and components could potentially interact with wetlands and result in changes to wetland area and wetland function. The assessment of Project-related environmental effects on wetlands is therefore focused on the following potential environmental effect:

- change in wetland area or function.

5.5.5.1 Change in Wetland Area or Function

Construction

The most substantive change in wetland area and function will result from site preparation activities. Clearing and grubbing during site preparation will directly remove wetland vegetation and soils and the construction of roadbeds/aboiteau will require that wetland habitats be infilled.

Indirect effects during site preparation activities may also result in a change in wetland area or function. The erosion of uplands as a result of vegetation removal and deposition of sediments in wetland habitat (unplanned event) may alter wetland habitat beyond the PDA. Construction activities also can disturb wetland habitat through off-road and off PDA activity. This may occur when vehicles are accessing the work site along tertiary roads, by the gradual widening of the thoroughfare, as well as through non-motorized activity in undisturbed areas adjacent to the PDA.

Local and regional hydrological changes resulting from the impediment of the road bed, changes in surface cover type (forested to asphalt or grass), and surface drainage features (roadside swales) may alter wetland water supply and drainage, resulting in a change in wetland character, quality and function.

There is a potential need for blasting for roadbed preparation, and this activity could have physical and chemical environmental effects on wetland habitat and associated wildlife. Blasting has potential to alter wetland hydrology by causing fractures in the underlying bedrock, thereby promoting the drainage of wetlands. Blasting may also have an adverse effect on wetland-associated wildlife; for example, by discouraging birds from establishing their nests during their breeding season.

The Project will require the installation of watercourse crossing infrastructure, such as culverts and bridges, as well as upgrading of the aboiteau at the Avon River. Installation of such features can alter wetland habitat through drainage, flooding or extensive erosion. Water crossing structures could also result in a potential loss of wetland function in wetlands supporting fish habitat (see Section 5.3).

Hydroseeding applications have the potential to alter the quality of wetland habitat. If applied in hydrological source areas for wetlands, hydroseeding applications have the potential to increase nutrient levels in wetlands, which could affect their biological process (*e.g.*, nutrient uptake by plants, decomposition rates, *etc.*). Although hydroseeding efforts will use an approved seed mix, these can be comprised of non-native species and therefore have potential to influence the composition of wetland communities. Construction activities also increase the susceptibility of wetland habitats to non-native and invasive plants through increased disturbances, proximity to anthropogenic infrastructure, and by promoting their dispersal.

Operation and Maintenance

Several activities related to the operation and maintenance of the Project could affect wetland habitat. In particular, maintenance of the Project infrastructure, winter maintenance activities, and vegetation management initiatives all have potential to adversely affect wetlands.

As part of infrastructure maintenance, the roadside shoulder will be periodically graded and ditched to improve water flow, reduce erosion and/or to deter excessive vegetative growth.

These maintenance activities have potential to adversely affect the quality of wetland habitat through the direct disturbance of their vegetation and soils, as well as affects to their hydrology. Indirect impacts can result from the release of sediment into wetlands.

During winter, salt is used by NSTIR on road surfaces to aid in melting snow and to provide clear road conditions. Road salt can enter into the environment (surface water, groundwater, and soil) through storage and application of these salts. The highest concentrations are usually associated with winter and spring thaws. Road salt application has the potential to result in damage to wetland habitat and/or loss of wetland function and quality.

Vegetation management will consist primarily of mechanical control of vegetation. Regular mowing will occur on the shoulder of the road to control the growth of trees and tall shrubs. Vegetation control on road shoulders and interchanges will be conducted by both manual and mechanical clearing during operation (see Section 5.4) and could result in the direct disturbance of wetland habitat.

The use of herbicides for vegetation management will generally be avoided but may be considered where undesirable species persist. For example, they may be required in areas where physical vegetation management techniques are unsuccessful at controlling noxious weeds. The use of herbicides in source water areas for wetlands has the potential to affect the survival and composition of the botanical community and wetland fauna.

5.5.6 Mitigation

Mitigation to reduce the environmental effects of the Project on wetlands are identified in Table 5.5.2. Standard mitigation and measures identified in Sections 5.3, 5.4, and 5.6 to reduce effects on aquatic resources, vegetation, and wildlife and wildlife habitat will also act to reduce effects on wetlands. The use of some mitigation will be determined on a site-by-site basis in consideration of local concerns and conditions. Locations for site-specific mitigation will be outlined in the EPP following detailed routing and in consultation with the appropriate regulatory authorities in consideration of the following criteria:

- water flow pathways and hydrological character of wetlands;
- alternatives to current design;
- temporary or permanent mitigation; and
- public or landowner support (*e.g.*, existing use/ownership).

Mitigation measures to be implemented to reduce potential effects on wetland area and function during construction and operation are presented in Table 5.5.2, and include both generic and VC-specific measures. Section 2.5.2.2 contains more information on NSTIR's habitat compensation program to offset predicted wetland habitat loss.

Table 5.5.2 Mitigation for Wetlands

Effect	Phase	Mitigation
Change in Wetland Area or Function	Construction	• Avoid direct disturbance to wetlands where feasible and reduce work in and near wetlands • Follow Generic EPP and Project Specific ECP • Implement erosion control measures • Clean construction machinery prior to entering wetlands • In areas of high peat depths, use progressive installation to reduce potential for overfilling or over excavation • Use clean, pH neutral, non-leaching coarse fill in wetlands • Conduct monitoring of the Windsor Salt Marsh, before, during and after construction according to recommended protocols • Follow NSE Water Approval conditions • Compensate for loss of wetland area and function following provincial requirements • Employee environmental awareness training
	Operation and Maintenance	• Follow Generic EPP • Maintain culverts as required to maintain hydrological conditions • Follow NSTIR Salt Management Plan • Operate vehicles outside wetland boundaries • Avoid herbicide use in wetlands • Follow NSTIR Integrated Roadside Vegetation Maintenance program • Employee environmental awareness training

5.5.7 Residual Environmental Effects and Significance Determination

The assessment of residual environmental effects considers effects on wetland area and function after mitigation measures, as provided above, have been implemented.

5.5.7.1 Change in Wetland Area or Function

Construction

A mitigation sequence has been adopted as the approach to wetlands in the Assessment Area with the objective of no net loss of wetland habitat because of the Project. The mitigative sequence promotes wetland conservation through the application of a hierarchy of preferred alternatives: 1) avoidance of impacts; 2) minimization of unavoidable impacts; and 3) compensation for residual impacts that cannot be minimized. Within the context of the mitigative sequence, approvals will be sought from NSE for unavoidable wetland alterations. However, an approval is not required for altering wetlands that are a) less than 100 m^2 in total area; b) within agricultural drainage ditches; c) constructed specifically for wastewater or storm water treatment; or d) designated as "Marshlands" under the Agricultural Marshland Conservation Act as agricultural land (NSE 2011c).

Due to the abundance of wetlands in the Assessment Area and limitations of other technical and environmental constraints, avoidance of impacts to wetlands is not practical. Where practical, avoidance will be used as a means of wetland conservation. Wetlands within or adjacent to the PDA and that do not require direct infill for roadbed construction will be flagged in environmental control plans and avoided by construction-related activities, including 5 m non-disturbance buffers, where possible. The Project is expected to directly impact 13 wetlands, accounting for a total of approximately 3.19 ha of alteration. Seven of these wetlands (Table 5.5.3) are exempt from permitting as they are either located within stormwater ditches/interchanges (*i.e.*, Wetlands 5 and 22) and / or are considered to be within the boundaries of the Tregothic or Elderkin Marshlands (*i.e.*, Wetlands 16, 20, 22, 23, 24, and 28). Impacts on the other six wetlands (*i.e.*, Wetlands 9, 10, 12, 25, 26, and 40) total approximately 2.67 ha of wetland habitat, including 2.28 ha of salt marsh (Table 5.5.3). Improved estimates of wetland impact will be provided in NSE Wetland Alteration Applications following more detailed design of the highway and the Avon River aboiteau.

Construction activities are expected to result in alteration to wetlands that provide important functions and values. Wetlands 25/26 are salt marsh features within the Avon River estuary and classify as WSS under the provincial wetland conservation policy (NSE 2011c). Construction activities are expected to result in the direct alteration of over two hecares of this wetland. In addition to the WSS designation, these wetlands have been identified to support, or have potential to support, important functions related to wildlife habitat, coastal storm surge protection, and water quality maintenance. Wetlands 25/26 are also considered important for community use / value. In particular, the salt marsh has important aesthetic, recreational, and educational value; is part of a registered Ramsar Wetland Site (Southern Bight – Minas Basin); and is included within the Bay of Fundy Hemispheric Shorebird Reserve. Other wetlands within the PDA support a variety of functions and values related to the promotion of water quality and wildlife habitat. For example, Wetlands 9, 10, 12, 23, 24, and 25 support rare or uncommon vascular plants and the portions of these wetlands that will be directly disturbed by Project construction will no longer provide habitat for these plants.

Table 5.5.3 Summary of Wetland Alteration

Wetland Number	Wetland Type	Source[1]	Wetland Area (ha		Percentage Impacted
			Study Area	PDA	
5	Graminoid Basin Marsh[2]	Field	0.03	0.03	100
9	Graminoid Basin Marsh	Field	0.04	0.01	38
10	Shallow Water Basin, Graminoid Basin Marsh	Field	0.12	0.11	91
12	Graminoid Basin Marsh, Shrub Basin Swamp	Field	1.79	0.20	11
16	Graminoid Basin Marsh[2]	Field	0.01	0.01	100
20	Graminoid Estuarine Marsh (brackish)[2]	Field	0.08	0.08	100
22	Graminoid Basin Marsh[2]	Field	0.06	0.06	100

Table 5.5.3 Summary of Wetland Alteration

Wetland Number	Wetland Type	Source[1]	Wetland Area (ha		Percentage Impacted
			Study Area	PDA	
23	Graminoid Basin Marsh[4]	Field	0.13	0.06	44
24	Graminoid Basin Marsh (brackish)[4]	Field	0.16	0.15	95
25	Graminoid Tidal Bay Marsh (salt marsh)[3]	Field / Desktop	45.66	2.23	5
26	Graminoid Tidal Bay Marsh (salt marsh)[3]	Field / Desktop	0.12	0.04	36
28	Graminoid Basin Marsh[2]	Field	0.43	0.14	32
40	Graminoid Basin Marsh / Hardwood Treed Basin Swamp	Field	0.18	0.07	40
Total		Field / Desktop	107.22	3.19	3

[1]Only wetlands within accessible portions of the Assessment Area were field surveyed; wetland boundaries identified through desktop assessment have not been confirmed

[2]Exempt from the Nova Scotia Wetland Conservation Policy and associated permitting (NSE 2011c): wetland, or portion of wetland within the PDA, is a roadside ditch which has been constructed specifically for storm water treatment (*i.e.*, Wetlands 5 and 22), or located within a designated Marshland (*i.e.*, Wetlands 16, 20, 22, and 28)

[3]Wetland of Special Significance (WSS) under the provincial wetland policy

[4]Although located outside of the historic boundary for the Tregothic Marshland, Wetlands 23 and 24 are considered within the revised marshland boundaries and to be exempt from the Nova Scotia Wetland Conservation Policy (Bekkers and Pett pers. comm. 2017)

Project effects to wetland habitat as a result of erosion and sedimentation are most likely to occur during site preparation activities, which include the clearing, grubbing, and infilling of upland and wetland habitat. However, erosion control systems will be in place to manage runoff from the construction areas Erosion control measures are identified in the Generic EPP, and also include erosion control fencing, check dams, and use of mulch (possibly from shrubs and trees removed during clearing). Additional information or erosion and sediment controls can be found in Section 2.3.1.1(Site Preparation).

Project-related off-road activity will be limited during roadbed construction through employee environmental awareness training and field flagging of wetland avoidance areas and setbacks.

As discussed in the Vegetation (Section 5.4) and Wildlife and Wildlife Habitat (Section 5.6) VCs, a number of mitigation actions will be undertaken to minimize the effect of site preparation on SOCI and other wildlife associated with wetlands.

Few of the wetlands within the Assessment Area are connected directly with watercourses or are immediately adjacent to them. Most wetlands exist as basin wetlands without well-defined channels. However, some wetlands in the Assessment Area are susceptible to adverse effects resulting from the construction of watercourse crossing structures, including drainage, flooding, or sedimentation from erosion events (*e.g.*, Wetlands 12, 20, 22, and 25). In addition to the erosion and sedimentation control practices outlined in the Generic EPP, additional mitigation measures regarding the installation of watercourse crossing infrastructure, such as culverts and bridges, will be followed and detailed through the NSE Water Approval process for wetland alteration and are also described in Section 5.3 (Aquatic Environment).

In consideration of the potential environmental effects of Project-related activities during construction and the proposed mitigation (including habitat compensation), residual environmental effects of the construction of the Project on wetland area and function are predicted to be significant. Although Project construction is not expected to result in an unauthorized net loss of wetland area, it will result in direct alterations to WSS. In particular, Wetland 25 is classified as salt marsh and is considered WSS under the provincial wetland conservation policy (NSE 2011c). Additional areas of salt marsh affected by the Project are located within designated marshlands and are exempt from the provincial policy and associated permit requirements. Policy objectives include a specific goal of no loss of WSS and government will not support or approve alterations proposed for a WSS or any alterations that pose a substantial risk to a WSS, except those that are required to maintain, restore, or enhance a WSS; or alterations deemed to provide necessary public function (NSE 2011c). An approval is likely to be provided for this Project to alter WSS because it provides necessary public function.

To offset the loss of valued services provided by an affected wetland, compensation is required for alteration of wetland habitat in Nova Scotia. Compensation requires that the residual impacts on the wetland functions are compensated by the enhancement, restoration, or creation of wetland habitat at an area ratio commensurate with the loss. NSTIR intends on using 0.39 ha of habitat credits from its St. Croix River High Salt Marsh Habitat Bank to offset the loss of 0.39 ha of freshwater wetlands and 4.56 ha of credits from its new Truro Salt Marsh Habitat Bank to offset the loss of 2.28 ha of salt marsh (see also Section 2.5.2.2). Additional salt marsh habitat restoration is also anticipated immediately adjacent to Exit 7, approximately 1-2 ha, in former dykeland that will be isolated by highway twinning (serves a dual purpose to reduce storm wave impact on the road infrastructure).

Operation and Maintenance

The operation and maintenance of the Project will not differ greatly from the ongoing operation and maintenance of the existing Highway 101 with the exception that the increase in road area will necessitate an increase in salt loading. The effects of operation and maintenance on wetland habitat are not expected to differ from existing conditions.

As part of infrastructure maintenance, ditch upgrading may be required to improve water flow, reduce erosion and/or to deter excessive vegetative growth. Small scale hydrological modifications, such as ditch maintenance, could adversely affect the functioning of adjacent wetlands. Additional unplanned maintenance required post-construction will be assessed for the potential to enhance or reduce drainage from wetlands or to discharge sediment to wetlands, and appropriate mitigation will be implemented.

Effects to vegetation within wetlands as a result of winter maintenance will be reduced through a number of mitigation measures including applying drainage controls, employee environmental awareness training prior to commencement of maintenance activities (*e.g.,* salt and sand application during winter), and increased vigilance and inspection of permanent ESC structures, particularly in areas identified as being sensitive.

Salt loading will be reduced by following the NSTIR Salt Management Plan, which specifies application rates and techniques to optimize the amount of road salt used. These include the use of road weather information systems to monitor road surface conditions, pre-wetting of salt, and the use of anti-icing systems such as brine solutions to minimize the amount of salt required. These techniques would reduce salt-induced stressors to wetland habitats as well as other important environmental components.

Vegetation control on road shoulders and interchanges will be conducted by both manual and mechanical clearing during operation. The use of herbicides for vegetation control may be required in areas where physical vegetation management techniques are unsuccessful at controlling noxious weeds. Physical vegetation control activities within 30 m of a wetland and the use of herbicides in drainage areas for wetlands have the potential to affect the survival and composition of the botanical community and wetland fauna. Vehicles will not operate from within the boundaries of wetlands for the purpose of controlling the growth of their trees and tall shrubs (*i.e.*, they will be operated from outside the edge of wetlands or hand tools will be used). Additional mitigative measures involving the flagging of setbacks and limits on the use of herbicides will be implemented to prevent disturbance to the remaining portions of partially affected wetlands and to avoid disturbance to nearby ones.

In consideration of the potential environmental effects of Project-related activities during operation and maintenance and the proposed mitigation, residual environmental effects of the operation and maintenance of the Project on wetland area and function are predicted to be not significant. In particular, operation and maintenance is not expected to result in an unauthorized permanent net loss of wetland area or a loss of WSS.

5.5.8 Monitoring and Follow-up

Monitoring will be conducted to measure the extent of wetland alteration, the effectiveness of mitigation measures, and the successful completion of compensatory wetland restoration. Efforts will be directed at a subset of remaining altered wetlands that are representative of the wetland types within the Field Survey Area. As in previous NSTIR wetland monitoring programs (*e.g.*, along Highways 101, 103, 104 and 125), freshwater wetlands will be monitored for at least three years and annual monitoring reports will be provided to NSE. Monitoring of salt marsh, Wetlands 25 and 26, adjacent to the Avon River causeway will occur for at least five years following recommendations in the van Proosdij and Bowron (2017) report (refer to Section 5.3.8 for more information).

Post-restoration monitoring will also be conducted for habitat offsetting projects – salt marsh habitat banks. As in previous salt marsh monitoring projects carried out by NSTIR, restoration monitoring activities will be based on the Global Programme of Action Coalition for the Gulf of Maine (GPAC) Regional Monitoring Protocols, which are available on the NSTIR and the Gulf of Maine websites (NSTIR 2013 and GPAC 1999). These protocols allow for characterization and measurement of change in geospatial attributes (DEM), hydrology, soils/sediments, and vegetation in response to restoration activities (refer to Section 2.5.2.2 for more information on habitat compensation).

5.6 WILDLIFE AND WILDLIFE HABITAT

Wildlife and wildlife habitat is considered a VC because of potential Project interactions with wildlife (mammals, birds, herpetiles) and associated habitats, particularly with respect to species of conservation interest (SOCI), and due to concerns with protecting species diversity. Provincial and federal legislation addresses protection of many wildlife species, including species at risk and migratory birds. This VC is particularly relevant given the proximity of the Southern Bight Important Bird Area (IBA) to the Project.

5.6.1 Regulatory and Policy Setting

Migratory birds are protected federally under the *Migratory Birds Convention Act* (MBCA), which states that "no person shall disturb, destroy or take a nest, egg, nest shelter, eider duck shelter or duck box of a migratory bird" without a permit. Section 5.1 of the MBCA describes prohibitions related to depositing substances harmful to migratory birds. Bird species not protected under the MBCA, such as raptors and cormorants, are protected under the provincial *Wildlife Act* along with other wildlife.

Wildlife species that are protected federally under the *Species at Risk Act* (SARA) are listed in Schedule 1 of the Act. The purpose of this Act is to protect wildlife species at risk (SAR) and their critical habitat. SARA is administered by Environment and Climate Change Canada, Parks Canada Agency, and DFO.

Certain wildlife species are also protected under the Nova Scotia *Endangered Species Act* (NS ESA). Species recognized as being at risk of extinction in Nova Scotia are identified by a provincial status assessment process through the Nova Scotia Endangered Species Working Group. The conservation and recovery of species assessed and legally listed under the NS ESA is coordinated by the Wildlife Division of the Nova Scotia Department of Natural Resources (NSDNR). There is also a provincial general status assessment process that serves as a first alert tool for identifying species in the province that are potentially at risk. Under this process, species are assigned to categories that designate their population status in Nova Scotia, including *secure*, *sensitive*, *may be at risk*, and *at risk*. Although species assessed under this process are not granted legislative protection, the presence of species ranked as *sensitive*, *may be at risk* and *at risk* is an indication of concern by provincial regulators, as are those ranked as *S1*, *S2*, or *S3* by the Atlantic Canada Conservation Data Center (AC CDC).

The Wildlife and Wildlife Habitat VC focuses on wildlife SOCI, which are defined as those wildlife species that are:

- listed under the NS ESA or Schedule 1 of the federal SARA as being either *endangered*, *threatened*, *vulnerable*, or of *special concern* (*i.e.*, species at risk);
- listed in Schedule 2 or 3 of SARA;
- not yet listed under provincial or federal legislations but identified by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) as being either *endangered*, *threatened*, or of *special concern*;
- listed by the NSDNR (2014) to be *at risk*, *may be at risk*, or *sensitive* to human activities or natural events; or
- ranked as *S1*, *S2*, or *S3* by the AC CDC (2014).

5.6.2 Boundaries

The assessment of potential environmental effects on wildlife and wildlife habitat encompasses the following spatial boundaries: the Project Development Area (PDA), the Field Survey Area, and the Assessment Area. The PDA (*i.e.,* footprint of physical disturbance) is defined in Section 4.2.1. The Field Survey Area is presented on Figure 5.6 as a 30 m buffer on either side of the PDA where field surveys were conducted. The Assessment Area for wildlife and wildlife habitat consist of a 1 km wide study corridor (500 m buffer on either side of the PDA), including a portion of the Southern Bight IBA.

The temporal boundaries for the assessment of the potential environmental effects of the Project on Wildlife and Wildlife Habitat include the duration of Project construction, operation and maintenance of the Project in perpetuity. Temporal boundaries consider that wildlife may interact with the Project year round, but sensitivity varies with life stage (*e.g.*, overwintering, breeding, migration).

5.6.3 Significance Definition

A **significant adverse residual environmental effect on wildlife and wildlife habitat** is defined as:

- one that results in a non-permitted contravention of any of the prohibitions stated in sections 32-36 of SARA, or in contravention of any of the prohibitions stated in section 3 of the NS ESA;
- one that threatens the long-term sustainability of a wildlife species within the Central Lowlands Ecodistrict; or
- one that is inconsistent with the goals, objectives or activities of recovery strategies and action plans for any SOCI.

5.6.4 Description of Existing Conditions

5.6.4.1 Methods

Information regarding use of the Assessment Area by wildlife was derived from several sources including field surveys and reviews of existing data sources. Field surveys were conducted between June and September of 2007 and 2016. During these surveys, information was collected regarding the presence of birds, mammals and herpetiles (amphibians and reptiles).

An AC CDC data search was conducted to determine if any wildlife SOCI have been recorded in the vicinity of the Assessment Area. AC CDC records come from a variety of sources, including from the Atlas of Breeding Birds of the Maritime Provinces (Stewart *et al*. 2015)). All SOCI records within a 10 km radius from the approximate center point of the 9.5 km alignment were identified. The habitat requirements of these species were compared to the environmental conditions present within the Assessment Area to determine if suitable habitat was present for these species. Reference sources such as aerial photography and *Amphibians and Reptiles of Nova Scotia* (Gilhen 1984) were also used.

5.6.4.1.1 Birds

The description of baseline conditions for birds was derived from desktop sources as well as field surveys. A description of the various field surveys is provided below.

Breeding Bird Surveys

Breeding bird surveys were initially conducted in 2007 and repeated in 2016. The recent breeding bird surveys were conducted in the Assessment Area on June 20, 21, 28 and 30, 2016. Additional bird observations were recorded during the vegetation, wetland, and aquatic surveys. The breeding bird surveys were conducted between sunrise and 10:00 am. During the breeding bird surveys all habitats found within the Field Survey Area were visited and all species heard or observed were recorded. The breeding status of each species was determined using the methodology employed by the Atlas of Breeding Birds of the Maritimes program (Stewart *et al*. 2015). Species identified but not exhibiting signs of breeding (such as flyovers) were classified as non-breeders. Species observed or heard singing in suitable nesting habitat was classified as possible breeders. Species exhibiting the following behaviours were classed as probable breeders:

- courtship behaviour between a male and female
- birds visiting a probable nesting site
- birds displaying agitated behaviour
- male and female observed together in suitable nesting habitat.

Species were confirmed as breeding if any of the following items or activities were observed:

- nest building or adults carrying nesting material
- distraction display or injury feigning

- recently fledged young
- occupied nest located
- adult observed carrying food or faecal sac for young.

Lists of provincially rare SOCI were derived from the AC CDC s-rankings (2014), General Status of Wildlife in Nova Scotia (NSDNR 2014) and Species at Risk in Nova Scotia (NSDNR 2013), while nationally rare SOCI were derived from COSEWIC (2016) and SARA.

Fall Migration Shorebird Surveys

In order to describe how birds currently use the habitat at the Avon River causeway and surrounding area, fall migration bird surveys have been conducted over multiple years. The first survey was conducted on Sept 14, 2007. Observations were made from a blind at 30 minute intervals from 09:00 to 19:00 hours which covered 10 out of 12 hours of a tidal cycle. A total of 21 observation periods were recorded during the 2007 survey.

Additional shorebird migration surveys were conducted in 2008 at the request of Canadian Wildlife Service (CWS). A total of eight surveys were conducted at the mouth of the Avon River at approximately 10 day intervals during the period from August 5 to October 15, 2008. Surveys were conducted from a portable blind placed near the causeway sluice gate (Figure 5.8). From this location it was possible to view the Avon River channel, and surrounding mud flats and salt marsh habitat for a distance of approximately 1 km. Observations were made from this blind at 30 minute intervals over an average survey period of nine hours. The total number of observation periods per day ranged from 17 to 20 and averaged 19 observation periods per day for a total of 152 observation periods over the course of the monitoring program.

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Shorebird Survey

Stantec

Figure 5.8

At one hour intervals the observer left the blind and walked along the causeway in order to make observations in a tidal creek that runs parallel to the causeway. This tidal creek (causeway channel) was only partially visible from the blind. The blind was set up such that it was possible to leave and enter it without disturbing nearby birds. The presence of the blind had no apparent effect on the behaviour of the birds as indicated by the fact that a flock of approximately 300 semipalmated (*Calidris pusilla*) and least sandpipers (*Calidris minutilla*) roosted for several hours within 20 m of the blind during a trial survey conducted in 2007.

Each observation period lasted 15 minutes during which the locations of all shorebirds and aquatic birds visible to the observer were plotted onto recent aerial photography showing the open water, mud flat and salt marsh habitat adjacent to the causeway. The maximum distance that observations were recorded was 1,100 m from the causeway. Shorebirds, particularly those belonging to the genus *Calidris* can be difficult to identify. In instances where shorebird observations were made at long distances and it was not possible to identify them to species, they were counted collectively under the category of "Peeps" if it was possible to identify them as members of the genus *Calidris,* or "Shorebirds" if they could not be identified to genus. Observations were made using 8X binoculars and a 15 – 45 X spotting scope. Data collected included bird species, location, number observed at each location, and comments regarding tidal conditions. These data were entered into a GIS system which was used to process the data. The intertidal habitat located north of the causeway was divided into a series of parallel bands 100 m wide (observation zones) extending from the center of the causeway (Figure 5.8). Bird observations were aggregated depending in which zone they were observed. This provided an indication of habitat usage relative to the proximity of the existing causeway.

Tidal cycles play an important role in influencing the distribution and abundance patterns of birds in the Avon River estuary. To collect data on bird activity at all tidal conditions, survey periods were chosen to include both low and high tides. The height of the tide relative to easily identified features such as the interface between mud flat and salt marsh habitat in front of the blind was recorded along with comments indicating whether the tide was rising or falling. This was supplemented with tidal data recorded at the tidal monitoring station at Windsor, Nova Scotia.

In 2016, six more migration surveys were conducted between July 15 and August 19. By starting surveys earlier in the season than in 2008, additional seasonal coverage for migratory data was provided. The 2016 survey used the same methods used in 2008, with a few minor exceptions. Surveys occurred once a week, instead of every 10 days. Surveys covered half a tidal cycle (*e.g.,* high to low tide, or vice versa), in order to include all tidal conditions. A minimum of 6.5 hours were surveyed at a time, with a minimum of 13 survey periods per survey day.

Nightjar Surveys

Nightjar surveys were conducted at six sites on July 14, 2016. Common nighthawks (*Chordeiles minor*) nest in diverse habitats, such as clear-cuts, agricultural lands, barrens, disturbed areas, non-productive forest and other open environments. Sites were chosen where potential habitat was available, and were distributed throughout the extent of the Assessment Area. Common nighthawk survey methodology followed that outlined by CWS (2016). The survey consists of a six-minute silent listening period at each station. Surveyors recorded environmental conditions (temperature, cloud cover and wind) at the time of the survey.

5.6.4.1.2 Mammals

Information regarding the presence of rare mammal SOCI within the Assessment Area was derived from field surveys, AC CDC data and a review of Nova Scotia significant habitat mapping data base (NSDNR n.d.). Incidental mammal observations were recorded during vegetation, wetland and breeding bird surveys in both 2007 and 2016. The field surveys provide a good indication of the presence of large mammal species in the Assessment Area. Presence of a species was determined be either a direct observation of an individual, tracks or scat.

5.6.4.1.3 Herpetiles

Information regarding amphibians and reptiles and their habitat within the Assessment Area was derived during the field surveys and from the AC CDC data search. Incidental observations of herpetiles were recorded during wetland, vegetation and bird surveys conducted in both 2007 and 2016.

5.6.4.2 Summary of Existing Conditions

5.6.4.2.1 Habitat

The Assessment Area is characterized by moderate habitat richness. Overall habitat diversity is relatively low because, although 27 different land cover types are present, most of the area is dominated by only a few types (Figure 5.9 and Table 5.6.1). Approximately 32% of the Assessment Area consists of agriculture, which is primarily composed of active hay fields and abandoned pasture. Approximately 16% of the area is classified as urban, which is mainly composed of residential housing and commercial and industrial facilities. Forest covers only 21% of the Assessment Area. Overall, the forest is primarily mixedwood and hardwood. Approximately half of the forest is in the older two age categories; multi-aged or late mature. Wetland is scattered along the proposed route and accounts for 10% of the Assessment Area. A large area of salt marsh occurs immediately adjacent to the Avon River causeway. Several small fresh and brackish marshes are present along with some tall shrub swamp. Many of the wetlands in close proximity to the Project, including the salt marsh within the Avon River Estuary, are either of anthropogenic origin or have been heavily modified by human activities (see Section 5.5-Wetlands).

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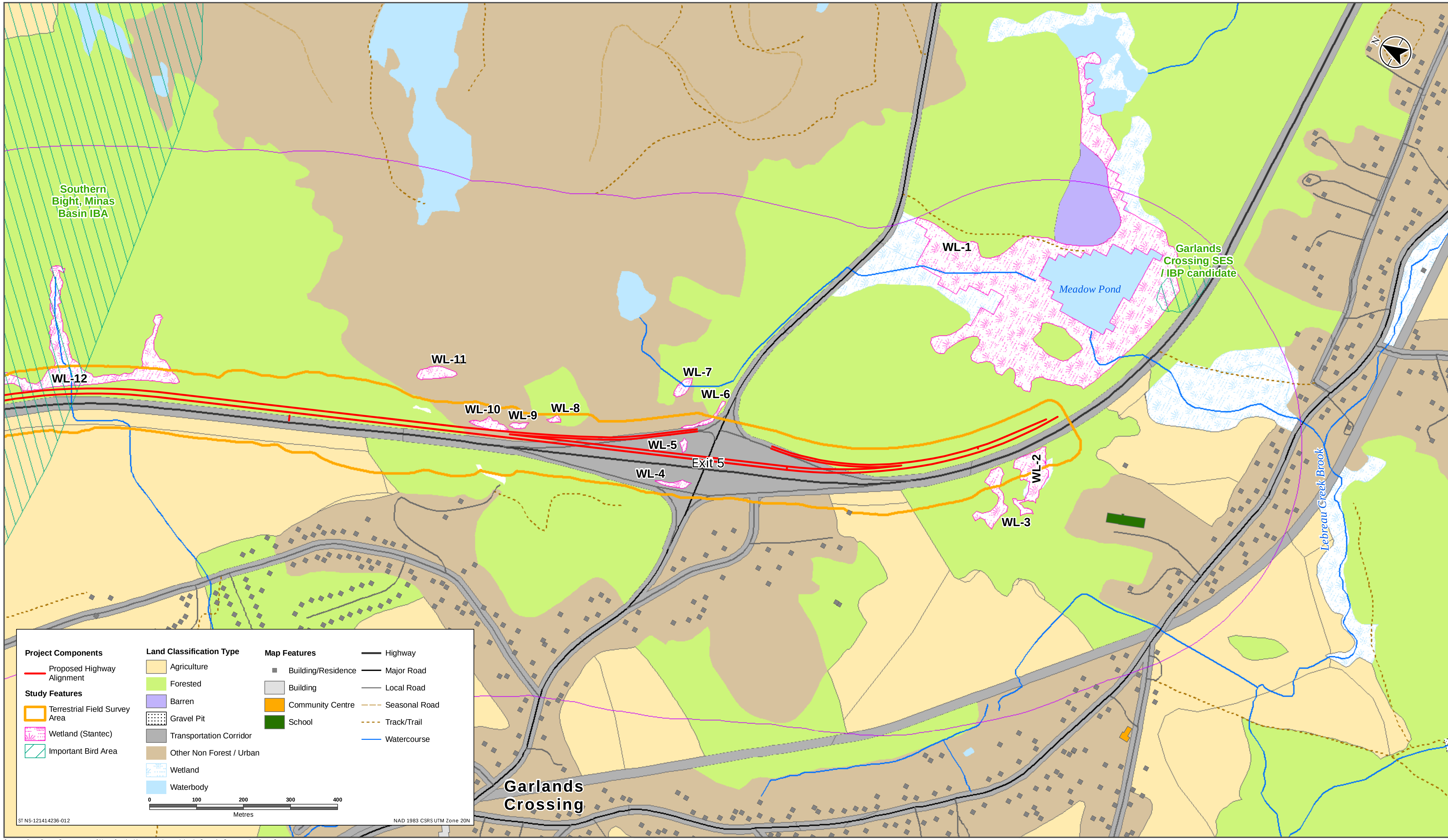


Sources: Base Data - Government of Nova Scotia, Managed Area - Atlantic Canada Conservation Data Centre

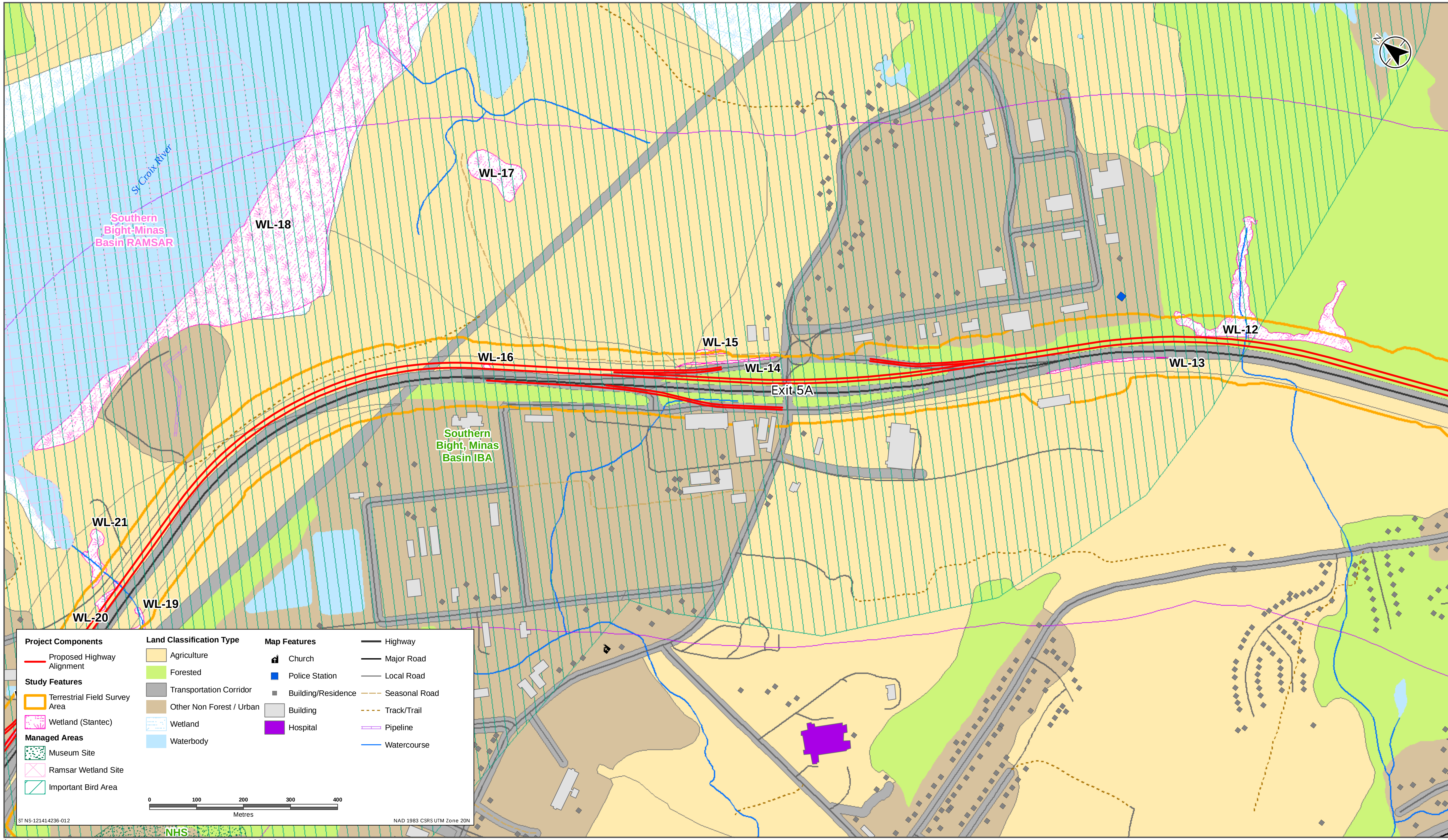
Disclaimer: This map is for illustrative purposes to support this project; questions can be directed to the issuing agency.

Land Classification Types

Stantec

ENVIRONMENTAL ASSESSMENT, HIGHWAY 101 THREE MILE PLAINS TO FALMOUTH

Figure 5.9
Map 1



Sources: Base Data - Government of Nova Scotia, Managed Area - Atlantic Canada Conservation Data Centre

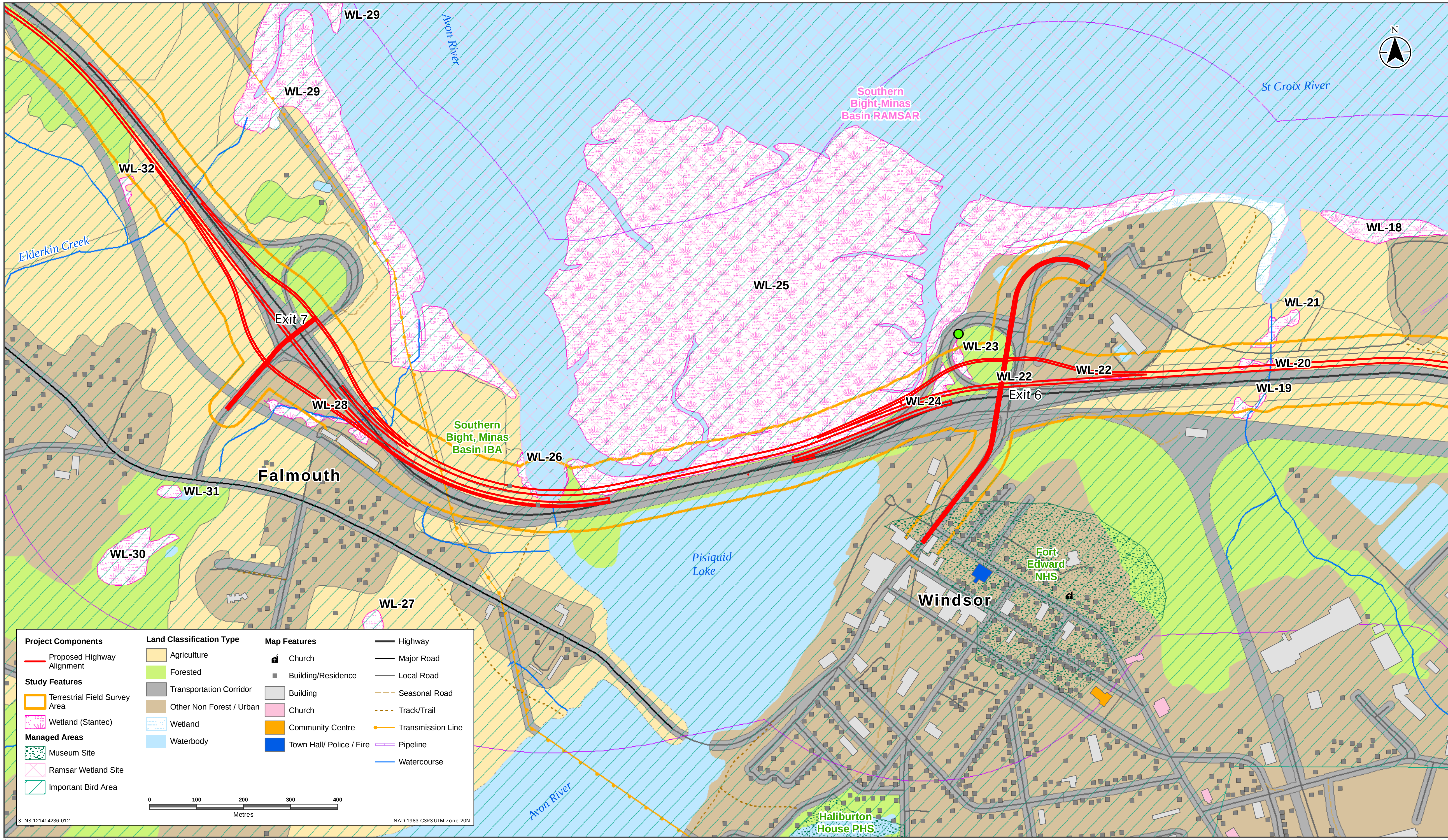
Disclaimer: This map is for illustrative purposes to support this project; questions can be directed to the issuing agency.

Land Classification Types

Stantec

ENVIRONMENTAL ASSESSMENT, HIGHWAY 101 THREE MILE PLAINS TO FALMOUTH

Figure 5.9
Map 2



Sources: Base Data - Government of Nova Scotia, Managed Area - Atlantic Canada Conservation Data Centre

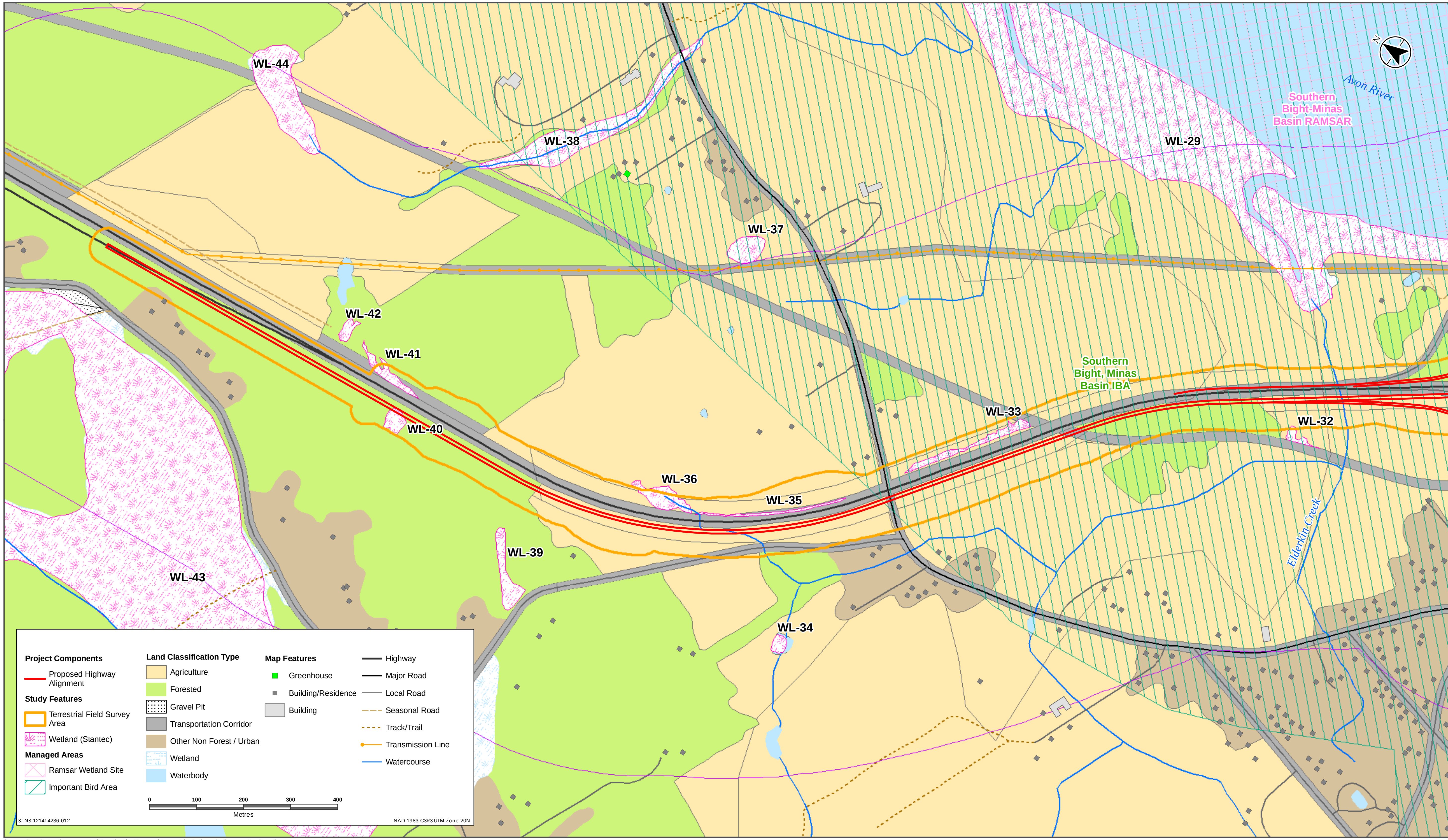
Disclaimer: This map is for illustrative purposes to support this project; questions can be directed to the issuing agency.

Land Classification Types

Stantec

ENVIRONMENTAL ASSESSMENT, HIGHWAY 101 THREE MILE PLAINS TO FALMOUTH

Figure 5.9
Map 3



Sources: Base Data - Government of Nova Scotia, Managed Area - Atlantic Canada Conservation Data Centre

Disclaimer: This map is for illustrative purposes to support this project; questions can be directed to the issuing agency.

Land Classification Types

Stantec

ENVIRONMENTAL ASSESSMENT, HIGHWAY 101 THREE MILE PLAINS TO FALMOUTH

Figure 5.9
Map 4

Table 5.6.1 Land Cover in the Assessment Area

	Land Cover	Area (ha)	Percent of Assessment Area (%)
Forest	Multi Aged Hardwood	11.99	0.98
	Multi Aged Mixedwood	41.04	3.37
	Multi Aged Softwood	17.45	1.43
	Late Mature Hardwood	41.63	3.42
	Late Mature Mixedwood	23.03	1.89
	Early Mature Hardwood	16.40	1.35
	Early Mature Mixedwood	17.60	1.44
	Early Mature Softwood	6.79	0.56
	Young Hardwood	0.73	0.06
	Young Softwood	0.70	0.06
	Establishment- Softwood	1.54	0.13
	Forest Other	81.91	6.72
Wetland	Bog or Fen	0.79	0.06
	Marsh	3.93	0.32
	Swamp	30.77	2.52
	Salt Marsh	68.56	5.63
	Shallow water wetland	0.72	0.06
	Marsh / Swamp	2.01	0.17
	Marsh / Swamp / Shallow Water	1.29	0.11
	Shallow Water / Marsh	10.91	0.90
Other	Agriculture	386.67	31.73
	Barren	1.54	0.13
	Highway	110.99	9.11
	Gravel Pit	0.28	0.02
	Other Non- forest	38.24	3.14
	Urban	199.38	16.36
	Waterbody	101.74	8.35
	Total	**1218.66**	**100.00**

The Assessment Area contains a portion of the Southern Bight Ramsar site and the Southern Bight IBA. These areas consist mainly of large expanses of shallow water and tidal mud flats. Extensive salt marshes are also present along with one island (Boot Island). The Southern Bight site is 26,800 ha in size and extends from just north of Wolfville to Windsor. The Avon River causeway is the southern tip of the Southern Bight site. This site is most notable as supporting the largest numbers of mixed species of shorebirds during fall migration in North America. It is a critical part of the Bay of Fundy Hemispheric Shorebird Reserve declared under the Western Hemispheric Shorebird Reserve Network. Each fall, the Southern Bight attracts up to 400,000 semipalmated sandpipers, 10,000 least sandpipers, and thousands of semipalmated plovers (*Charadrius semipalmatus*), black-bellied plovers (*Pluvialis squatarola*), and short-billed dowitchers (*Limnodromus griseus*) (CWS 2001). These birds are attracted by high concentrations of the amphipod *Corophium volutator*. The Southern Bight also attracts relatively large numbers of waterfowl, mainly American black ducks (*Anas rubripes*), Canada geese (*Branta Canadensis*) and green-winged teal (*Anas carolinensis*). Boot Island provides nesting habitat for double-crested cormorants (*Phalacrocorax auritus*), herring gulls (*Larus argentatus*), and great blue herons (*Ardea Herodias*) (Environment Canada 2003).

Field surveys indicate that the area adjacent to the Avon River causeway is used as a foraging and staging area for waterfowl. This area provides ample food resources and is located close enough to Windsor that there is little if any hunting activity in the fall. At the causeway, most waterfowl feeding activity occurs in the Avon River channel and in the causeway channel that runs parallel to the causeway. These areas are used mainly during portions of the tidal cycle when mud flats are exposed. Waterfowl tend to leave the area when high tides flood the channels. Feeding activity is most intense when the tidal bore runs up the Avon River channel. American black ducks have been observed riding the tidal bore upriver towards the causeway, foraging on invertebrates that have been exposed by the turbulent waters.

5.6.4.2.2 Birds

AC CDC Data

The AC CDC records identified 55 bird SOCI that may be present in the Assessment Area. Ten of these species are SAR, with provincial or federal statuses. Three of these SAR were observed in the Assessment Area including eastern wood-pewee (*Contopus virens*), barn swallow (*Hirundo rustica*), and bobolink (*Dolichonyx oryzivorus*). The other seven SAR include northern bobwhite (*Colinus virginianus*), red knot rufa ssp (*Calidris canutus rufa*), common nighthawk, chimney swift (*Chaetura pelagica*), olive-sided flycatcher (*Contopus cooperi*), bank swallow (*Riparia riparia*), and Canada warbler (*Wilsonia canadensis*).

The Canadian population of northern bobwhite is generally confined to Southern Ontario. Any records in Nova Scotia would be considered to be accidental. Bobwhite are often imported and used as a training aid for hunting dogs.

Red knots do not nest in Nova Scotia; however, they do stop in Nova Scotia mainly during fall migration to build up fat reserves for their long migration flights. This species is listed as *endangered* under the NS ESA and the *rufa* subspecies that migrates through Nova Scotia has been designated an *endangered* species by COSEWIC. The *rufa* subspecies has declined by 70% in recent years largely as a result of overfishing of horseshoe crabs (*Limulus polyphemus*) in Delaware Bay. Horseshoe crab eggs are a critical energy source for this species during their spring migration. In Nova Scotia, red knots are most frequently observed in areas where sandy beaches are found adjacent to mud flats. Sandy beaches are not found in the Assessment Area although mud flats are abundant. Peak red knot abundance in Nova Scotia typically occurs in August and September which coincides with the date of the first fall migration survey on September 14, 2007 and substantially overlaps with the second fall migration survey that was conducted during the period from August 5 to October 15, 2008. None were observed in any of the field surveys. However, there are several records of red knots in the AC CDC data; these birds were associated with the sewage lagoons near Windsor.

Common nighthawks are a SAR which is listed as *threatened* under the SARA, COSEWIC and the NS ESA. This species occupies a variety of open habitats for breeding, including barrens, burned-over areas, pastures, rocky outcrops forest clearings and peatbogs. Anthropogenic habitat is also used for breeding, including flat gravel roofs or gravel lots (COSEWIC 2007a). Eggs are laid directly on the ground. Suitable habitat for common nighthawks is found in the Assessment Area. No common nighthawks were observed during targeted surveys for this species in 2016.

Chimney swifts are typically associated with urban areas due to their propensity to nest and roost in masonry chimneys. The chimney swift is listed as an *endangered* species under the NS ESA and as a *threatened* species under Schedule 1 of SARA. Chimney swift populations have recently decreased by almost 30%. The cause of the decline is unclear but is thought to be the result of changes in the availability of flying insects possibly associated with insecticide use and reductions in the availability of suitable nesting sites. Large mortality events caused by exposure of migrating chimney swifts to hurricanes may also be a factor in the decline of this species (COSEWIC 2007b). Several records of chimney swifts were identified in the AC CDC data search, three of which indicated that breeding was confirmed. All records are located outside of the Assessment Area. These observations occurred near Windsor Forks (south of the Assessment Area), and near the intersection of Avondale Road and Ferry Road (north of the Assessment Area). No chimney swifts were observed during field surveys.

Olive-sided flycatchers typically nest in open woodlands that have scattered conifers present. They often prefer edge habitats, where they can perch in a tall snag over-looking an open area to forage (fly-catch). Olive-sided flycatchers are often associated with open wetlands with scattered conifers. This species is designated as *threatened* under SARA and the NS ESA. No olive-sided flycatchers were observed during the field surveys. However, some suitable habitat does exist for this species in the Assessment Area.

Bank swallows are listed as *threatened* by the COSEWIC. Bank swallows nest in burrows that they excavate in steep embankments along eroding shores such as river banks and seashores. They prefer to forage in open habitats such as agricultural areas. Most colonies are found along the coast in areas where farming occurs. Bank swallows will also nest in human-made habitats such as embankments in borrow pits or large piles of sand. Breeding Bird Survey (BBS) data indicate a steady decline in Bank Swallow abundance in Nova Scotia beginning in the late 1970s (COSEWIC 2013). The pattern for the Canadian population is very similar. The reasons for the decline are thought to be related to loss of nesting sites and reductions in the availability of the flying insects that they forage on possibly as a result of pesticide usage. Based on habitat requirements, this species could occur in the Assessment Area.

Canada warblers are listed as *threatened* under both SARA and COSEWIC, and as *endangered* under the NS ESA. Breeding Bird Survey (BBS) data (Environment Canada 2014b) indicates that in Nova Scotia, Canada warbler abundance has decreased steadily since the early 1980s and is currently at the lowest level recorded since monitoring began in 1966. Although this species has undergone significant population declines, it is still widely distributed in Nova Scotia. Canada warblers use a variety of habitat for nesting including both upland and wetland habitats. The key features of breeding habitat for Canada warblers is a forested area with an open tree canopy with a dense understory and a structurally complex forest floor to provide sheltered nest sites. Canada warblers will nest in both mature and immature forest stands provided the conditions described above are present. In Nova Scotia, treed swamps with dense understory shrub or tree cover are one of the habitats most frequently used by Canada warblers. Suitable habitat for Canada warblers exists in the Assessment Area.

Results of Breeding Bird Surveys

2016 Surveys

A total of 60 species were observed in the 2016 breeding bird surveys. All species are presented in Appendix E, along with their federal and provincial status rankings, and highest recorded breeding status. Species observed included three raptors: osprey (*Pandion haliaetus*), bald eagle (*Haliaeetus leucocephalus*), and red-tailed hawk (*Buteo jamaicensis*). Some of the most commonly observed species included American goldfinch (*Carduelis tristis*), European starling (*Sturnus vulgaris*), red-winged blackbird (*Agelaius phoeniceus*), song sparrow (*Melospiza melodia*), rock pigeon (*Columba livia*) and yellow warbler (*Dendroica petechia*). Of the 60 species recorded during the breeding bird surveys, three species were confirmed as breeding on the site, 13 were listed as probable breeders, 33 were listed as possible breeders, and no evidence of breeding activities were found for 11 species.

2007 Surveys

Fifty-six species of birds were recorded during the 2007 breeding bird surveys. The breeding status and population status of each bird species recorded during the breeding bird surveys is presented in Appendix E. The most abundant species in decreasing order of abundance were song sparrow, savannah sparrow, European starling, American black duck, yellow warbler, cedar waxwing (*Bombycilla cedrorum*), American goldfinch, common grackle (*Quiscalus quiscula*), and American crow (*Corvus brachyrhynchos*). The species composition of the dominant species reflects the abundance of disturbed and agricultural land along the proposed route as well as the presence of good waterfowl foraging habitat adjacent to the existing Avon River causeway. Of the 56 species recorded during the breeding bird surveys, 13 species were confirmed as breeding on the site, six were listed as probable breeders, 24 were listed as possible breeders, and no evidence of breeding activities were found for 13 species.

Results of Fall Migration Surveys

Bird Abundance

The data collected during the fall migration in both 2008 and 2016 are presented in Appendix E. These data provide information on the distribution of all birds that were observed in intertidal habitat at the mouth of the Avon River and are presented at half hour intervals for each sampling date. Bird abundance has been recorded as the number of birds observed per 15 minute observation period and the total of all observation periods per day. The daily abundance data has been standardized by the number of observation periods on each survey date (Appendix E, Table E4). This was done to eliminate bias in the abundance data associated with recounts of birds observed over more than one survey period. These standardized data also allow a more accurate comparison of data from different survey dates since the total number of observation periods varied somewhat between days. The standardized data underestimate the abundance of birds in the Assessment Area while the non-standardized totals represent an overestimate of the number of birds in the estuary.

In the 2008 surveys (August 5 – October 18), shorebirds were most abundant during the August 15 survey. At this time they accounted for 87% of all birds observed. Flocks of shorebirds (probably largely semipalmated sandpipers) numbering up to an estimated 3,000 birds were recorded. Shorebird abundance remained high until August 25, after which it decreased substantially. In the 2016 surveys (July 15 – August 12), shorebird abundance peaked on July 29, when they accounted for 69% of all species. Shorebird abundance remained high until the last 2016 survey, with values of 63, 66 and 65% on August 5, 12 and 19, respectively.

Overall, bird numbers were higher in the 2008 surveys than they were in the 2016 surveys. For example, the mean number of birds observed per observation period on August 15, 2008 was 705. For the two closest dates surveyed in 2016 (August 12 and August 19), the mean number of birds observed for observation period were 137 and 195, respectively. The reason for this discrepancy is not known, but may be related to the fact the areas of open mudflats are located farther from the observation station now than they were in 2008; salt marsh vegetation has filled in some areas what were previously open mud. Large flocks of shorebirds may therefore be located farther out into the estuary, and are harder to count from the observation station.

Within the shorebird species group, the abundance of various species peaked at different times. The trends for the *Calidris* species are masked somewhat by the inability to reliably discern individual *Calidris* species at ranges longer than approximately 300 m. It is assumed that most of the “unidentified shorebirds” observed during the surveys were semipalmated sandpipers. Given this assumption, semipalmated sandpiper abundance peaked during the August 15 survey, in 2008 (Appendix E, Table E4). If only positively identified semipalmated sandpipers are used in the analysis then peak abundance occurred during the August 25, 2008 survey. Both least sandpiper and lesser yellowlegs abundance were highest during the August 5, 2016 survey. Greater yellowlegs abundance peaked on September 5 (during the 2008 survey) but remained fairly high during the period between August 12 and October 6. Black-bellied plover abundance peaked on August 25, 2008 while semipalmated plovers were most abundant on October 6, 2008.

The mouth of the Avon River is used by a variety of bird species, in addition to shorebirds, including waterfowl, gulls, raptors and herons (Appendix E, Table E4). The most abundant of these species in descending order were American black duck, ring-billed gull (*Larus delawarensis*), Canada goose, green-winged teal, and great blue heron. American black ducks were observed at the mouth of the Avon River on all survey dates. Abundance of this species increased substantially in mid-September of 2008. This was probably attributable to an influx of early migrants from the northern part of the range of this species. Abundance was somewhat elevated during the rest of September and into early October then increased greatly on October 15. This coincides with the beginning of the waterfowl hunting season. The mouth of the Avon River receives little hunting pressure due to its close proximity to the town of Windsor.

Ring-billed gulls were observed in the Assessment Area during all surveys, except one. Ring-billed gull abundance was relatively low when surveys began in mid-July, then increased during August, peaking on August 25. Abundance then decreased substantially.

Great blue herons were present in the salt marsh at the mouth of the Avon River starting on August 12, and were then present in every survey afterwards. They were typically observed in relatively low to moderate concentrations, with up to nine birds being observed at one time.

Four species of raptors were observed during the fall migration surveys. One sharp-shinned hawk and one osprey was each observed on July 21, 2016. Bald eagles were observed during five surveys; three in 2016 and two in 2008. At each sighting, only one individual was seen. A northern harrier was seen multiple times during two surveys in 2016 and one survey in 2008. All observations of this species from both survey years occurred between August 12 and 19.

Bird Distribution

Shorebird species were regularly observed foraging and feeding within 100 m of the causeway during the fall migration surveys. Other bird species, including ring-billed gull, herring gull, great black-backed gull, American black duck and mallard (*Anas platyrhynchos*), were also regularly observed in close proximity to the causeway.

Although most species were observed foraging or resting throughout the survey area, they typically were not evenly distributed throughout the area. This uneven distribution was probably largely attributable to differences in habitat type, quality, visibility, and avoidance of human activity. During most survey periods only bird activity on the mud flats could be observed. The area of visible mud flat was much greater in areas farther from the causeway. The area of mud flat habitat visible in each 100 m wide observation zone generally increases with increasing distance from the existing causeway. The larger areas of mud flat can support more birds than smaller areas of the same habitat type; consequently, larger numbers of birds can be expected in the observation zones located farthest from the existing causeway. Based on 2008 aerial imagery, an estimate of area visible of mud was calculated for each of the observation zones (Table 5.6.2). Although a more recent quantification of mud flat habitat has not been completed, a comparison with 2016 aerial imagery indicates that that there is now less exposed mud. Salt marsh vegetation has grown in in some areas, particularly between 700 and 900 m from the observation station. Vegetation now extends up to 1000 m from the station in some areas.

Table 5.6.2 Area of Visible Mud Flat Habitat in the Ten Observation Zones in the Survey Area

	Distance from Existing Causeway (m)									
	0-100	**100-200**	**200-300**	**300-400**	**400-500**	**500-600**	**600-700**	**700-800**	**800-900**	**900-1000**
Area of Mudflat Habitat* (ha)	2.59	0.80	0.36	0.73	0.99	1.61	1.76	2.78	5.48	6.25
*Based on imagery from 2008										

The quality of habitat also varies with location in the survey area. The concentration of invertebrate prey items is much higher in areas of bare mud than in salt marsh areas and higher in the less frequently exposed mud flats farther out in the estuary than in the more frequently exposed mud near the causeway (Daborn *et al.* 2003).

Birds were most abundant between 600 and 900 m from the causeway (Figure 5.10). This corresponds with high areas of visible mud flats (Table 5.6.2), where large concentrations of birds forage. Although the 9000-1000 m category has the largest area of visible mudflat, it is difficult for observers to see this far from the observation blind. It is likely that the number of birds recorded at this distance was an underestimate of how many birds were present. Birds are also fairly abundant within 200 m of the causeway. This may be due to the relatively high area of open mud at the shoreline (Table 5.6.2), a preference of some species to be near the shoreline, or an increased ability to detect small birds because of proximity to the observer.

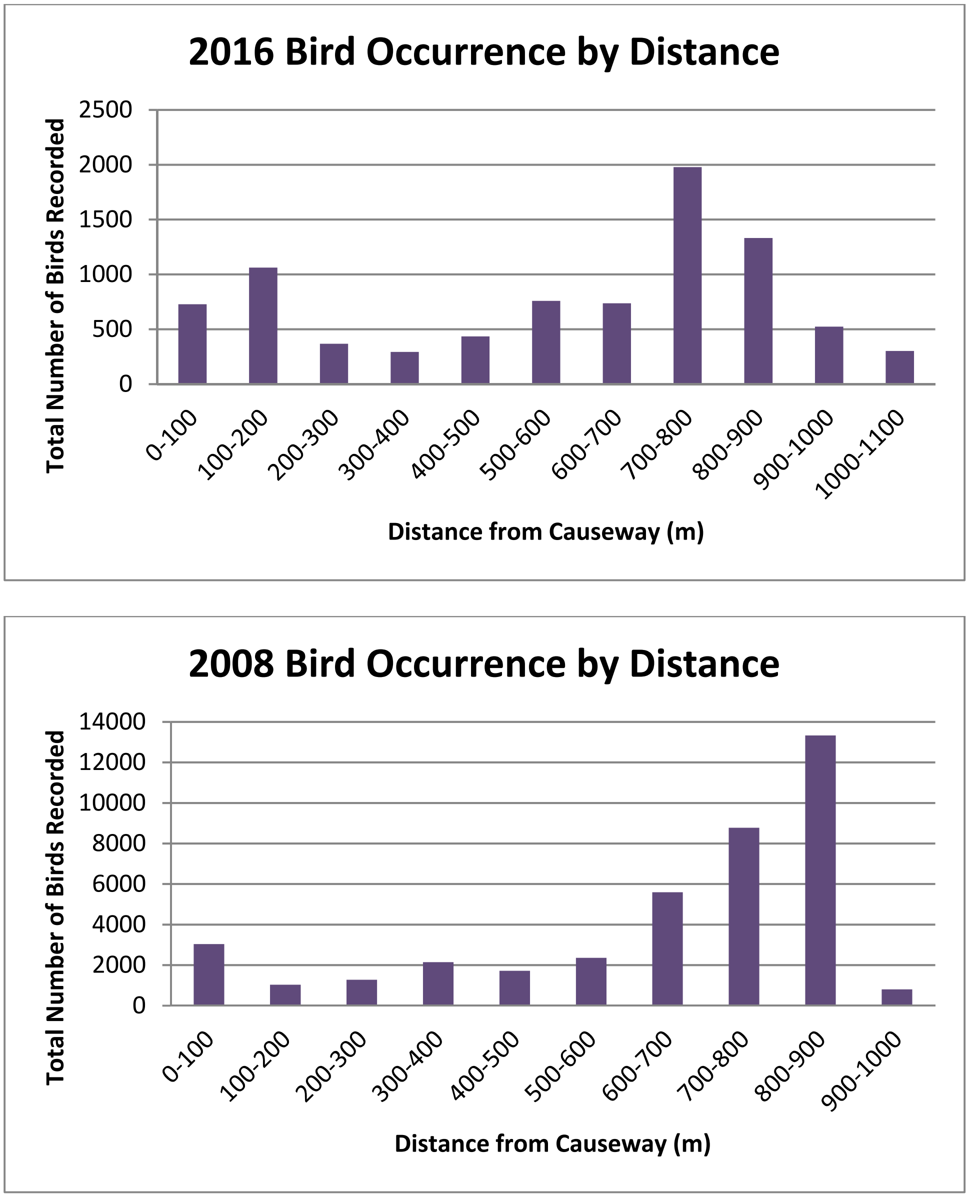


Figure 5.10 Bird Occurrence by Distance from Causeway: 2016 Field Data (top panel); and 2008 Field Data (bottom panel)

Although most species recorded during the surveys displayed some tolerance of human activities such as traffic and were observed in close proximity to the causeway, individual birds can be expected to vary in their degree of tolerance. Shorebirds as a group (including the unidentified shorebird category, as well as identified sandpipers and plovers) were most abundant between 700 and 900 m from the existing causeway (Appendix E, Table E5). This area contains a large area of open mud flat with high densities of invertebrates. When looking at the results of all surveys combined, less than 8% of shorebirds were observed within 200 m of the causeway. However, in late September and early October, shorebirds tended to become more concentrated in the areas near the causeway, although the greatest number of shorebirds present close to the causeway was recorded on August 15, 2008 when 161 shorebirds were counted within 200 m of the causeway during one survey period.

When the distribution patterns of individual shorebird species are examined, the proportion of the population found close to the existing causeway is typically much higher than for the general category of “unidentified shorebirds”. The smaller and more difficult to identify species typically occur in the highest concentrations near the causeway. Approximately 97% of all least sandpipers were observed within 200 m of the causeway. Larger shorebirds that can be identified at greater distances, such as greater yellowlegs and black-bellied plovers, tend to occur at lower concentrations close to the causeway. This pattern is attributable to the difficulty in identifying the smaller *Calidris* sandpipers and semipalmated plovers at ranges greater than a few hundred meters. At greater distances these species tended to get lumped into the peep/unidentified shorebird categories. Given this inability to accurately identify small shorebirds at greater distances, the distribution patterns of individual shorebird species will not be addressed further in this section.

Shorebirds used the survey area for both feeding and resting. Daily distribution patterns of shorebirds are highly related to tidal cycles. Feeding activity was observed throughout the survey area but was most intense on the large food rich mud flats located 700 to 1,000 m from the causeway, particularly at lower tides when the most mud is exposed. Shorebirds observed in this area were constantly feeding or moving; in areas close to the causeway, there was less feeding activity and more resting activity. As the tide rises covering the large expanses of mud flat 700 to 1,000 m out from the causeway, shorebirds would begin to leave these mud flats. Some birds moved into the area adjacent to the causeway and continued to feed or rest; however, most birds left the survey area entirely. Once the areas close to the causeway were flooded the remaining shorebirds typically left the survey area.

Similar patterns of shorebird use of the salt marsh and mud flat habitat adjacent to the causeway were observed by Daborn *et al.* (2003). They noted that the most common shorebird species using the area in early August were “peeps” (mostly semipalmated sandpipers), and semipalmated plovers. Daborn *et al.* (2003) noted that “peeps” were most abundant on the St. Croix River mud flats located approximately 500 m north of the causeway. They also noted that at high tide several thousand roosting “peeps” congregated just below the dyke on the Avon River channel. Once the tide fell low enough to expose the mud flats north of the salt marsh these roosting birds moved back to the mud flats.

Waterfowl including American black duck, green-winged teal, and mallard tended to be found mostly in areas of open water although resting birds were often observed on the mudflats. Most feeding activity occurred at the interface between open water and the mud flats. Feeding activity appeared to be most intense when the tide began to come in. At this time, small rafts of American black ducks were observed foraging vigorously in the mud that had just been disturbed by the passage of the incoming tide. Waterfowl tended to congregate in certain parts of the Avon River channel. Most American black ducks were observed between 200 and 800 m from the causeway with highest concentrations occurring at 300 to 400 m from the causeway. Moderate numbers of American black ducks were observed within 200 m of the causeway. When the results of all surveys are combined, approximately 12% of American black ducks were recorded in this area. The maximum number of American black ducks observed within 200 m of the causeway was 39 birds observed on October 15, 2008. Most American black ducks observed in close proximity to the causeway were resting or transiting through the area suggesting that there was less food in this area than farther out in the estuary.

Green-winged teal was only observed in 2008. Based on this data, this species tended to be concentrated in the area between 300 and 600 m from the causeway with the greatest concentrations of birds found between 300 and 500 m (Appendix E, Table E5). Green-winged teal very rarely ventured out of this area. October 15 was the only survey date when green-winged teal were observed within 200 m of the causeway. On that date 2% of green-winged teal in the survey area were found within 200 m of the causeway.

Canada geese were never observed feeding in the survey area and appeared to use it entirely as a resting area and only utilized the open water habitat. They were also commonly seen flying over the survey area in large groups. This species was recorded between 0 and 1000 m from the causeway but was most frequently observed between 500 and 700 m from the causeway (Appendix E, Table E5).

Ring-billed gulls used the survey area as both a resting area and a feeding area. Feeding gulls tended to be widely dispersed and were often intermingled with other bird species. Resting ring-billed gulls tended to concentrate in flocks at various locations in the survey area. Large concentrations of ring-billed gulls were recorded throughout the survey area. The largest abundances occurred at 600 to 700 m and at 0 to 100 m (Appendix E, Table E5). The proportion of the total number of ring-billed gulls found within 200 m of the causeway was approximately 37%. The maximum number of ring-billed gulls found within 200m of the causeway was 191 birds recorded on August 15, 2008.

Great blue herons were most frequently observed between 200 and 400 m from the existing causeway (Appendix E, Table E5). They were typically observed along the edges of tidal creeks in the interior of the salt marsh where they foraged over most of the tidal cycle, or along the shoreline, at the interface between mudflat and salt marsh. Approximately 18% of all great blue herons recorded were observed within 200 m of the existing causeway.

Species of Conservation Interest

When the results from the 2007 and 2016 breeding bird surveys are combined, a total of 74 species of birds were recorded. Of these species, 15 are SOCI, which includes three SAR: barn swallow (*Hirundo rustica*), bobolink (*Dolichonyx oryzivorus*) and eastern wood-pewee (*Contopus virens*). Table 5.6.3 presents all SOCI recorded in the Assessment Area, and their respective provincial and federal status and ranks. The location of 2016 observations of SOCI are noted on Figure 5.6.

The shorebird migration surveys also identified several SOCI that use the Avon River channel, and surrounding mud flats and salt marsh habitat.

Table 5.6.3 Species of Conservation Interest Observed During 2007, 2008 and 2016 Surveys

Common Name	Scientific Name	SARA	COSEWIC	NS ESA	AC CDC S-Rank	DNR General Status Rank	Year Observed
Semipalmated Plover	*Charadrius semipalmatus*	-	-	-	S1S2B,S5M	Secure	2007, 2008, 2016
Killdeer	*Charadrius vociferus*	-	-	-	S3S4B	Sensitive	2007
Greater Yellowlegs	*Tringa melanoleuca*	-	-	-	S3B,S5M	Sensitive	2007, 2008, 2016
Solitary Sandpiper	*Tringa solitaria*	-	-	-	S1?B, S4S5M	Secure	2016
Willet	*Tringa semipalmata*	-	-	-	S2S3B	May Be At Risk	2007
Spotted Sandpiper	*Actitis macularius*	-	-	-	S3S4B	Sensitive	2008, 2016
Semipalmated Sandpiper	*Calidris pusilla*	-	-	-	S3M	Sensitive	2007, 2008, 2016
Least Sandpiper	*Calidris minutilla*	-	-	-	S1B,S5M	Secure	2007, 2008, 2016
Ring-billed Gull	*Larus delawarensis*	-	-	-	S1?B,S5N	Secure	2007, 2008, 2016
Eastern Wood-Pewee	*Contopus virens*		Special Concern	Vulnerable	S3S4B	Sensitive	2007, 2016
Yellow-bellied Flycatcher	*Empidonax flaviventris*	-	-	-	S3S4B	Sensitive	2007
Eastern Kingbird	*Tyrannus tyrannus*	-	-	-	S3S4B	Sensitive	2007, 2016
Tree Swallow	*Tachycineta bicolor*	-	-	-	S4B	Sensitive	2016
Barn Swallow	*Hirundo rustica*	-	Threatened	Endangered	S3B	At Risk	2007, 2016
Golden-crowned Kinglet	*Regulus satrapa*	-	-	-	S4	Sensitive	2007, 2016
Gray Catbird	*Dumetella carolinensis*	-	-	-	S3B	May Be At Risk	2007, 2016

Table 5.6.3 Species of Conservation Interest Observed During 2007, 2008 and 2016 Surveys

Common Name	Scientific Name	SARA	COSEWIC	NS ESA	AC CDC S-Rank	DNR General Status Rank	Year Observed
Rose-breasted Grosbeak	*Pheucticus ludovicianus*	-	-	-	S3S4B	Sensitive	2007, 2016
Bobolink	*Dolichonyx oryzivorus*	-	Threatened	Vulnerable	S3S4B	Sensitive	2007, 2016
Baltimore Oriole	*Icterus galbula*	-	-	-	S2S3B	May Be At Risk	2007

Semipalmated Plover

Semipalmated sandpipers have an AC CDC ranking of *S1S2B*, *S5M*. This species breeds in Arctic and sub-Arctic regions of northern Canada and Alaska. This species was most abundant in the Assessment Area during the late summer and early fall, during the migration from winter breeding grounds to southern wintering grounds. During this time, semipalmated sandpipers concentrate at mudflats where they feed on marine invertebrates to prepare for their southwards migration. This species was observed at the mouth of the Avon River during the shorebird migration surveys but was not recorded in the area during the breeding season.

Killdeer

Killdeer have an AC CDC ranking of *S3S4B* and a NSDNR general status rank of *sensitive*. This species typically nests in open disturbed areas such as gravel pits or agricultural land. Although this species has generally benefitted from human activities, its Nova Scotia population has been in decline since the early-1990s. It is believed that intensive farming practices may reduce the suitability of nest sites in various ways including accidental tillage of nests, exposure to pesticides, and reductions in the availability of food items such as invertebrates. Three killdeer were observed during the 2008 breeding bird surveys: one was located in a disturbed area, one in a pasture, and the third was a flyover. No killdeer were observed during the 2016 bird surveys.

Greater Yellowlegs

Greater yellowlegs have an AC CDC ranking of *S3B, S5M* and a NSDNR general status rank of *sensitive*. This large shorebird is an uncommon breeder in Nova Scotia, but more commonly nests in northern Canada and Alaska, at latitudes between 48 and 53°N. Greater yellowlegs can be seen frequently during the Assessment Area during migration between summer breeding grounds and southern wintering grounds. They occur at the mouth of the Avon River, where they forage on the mudflats. This species was commonly observed during the fall migration surveys in both 2008 and 2016.

Solitary Sandpiper

Solitary sandpipers have an AC CDC s-rank of *S1?B, S4S5M*, which indicates that they may be imperiled during the breeding season. Like many other species of shorebirds, solitary sandpipers breed in northern Canada, and are found in the Assessment Area during their southward migration in the late summer/fall. During the 2016 breeding bird surveys, one solitary sandpiper was observed in wetland 10, east of the existing highway, just north of Exit 5 (refer to Figure 5.6).

Willet

Willets have an AC CDC s-rank of *S2S3B* and a NSDNR general status rank of *may be at risk*. The eastern subspecies of willet is a shorebird that breeds around the coastline of Nova Scotia. Breeding habitat includes salt marshes, barrier islands and barrier beaches, as well as in pastures and farmlands (Lowther *et al.* 2001). Its diet includes a variety of crustaceans, gastropods, marine worms, fish, and insects. This species leaves Nova Scotia in the fall, when they head south to wintering grounds. Two willets were observed in the 2008 field surveys; one in a salt marsh and the other in a pasture. No willets were observed in the 2016 surveys.

Spotted Sandpiper

The spotted sandpiper has an AC CDC s-rank of *S3S4B* and an NSDNR general status rank of *sensitive*. This species breeds throughout Nova Scotia. They typically nest in herbaceous plant communities in riparian habitats and forage along the shores of lakes and rivers. The Nova Scotia spotted sandpiper population has declined since the late 1970s (CWS 2010), as a result of a variety of factors that may include habitat loss, pesticide use, channelization of rivers and displacement of spotted sandpipers from suitable nesting habitat through human use of freshwater beaches and shores. This species was seen frequently at the mouth of the Avon River and the associated salt marsh in both 2008 and 2016. It was observed during breeding, and during the fall migration period.

Semipalmated Sandpiper

In Nova Scotia, semipalmated sandpipers have an AC CDC s-ranking of *S3M* and a NSDNR general status rank of *sensitive*. This species breeds in low and sub-arctic tundra, and is present in Nova Scotia during migration. During late summer, this species gathers in larger numbers at staging areas in where food is abundant, prior to migration. Semipalmated sandpipers feed on small aquatic and marine invertebrates, which are abundant at intertidal zones with exposed mudflats. Many staging areas exist along the Bay of Fundy. This species was observed frequently and sometimes in large flocks of hundreds of birds at the mouth of the Avon River during the shorebird migration surveys. They often occur with other types of shorebirds.

Least Sandpiper

Least sandpipers have an AC CDC rank of *S1B, S5M*, which indicates that the breeding population is at-risk. This species does breed in Nova Scotia, although breeding is more common in more northern areas of Canada. Breeding habitat includes mossy or grassy bogs around fresh or brackish water, coastal islands with low vegetated sand dunes or boggy fringes of coastal lakes (Nebel and Cooper 2008). During migration, this species uses coastal mudflats, as well as inland habitats such as muddy lake margins. Least sandpipers are often found with semipalmated sandpipers in migration. Least sandpipers were frequently observed at the mouth of the Avon River during the fall migration surveys in both 2008 and 2016.

Ring-billed Gull

Ring-billed gulls have an AC CDC s-rank of *S1?B, S5N*. This species is common throughout Nova Scotia, and is found inland as well as coastally. Although known to breed in PEI and New Brunswick, ring-billed gulls have never been confirmed as breeding in Nova Scotia (Stewart *et al*. 2015). Nests are built on the ground, usually on sparsely vegetated islands and as a part of a colony. Ring-billed gulls were commonly observed in the Assessment Area, and were particularly concentrated at the mouth of the Avon River and around the associated salt marsh. However, this species is not known to nest anywhere in the vicinity of the Assessment Area.

Eastern Wood-Pewee

Eastern wood-pewees are listed as a species of *special concern* under COSEWIC and as *vulnerable* under the NS ESA. They have AC CDC and NSDNR general status rankings of *S3S4B* and *sensitive*. This species breeds in Nova Scotia and occupies both deciduous and coniferous forests during the breeding season. They generally nest near gaps and edges (Erskine 1992). Wintering grounds are located in South America. Three eastern wood-pewees were observed during the 2016 field surveys. Two were located in late mature hardwood stands, and one was located in multi-aged hardwood (refer to Figure 5.6).

Yellow-bellied Flycatcher

Yellow-bellied flycatchers have an NSDNR status ranking of *sensitive*. They are assigned a rank of *S3S4B* by the AC CDC indicating that they are uncommon to fairly common throughout their range in the province and are of long-term concern. This species is associated with a variety of habitats, including swamps and damp coniferous woods. Two individuals were observed in the 2007 field surveys, both in immature hardwood forest. No yellow-bellied flycatchers were observed in the 2016 bird surveys.

Eastern Kingbird

Eastern kingbirds have an AC CDC s-ranking of *S3S4B*. This species breeds in Nova Scotia. Eastern kingbirds prefer to nest in open habitats with scattered tree cover such as agricultural land. They also nest in open wetlands with scattered trees. This species has undergone significant population declines in recent years. Three eastern kingbirds were recorded in the 2016 field surveys. All were located between Exit 5 and Exit 5A in or adjacent to shallow water/marsh wetlands east of the existing highway. One eastern kingbird was observed in the same area during the 2007 breeding bird surveys.

Tree Swallow

Tree swallows were ranked as a *sensitive* species in Nova Scotia by NSDNR in 2010. Tree Swallows nest in unoccupied woodpecker holes and will also use nest boxes. They feed largely over lakes, rivers and wetlands containing open water. Their nests are often situated near these foraging sites. Four tree swallows were observed in the 2016 field surveys, and were distributed fairly equally along the Assessment Area. These birds were generally associated with anthropogenic habitats, and were located either directly adjacent to the highway or in an urban habitat. One bird was observed in forest habitat.

Barn Swallow

Barn swallows are listed as *threatened* under COSEWIC, *endangered* under the NS ESA, have an AC CDC s-rank of *S3B* and a NSDNR general status rank of *at risk*. This species breeds in Nova Scotia and typically nests in or on anthropogenic structures such as buildings, bridges and culverts. In Nova Scotia they only rarely nest on natural nesting sites such as caves or overhanging cliffs (Erskine 1992). Although this species has generally benefitted from human activities, it has undergone recent population declines. Barns swallows were observed in field surveys in both 2007 and 2016. Two barn swallows were observed in the 2016 field surveys, located at each end of the Assessment Area (see Figure 5.6). Both were seen in developed areas near agriculture, and near a barn or old building.

Golden-crowned Kinglet

Golden-crowned Kinglets have a NSDNR status of *sensitive*. The AC CDC assigns a rank of *S4* to this species indicating that although they are fairly common throughout their range in the province, but they are of long-term concern. Golden-crowned kinglets are typically found in dense coniferous stands of the province where they are year-round residents. Nests are generally built in coniferous trees, such as balsam fir, black spruce, or white spruce (Swanson *et al*. 2012). One golden-crowned kinglet was observed in the 2016 field surveys in a stand of late mature hardwood located east of the existing highway, approximately halfway between Exit 5 and Exit 5A (see Figure 5.6).

Gray Catbird

Gray catbirds have an AC CDC s-rank of *S3B* and a NSDNR general status rank of *may be at risk*. This species breeds in Nova Scotia, and migrates south for the winter. Gray catbirds are typically associated with dense, tall shrub thickets and are generally tolerant of human disturbance. Nests are built in living shrubs, saplings, small trees, or vines (Smith *et al*. 2011). Gray catbirds were observed in both 2007 and 2016 in the Assessment Area. One gray catbird was observed in 2016, on the edge the railroad tracks, just west of the Avon River (see Figure 5.6).

Rose-breasted Grosbeak

Rose-breasted grosbeaks have an AC CDC ranking of *S3S4B* and a NSDNR ranking of *sensitive*. This species breeds in Nova Scotia and winters in central and South America. Rose-breasted grosbeaks usually nest in open deciduous forest with well-developed shrub understories, often near water bodies or wetlands. This species has undergone moderate population reductions for unknown reasons. Two rose-breasted grosbeaks were recorded in the 2016 field surveys. One was located in a stand of late mature hardwood, and the other was located on the edge of the highway (see Figure 5.6).

Bobolink

Bobolinks are listed as *threatened* under COSEWIC and as *vulnerable* under the NS ESA. They have an AC CDC s-ranking of *S3S4B* and a NSDNR ranking of *sensitive*. Bobolinks nest in hay fields and pastures where there is tall dense grass cover (Erskine 1992). In Nova Scotia, bobolinks have historically benefited from the clearing of land for agricultural production, particularly livestock production. However, bobolink numbers have declined in Nova Scotia. There are several possible reasons for the decline of this species including early and repeated cropping of hay that does not provide sufficient time for nestlings to fledge, as well as persecution in wintering areas where it is considered a pest in grain fields. Two bobolinks were observed in the 2016 field surveys. Both were located in a field on the east side of the highway, north of Exit 7 (see Figure 5.6). Two bobolinks were also observed in the 2007 field surveys.

Baltimore Oriole

Baltimore orioles have an AC CDC ranking of *S2S3B* and a NSDNR general status ranking of *may be at risk*. This species is found at wooded edges or riparian woods, as well as in urban and suburban parks and landscapes. They occur in Nova Scotia during the breeding season and migrate south in the fall. Breeding often occurs in open areas with scattered trees. This species was not observed in the 2016 field surveys; however, one individual was observed in 2008 at the edge of a forested area near Exit 5.

5.6.4.2.3 Mammals

The mammal species recorded in the Assessment Area are a mixture of species characteristic of open habitats and woodlands. Species recorded during the field surveys included meadow vole (*Microtus pennsylvanicus*), southern red-backed vole (*Clethrionomys gapperi*), muskrat (*Ondatra zibethicus*), meadow jumping mouse (*Zapus hudsonius*) woodchuck (*Marmota monax*), red squirrel (*Tamiasciurus hudsonicus*), eastern chipmunk (*Tamias striatus*), snowshoe hare (*Lepus americanus*), eastern coyote (*Canis latrans*), red fox (*Vulpes vulpes*), northern raccoon (*Procyon lotor),* mink (*Mustella vison*), striped skunk (*Mephitis mephitis*), bobcat (*Lynx rufus*) and white-tailed deer (*Odocoileus virginianus*).

A review of the NSDNR significant habitat mapping database (NSDNR n.d.) did not reveal the presence of any known rare or sensitive mammal SOCI in the vicinity of the Assessment Area or important habitat such as deer wintering areas. All of the habitats present in the Assessment Area are commonly encountered throughout the province and are unlikely to provide habitat for rare small mammal species.

Three species of bat are listed as endangered both provincially and federally. The little brown myotis (*Myotis lucifugus*), northern long-eared myotis (*Myotis septentrionalis*) and tri-coloured bat (*Perimyotis subflavus*) all have potential to occur in the Assessment Area. However, the populations of all three species have crashed in recent years as a result of the invasive fungal pathogen white-nose syndrome, which was first detected in Nova Scotia in 2011. By the spring of 2013, populations at Nova Scotia's five largest overwintering sites had declined by 95% (NSDNR and MTRI n.d.)

All species are insectivorous bats that are dependent on forest environments for foraging opportunities and roosting during the spring, summer and fall. Both little brown and northern long-eared myotis roost in trees, although little brown myotis also often roost in human-made structures, such as roofs, attics or barns. Tri-coloured bats are unique in their roosting strategies, and roost in clumps of *Usnea* lichen, often in spruce trees (Poissant 2010). In all three species, females form maternity colonies where they birth and raise pups, whereas males tend to roost alone or in small groups. In the fall, bats enter underground sites, such as caves or abandoned mines, where they hibernate for the winter (October – May). Bats are most vulnerable at their hibernation sites where large proportions of the regional population may gather in a single location.

No records of bats were identified in the AC CDC search. The nearest known hibernacula is located southeast of the Assessment Area in Saint Croix, near Exit 4 of Highway 101. It is not known if this cave is still used by bats, after the population decline caused by white-nose syndrome. All three species of hibernating bats have potential to occur in the Assessment Area during the spring summer and fall months.

5.6.4.2.4 Herpetiles

During the 2008 surveys, four herpetile species were encountered during the surveys: green frog (*Rana clamitans*), northern leopard frog (*Rana pipiens*), northern spring peeper (*Pseudacris crucifer*) and red-spotted newt (*Notophthalmus viridescens viridescens*). In the 2016 vegetation and wetland surveys, an eastern painted turtle (*Chrysemys picta picta*) was observed. Painted turtles are generally found in freshwater waterbodies, including ponds and lakes with aquatic vegetation. All of these species are considered to have *secure* populations in the province and none of these species are considered to be SOCI.

Based on records from the AC CDC, two species of herpetiles have been recorded in the general vicinity of the Project: four-toed salamander (*Hemidactylium scutatum*) and snapping turtle (*Chelydra serpentine*). Although the four-toed salamander is not designated as protected under either SARA or the NS ESA, and is considered to have a *secure* population by NSDNR, it is uncommon in the province and currently ranked as *S3* by the AC CDC. Four-toed salamanders nest mostly in swamps and bogs but will also nest in anthropogenically created or modified sites such as roadside ditches and ponds, wheel ruts, and quarry ponds. The critical requirements for this species are the presence of sphagnum moss in which to lay eggs and a semi-permanent or permanent, soft bottomed pond or slow flowing stream adjacent to the sphagnum moss in which the hatched larvae can develop (JWEL 1999). Suitable habitat for four-toed salamanders could occur within the Study Area, particularly in association with swamps.

Snapping turtles are listed as *special concern* by both SARA and COSEWIC, and as vulnerable by the NS ESA. This species is most commonly found in ponds and lakes with abundant aquatic vegetation. These features are also used for hibernation in the winter. During the spring, female turtles dig nests in sand or gravel areas near water. Suitable snapping turtle habitat does exist at several ponds in the Assessment Area, and at Pisiquid Lake.

5.6.5 Potential Environmental Effects and Project-Related Interactions

Activities and components could potentially interact with wildlife and wildlife habitat through direct loss or alteration of habitat, and direct mortality. In consideration of these potential interactions, the assessment of Project-related environmental effects on wildlife and wildlife habitat is focused on the following potential environmental effects:

- change in habitat quantity, quality or use; and
- change in risk of mortality or physical injury.

5.6.5.1 Change in Habitat Quantity, Quality or Use

Construction

Project construction is expected to result in a change of habitat quantity, quality and/or use by wildlife. Clearing and grubbing for site preparation within the PDA will remove vegetation, reducing the quantity of terrestrial habitat, and will affect the quality of habitat bordering the PDA. Causeway construction may also result in the loss of upland roosting sites, such as those located adjacent to the aboiteau.

Habitat fragmentation and sensory disturbance can affect habitat quality and use by wildlife. Small mammal and herpetile populations which have limited dispersal capabilities are particularly susceptible to habitat fragmentation. Populations isolated from other populations in small habitat fragments are more prone to local extirpation since these fragments may be too small to support a population. Fragments may be large enough to support a population, but may not be large enough to provide enough animals to rebuild the population should it be heavily impacted by disease or predators. Isolation of the fragment can also impair the immigration of new animals into an area where a local population has been extirpated. Impaired immigration can also adversely affect populations by restricting gene flow between populations leading to inbreeding.

Habitat fragmentation can also affect highly mobile animals such as birds. During the breeding season some species may be reluctant to cross clearings causing populations to be isolated in resultant habitat fragments.

Construction activity could also result in the disturbance of shorebirds feeding or roosting in areas adjacent to the construction activity.

Construction activities can be expected to be disturbing to shorebirds through visual stimuli and noise and the presence of humans which they generally do not encounter when exposed to just highway traffic. It is likely that shorebirds will avoid areas within 100 m of construction activity during the period when widening of the causeway will occur.

Operation and Maintenance

During the operation and maintenance phase, traffic and maintenance equipment could disturb birds and mammals nesting or foraging in habitats near the new alignment. The presence of traffic would enhance the efficacy of the road as a barrier to wildlife movement intensifying the effect of habitat fragmentation caused by construction of the road.

A variety of maintenance activities will occur on the highway periodically, including periodic infrastructure maintenance on bridges or culverts, winter maintenance (*e.g.* plowing and salting), and vegetation maintenance. These activities have the potential to disrupt birds (and nests) and mammals, especially during the breeding season and lower the habitat quality by the addition of noise, disturbance and possible vibrations of the equipment being used to carry out the maintenance.

During the operational phase of the Project, shorebirds will be subject to disturbance related to exposure from traffic noise and visual stimuli associated with vehicle movement.

5.6.5.2 Change in Risk of Mortality or Physical Injury

Construction

Construction activities such as clearing, grubbing, and blasting (if required) have potential to cause direct mortality or injury to birds and other wildlife within the PDA. For small mammals, such as shrews, habitat loss is likely to result in direct mortality of individuals since they stay in close proximity to cover. Larger mammals are less likely to suffer direct mortality since they will tend to flee the area as soon as they detect humans. The Project-related increase in edge area also has potential to cause a change in risk of mortality or physical injury due to increased predation on birds and small mammals.

Some wildlife within the PDA will be permanently displaced, potentially causing direct mortality of those wildlife species that are unable to relocate to suitable habitat.

Operation and Maintenance

The presence of traffic during operation of the highway poses a risk of mortality or physical injury for wildlife species that are not able to successfully avoid traffic strikes. Traffic volume is not predicted to increase as a result of the twinning, so the volume of wildlife/vehicle collisions is unlikely to noticeably increase. The wider cleared RoW of the twinned highway will likely provide a greater deterrent for wildlife to cross the highway potentially decreasing the rate of wildlife/vehicle collisions.

Vegetation management will be conducted by mechanical clearing during highway operation (*e.g.,* road shoulders and interchanges). It is possible, despite the disturbance from passing vehicles, that the open habitats in medians, ditches, and/or side slopes may be used as breeding habitat by species such as Savannah sparrows and song sparrows. Mowing and brush cutting of the vegetated slopes and drainage ditches could destroy the nests of these birds. NSTIR mows the grassy edges and medians of the Province's highways, as required, usually once per year, for safety and partially for aesthetic reasons. Vegetation cutting will occur within the PDA in areas that had already been disturbed as a result of construction activities. Vegetation cutting (mowing) can result in fewer wildlife/vehicle collisions when viewing conditions for motorists are improved.

Highway maintenance and repair work will typically be limited to the paved and immediately adjacent areas of the highway (*e.g.*, guide rail, lighting and shoulder). Maintenance involving watercourse crossing structures or culverts will be limited to the cleared portion of the highway and thus is not anticipated to interact with the terrestrial environment beyond the PDA.

Ongoing winter maintenance of the Project may potentially affect risk of mortality or physical injury of wildlife. Consumption of deicing brine by birds can cause narcosis that can result in increased rates of collision with vehicles. Saline soils at the edges of highways can attract mammals such as porcupines resulting in increased rates of wildlife/vehicle collisions (Environment Canada 2000).

5.6.6 Mitigation

Mitigation measures to be implemented to reduce potential effects on wildlife and wildlife habitat during construction and operation are presented in Table 5.6.4.

Table 5.6.4 Mitigation for Wildlife and Wildlife Habitat

Effect	Phase	Mitigation
Change in Habitat Quantity, Quality or Use	Construction	• Follow Generic EPP and Project Specific ECP • Reduce the extent of vegetation clearing for RoW preparation to only the amount required for Project construction • Clear RoW outside of breeding bird season (April 1 to August 15). Where this is not feasible, develop a Bird Nest Mitigation Plan (prior to construction) in consultation with ECCC and provincial regulators • Compensate for loss of wetland area and function following provincial requirements • Limit Project-related off road activity • Employee environmental awareness training • Use designated roadways and access to reduce unnecessary ground disturbance
	Operation and Maintenance	• Follow Generic EPP • Use existing access for maintenance activities • Conduct vegetation maintenance outside of breeding season (April 1 to August 15), where feasible • Keep activities within disturbed RoW where feasible • Employee environmental awareness training • Deactivate temporary roads to reduce access • Follow NSTIR Salt Management Plan
Change in Risk of Mortality or Physical Injury	Construction	• Follow Generic EPP and Project Specific ECP • Conduct vegetation clearing outside of breeding bird season (from April 1to August 15. Where this is not possible, develop a Bird Nest Mitigation Plan (prior to construction) in consultation with ECCCand provincial regulators • Limit Project-related off road activity • Reduce area of physical ground disturbance • Employee environmental awareness training • Use designated roadways and access to reduce unnecessary ground disturbance
	Operation and Maintenance	• Follow Generic EPP for maintenance activities • Where feasible, do not mow cleared RoW between April 1 and August 15 to avoid destruction of the nests of species which nest on the ground in grasslands. Where this is not possible, develop a Bird Nest Mitigation Plan (prior to construction) in consultation with ECCC and provincial regulators • Inspect bridges prior to maintenance work to determine if occupied nests of protected birds are present. If nests are present, avoid maintenance work until chicks have fledged • Follow NSTIR Salt Management Plan

5.6.7 Residual Environmental Effects and Significance Determination

The assessment of residual environmental effects considers effects on wildlife and wildlife habitat after the mitigation measures, as provided above, have been implemented.

5.6.7.1 Change in Habitat Quantity, Quality or Use

Construction

Construction within the PDA will result in the permanent loss of habitat for some wildlife species, and the creation of edge habitat along the RoW. Clearing of mature forest for highway construction resembles clear-cutting of forest in which the existing forest becomes unavailable or reduced in the immediate area. The RoW will be cleared outside of breeding bird season (April 1 to August 15). Where this is not feasible, NSTIR will develop a Bird Nest Mitigation Plan (prior to construction) in consultation with ECCC and provincial regulators.

The total area that will be directly affected by highway construction (*i.e.*, PDA) is approximately 81 ha (Table 5.6.5). Approximately 69% of the habitat consists of transportation corridor (36 ha) and agriculture (20 ha). Corridor consists of the cleared RoWs of existing linear features such as highways, railroads and transmission lines. In the Assessment Area this mainly includes the previously cleared portion of the Highway 101 RoW. This habitat consists mostly of areas dominated by grasses and forbs or shrubs.

Although the Project passes through some multi-age/mature forest (approximately 0.17 ha of the PDA), only 0.4% of the total multi-age/mature forest in the Assessment Area will be lost. Approximately 21% of the Forest – Other land class will be lost. The area cleared will be as narrow as practical to reduce the amount of lost habitat but wide enough as required by highway design and to ensure good visibility of large animals crossing the road.

Approximately 3.6 ha of wetland will be lost, which represents 3% of wetlands in the Assessment Area. Marshes will lose the largest proportion of cover (14.6%). The assessment of Project effects on wetlands, as well as proposed mitigation and compensation for no net loss, are discussed in Section 5.5.

Table 5.6.5 Land Classification: Habitat Alteration

	Land Cover	PDA[1]		Percent of habitat in Assessment Area to be altered
		Area (ha)	Percent (%)	
Forest	Multi Aged Mixedwood	0.07	0.09	0.18
	Late Mature Hardwood	0.10	0.12	0.23
	Early Mature Hardwood	0.06	0.07	0.37

Table 5.6.5 Land Classification: Habitat Alteration

	Land Cover	PDA[1]		Percent of habitat in Assessment Area to be altered
		Area (ha)	Percent (%)	
	Early Mature Mixedwood	0.02	0.02	0.11
	Establishment-Softwood	0.09	0.11	5.71
	Forest - Other	17.00	21.10	20.76
Wetland	Marsh	0.57	0.71	14.61
	Salt Marsh	2.66	3.30	3.88
	Swamp	0.01	0.02	0.05
	Marsh / Swamp	0.21	0.26	10.33
	Shallow Water / Marsh	0.11	0.13	0.98
Other	Agriculture	20.05	24.88	5.18
	Corridor	35.69	44.29	32.15
	Other Non-Forest	0.85	1.05	2.21
	Urban	2.44	3.03	1.22
	Waterbody	0.64	0.80	0.63
Total		80.57	100.00	6.59
[1]The area within the PDA is likely an overestimate and will be refined following more detailed design of the highway				

Twinning of the existing highway will not increase the number of habitat fragments but will reduce the size of some of the existing patches of mature forest. In comparison with constructing a new highway, twinning an existing highway also reduces the loss of forest interior habitat since new edge effects are only generated on one side of the proposed RoW. The Assessment Area consists mainly of agricultural and urban land uses. The effects of habitat fragmentation will be most pronounced at the southern end of the Assessment Area where patches of mature forest habitat will be reduced in size. A total of 0.6 ha of mature forest habitat will be lost to highway construction. The Assessment Area is already heavily disturbed and fragmented, and no forest interior habitat will be lost since none currently exists in the PDA.

No rare mammal SOCI were recorded in the vicinity of the Assessment Area. However, three species of bats (little brown myotis, northern long-eared myotis and eastern pipistrelle) may occur in the Assessment Area, given their provincial distribution and habitat availably in the area. Potential adverse effects on bats associated with highway construction activity include loss of hibernation sites and disturbance of hibernating bats as a result of activities such as blasting. No caves are known to be present in the PDA or Assessment Area. Overburden is quite thick in this area and it is anticipated that no blasting will be required to make road cuts. The anticipated lack of blasting will reduce the potential for disturbance of bats.

Sensory disturbance of mammals is not expected to have a substantial effect on local mammal populations. The Assessment Area is located in an area of high human activity including agricultural use (*e.g.,* livestock), the presence of the existing Highway 101, a railroad, and a wide variety of human activities associated with residential, industrial and commercial facilities. Species sensitive to human activities are unlikely to be present and the species that are present are likely habituated to the presence of humans. Construction activities are unlikely to significantly affect the abundance or distribution of mammals in the Assessment Area. Mitigation measures are limited to reducing vegetation clearing to the extent practical during RoW preparation to preserve habitat.

The area adjacent to the Avon River causeway is used as a foraging and staging area for waterfowl and shorebirds. Construction activities could affect the use of this area as a foraging and staging area by frightening birds and preventing them from settling into the staging habitat or preventing them from making use of the entire available habitat. A study of the effects of bridge construction on the abundance and distribution of water birds (mainly waterfowl and shorebirds) in two wetlands (Cape Jourimain National Wildlife Area, New Brunswick, and Amherst Cove Marsh in Prince Edward Island) (JWEL 1998) indicated that construction activities had no significant effect on waterfowl abundance or distribution. At Amherst Cove Marsh, neither bird abundance nor distribution was affected by operation of the Confederation Bridge fabrication yard located at the edge of the salt marsh. At Cape Jourimain, there was no change in bird abundance but the distribution of birds in the marshes was altered in a way that would indicate a disturbance effect (*i.e.*, birds shifting their distribution away from the source of disturbance) in two out of 36 post disturbance sampling periods. These results would suggest that construction activity at the Avon River causeway may have a minor effect on waterfowl and shorebird distribution in the wetland. It is expected that construction/upgrading of the aboiteau and causeway would be completed within two years, consequently, the effect on foraging and staging birds would be temporary. It is likely that shorebirds will avoid areas near construction activity during the period when widening of the causeway will occur.

No rare or sensitive herpetile SOCI were encountered along the proposed highway RoW during the various field surveys. However, two SOCI, snapping turtles and four-toed salamanders have been reported in the general vicinity of the Assessment Area. Snapping turtles rely on waterbodies. Only 0.6 ha of water bodies are located within in the PDA, which represents only 0.6% of waterbody area within the Assessment Area. Construction activity will result in the loss of some amphibian habitat (including potential habitat for four-toed salamanders) in several of the wetlands that are crossed by the proposed highway RoW. This habitat will be replaced as part of the wetland compensation program.

In consideration of the potential environmental effects of Project-related activities during construction, and the proposed mitigation, the residual environmental effects of the construction of the Project on wildlife habitat quantity, quality and use are predicted to be not significant. However, as noted in Section 5.5 (Wetlands), the loss of a wetland of special significance (salt marsh) is considered to be significant.

Operation and Maintenance

During the operation and maintenance phase of the Project, winter safety activities, vegetation maintenance and the physical presence of the Project could result in a change in wildlife habitat quantity, quality or use. Wildlife could also be affected by sensory disturbance caused by traffic.

Species whose habitat use would be most affected by the presence of traffic include those particularly sensitive to anthropogenic activity and those reluctant to cross open habitat. Given the close proximity of the proposed road to an urban centre and the fact that Highway 101 already exists, species sensitive to anthropogenic activity are not likely to be common in the area where the proposed highway will be established.

Several studies have shown that disturbance associated with automobile traffic can have an adverse effect on bird abundance and breeding success. A study of terrestrial bird abundance, species composition and breeding success in forested habitats adjacent to a busy highway in New Brunswick (JWEL 1998) revealed a reduction in bird abundance of 18 to 25% in plots located 100 and 200 m away from the road relative to control plots 500 m from the road. Evidence of breeding activity was reduced by 34 to 39% relative to control plots. These reductions were not statistically significant. A similar study conducted in the Netherlands revealed a reduction in the number of singing males from 3.3/ha in control plots to 2.1/ha in areas within 200 m of a highway (Reijnen and Foppen 1994). Reijnen and Foppen (1994) noted that the degree of disturbance to birds by highway traffic was best correlated with noise levels. These data indicate that disturbance associated with operation of the road will have a measurable adverse effect on local populations but is not expected to significantly adversely affect regional populations. However, since Highway 101 already exists and twinning will occur immediately adjacent to the existing highway there will be no net increase in the level of disturbance to wildlife in habitats adjacent to the highway. The twinning of the highway is not expected to significantly increase traffic volumes. The main disturbance effect associated with twinning of the highway will be that disturbance effects are increased on the side of the highway where the new lanes are established. Therefore, no significant increase in the level of disturbance to wildlife is expected.

Widening of the Avon River causeway will extend the zone of influence of sensory disturbance associated with highway operation. Existing traffic levels will not be increased as a result of the operation of the new highway lanes, so the level of sensory disturbance to which shorebirds, waterfowl and other water birds are exposed will not increase. It is expected that these birds will use the mud flat and salt marsh habitat in a manner similar to what they do at the present time except that their distribution will be shifted away from the new lanes of highway. The effect of this encroachment is not expected to be significant.

The results of the two fall migration surveys at the Avon River causeway suggested that shorebirds are relatively tolerant of constant vehicle traffic. During the 2007 survey, approximately 300 semipalmated and least sandpipers roosted for several hours within 25 m of Highway 101. Highway traffic is quite predictable and birds readily habituate to it.

Maintenance activities such as resurfacing and mowing of the RoW are not expected to have significant effects on local bird populations. Disturbance associated with repairs to the road surface are not expected to be any more intense than that encountered during the construction or operational phases of the Project.

Winter maintenance of the Project may have a potential adverse effect through degradation of wildlife habitat quality. Salt or other de-icing agents may affect water/habitat quality for wildlife adjacent to the RoW. Adherence to the NSTIR Salt Management Plan, which specifies application rates and designates vulnerable areas, will reduce the environmental effects to wildlife habitat.

Some bird species such as cliff swallows, barn swallows and eastern phoebes frequently nest on bridges. Maintenance activities such as sandblasting, painting or structural repairs to the sides or underside of the bridge during the breeding season could result in the abandonment of active nests, a violation of the MBCA. This could be prevented by inspecting bridges prior to maintenance work to determine if occupied nests of protected bird species are present. If active nests are present maintenance activities would be delayed until after young have fledged. Other bird species not protected under the MBCA also nest on bridge structures including rock dove, European starling, and house sparrow. Maintenance work would not necessarily have to be delayed if these species were nesting on the structure.

In consideration of the potential environmental effects of the individual activities required for the operation and maintenance phase of the Project, and the proposed mitigation, the residual environmental effects of operation and maintenance of the Project on wildlife habitat quantity, quality and use are predicted to be not significant.

5.6.7.2 Change in Risk of Mortality or Physical Injury

Construction

Clearing and grubbing may cause injury or direct mortality of small mammals and birds. These potential effects will be mitigated by reducing vegetation clearing as far as practical during RoW preparation.

The environmental effects of clearing and grubbing are most severe when these activities are conducted during the period when most bird species are breeding (April 1 to August 15). Clearing and grubbing at this time could result in the direct mortality of eggs and unfledged nestlings. The killing of birds or the destruction of their nests, eggs, or young is an offence under the MBCA. NSTIR plans to conduct clearing during the fall/winter, which should avoid potential direct adverse environmental effects on most nesting birds. It is important to note that some species of bird such as white-winged crossbills, red crossbills, and common ravens nest outside of this period and could be affected by clearing and grubbing. Other species such as killdeer nest on bare ground and dark-eyed juncos and white-throated sparrows nest in recent clear-cuts. These species could occupy sites that have been cleared and/or grubbed during the winter months.

Although NSTIR plans to conduct clearing during the fall/winter, some minimal clearing of watercourse buffer zones (typically 30 m either side of the watercourse; approximately 5% of the total) may take place during the May to August timeframe. Some clearing activities such as surveying and clearing for alignment adjustments may also be required during this period. Alignment adjustments may be required due to engineering and design limitations (*e.g.,* slope stability). Due to construction timing restrictions as a result of other legislation (*e.g., Fisheries Act*), site preparation activities other than clearing (*e.g.,* grubbing and grading) will take place during the May to September period. This may result in the disturbance of some ground-nesting birds for a period of up to 30 days, which is the time in which grading activities must be completed (within a given work area) as specified by the Work Progression Schedule (Section 3.1 of the Generic EPP). If nesting birds are observed, then work in that area will be avoided and NSDNR, CWS and the Project Engineer will be consulted for direction (see Section 2.2 of the Generic EPP).

No bats were observed in the Assessment Area, but three species (little brown myotis, northern long-eared myotis and eastern pipistrelle) may occur in this region. Highway construction activities could potentially affect bats through direct mortality of roosting bats as a result of the felling of roost trees. Most clearing and grubbing will occur during the winter months so the potential for direct mortality of adults and pups as a result of loss of roost trees will be largely eliminated.

In consideration of the potential environmental effects of Project-related activities during construction and the proposed mitigation, the residual environmental effects of the construction of the Project on the risk of mortality or physical injury to wildlife are predicted to be not significant.

Operation and Maintenance

Operation of the Project could result in an increased risk of mortality or physical injury for wildlife due to the potential for collisions with vehicles, as well as the potential for wildlife to be harmed during vegetation and winter maintenance activities.

Roadkill is generally not considered as a significant source of mortality for bird populations (Leedy and Adams 1982). This is supported by a study which demonstrated that the survival rates of male willow warblers (*Phylloscopus trochilus*) were equal in areas near and far from highways (Reijnen and Foppen 1994). Mammals are more susceptible to collisions with automobiles than birds due to the facts that they are less able to avoid traffic and are generally active at night. A study of road kill in Nova Scotia collected data on mammal road kills on various highway classes in Nova Scotia. The number of deer expected to be killed by collisions on a four lane, 100 series highway was 0.14 kills/km/year. For small mammals, including raccoon, porcupine and skunk, the rate is 6 kills/km/year (Fudge *et al*. 2007). The section of highway being twinned for this Project is 9.5 km long. The total number of deer killed along the proposed highway each year is therefore estimated to be approximately one, and the number of small mammals expected to be killed is 57. The species which can be expected to account for most of the road kills are raccoon and striped skunk. Because the Project consists of twinning an existing highway, it is unlikely that the Project will cause a substantial increase in road kill.

Vegetation management will be conducted by mechanical clearing during highway operation (*e.g.,* road shoulders and interchanges). It is possible, despite the disturbance from passing vehicles, that the open habitats in medians, ditches, and/or side slopes may be used as breeding habitat by species such as savannah sparrows and song sparrows. Mowing and brush cutting of the vegetated slopes and drainage ditches could destroy the nests of these birds, causing mortality or injury to nestlings. The maintenance branch of NSTIR mows the grassy edges and medians of the Province's highways, as required, usually once per year, for safety and partially for aesthetic reasons. Vegetation cutting will occur within the highway RoW in areas that had already been disturbed as a result of construction activities. Vegetation cutting (mowing) can result in fewer wildlife/vehicle collisions when viewing conditions for motorists are maximized.

Given the mitigation to avoid maintenance activities such as mowing of the RoW during breeding season, these activities are not expected to have substantial effects on local bird populations.

During winter maintenance, consumption of de-icing brine by birds can cause narcosis that can result in increased rates of collision with automobiles. Adherence to the NSTIR Salt Management Plan, which specifies application rates and designates vulnerable areas, will reduce the environmental effects to wildlife habitat.

In consideration of the potential environmental effects of the individual activities required for the operation and maintenance phase of the Project and the proposed mitigation, the residual environmental effects of operation and maintenance of the Project on the risk of mortality or physical injury to wildlife are predicted to be not significant.

5.6.8 Monitoring and Follow-up

No specific follow-up and monitoring is recommended.

5.7 LAND USE

Land use was selected as a VC in consideration of potential Project-related interactions with current and anticipated land uses near the proposed Project. These areas included the immediate vicinity of the Project and surroundings such as Three Mile Plains, Windsor, and Falmouth.

The discussion of land use also considers agricultural marsh bodies and current use of lands and resources by Aboriginal persons, including lands and resources of social, cultural, or spiritual value to the Mi'kmaq of Nova Scotia, with a focus on current use of land and resources (including terrestrial and freshwater resources) for traditional purposes.

The land use VC has linkages to the following other VCs: Archaeological and Heritage Resources (Section 5.8), Aquatic Environment (Section 5.3), Vegetation (Section 5.4), Wetlands (Section 5.5), and Wildlife and Wildlife Habitat (Section 5.6).

5.7.1 Regulatory and Policy Setting

The Project is located in the Town of Windsor and the Municipality of West Hants, Nova Scotia. In Nova Scotia, communities are enabled to create legally binding Municipal Planning Strategies (MPS) in compliance with the Province of Nova Scotia's *Municipal Government Act*. Among other things, an MPS outlines the overarching growth and development strategy for a planning area, presents the environmental constraints for potential development at various locations, and determines the permitted land uses of an area via zoning determinations. The Town of Windsor and the Municipality of West Hants each have an MPS and associated land use bylaws. Land use planning for Windsor and West Hants areas is coordinated through the Windsor-West Hants Joint Planning Advisory Committee. The role of the committee is to review planning issues and development proposals that will have a regional impact.

The Town of Windsor Municipal Planning Strategy and Land Use Bylaw were adopted in 2005 and amended in 2012. The Municipality of West Hants Municipal Planning Strategy and Land Use Bylaw were adopted in 2008 and amended in 2015. Both planning strategies have designated Highway 101 as a regional road given this highway is the provincial access highway connecting Halifax, the Annapolis Valley and southwest Nova Scotia. Both municipal planning strategies note the importance of Highway 101 and the future twinning in increasing access to the nearby communities and potentially leading to increased development (Town of Windsor 2012; Municipality of West Hants 2015).

The proposed Project crosses three agricultural marsh bodies, NS14 Elderkin, NS68 Tregothic and NS75 Armstrong Marsh (see Figure 5.7 and van Proosdij 2009). The three marsh bodies are incorporated under the *Agricultural Marshlands Conservation Act* and managed by the Land Protection Section of NSDA, as part of the provincial marshlands, 17,400 ha (43,000 acres) and 241 km of protective dykes and 260 aboiteau structures. Staff are engaged with various marshland stakeholders including other government departments, marsh bodies, municipalities, landowners, and community groups. The dykes are mowed annually to maintain a grass cover protecting against wave action, failure, and weed control. The dykes and aboiteau are repaired and maintained to prevent breaches from storms and high tides, and continued efficient operation.

With respect to Aboriginal land use, there are two key Mi'kmaq guidelines which have influenced the EA process for this Project: Proponent's Guide: *The Role of Proponents in Crown Consultation with the Mi'kmaq of Nova Scotia* (NSOAA 2011); and the Mi'kmaq Ecological Knowledge Study Protocol (Assembly of Nova Scotia Mi'kmaq Chiefs 2014). A Project-specific Mi'kmaw Knowledge Study (MKS) was completed by the Confederacy of Mainland Mi'kmaq (CMM) in 2004 and was updated in November 2016. The purpose of the MKS, now referred to as a Mi'kmaq Ecological Knowledge Study (MEKS), is to support the integration of Mi'kmaq knowledge of use and occupation and identify Mi'kmaq traditional use activities that have taken place or currently are taking place near the Project. The MEKS predominantly involves archival research and interviews on current Mi'kmaq land and resource occurring within "living memory" and addresses current Mi'kmaq land and resource use sites and plants of significance to Mi'kmaw communities.

5.7.2 Boundaries

The assessment of potential environmental effects on land use encompasses the following spatial boundaries: the Project Development Area (PDA) and the Assessment Area. The PDA (*i.e.,* footprint of physical disturbance) is defined in Section 4.2.1. The Assessment Area includes the PDA as well as adjacent communities (*e.g.*, Three Mile Plains, Windsor, Falmouth), where Project activities could potentially interact with current and anticipated land uses.

The temporal boundaries for the assessment of the potential Project-related environmental effects on land use include the construction and operation and maintenance of the Project in perpetuity. Certain aspects of land use and community life (*i.e.*, recreational activities and economic activity related to tourism) are seasonal and will be affected to a greater or lesser extent according to the timing of the Project interaction.

5.7.3 Significance Definition

A **significant residual adverse environmental effect on land use** will occur if proposed activities are not compatible with adjacent land or resource use activities as designated through the municipal land use planning process, and/or the proposed use of the land will create a change or disruption that widely restricts or degrades the present land or resource use to a point where activities cannot continue at current levels and for which this change is not mitigated.

A **significant adverse residual environmental effect on current use of land and resources for traditional purposes by Aboriginal persons** is defined as a Project-related environmental effect that results in a long-term, unaccommodated loss of the availability or access to land and resources that are currently used by the Mi'kmaq for traditional purposes, such that these lands and resources cannot continue to be used by the Mi'kmaq at current levels for extended periods of time.

5.7.4 Description of Existing Conditions

5.7.4.1 Methods

A combination of spatial analysis and baseline research was used to characterize the types and extent of the land uses and resource use activity within the Assessment Area. Baseline research included a review of online sources, including:

- GIS databases
- municipal websites
- publicly available reports and information collected from the websites of government agencies and other sources
- incidental observations of land use by Stantec field crews during surveys completed for the proposed Project.

A Mi'kmaw Knowledge Study (MKS) was prepared by the Confederacy of Mainland Mi'kmaq in 2004 which studied Highway 101 twinning from St. Croix to Greenwood, encompassing the current Assessment Area for the proposed twinning from Three Mile Plains to Falmouth. In November 2016, this study was updated and now referred to as a Mi'kmaq Ecological Study (MEKS). The MEKS was used to describe baseline conditions for current use of lands and resources for traditional purposes including land and resource use sites, plants of significance to Mi'kmaq, and Mi'kmaw communities in the area.

5.7.4.2 Summary of Existing Conditions

The Project is located in the Municipality of the District of West Hants, and encompasses a 9.5 km section of the existing highway, from Exit 5 at Three Mile Plains to approximately 2 km west of Exit 7 at Falmouth. There are two communities in the immediate vicinity of the Assessment Area: Falmouth and the incorporated Town of Windsor, and additional properties along the proposed highway RoW.

Table 5.7.1 provides statistics from 2011 on the population and dwelling counts of Windsor and Falmouth compared to the Municipality of West Hants, and Nova Scotia.

Table 5.7.1 2011 Population and Dwelling Counts

Data	Windsor	Falmouth	Municipality of West Hants	Hants County	Nova Scotia
Population in 2011	3,785	1,213	14,165	42,304	921,727
Total Private Dwellings	1,669	486	6,205	18,141	442,155
Population Density (individuals per sq km)	417.8	232.4	11.4	13.9	17.4
Land Area (sq km)	9.06	5.22	1,241.95	3,051.73	52,939.44

Source: Statistics Canada 2011

The Town of Windsor and surrounding area prides itself on providing its residents with the benefits of rural living as well as convenient proximity to metropolitan Halifax. As the first substantial community encountered by travelers moving west from the Halifax area into the Annapolis Valley, Windsor has become an attractive option for commuters to the city (Stantec 2010). Travel time between Windsor and Halifax has declined steadily over the past two decades as Highway 101 between the two centres has been gradually expanded to four separated lanes, and therefore has increasingly become a bedroom community for Halifax and, to some extent, a retirement centre (Stantec 2010). Geographic location provides Windsor with opportunities for growth that generally exceed options available to most other small towns in Nova Scotia.

The Municipality of West Hants also continues to experience growth in the Municipality, particularly focused on the growth centres in Three Miles Plain and Falmouth. Construction costs, development/building permits issued and number of lots created for the Municipality of West Hants from 2009-2015 is shown in Table 5.7.2. In 2009 there was a single development permit worth $26 million issued for a residential care facility, the Windsor Elms Village for Continuing Care, in Falmouth. Garlands Crossing, 23-lot residential subdivision, was approved in 2009.

In 2012, there was a 56% growth in the agricultural sector over 2011, due mainly to three permits issued totaling nearly $800,000 for additions to a Falmouth winery, a dairy farm operation, and a new agricultural storage building (West Hants Planning Department 2012). In 2013, key development consisted of a $400,000 expansion to a fish farm operation, a $500,000 addition to a recreational arena and $2.1 million in projects to Forest Lakes Country Club Resort in Ardoise (West Hants Planning Department 2013).

In 2014, there was another $1.25 million addition to a fish farm operation, $1 million chick hatchery, $1 million renovation to the Biovectra Pharmaceutical Company and $1 million in projects to Forest Lakes Country Club in Ardoise (West Hants Planning Department 2014).

Table 5.7.2 Annual Development Report for the Municipality of West Hants

	2009	2010	2011	2012	2013	2014	2015
Construction value	$47 million	$17 million	$16.8 million	$20.4 million	$16.4 million	$47.7 million	$26.9 million
Number of building and development permits	471	406	426	445	354	325	366
Number of new serviced residential units*	26 units	25 units	37 units	37 units	32 units	28 units	23 units
Commercial and industrial construction value	$641,000	$529,396	$779,000	$2,275,480	$593,000	$2.7 million	$7 million
Agricultural construction value	$405,000	$739,700	$731,000	$1,140,000	$725,900	$1 million	$713,500

Table 5.7.2 Annual Development Report for the Municipality of West Hants

	2009	2010	2011	2012	2013	2014	2015
Institutional and government construction value	$29,005,500	$269,478	$64,888	$182,445	$503,000	$563,000	$4 million
Number of new subdivision lots	55	39	25	44	27	29	44
*located in the serviced areas of the Falmouth and Three Mile Plains Growth Centres							

Source: West Hants Planning Department 2009, 2010, 2011, 2012, 2013, 2014, 2015

Land use in the Assessment Area is a combination of residential, agricultural, industrial, and commercial (Figure 5.9). Land use in the eastern section of the Assessment Area (Windsor) is characterized by a variety of uses (residential, agricultural, industrial, and commercial), while land use in the western section (Falmouth) is predominately residential and agricultural.

The majority of the RoW required for Project construction and operation is already owned by NSTIR and NSA. Prior to construction start, NSTIR will complete the acquisition of any properties that are required to facilitate Project completion.

Residential, Industrial and Commercial Use

Residential development within the Assessment Area occurs within the Town of Windsor and Three Miles Plains and Falmouth growth centres. In the Town of Windsor, residential development is anticipated to continue at Fairfield Park, an adult residential phased approach community. There is a development proposal currently under review for a new 3-storey, 17 unit building on Gerrish Street containing flexible ground floor space that could be used for commercial or residential purposes (Town of Windsor Department of Planning and Development 2016).

In West Hants, a 220-unit mini home park in Garlands Crossing has been developed and is continuing to expand with recent approval for Phase 4 of the development. Another nearby development has approximately four or five lots left to be developed.

There are two buildings located within the PDA and 12 buildings within the Assessment Area. Buildings consist of residential dwellings and accessory structures (*i.e.*, garages, sheds), commercial businesses and industrial buildings. The two buildings within the PDA are owned by NSDA and are associated with the Avon River causeway. The nearest residence is located on Bog Road 92 m from the centre of the existing highway. Other nearby residents include one near Exit 6, 93 m from the existing highway, one on Mt. Denson Road, 94 m from the highway and one 99 m from the existing highway on Bog Road.

There is the former Nova Scotia Textile Mill which was partially renovated into a residential/commercial building, located 60 m north of the existing highway, near Exit 6 (currently unoccupied).

Much of Windsor's commercial space is concentrated in the downtown core with several businesses along Water Street and Gerrish Street, including a small shopping mall, a pool-hall, and independent sports equipment store, and a national auto-parts store. However, the area immediately adjacent to the existing Highway 101 has experienced substantial development with newer development largely extending along Wentworth Road, which connects the older core of the town to Exit 5A on Highway 101. Wentworth Road has developed as a highway commercial area, accommodating the Fort Edward Mall, a large Superstore grocery, and assorted fast food outlets and small businesses that serve highway users and residents of the town and surrounding areas (Stantec 2010). There is a Super 8 hotel on the southern side of the existing highway, near Exit 5A (approximately 84 m from the PDA).

There are two industrial parks in the immediate vicinity of the existing highway: the Windsor Industrial Park, located adjacent to the Exhibition Grounds just south of Exit 5A, and the Windsor-West Hants Joint Industrial Park, located at the Highway 101-Wentworth Road interchange, north of Exit 5A. The Windsor-West Hants Joint Industrial Park is developing strongly with highway-oriented commercial uses occupying 12.4 ha (Stantec 2010). The parks are both mostly developed, and the resident businesses would be considered light industrial. However, there are several businesses, such as a bowling alley and car wash that are classified as commercial uses. Other, more industrial enterprises include: the Annapolis Valley Ready Mix Concrete Plant; Heritage Memorials Ltd.; a monument manufacturing plant; several automotive repair services; an ambulance bay; and other commercial services typical of these parks.

A wastewater treatment facility was built in 2011 to address the Town of Windsor's long-term sewage treatment requirements located adjacent to Highway 101 along Colonial Road, 62 m from the existing highway edge.

The Windsor and Hantsport Railway Company (WHRC), owned by the Iron Roads Railways, started operations in August 1994, after purchasing the rails from Canadian Pacific. It is a 90 km 'short line' railway operating between Windsor Junction (north of Bedford) and New Minas, with a spur at Windsor which runs several kilometres east. Most WHRC traffic originated at the two gypsum quarries on the spur running east of Windsor, whereby the gypsum was hauled by unit trains to the port at Hantsport. Until the closure of the Fundy Gypsum mine in 2011, the busiest spur on the line ran through the PDA, from the mine to the port at Hantsport. The WHRC is currently inactive. The old train station building is located 88 m from the existing highway.

Gypsum deposits within West Hants have supplied mining operations for over 200 years (Municipality of West Hants 2015). Until 2011, the Fundy Gypsum Company, located between Exit 5 and Exit 5A, was actively extracting gypsum and anhydrite from the Wentworth Creek Quarry location. It was announced in 2011 that the mine that had been in operation since 1934 was permanently closing. Past local gypsum mining (Fundy Gypsum Company) has altered the local landscape, removing natural habitats present within open mine boundaries, and impacts to surrounding land uses. The mining industry; however, had an important economic impact on West Hants providing up to 150 jobs and spin-off employment with companies such as the WHRC (Municipality of West Hants 2015).

Recreational Use

There are several notable recreational areas near the existing highway. The Pisiquid Canoe Club, located 97 m from the existing highway, uses Pisiquid Lake, the freshwater lake created by the construction of the Avon River causeway. The boathouse for the club is located on the most northeastern shore of the lake, at the point where the causeway meets land.

In that same area is a walking path that starts on property owned by WHRC. The trail follows the causeway and loops the shore of Pisiquid Lake. There is also a basketball court located at the trailhead. The Sam Slick Coach House, home of the Sam Slick Society, is located across the small parking lot from the boathouse. This society organizes the annual Avon River Days (formerly Sam Slick Days), a festival that celebrates family reunions, and the town's history and cultural roots (Town of Windsor n.d.).

Adjacent to the proposed highway RoW at Exit 5A is the Exhibition Grounds. The Windsor Agricultural Centre own this property, and hosts an annual county fair in addition to other regular recreational sport (*e.g.,* hockey) and hobby events (*e.g.,* horse shows, car shows and flea markets) that occur at the onsite arena. There is also a permanent go-cart track and waterslide on the grounds.

For recreation, sports, and leisure interests in the area, there is a broad range of available opportunities. Recreation facilities include a Hants County War Memorial Community Centre, the Avon Valley Golf and Country Club, an outdoor pool, a tennis club, a bowling centre, a skate-park, a beach volleyball court, several playgrounds and basketball courts, and a regional library. The historic Windsor Curling Club, which was soon to celebrate its centennial anniversary, burnt down in 2007. The curling club was rebuilt in October 2008, thirteen months after the fire. There are several ball parks, a canoe club, an indoor rink, and several walking trails offering many options for indoor and outdoor active living opportunities. The Hants Aquatic Centre, a recreational feature located in Elmcroft Park, is a facility including an outdoor pool, community building, bath house, and small walking trail.

The Town of Windsor and surrounding areas are located within Zone Three of the Snowmobilers Association of Nova Scotia (SANS) trail system (SANS n.d.). The 101 main corridor snowmobile trail travels southwest from Windsor to Middleton, before turning northwest, where it follows Highway 101 to Kentville. There are no designated trails that would be affected by the proposed Project (SANS n.d.).

Historic Fort Edward, located in the town of Windsor, is the oldest Acadian blockhouse of its kind in North America, and the last surviving blockhouse in Nova Scotia. Built by the British in 1750, Fort Edward was used to guard the on-land route between Halifax and the Bay of Fundy. It also served as a detention centre for more than 1,000 Acadians who were being deported between 1755 and 1762. This historic destination is open for visitation between the months of June and September.

There are other popular museums in the town of Windsor, including The Shand House Museum, an ornate late Victorian house built by the Shand family in 1890-91, with many of the things acquired and used by the family still on display (Nova Scotia Communities, Culture, and Heritage 2016). Another is the West Hants Historical Museum, located in a former Methodist Church, where the West Hants Historical Society collects and preserves artifacts and historical information related to Hants County (West Hants Historical Society n.d.). The Windsor Hockey Heritage Museum is located in the Haliburton House and provides artifacts and history from the beginning, evolution and development of ice hockey (Windsor Hockey Heritage Society n.d.)

The Tregothic Creek and Windsor Railway is situated in the Town of Windsor, immediately adjacent to Highway 101. The historic site, run by the Atlantic Model Engineering Society, is open from May to October for tourists and community members to visit. The railway is 1/8 scale, almost 1 km long, and provides trips on the miniature passenger-carrying train.

Martock Ski Hill is very popular area for tourism, recreation, and fitness, and one of the sites for the 2011 Canada Winter Games. Located off Exit 5, this 183-metre-high mountain has 100% snowmaking on all of its seven trails, including a terrain park and half pipe. All of the downhill trails are lit for night skiing and snowboarding, and there are cross country tails to explore in the daylight hours. Martock depends on freshwater from the Avon River to make snow for skiing operations during winter months.

Resource Use

There is 0.34 ha of forested land in the PDA and 6.6 ha in the Assessment Area; however, these lands are not actively used for forestry operations.

There is 20.1 ha of agricultural land located within the PDA and 45.7 ha within the Assessment Area. For the most part, these properties are used for livestock grazing and pasture lands. During field surveys, a field with beef cattle grazing was observed between the Avon River causeway and Exit 7.

Dykes are an important agricultural feature in the Windsor area to prevent seawater inundation and are ditched to allow for freshwater drainage. The dykes contain aboiteaux that open gates on the seaward side of the structure when the tide is low to allow for freshwater drainage and close when the tide is high to prevent saltwater contamination of the farmland behind the dyke (Government of Nova Scotia 2015). The Avon River causeway is the most prominent dyke structure in the area. Constructed from 1968 to1970, it crosses the Avon River just south of the St. Croix River, and was part of the construction of the original Highway 101. The causeway controls the Avon River's discharge and the incoming tidal waters of the Minas Basin through two flood control gates. Approximately 1,376 ha of high quality and best-utilized farmland are protected by the causeway dyke (Government of Nova Scotia 2015). In addition to the protection of farmland, the causeway created a freshwater lake, Lake Pisiquid, and is a water supply for the nearby Ski Martock to use in its snow making equipment during the winter season (Government of Nova Scotia 2015).

The provincial government (NSDA) is responsible for the maintenance and operation of the water control structure on the Avon River causeway. Originally, manually operated gates had only two settings (open and closed); now the gates can be opened at several settings and automatically open on the falling tide when the lake level exceeds the target which is set by the gate operator. However, even with this improvement, target lake levels cannot be maintained consistently and depending on weather conditions, levels can fluctuate by up to 0.5 m (Government of Nova Scotia 2015).

Marshland protected by the Avon River causeway, particularly the Martock and Falmouth Great Dyke Marshlands, are some of Nova Scotia's highest quality and best utilized marshlands, managed by some of Nova Scotia's leading farmers and produce a wide variety of crops (Government of Nova Scotia 2015). As standing water on fields can lower crop yield, drown crops by preventing oxygen from reaching crops, and promote development of diseases, a consistently maintained lake level is key for agriculture activity.

Current Use of Lands for Traditional Purposes Aboriginal Persons

There are two Mi'kmaw communities near the Assessment Area, Annapolis Valley First Nation and Glooscap First Nation. Annapolis Valley First Nation comprises two parcels, one at Cambridge Station (immediately south of Highway 101 between Exits 14 and 15) and one in St. Croix (IR 34) (approximately 6 km south of Highway 101 at Exit 4). Glooscap First Nation, which is the closest Mi'kmaw community to the Project, consists of one parcel, located approximately 3 km south of Highway 101 between Exits 8 and 8A.

A description of baseline conditions for current use of lands and resources for traditional purposes includes consideration of land and resource use sites, plants of significance to Mi'kmaq, and Mi'kmaw communities.Current Mi'kmaq land and resource use activities are divided into five categories:

- kill/hunting (*e.g.*, game/fish)
- burial/birth
- ceremonial (*e.g.*, ceremonial plants)
- gathering food/medicinal
- occupation/habitation (*e.g.*, group campsite).

Current traditional land and resource use activities that occur within the MEKS Study Area include hunting/fishing eel and mackerel and gathering berries, wild fruit, specialty wood, and decoration plants (CMM 2016). As shown on Figure 2 of the MEKS (Appendix F), some of these areas for land resource use overlap with the Assessment Area for the Project.

Spring and fall plant surveys conducted as part of the MEKS identified several plant species of significant to the Mi'kmaq in three categories: medicinal, food/beverage, and craft/art. These survey areas are also denoted on Figure 2 of the MEKS (Appendix F) and show areas of overlap with the Assessment Area for the Project.

5.7.5 Potential Environmental Effects and Project-Related Interactions

Activities and components could potentially interact with land use by disrupting existing uses. The assessment of Project-related environmental effects on land use is therefore focused on the following potential environmental effect:

- change in land use
- change in traditional use.

5.7.5.1 Change in Land Use

Construction

Residential, Industrial and Commercial Use

During construction activities, potential Project-related environmental effects on residential land use adjacent to the PDA include a potential loss of enjoyment of residential property (as a result of noise, dust, and other air emissions) and a change to, or loss of, access to property. There are no residential dwellings within the proposed PDA; however, there are several buildings, including residential dwellings that could be affected by noise or dust associated with construction activities (refer to Section 5.1).

Commercial and industrial land use in the Town of Windsor and surrounding areas may experience some traffic disruptions along the existing highway at various points along the PDA as a result of construction activities.

Recreational Use

During construction, potential Project-related environmental effects on recreational use include noise, dust, and air emissions. This may reduce the quality of experience for recreational users. The upgrading of the aboiteau has potential to change water levels of Pisiquid Lake and therefore, could potentially affect the recreational use of this lake temporarily. Access to the immediate area of construction will be limited for safety reasons that may cause disruption to normal recreational use as regular points of access thoroughfare may be inaccessible for periods of time. For instance, access to the walking path that follows the Avon River causeway may be restricted during construction phases. Construction activities may cause traffic disruptions on transportation routes to nearby attractions, including the Avon Valley Golf Course, Ski Martock, and the Annapolis Valley.

Resource Use

Construction activities may result in the permanent loss of merchantable forest resource as a result of the clearing of the RoW. There is 0.34 ha of forested lands within the PDA and 6.6 ha in the Assessment Area; however, this land is not actively used for forestry operations. Forestry activity is therefore not discussed further in this assessment.

Agricultural activity that occurs in the immediate area surrounding the proposed Project is used for livestock grazing and pasture lands; however, there are no major agriculture operations along the RoW. The potential environmental effects of construction on agricultural activities include the loss of small portions of property intersected by the Project RoW and the loss of agricultural resources. Access to portions of agricultural lands adjacent to the PDA may be interrupted or changed for safety reasons during construction (*e.g.*, near Exit 7). Construction activities associated with the Avon River causeway have the potential to affect lake levels and therefore may affect crops within the three adjacent marsh bodies. Should the lake levels increase, farmland may not be able to drain effectively after rainfall events and can lower crop yield (Government of Nova Scotia 2015).

Operation and Maintenance

There are several residential, commercial and industrial properties located along the existing Highway 101. During the operation of the Project, these properties may experience noise and air emissions that result from the operation and maintenance of the Project.

During the winter, salt will be used for winter maintenance and may affect land in the immediate vicinity of the Project. Salt is presently used along the existing highway; however, the additional lanes will require an increase in the amount of salt used.

It is not expected that any recreational use will have to be permanently relocated during operation of the Project. Also, operation of the upgraded aboiteau will not result in changes to existing lake levels such that recreational uses associated with Lake Pisiquid would be affected.

5.7.5.2 Change in Traditional Use

Construction

Construction activities have potential to affect Mi'kmaq land and resource use for current and future generations. Project components could potentially interact with traditional land and resource use by restricting access to the PDA during construction which could constrain Mi'kmaq fishing, hunting, and gathering opportunities as well as the availability of resources used for traditional purposes. However, given the presence of the existing highway and relatively small overlap with the PDA (most resource use areas extend away from the existing highway onto undisturbed lands), this interaction is expected to be limited.

Operation and Maintenance

During operation and maintenance, the presence of permanent infrastructure associated with the Project could restrict Mi'kmaq fishing, hunting, and gathering opportunities. It is not expectedhowever, that traditional use will be permanently affected or required to be relocated during operation of the Project.

5.7.6 Mitigation

Mitigation measures to be implemented to reduce potential Project-related effects on land use and traditional use during construction and operation and maintenance are presented in Table 5.7.3. Mitigation measures identified in Sections 5.1, 5.2, 5.3, 5.4, and 5.6 to reduce effects on atmospheric environment, groundwater resources, aquatic resources, vegetation, and wildlife and wildlife habitat will also act to reduce effects on land use.

Table 5.7.3 Mitigation for Land Use

Effect	Phase	Mitigation
Change in Land Use	Construction	• Follow Generic EPP (Sections 3.12 and 3.13) that includes guidelines for reducing noise and air emissions • Reduce dust through the application of water • Fair market value compensation for lands acquired during RoW acquisition process • Maintain access to lands where possible • Standard traffic control procedures including temporary detours, if necessary • Reasonable accommodation to allow forestry / agricultural operations access to adjacent lands during construction as applicable • Communication of Project schedule with local stakeholders, particularly with regard to the upgrading of the aboiteau and potential effects on Lake Pisiquid water levels
	Operation and Maintenance	• Follow Generic EPP (Sections 3.12 and 3.13) that includes guidelines for reducing noise and air emissions • Follow NSTIR Salt Management Plan
Change in Traditional Use	Construction	• Access restrictions will be defined in advance and will be limited in size to reduce interactions with land and resource users.
	Operation and Maintenance	

5.7.7 Residual Environmental Effects and Significance Determination

The assessment of residual environmental effects considers effects on land use after the general mitigation measures, as provided above, have been implemented.

5.7.7.1 Change in Land Use

Construction

Residential, Industrial and Commercial Use

Project-related environmental effects on adjacent residential land uses include the loss of enjoyment of their property from dust and noise during construction activities. As discussed in Section 5.1, air emissions will include dust and exhaust emissions during construction. Control measures, such as the use of dust suppression techniques, will be used in construction zones to reduce dust. Air emissions will be maintained within the limits specified by the Nova Scotia *Air Quality Regulations* (*Environment Act*). As discussed in Section 5.1.7.2, noise levels may not be within the Guidelines at all times, particularly in areas that already experience higher noise levels due to the operation of the existing highway. These levels, however, are not expected to be sustained over a long period or on a frequent basis.

Commercial and industrial land use in the Town of Windsor and surrounding areas are not expected to be affected during construction phases, as most construction will occur along the existing alignment. However, some temporary traffic disruptions along the existing highway may occur at various points along the alignment. Disruptions in traffic flow may include change in access, delays and increased wait times. Standard traffic control procedures will be implemented to reduce traffic interruptions and maintain traffic continuity.

Although the railway is currently inactive, NSTIR will communicate with WHRC regarding Project activities and scheduling.

Recreational Use

Construction activities can interact with recreational land use. The upgrading of the aboiteau at the Avon River causeway has potential to temporarily change the water level of Pisiquid Lake. However, it is proposed that aboiteau work be timed to coincide with the regular planned drawdown of the lake which occurs annually for regular maintenance of the existing aboiteau. Lake Pisiquid is used by boaters in the Town of Windsor and surrounding areas, including for several well-known events throughout the boating season such as the annual Giant Pumpkin Regatta. It is important that boaters and swimmers are aware of potential changes to the water levels as lower water levels can create unpredictable currents and shoals that could but boaters and swimmers at risk (Government of Nova Scotia 2015). A committee representing most of the stakeholders with interest in the lake levels was put in place in 1985 to establish benchmarks levels suitable to meet the needs of the lake users. NSTIR will communicate Project schedule and potential water level changes to the committee as well as other applicable stakeholders as part of the ongoing CLC (see http://hwy101windsor.ca/).

Traffic disruptions resulting from construction are anticipated to be infrequent and short in duration. Access to the walking trail that follows the Avon River causeway across the Avon River may be restricted during certain phases of construction; however, reasonable accommodation will be made to maintain access to this trail during construction, and to allow for parking at the trail head, near the WHRC.

Effects to recreational use are anticipated to occur only during construction and should cease during operation of the highway.

Resource Use

The Project-related environmental effects on agricultural land use are related to the removal of and/or access to the lands during construction. Approximately 20.1 ha of lands classed as agricultural lands will be affected within the PDA (refer to Figure 5.9). This calculation is based on land use classifications; actual agricultural use of lands would be less than represented by mapping. Mitigation for productive land loss is through compensation for lands acquired, used, or otherwise affected by the Project. Reasonable accommodations will be made to allow operations access to adjacent lands during construction.

Marshlands used for farming outside of the PDA may be affected should there be a change in water levels of Lake Pisiquid during construction activities. It is anticipated; however, that the aboiteau will remain in operation during upgrading activities to allow the operators to continue monitoring water level and to maintain consistent water levels during construction activities.

Summary

In consideration of the potential environmental effects of the Project-related activities during construction, the proposed mitigation, and the significance definition, residual environmental effects of the construction of the Project on land use are predicted to be not significant.

Operation and Maintenance

The Project may result in a reduction of use and enjoyment of residential and recreational land near the proposed Project when the new highway is in operation due to increased levels of noise and air emissions. However, based on the predicted noise levels (as described in Section 5.1) and the presence of the existing highway, these levels are generally not expected to exceed those of the existing highway for most receptors. Infrastructure and vegetation maintenance will generate dust, noise, and air emissions similar to those during construction, only considerably less in magnitude, extent, and duration. Dust will be mitigated though the application of water when required, and noise will be mitigated through noise controls on equipment (refer to Section 5.1).

Winter road maintenance may affect land use in the immediate vicinity of the Project. The twinning of Highway 101 will increase the quantity of salt required for winter maintenance; however, the implementation of the NSTIR Salt Management Plan will reduce potential effects. Therefore, it is not expected that winter maintenance activities will result in damage to nearby agricultural activities.

Operation and maintenance of the upgraded aboiteau is not expected to affect land use since it is anticipated that the upgraded aboiteau will regulate water levels in Lake Pisiquid similarly to the current aboiteau and will require no additional maintenance activity (including lake lowering) than already occurs.

The proposed Project will take place within an existing transportation corridor and traffic levels not expected to greatly change and it is expected that traffic will move more safely and efficiently which should benefit the travelling public as well as land users in the Assessment Area that depend on safe and efficient roadway for business and other uses.

Summary

In consideration of the potential environmental effects of the Project-related activities during operation and maintenance, the proposed mitigation, and the significance definition, residual environmental effects of the operation and maintenance of the Project on land use are predicted to be not significant. It is expected that the operation of the proposed highway Project will contribute social and economic benefits in the nearby area (refer to Section 1.2).

5.7.7.2 Change in Traditional Use

Construction

Changes in traditional land and resource use may result in direct and indirect disturbance to or loss of resources traditionally harvested on the lands in the Assessment Area. Several species of significance were noted in the MEKS as being harvested by the Mi'kmaq in the MEKS Study Area which overlaps with the Assessment Area of the EA. Communication and engagement with the Mi'kmaq will be important prior to and during construction activities. During construction activities, there will be a loss of access to lands within the PDA used for traditional activities including fishing and gathering. This loss of access will be temporary for the construction of the Project. There may also be a permanent loss of some plant specimens of significance. However, the loss of these specimens does not represent a threat to Mi'kmaq use of these species (CMM 2016).

In consideration of the potential environmental effects of Project-related activities during construction, the findings of the MEKS, the proposed mitigation, and the significance definition, residual environmental effects of the construction of the Project on traditional use are predicted to be not significant.

Operation and Maintenance

During operation and maintenance, the presence of permanent infrastructure associated with the Project could similarly restrict Mi'kmaq fishing and gathering opportunities. As indicated in the MEKS, permanent loss of some specimens of plant species of significance to Mi'kmaq is evaluated as not likely significant (CMM 2016). Species identified within the MEKS are considered common and abundant throughout Nova Scotia and it is anticipated that areas for fishing and gathering are available for Mi'kmaq use outside of the PDA. It is therefore expected that these resources can be readily accessed by the Mi'kmaq for traditional use in adjacent areas.

In consideration of the potential environmental effects of the Project-related activities during operation and maintenance, the findings of the MEKS, the proposed mitigation, and the significance definition, residual environmental effects of the operation and maintenance of the Project on traditional use are predicted to be not significant.

5.7.8 Monitoring and Follow-up

No follow-up or monitoring is recommended for the Land Use VC (refer to Section 5.1.8 for potential follow-up and monitoring related to air quality and noise effects).

5.8 ARCHAEOLOGICAL AND HERITAGE RESOURCES

Archaeological and heritage resources is a VC in recognition of the potential interest of the Mi'kmaq of Nova Scotia, the general public, and provincial and federal regulatory agencies in ensuring the effective management of these resources. For the purposes of this assessment, archaeological and heritage resources are defined as any physical remnants found on top of and/or below the surface of the ground that inform us of past human use of and interaction with the physical environment. These resources may be from the earliest time of human occupation up to the relatively recent past and include both built and depositional resources.

Heritage resources are generally considered to include historic period sites such as cemeteries, heritage buildings and sites, monuments, and areas of significance to Aboriginal communities (*i.e.*, the Mi'kmaq of Nova Scotia) or other groups. Also considered in this VC are paleontological (fossil) resources.

5.8.1 Regulatory and Policy Setting

All archaeological, historical, paleontological, and ecological sites located within the Assessment Area fall under the jurisdiction of the *Special Places Protection Act*, which is administered by the Nova Scotia Department of Communities, Culture and Heritage (NSCCH).

Archaeological resource impact assessments (ARIA) are conducted in accordance with a Heritage Research Permit (archaeology) issued under the *Special Places Protection Act*. Archaeological and paleontological sites considered to have value as heritage resources may not be disturbed except under strictly controlled conditions imposed by the terms of a permit issued by the Province. An archaeological survey was conducted by a licenced archaeologist for this Project in 2007 under Heritage Research Permit A2007NS053.

5.8.2 Boundaries

The assessment of potential environmental effects on archaeological and heritage resources encompasses two spatial boundaries: the Project Development Area (PDA) and the Assessment Area. The PDA (*i.e.,* footprint of physical disturbance) is defined in Section 4.2.1. The Assessment Area for archaeological and heritage resources includes the locations of all Project-related activities associated with construction, and operation and maintenance, which could involve any ground disturbance and is essentially the same as the PDA. Figure 5.11 shows the extent of the archaeological field survey conducted in 2007.

Temporal boundaries for archaeological and heritage resources consider that these resources are relatively permanent features of the environment. Construction activities carried out at any time of year can therefore affect the integrity any archaeological or heritage site encountered. Ground disturbance associated with construction will be relatively short term. However, any potential adverse environmental effect on archaeological and heritage resources will be permanent. Temporal boundaries also consider that archaeological and heritage sites may be affected in the long term by an increase in accessibility.

5.8.3 Significance Definition

A **significant adverse residual environmental effect** on archaeological and heritage resources is defined as a Project-related environmental effect that results in a disturbance to, or destruction of, an archaeological or heritage resource considered by affected Aboriginal groups, communities, or provincial heritage regulators to be of major importance due to factors such as rarity, condition, spiritual importance, or research importance, and that is not mitigated or compensated.

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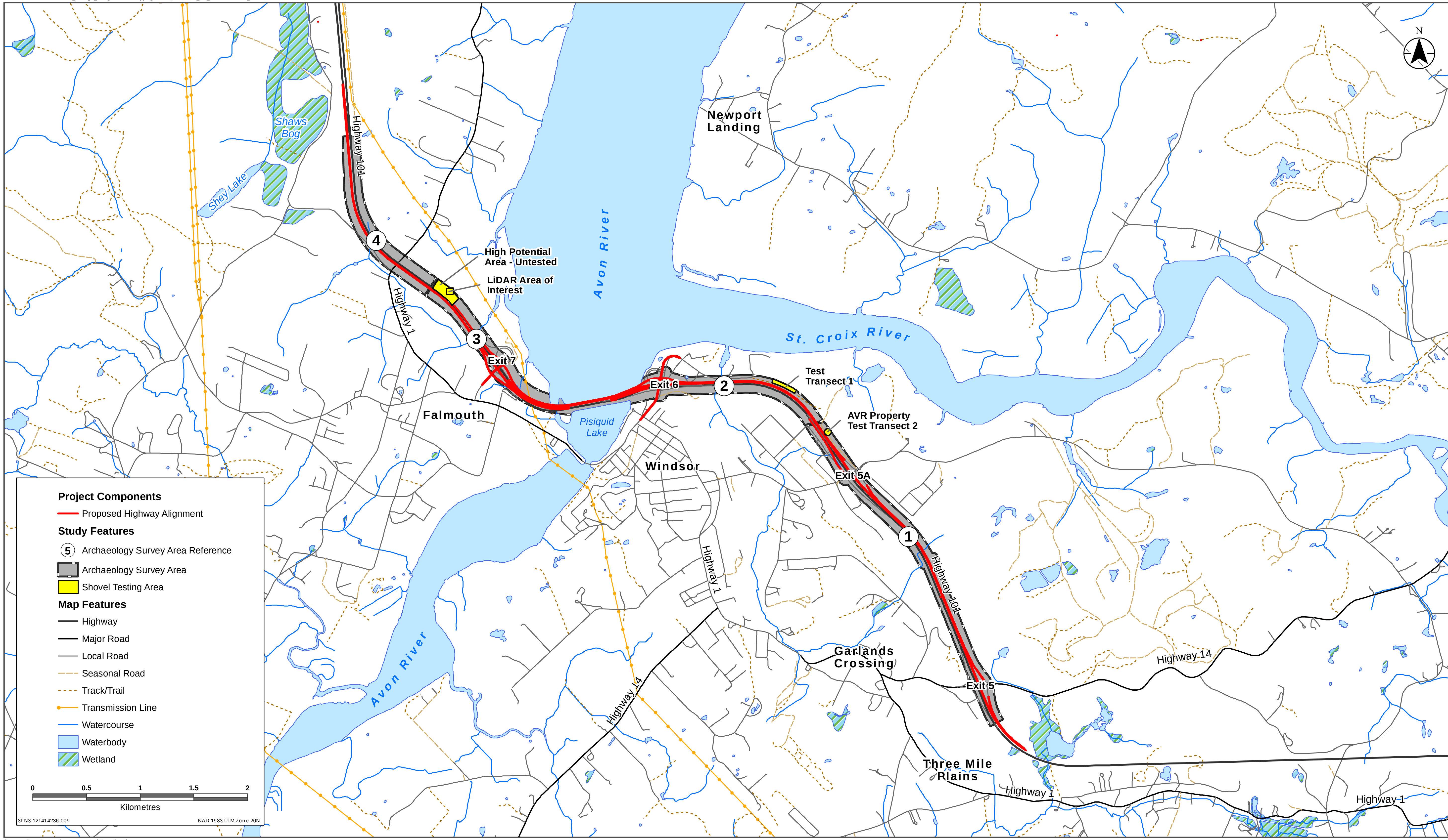

Sources: Base Data - Government of Nova Scotia

Disclaimer: This map is for illustrative purposes to support this Stantec project; questions can be directed to the issuing agency.

Archaeological Survey Locations

Stantec

ENVIRONMENTAL ASSESSMENT, HIGHWAY 101 THREE MILE PLAINS TO FALMOUTH

Figure 5.11

5.8.4 Description of Existing Conditions

5.8.4.1 Methods

The assessment of effects on archaeological and heritage resources, and in particular, assessing archaeological resource potential, is based on background research and a field survey in September, 2007 which included limited sub-surface testing of high to moderate potential areas along the PDA (Heritage Research Permit A2007NS053). Background research considered resources located at the Nova Scotia Museum, the Public Archives of Nova Scotia, as well as the Internet. The objective of this research was to identify any historic features that may have been located within the Assessment Area, mainly through the use of contemporary documents and maps.

5.8.4.2 Summary of Existing Conditions

5.8.4.2.1 Known Archaeological and Heritage Resources

There are no known archaeological and heritage resources (including paleontological resources) in the Assessment Area.

5.8.4.2.2 Potential Archaeological and Heritage Resources

Aboriginal

There is little doubt that the Mi'kmaq peoples would have been attracted to the Windsor area, particularly given its location at the confluence of the Avon and Saint Croix rivers, two major travel and trade routes. This location was also rich in food resources and allowed easy access to both the interior and coast of the province, which would have eased the twice-yearly migration of the Mi'kmaq. There are some contemporary references to the Mi'kmaq, but very few with any details. One 1744 map of the province does label a "Village Sauvage" located some distance below Pigiguit (Windsor), but does not give a more precise location. Hind describes two tribes, the Amquaret and the Nocoot, who lived 'between the head waters of the River Pisiquid (Avon) and the head waters of the River Gaspreaux' (Hind 1893:32). Hind also speaks of an "Indian Burying Ground" but, according to his description, it is located well outside of the Assessment Area (Ibid:1). The MEKS (refer to Appendix F) also describes historical Mi'kmaq presence in the region with specific references to Hants County and Windsor (CMM 2016). Although neither the MEKS nor archival research conducted by the Study Team archaeologist revealed any Mi'kmaq archaeological sites within the Assessment Area, given the historical presence and proximity to exploitable resources and major watercourses, the potential for archaeological resources must be considered as high potential.

The area of highest archaeological potential for Aboriginal resources within the Assesment Area would be where the alignment crosses the east and west banks of the Avon River. A second high potential area identified was the large tributary on the south bank of the Saint Croix, just northeast of Fort Edward. It is likely; however, that any potential Aboriginal archaeological resources were adversely affected by the construction of Highway 101 as well as other industrial activities in the area.

Historic Period

The Windsor area, originally known as Pisiquid, was settled in the late seventeenth century, as a result of Acadian expansion out of the Annapolis River area into the Minas Basin. The Acadian farmers used a system of dykes to drain water from the salt marshes so they could be converted to fields, mainly for the growing of wheat. In general, the Acadians built their houses very close to the water, usually on whatever high ground was convenient. The Pisiquid area was ideal for Acadian agriculture and it also offered easy marine access to the Bay of Fundy. By 1714 there were 56 families (300 people) near Avon, Kennetcook, and Saint Croix rivers and, by 1748 that number had increased to 2,700. A 1744 map found in Dunn (1985) shows only a settlement labeled Pigiguit located perhaps a little southwest of present-day Windsor. A 1748 map by Charles Morris shows Acadian settlements along the southeast bank of the lower Avon River as well as on the northeast bank of the Saint Croix (Dawson 1985:110). In 1713, the Treaty of Utrecht gave the English control of mainland Nova Scotia and the majority of Acadians found themselves no longer a part of France. This was a situation the English were never comfortable with and, with the increasing French presence in Louisbourg, they decided to exert more control in the Minas Basin area. In 1750, they built Fort Edward that was to house a small garrison that would be responsible for Pisiquid. This English mistrust culminated in the well-documented Expulsion of 1755 when Fort Edward became a main collection point for the captured Acadians.

Sometime after the Expulsion, Pisiquid became Windsor and its river became the Avon. The economic loss of the Acadians was significant and the English took steps to bring settlers into the Windsor area. Between 1759 and 1760, 100 New England settlers, later known as Planters, were settled in the Newport and Falmouth areas, on the north bank of the Avon. The next wave of immigrants was in 1783 when the Loyalists arrived.

Windsor thrived into the nineteenth century and became an important centre for business, including shipbuilding. Much of the town, including the wharves, was destroyed by fire in 1897 (Vaughan 2006:33). The Assessment Area is shown on two early nineteenth century maps of Windsor, Anson (1820) and Wentworth (1827), but there are no features of interest evident on either map. A 1909 Geological Survey of Canada map is somewhat more interesting as it shows a small cove at the mouth of the tributary of the Saint Croix northeast of Fort Edward. This may have been the result of industrial activity relating to the shipbuilding industry. It is likely that the cove has been filled in by silt generated by the construction of the causeway as almost nothing of it remains.

Based on the background research, the archaeological potential for the Windsor area would be considered high, particularly for Acadian period sites. These high potential areas would be any elevated ground on the north side of the existing highway that allowed easy access to the dyked salt marshes. The highest potential appears to be at the west end of the Assessment Area and perhaps in the area just before Highway 101 veers to the southeast, near Exit 5a. The east end of the alignment appears to have been almost completely disturbed by a combination of highway work and gypsum mining.

5.8.4.2.3 Field Survey Results

Two archaeologists, using a combination of windshield and pedestrian surveys, surveyed the total length of the Assessment Area in September 2007. The surveys are summarized below according to geographical areas designated on Figure 5.11.

Survey Area 1

This area runs from Exit 5 north to just beyond Exit 5a. The first 1.7 km of this area is within the gypsum mine and the land was observed to be disturbed by gypsum mining operation, which would have previously affected any archaeological resources. The next 600 m is along the east side of a hill and has been affected by the construction of the existing Highway 101. This area would have been considered low potential for the presence of archeological and heritage resources even prior to this disturbance. There are no resources here that would have attracted Aboriginal people and there is too much of a slope on which to build a house. The next 700 m is an open, developed area on the north side of the hill, but the alignment has been affected by a combination of Highway 101 construction and business/residential development. The final 500 m is open fields that are slightly low at the south end and rise to a small high area in the north. There is a television broadcast structure located on top of this high ground. While this area had also been disturbed by the highway and years of cultivation, there was one section that fell on the east edge of the alignment that could be tested. It was felt that this area held a moderate to high potential for containing historic period archaeological resources, particularly those relating to the Acadian period. A total of seven shovel tests were excavated on this property, to an average depth of 48 cm, but all proved to be negative. This would suggest a low probability of encountering archaeological resources during Project construction.

Survey Area 2

This area represents the centre of the Assessment Area, from Exit 5 to just west of the causeway. Much of this area has been heavily disturbed in the past by highway construction, railway construction, and various industrial activities. This central portion of this area is mostly under cultivation and modern dykes can be seen criss-crossing it to the north and northeast, likely built on the same location as the Acadian dykes from the eighteenth century. None of these dykes will be affected. The proposed alignment parallels the current route of Highway 101 and the ground on the north side appears very unnatural. It is obvious that the highway has been built up several metres above the original grade, and there may be some disturbance related to the removal of soil from some places to use as fill. The location was further disturbed by the construction of a railway spur line that ran from the main line northwest to the road leading to the former location of the Nova Scotia Textiles plant. This resulted in a very deep cut through the original landscape and, between that disturbance and the highway construction, the northern edge of the alignment is almost completely disturbed. There was one small section of a hay field, just catching the edge of the alignment, which was elevated and seemed to be less disturbed. One line of shovel tests was dug along this edge to determine the likelihood that archaeological resources were present. A total of seven shovel tests were dug to an average depth of 58 cm, but all of the tests were negative. It was concluded that this area had also been disturbed but that it likely held only moderate potential for containing intact archaeological resources.

There is a small watercourse shown on the map about 525 m west of the shovel testing area that corresponds to the cove and tributary shown on the Geological Survey of Canada map (1909; Watercourse) (S3 – Tregothic Creek). What used to be the cove is now bermed on three sides, and the watercourse channel is almost completely artificial. There is no potential for intact archaeological resources in this area. Approximately 300 m west of the watercourse the alignment passes along the southern edge of the former Nova Scotia Textiles factory. This plant was originally operated as the Windsor Cotton Mill between 1881 and 1884 and its leaning chimney was a well-known sight to most Nova Scotians (Vaughan 2006). This site will not be affected by the proposed Project. The section of the Assessment Area between the north edge and the south, up to Exit 6, has been heavily impacted by industrial development and highway construction in the past and is considered to have low potential for archaeological resources. The area from Exit 6 across the causeway is also considered to have low resource potential.

Survey Area 3

This area begins at the west end of the causeway over the Avon River and travels over low, uninhabitable land until higher ground at Exit 7. The disturbance caused by the construction of Exit 7 is quite complete, and a municipal sewage treatment plant to the north just skirts the northern edge of the alignment. The terrain in this area is fairly elevated, but it appears to have been disturbed in the past, and the small waterway 250 m northwest of Exit 7 (S6 – Elderkin Creek) has also been altered a great deal. There is a small knoll on the north side of the waterway but it also appears to have been disturbed by the highway construction. From this point the ground slopes up to a hill in the northwest and looks to have been used as pasture for some time. The undulations in the ground in this area appear more natural than any other part of the Assessment Area. This area was identified during the survey as having a high potential for containing Acadian period archaeological resources, particularly on the southeast side of the slope. Repeated efforts to contact the landowner to gain permission for shovel testing were unsuccessful and the area was untested. However, it was confirmed after the field survey was completed, that the RoW will avoid this property.

Survey Area 4

This section contains the northwest end of the Assessment Area, where the terrain rises and moves away from the Avon River. This area displays a great deal of highway-related disturbance along the alignment. Much of the land is cleared and appears to be for pasture as opposed to cultivation. There is a single watercourse that crosses Highway 101 at this point (S8) but it is very small and almost still. There is a small ridge that also hits the highway at this point but there is nothing from the background research that indicates the presence of any concerns in this area. It appears to be a bit too far away from the salt marshes to have been used by the Acadians.

This area is considered to be of low to moderate potential for historic archaeological resources. The settlement pattern during the Acadian period would have been along the Avon River as the rivers seem to have been the transportation route of choice during that period. It wasn't until the nineteenth century (1836) that a bridge established a permanent link between Windsor to the southeast and Falmouth to the northwest and the crossing became practical (Vaughan 2006).

5.8.4.2.4 Paleontological Resources

There are no known paleontological sites in the Project area.

5.8.4.2.5 Heritage Buildings

There are no registered heritage properties within the Assessment Area.

5.8.5 Potential Environmental Effects and Project-Related Interactions

Construction activities could interact with archaeological and heritage resources through surficial or subsurface ground disturbance, potentially resulting in disturbance to archaeological and heritage resource sites, if such sites are present. In consideration of these potential interactions, the assessment of Project-related environmental effects on archaeological and heritage resources is therefore focused on the following potential environmental effect:

- change in archaeological and heritage resources.

5.8.5.1 Change in Archaeological and Heritage Resources

Construction

Certain activities associated with Project construction (*i.e.*, grading, blasting) will cause surface or subsurface disturbance that could affect archaeological and heritage resource sites. These disturbances, if left unmitigated, could result in the loss of the resource and the potential knowledge to be gained from its interpretation. As noted in Section 5.8.4.2, the Assessment Area has a low potential for Aboriginal archaeological resources. The Assessment Area also has a low potential for historic archaeological resources with the exception of the high potential area identified at the northwest end of the Assessment Area (refer to Table 5.8.1) that remains untested. It has since been confirmed that the untested property will be avoided by the RoW, although it is recommended that pre-construction testing is undertaken in this area in case disturbance is required.

Operation

There are no predicted interactions between the Project archaeological and heritage resources during the operation and maintenance phase of the Project. Therefore, this Project phase is not considered further in the assessment of this VC.

5.8.6 Mitigation

Mitigation measures to be implemented to reduce potential effects on archaeological and heritage resources during construction are presented in Table 5.8.1.

Table 5.8.1 Mitigation for Archaeological and Heritage Resources

Effect	Phase	Mitigation
Change in Archaeological and Heritage Resources	Construction	• Follow Generic EPP (Section 5.2) • Complete archaeological testing in high potential area or monitor during construction if necessary • Develop an Archaeological Resource Contingency Plan for the unanticipated discovery of an archaeological or palaeontological resource, including requirements to stop work and consult with applicable authorities including the NSCCH • Report any features, artifacts, or other cultural material discovered during testing or monitoring to NSCCH (Laura Bennett, Special Places Coordinator at the Nova Scotia Museum) prior to proceeding with construction activities • In the event that Mi'kmaw archaeological deposits are encountered during construction or operation of the Project, all work should be halted and immediate contact should be made to NSCCH (see above) and Kwilmu'kw Maw-klusagn Negotiation Office (KMKNO) and the First Nation communities of Millbrook and Sipekne'katik.

5.8.7 Residual Environmental Effects and Significance Determination

The assessment of residual environmental effects considers effects on archaeological and heritage resources after the general mitigation measures, as provided above, have been implemented.

5.8.7.1 Change in Archaeological and Heritage Resources

Construction

Project construction will cause surface or subsurface disturbance that could affect previously undetected archaeological and heritage resource sites. These disturbances, if left unmitigated, could result in the loss of the resource and the potential knowledge to be gained from its interpretation. The Assessment Area has a low potential for Aboriginal archaeological resources. The Assessment Area also has a low potential for historic archaeological resources with the exception of the high potential area identified at the northwest end of the Assessment Area. At the time fieldwork was conducted, it was not possible to obtain landowner permission for access and testing of this land. Therefore this area, which is considered to have a very high potential for historic Acadian period archaeological resources should be tested prior to start of construction activities if it is believed that this area could be disturbed as part of the PDA. If this is not possible, construction monitoring may be necessary. Based on the current design, this area is outside the predicted PDA.

Any features, artifacts, or other cultural material that is found during ground disturbance will be reported to the NSCCH prior to proceeding with construction activities. The Generic EPP (Section 5.2) contains a contingency plan for archaeological and heritage resources to address any previously unknown resources discovered during ground disturbance.

The majority of the Assessment Area has been highly disturbed by past construction activities which may have had an adverse effect on any archaeological and heritage resources. If the remaining high potential area is tested prior to construction, and proper mitigation measures are implemented, there should be no adverse environmental effects on archaeological and heritage resources.

In consideration of the potential environmental effects of the Project-related activities during construction, the proposed mitigation, and the significance definition, the residual environmental effects of the construction of the Project on archaeology and heritage resources are predicted to be not significant.

5.8.8 Monitoring and Follow-up

Assuming that the mitigation measures are implemented, no follow-up is recommended. Monitoring may be required in the high potential, untested area of the Assessment Area if the PDA is predicted to interact with this area (no ground disturbance is currently planned to occur in this area based on current design). If the construction or development of ancillary elements is planned for areas with potential for archaeological resources that have not been surveyed by a professional archaeologist, then a pre-construction archaeological assessment of these areas will be conducted prior to any disturbance.

6.0 OTHER UNDERTAKINGS IN THE AREA

Under section 12 of the Nova Scotia *Environmental Assessment Regulations*, the Minister must consider other undertakings in the area of a proposed project registered as a Class 1 Undertaking. For this EA, other undertakings that may potentially act in combination with the environmental effects of the Project have been grouped into the following categories:

- existing and planned linear features (including existing Highway 101, secondary roads, telecommunication and power lines, and railway);
- land use (including existing and anticipated residential, commercial, industrial and recreational land use); and
- resource use (including past, present, and future agricultural, mining and forestry use).

Potential environmental effects associated with these other undertakings is described below, as well as a description of the potential for these other undertaking to act in combination with the environmental effects of the proposed Project.

6.1 EXISTING AND PLANNED LINEAR FEATURES

Linear developments include roads, railways, telecommunication and power transmission infrastructure near the Project. Existing linear features in the nearby area include the existing Highway 101, Trunk 1 and Trunk 14, and other local roads. Beside the proposed Project, there is no other road development planned in the nearby area, other than routine maintenance of the roads. There is a short line railway owned by Windsor and Hantsport Railway Company within the Assessment Area; however, the railway is currently inactive. The Town of Windsor and the Municipality of West Hants manage a number of active transportation (AT) trails for local residents (http://www.town.windsor.ns.ca/days-trips-sights-and-sands.html), and planned portions of the provincial *Blue Route* cycling network (http://blueroute.ca/) and the Trans Canada Trail (http://www.trails.gov.ns.ca/tct/tcthants.html).

Linear features have the potential to result in environmental effects, including:

- air and noise emissions from operation of roadways;
- changes in groundwater quality through the use of road salt, particularly downgradient to the existing highway RoW;
- increased sedimentation and salinity in nearby vegetated areas and watercourses due to winter maintenance activities and periodic repairs required during operation of existing roadways;
- the creation of Pisiquid Lake, created by the construction of the Avon River causeway;
- a reduction of wetland and other natural habitats through removal, and indirectly through changes to wetland quality and function and adjacent habitats; particularly the existing highway has contributed to the creation of wetland habitat by acting as a hydrological barrier and impounding water long enough to promote aquatic processes; and
- increased fragmentation, potential barrier to wildlife movement and direct mortality of wildlife from collisions between vehicles and animals.

The proposed Project is anticipated to further contribute to environmental effects that currently exist as a result of linear developments (and are described in Section 5 as baseline conditions for VCs); however, it is anticipated that the contribution of Project-related effects will be reduced through the implementation of mitigation measures identified in this assessment. Cumulative effects as a result of the Project will include increased habitat loss and reduction of habitat quality as a result of habitat fragmentation, adverse edge effects and disturbance of wildlife (see Sections 5.4 and 5.6). However, the contribution of the proposed Project to existing effects associated with habitat fragmentation is limited given the Project is a twinning in which the new lanes are nested inside an area already affected by edge effects from the existing highway, and the area through which the highway passes is already highly fragmented.

Other linear activities have historically altered wetlands and watercourses in the Assessment Area. The Project will contribute to these effects. Although Project construction is not expected to result in an unauthorized net loss of wetland area, it will result in direct alterations to Wetlands of Special Significance. Mitigation and compensation will be required to offset these effects (see Section 5.5) It is therefore anticipated that no long term additional net loss of wetland function on wetlands is expected from Project construction and operation.

6.2 LAND USE

Land use within the nearby area includes residential, commercial, industrial, and recreational land uses. Numerous residential properties are located adjacent to Highway 101 focused in the Three Miles Plains, Town of Windsor and the Village of Falmouth. Much of the commercial space is concentrated in the downtown core of Windsor with several businesses along Water Street and Gerrish Street. The area immediately adjacent to Highway 101 has experienced significant development with newer development largely extending along Wentworth Road connecting the older core of the town to Exit 5A on Highway 101. There are two industrial parks in the immediate vicinity of the existing highway: the Windsor Industrial Park, and the Windsor-West Hants Joint Industrial Park. There are several notable recreational areas near the existing highway including the recreational use of Pisiquid Lake, a multi-purpose AT trail (walking and cycling) that follows the causeway and loops the shore of Pisiquid Lake, and various ATV trails.

Residential, commercial, industrial, and recreational land uses have potential to result in environmental effects, including:

- air and noise emissions from existing land uses;
- reduced groundwater quality and quantity from residential, commercial, and industrial land uses including chemical use and spills and other discharges;
- effects on fish habitat, and water quality from garbage, nutrient enriched runoff (*i.e.,* fertilizer), chemical use, spills stormwater runoff, and heavier traffic (foot and automobile);
- direct loss of plants and plant habitat as well as adverse habitat alterations associated with changes in local hydrology, pesticide use, eutrophication of wetlands and water bodies, introduction of non-native plants and animals, and contamination of plant habitats;

- effects to wetland quality, through sedimentation, erosion, removal of wetland area from hazardous materials storage and discharges of wastewater which can affect wetland quality and function;
- direct reduction of total wetland through removal, and indirectly through changes to wetland quality and function;
- damage to wetland and other natural habitats from recreational use through rutting, which causes direct damage to wetland vegetation and soils, and indirect damage by changing hydrological patterns and increasing sedimentation; and
- direct loss of habitat and alteration of the quality of remaining habitat as a result of edge effects and habitat fragmentation.

The proposed Project is anticipated to maintain or increase environmental effects that exist as a result of existing residential, commercial, industrial, and recreational land uses (as described in Section 5 as baseline conditions for VCs); however, it is anticipated that the contribution of Project-related effects will be reduced through the implementation of mitigation measures identified in this assessment.

6.3 RESOURCE USE

The NSDA operates and maintains tidal gates at the Avon River causeway, five other major aboiteaux for the Tregothic and Elderkin Marsh Bodies, and a dyke system to protect approximately 1,618 ha of agricultural marshlands, communities, and associated infrastructure. Historically, the Fundy Gypsum Company, located between Exit 5 and Exit 5A, was actively extracting gypsum and anhydrite from the Wentworth Creek Quarry location until closure in 2011.

Resource use activity have the potential to result in environmental effects, including:

- loss/alteration of adjacent riparian and wetland areas (*e.g.*, from water control structures), increased total suspended sediments, increased water temperature, elevated nutrient levels, decreased dissolved oxygen, sedimentation of benthic habitat and subsequent alteration of stream hydrology;
- loss and/or change in terrestrial habitat including a direct effect on SOCI in the area through direct disturbance or by causing indirect changes to their habitat resulting in a loss of individuals or overall abundance;
- indirect changes from sedimentation and eutrophication of watercourses and wetlands, introduction of exotic weeds, and insects as well as off-site effects of herbicide drift;
- clearing activities associated with resource activity affects wetland quality, through sedimentation, erosion, and changes to local hydrological patterns;
- sedimentation and salt marsh development at the Avon River causeway;
- direct reduction of total wetland through removal, and indirectly through changes to wetland quality and function; and
- direct mortality of wildlife as a result of plowing and mowing associated with agriculture activities as frequent and early mowing is a contributing factor to declines in Bobolink numbers in Nova Scotia. Small mammals can also be killed as result of mowing and plowing, and predators such as American Crows and gulls are often attracted to newly mowed and

plowed fields where they feed on birds, mammals and herpetiles that have been exposed by mowing or plowing.

It is expected that the entire region has been influenced by past agricultural and mining practices, beginning with deforestation. Agricultural and quarrying activities have historically resulted in the loss and/or change in the quantity and quality of wildlife and wetland habitat. Construction activities for the proposed Project, particularly site preparation activities will result in the change in wildlife and wetland area and function. Clearing and grubbing during site preparation will directly remove wetland vegetation and soils and the construction of roadbeds will require that wildlife and wetland habitats be infilled. Mitigation measures identified in this report will reduce potential adverse environmental effects to wildlife and wildlife habitat and wetlands, as well as satisfy the provincial requirement of no net loss of wetland habitat as a result of the Project.

Sediment contributed from the Project to watercourses that have already experienced substantial input from agricultural practices will not likely realize further reduction of the quality of fish habitat. Agriculture activities are likely one of the largest contributors to sedimentation in watercourses that interact with the nearby area in the past and present. There may be some reduction in the quality of fish habitat in those watercourses where sedimentation was not substantial prior to potential sediment-generating activities for the current Project; however, instream structures will be designed and constructed according to the no-net-loss provisions of the *Fisheries Act* and requirements of provincial Water Approvals.

6.4 SUMMARY

Since the proposed Project is not anticipated to result in an increase in traffic, and assuming the effective application of mitigation measures proposed throughout this document, it is not anticipated that residual adverse effects from the proposed Project will substantially contribute to existing adverse effects from other undertakings. It is anticipated that other future undertakings will be required to implement similar mitigation measures and standards, further reducing potential for other undertakings to contribute additional adverse effects. It is expected that the construction and operation of the proposed highway Project will contribute social and economic benefits in the nearby area (see Section 1.2).

7.0 ACCIDENTS AND MALFUNCTIONS

Malfunctions and accidental events associated with the Project have potential to result in environmental effects. Potential malfunctions and accidental events associated with the Project include spills of hazardous materials, failure of erosion and sediment control (ESC) measures, fires and vehicular collisions.

Precautions and preventative measures will be taken to minimize potential for the occurrence of malfunctions and accidental events that may occur during the life of the Project and to reduce the impacts of any associated environmental effects. It is difficult to predict the precise nature and severity of malfunctions and accidental events. However, the probability of serious accidental events or those causing significant adverse environmental effects is low, particularly when construction and operation procedures incorporate environmental protection and contingency and emergency response plans. Construction, and operation and maintenance procedures will be conducted in accordance with relevant regulations, guidelines and accepted industry practice.

Prior to construction, NSTIR will develop a site-specific contingency plan which meets NSE's Contingency Planning Guidelines. In the event of a serious incident, pre-planning and preparedness are the key elements to maximize personal safety, minimize confusion and control damage. The site-specific contingency plan will provide response procedures in the unlikely event of an unplanned situation that could pose a risk to health or safety or the environment. The plan will encompass reasonably conceivable emergency situations that could occur during the construction phase of the proposed highway (*i.e.*, spills, failure of ESC features, fires, vehicular collisions). This plan will be reviewed and revised as needed, and at least annually.

7.1 SPILLS

Spills of petroleum, oils, or lubricants (POLs) may occur during construction during refuelling of machinery, maintenance activities or failure of hydraulic lines. These spills are usually highly localized and readily cleaned up by onsite crews using standard spill remediation equipment. However, even small spills can have very serious effects on aquatic habitat and migratory birds. In the unlikely event of a large spill, soil, groundwater, and surface water contamination may occur, thereby potentially adversely affecting the quality of groundwater, fish and fish habitat, and wetland habitat, and resulting in the ingestion/uptake of contaminants by wildlife. Depending on the nature of the spill, it could also potentially affect residential, commercial, agricultural, and other land uses.

The Generic EPP, Section 5, and Volume 4 of NSTIR's Health, Safety and Environmental Program contains best management procedures to minimize the likelihood of spills, and the site-specific contingency plan to be developed prior to construction will contain instructions for crew training and orientation in spill prevention and management. POLs and other hazardous materials will be handled in accordance with applicable regulations and with the procedures noted in the

Generic EPP and Standard Specifications. Construction equipment will be frequently inspected for possible fuel and hydraulic system leaks and leaks detected will be repaired immediately where possible. If the repair cannot be completed immediately, drip pans or alternative containment will be put in place to prevent loss of POLs to the environment. Equipment refuelling and maintenance will be conducted at designated sites, away from residential and known cultural or heritage properties, and not within 30 m of a wetland or watercourse or other areas known to be frequented by migratory birds.

A large spill of contaminants (*i.e.*, tanker accidents during highway operation) could result in a significant effect on the terrestrial or aquatic environment. In this unlikely event, local and provincial emergency response procedures will be invoked to minimize impacts. Emergency response and contingency plans are accepted and effective means to limit the severity of accidental effects. These plans and procedures will be implemented through standard NSTIR and EMO practices and supported through training programs.

Significant adverse effects on any VC due to accidental spills are not considered likely to occur.

7.2 EROSION AND SEDIMENT CONTROL FAILURE

The potential exists for failure of ESC measures due to precipitation events. Such a failure could result in the release of sediment-laden runoff to receiving watercourses with adverse effects on fish and fish habitat. ESC measures will be implemented according to NSTIR's Generic EPP, the Nova Scotia Watercourse Alterations Standards (2015), the site-specific contingency plan, and the construction contractor's environmental control plans (ECPs) developed for construction. Remedial action including pumping, runoff diversion and additional control measures will be taken as necessary. In the event of a failure, Project construction will be shut down until controls are restored. Significant adverse environmental effects are unlikely to occur as a result of ESC failure due to the implementation of best management practices.

7.3 FIRES

Project construction activities could result in fires due to activities such as equipment refuelling, brush burning, and careless smoking. Fires may result in habitat loss, sensory disturbance, direct mortality to wildlife, loss or damage of property and loss or damage to archaeological and heritage resources. Fire-fighting chemicals could enter surface water, affecting fish and fish habitat if allowed to disperse and persist.

Specific mitigation includes: proper supervision of brush fires; compliance with conditions of burning permits; regular work inspections; proper design and use of chemical storage areas and provision of fire-fighting equipment. Material management and operational procedures will further reduce the frequency and extent of accidental fires related to the Project. Burning on the RoW will not be permitted and hazardous materials storage areas will bear appropriate flammability warning signs where applicable.

In the unlikely event of a fire, local emergency response and fire-fighting capability will be able to reduce the severity and extent of damage. A fire prevention procedure will be included in , the site-specific contingency plan and the EPP contractor's environmental control plans to reduce the potential for fires along with training and orientation information for work crews. Adverse effects on air quality (*i.e.*, exceeding regulatory limits) could result due to fires, however, these accidents are unlikely to occur and would be rapidly controlled by first responders. Any such effects on local air quality would be localized and temporary therefore no significant effects on air quality are predicted as a result of fires.

A significant adverse effect on any VC due to fires is therefore considered unlikely.

7.4 VEHICULAR COLLISIONS

While traffic collisions are inevitable, the twinning of Highway 101 is expected to have an improved collision rate compared with the existing Highway 101. As noted in Section 1.2, the twinning will result in a controlled access four-lane divided highway with collision rates expected to be considerably lower than those on the existing two-lane highway.

Any construction project that affects public highways has the potential for transportation related malfunctions and collisions. However, the following features of the Project will minimize the number, severity and effects of malfunctions and accidents in the Assessment Area:

- The eastbound and westbound lanes of the twinned highway will be separated by a median or other barrier systems.
- All entrances, exits and crossings of the new highway will be by interchanges, overpasses or underpasses.
- The horizontal and vertical alignments will be designed and constructed to resemble the existing lanes and in accordance with current freeway design guidelines.
- The cross section of the new alignment will resemble the existing lanes.
- The divided highway will improve traffic flow on the highway.

Malfunctions and collisions are not predicted to have a significant effect on any VC.

7.5 SUMMARY

In summary, with adherence to best management practices, including adherence to the Generic EPP, the site-specific contingency plan, and, if necessary, implementation of emergency response and contingency procedures, opportunities for malfunctions or accidental events as a result of this Project are minimized. In the event of occurrence, significant adverse environmental effects are not likely. Significant effects from fires on air quality and large spills on the terrestrial and/or aquatic environment are possible but not likely to occur.

8.0 SUMMARY AND CONCLUSIONS

8.1 OVERVIEW

NSTIR proposes the twinning and upgrading of the existing two-lane section of Highway 101 from Trunk 14 (Exit 5) at Three Mile Plains to an area 2.5 km west of the Falmouth Connector (Exit 7) in Hants County, Nova Scotia. NSDA is partnering with NSTIR to upgrade the tide gate structure (aboiteau) at the Avon River causeway as part of the overall construction project. The Project will affect more than two hectares of a wetland, the Windsor Salt Marsh, and hence requires an environmental assessment. This EA was completed in accordance with the provincial *Environmental Assessment Regulations* made pursuant to the *Environment Act* as the Project is subject to the requirements associated with a Class I registration.

The assessment included an evaluation of the potential Project-related environmental effects for construction, operation and maintenance, and accidents and malfunctions for the following Valued Components (VCs):

- atmospheric environment;
- groundwater resources;
- aquatic environment;
- vegetation;
- wetlands;
- wildlife and wildlife habitat;
- land use; and
- archaeological and heritage resources.

Potential Project-related effects from Project construction include direct and indirect effects to the terrestrial and aquatic environments through loss or alteration of habitat and/or mortality of wildlife species including species of conservation concern. Construction activities may also restrict or change access to lands and resources used by the community members and the general public. Adverse effects related to Project operations and maintenance activities are less prominent due to the ongoing operation and maintenance of the current Highway 101.

In general, potential adverse effects on these VCs will be short term and/or highly localized and can be effectively mitigated through design plus technically and economically feasible methods recommended in this report. With respect to the mitigation of effects on fish and fish habitat and wetlands, compensation to offset predicted losses is proposed in accordance with the *Fisheries Act* and Nova Scotia Wetland Conservation Policy, respectively.

8.2 SUMMARY OF MITIGATION AND MONITORING COMMITMENTS

A summary of mitigation and monitoring proposed to reduce or eliminate potentially adverse effects for each VC is provided in Table 8.2.1.

Table 8.2.1 Summary of Mitigation and Monitoring Commitments

Valued Component	Proposed Mitigation	Proposed Monitoring and Follow-up
Atmospheric Environment	• Follow Generic EPP (Section 3.13) including application of dust suppressants, where feasible, follow equipment maintenance schedules, preserving natural vegetation where possible • Reduce activities that generate large quantities of dust during high winds • Follow Generic EPP (Section 3.13) including notification, muffling devices, machines in good working order, minimization of idling, and time of day restrictions (daytime) • Use noise controls where possible (*e.g.*, mufflers) • Environmental awareness session to reduce vehicle idling • Follow equipment maintenance schedules	• Should complaints of excessive noise or airborne dust be received, the root causes of these complaints will be determined by NSTIR, and corrective action will be taken if warranted. Should it be determined to be necessary to identify the source or extent of such problems, ambient monitoring of dust or noise will be conducted, as appropriate.
Groundwater Resources	• Pre-construction well survey • Pre-blast surveys (if required) • Ripping instead of blasting where possible near residential areas • ESC measures to reduce surface runoff • Minimize extent of clearing • Remedial action as necessary to restore damaged wells and provide temporary potable water as needed • Follow generic EPP and site-specific spill contingency plan • Drainage and, if blasting, vibration controls • Limit use of herbicides for vegetation management to the extent practical and adhere to the NSTIR's IVRM program • Follow NSTIR Salt Management Plan	• Detailed standardized survey of wells within 300 m of the centreline of the new alignment prior to construction. • Post-construction well monitoring if required (to be determined pending pre-construction data results).
Aquatic Environment	• ESC measures (Section 2.3.1) will be implemented • Follow Guidelines for the use of Explosives in or Near Canadian Fisheries Waters (Wright and Hopky 1998) • A NSE Water Approval for watercourse alteration will be obtained for all watercourse crossings and conditions of the Water Approval will be met • An authorization under the *Fisheries Act* will be obtained as required and conditions of the authorization will be met • A Certified Watercourse Alteration Installer will carry out or directly supervise all watercourse crossings • Structure sizing should be equal to or greater than existing structures (and meet DFO guidelines for fish passage and NSE requirements for 100-year storm events)	• Monitoring will be conducted during construction activities to promote and confirm application of applicable environmental protection and permitting requirements for work in and adjacent to watercourses and successful implementation of remedial actions where necessary. • Post-construction monitoring will be developed to assess fish habitat along the RoW and downstream.

Table 8.2.1 Summary of Mitigation and Monitoring Commitments

Valued Component	Proposed Mitigation	Proposed Monitoring and Follow-up

	• A fish habitat offsetting plan will be developed and implemented if it is determined that there is a serious harm to CRA fisheries
	• In-stream work and/or disturbance will be minimized, where possible
	• Stream crossings will be assessed for erosion, with areas of erosion stabilized
	• No washing, fuelling or maintenance of vehicles or equipment in the vicinity of a watercourse or wetland without secondary containment
	• No storage of chemicals or Petroleum Oils Lubricants (POLs) within 30 m of a watercourse or wetland
	• Heavy machinery use during clearing will be kept a minimum of 10 m from the watercourse banks
	• A limited disturbance buffer zone of 30 m from watercourses will be maintained, where possible
	• Instream construction will be limited to the lower biological risk period between June 1 – September 30, when feasible
	• Fish passage will be maintained for all species that use the watercourses for life-cycle purposes
	• Fish rescues will be carried out before in-water work occurs during watercourse crossings
	• Preferential use of mechanical vegetation control with limited use of herbicides (no pesticides). Herbicides are used only under the guidance of the department's Integrated Roadside Vegetation Maintenance (IRVM)
	• Follow NSTIR Salt Management Plan
	• Follow operations manual for the upgraded aboiteau to ensure ongoing fish passage and regulator terms and conditions
	• Area of disturbance will be minimized, especially within 30 m of watercourses
	• In-stream work will be minimized
	• The design of the aboiteau will be developed for:
	    • fish passage requirements (in consultation with DFO)
	    • climate change predictions matching the life of the structure (*e.g.*, sizing for the expected freshwater flow and protection of sea level rise, storm surge and wave runup)
	    • storm event predictions
	    • constructability, maintenance and monitoring considerations
	    • relevant stakeholder interests and concerns related to lake level management
	• Operations of the aboiteau will be in accordance with the operations manual to ensure ongoing fish
		• Monitoring associated with habitat compensation under the *Fisheries Act* may also be required.

Table 8.2.1 Summary of Mitigation and Monitoring Commitments

Valued Component	Proposed Mitigation	Proposed Monitoring and Follow-up
	passage and compliance with approval terms and conditions	
Vegetation	• Locations for site-specific mitigation will be outlined in the ECP following detailed design and in consultation with the appropriate regulatory authorities • Project design will reduce PDA and area to be cleared, where feasible • Limit Project-related off road activity • Follow Generic EPP • Employee environmental awareness training • Follow Watercourse and Wetland Alterations permit conditions • ESC measures will be implemented • Proper installation of culverts to prevent flooding or draining of wetlands • Flagging and avoidance of plant SOCI outside PDA but within the RoW • Develop mitigation plans for unavoidable effects on SOCI in consultation with regulators. Mitigation may include salvage and translocation of SOCI • During construction, use snow fencing and signage in areas of SOCI to protect plant occurrences near disturbance activities • Install cross ditches and berms on moderately steep and steep slopes in non-agricultural areas to prevent runoff along the RoW and subsequent erosion • All equipment must arrive at the site clean and free of soil or vegetative debris. Equipment will be inspected by the Environmental Inspector(s), or designate • Follow NSTIR Salt Management Plan • Apply drainage controls • Follow NSTIR Integrated Roadside Vegetation Management Manual • Restrict the general application of herbicide near SOCI and in wetlands. Spot spraying, wicking, mowing, or hand-picking are acceptable measures for integrated vegetation management in these areas.	• A follow-up survey is proposed to obtain more information on the occurrence of the Roland's sea-blite species within the region.
Wetlands	• Avoid direct disturbance to wetlands where feasible and reduce work in and near wetlands • Follow Generic EPP and Project Specific ECP • Implement erosion control measures • Clean construction machinery prior to entering wetlands • In areas of high peat depths, use progressive installation to reduce potential for overfilling or over excavation	• A NSE Water Approval for wetland alteration is required from NSE before wetlands can be altered. Approvals will be sought for wetlands that cannot be avoided and for wetlands that may be indirectly affected by the

Table 8.2.1 Summary of Mitigation and Monitoring Commitments

Valued Component	Proposed Mitigation	Proposed Monitoring and Follow-up
	• Use clean, pH neutral, non-leaching coarse fill in wetlands • Conduct monitoring of the Windsor Salt Marsh, before, during and after construction according to recommended protocols • Follow NSE Water Approval conditions • Compensate for loss of wetland area and function following provincial requirements • Employee environmental awareness training • Maintain culverts as required to maintain hydrological conditions • Follow NSTIR Salt Management Plan • Operate vehicles outside wetland boundaries • Avoid herbicide use in wetlands • Follow NSTIR Integrated Roadside Vegetation Maintenance program	development despite the employment of appropriate mitigation measures. • Monitoring will be conducted to measure the extent of wetland alteration, the effectiveness of mitigation measures, and the successful completion of compensatory wetland restoration and creation. • Monitoring of salt marsh, Wetlands 25 and 26, adjacent to the Avon River causeway will occur for at least five years following recommendations in van Proosdij and Bowron (2017).
Wildlife and Wildlife Habitat	• Follow Generic EPP and Project Specific ECP • Reduce the extent of vegetation clearing for RoW preparation to only the amount required for Project construction • Clear RoW outside of breeding bird season (April 1 to August 15). Where this is not feasible, develop a Bird Nest Mitigation Plan (prior to construction) in consultation with ECCC and provincial regulators • Compensate for loss of wetland area and function following provincial requirements • Limit Project-related off road activity • Employee environmental awareness training • Use designated roadways and access to reduce unnecessary ground disturbance • Use existing access for maintenance activities • Conduct vegetation maintenance outside of breeding season (April 1 to August 15), where feasible • Keep activities within disturbed RoW where feasible • Deactivate temporary roads to reduce access • Follow NSTIR Salt Management Plan • Reduce area of physical ground disturbance • Where feasible, do not mow cleared RoW between April 1and August 15 to avoid destruction of the nests of species which nest on the ground in grasslands. Where this is not possible, develop a Bird Nest Mitigation Plan (prior to construction) in consultation with ECCC and provincial regulators • Inspect bridges prior to maintenance work to determine if occupied nests of protected birds are	• No specific follow-up and monitoring is recommended.

Table 8.2.1 Summary of Mitigation and Monitoring Commitments

Valued Component	Proposed Mitigation	Proposed Monitoring and Follow-up
	present. If nests are present, avoid maintenance work until chicks have fledged	
Land Use (including Traditional Use)	• Follow Generic EPP (Sections 3.12 and 3.13) that includes guidelines for reducing noise and air emissions • Reduce dust through the application of water • Fair market value compensation for lands acquired during RoW acquisition process • Maintain access to lands where possible • Standard traffic control procedures including temporary detours, if necessary • Reasonable accommodation to allow forestry / agricultural operations access to adjacent lands during construction • Communication of Project schedule with local stakeholders, particularly with regard to aboiteau upgrade work and potential effects on Lake Pisiquid waterlevels • Follow NSTIR Salt Management Plan • Access restrictions will be defined in advance and will be limited in size to reduce interactions with land and resource users.	• No specific follow-up and monitoring is recommended.
Archaeological and Heritage Resources	• Complete archaeological testing in high potential area or monitor during construction if necessary. • Develop an Archaeological Resource Contingency Plan for the unanticipated discovery of an archaeological or palaeontological resource, including requirements to stop work and consult with applicable authorities including the NSCCH • Report any features, artifacts, or other cultural material discovered during testing or monitoring to NSCCH (Laura Bennett, Special Places Coordinator at the Nova Scotia Museum) prior to proceeding with construction activities • In the event that Mi'kmaw archaeological deposits are encountered during construction or operation of the Project, all work should be halted and immediate contact should be made to NSCCH (see above) and Kwilmu'kw Maw-klusagn Negotiation Office (KMKNO) and the First Nation communities of Millbrook and Sipekne'katik.	• If the construction or development of ancillary elements is planned for areas with potential for archaeological resources that have not been surveyed by a professional archaeologist, then a pre-construction archaeological assessment of these areas will be conducted prior to any disturbance.

8.3 SUMARY OF RESIDUAL EFFECTS

With the implementation of the proposed mitigation (including design and compensation) and monitoring, no significant adverse residual environmental effects are predicted for most VCs due to routine Project construction or operation and maintenance activities. However, residual environmental effects of the construction of the Project on wetlands are predicted to be significant. Although compensation will be provided by NSTIR to achieve no net loss, the direct and indirect alterations to salt marsh habitat at the Avon River causeway, which is recognized as a WSS under the provincial Wetland Conservation Policy, represents a significant effect. However, NSE is expected to authorize this alteration of a WSS because the construction of the highway and upgraded aboiteau will provide necessary public function. The proponent has also conducted fish and wetland habitat compensation well in advance of the Project and has committed to additional, on-site salt marsh compensation and post-construction monitoring of both the salt marsh and CRA fisheries.

The main purpose of a 100 series highway network in Nova Scotia is the safe, convenient and efficient movement of large volumes of people and goods over long distances at high speeds while reducing negative economic, social and environmental impacts. This Project will provide benefit to the local region as well as the Province of Nova Scotia as it will improve the current safety performance and level of service along this stretch of Highway 101. The Project will also sustain other public and private links (rail, Active Transport [AT], telecommunications, and power) that have developed on the Avon River causeway over the past 50 years, and protect communities, infrastructure, and agricultural land from anticipated climate-related changes in sea level, precipitation and storm surge.

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