CHAPTER 5

Description of the Project Environment

5.1 Atmospheric Environment

5.1.1 Air Quality

Ambient air quality is assessed through the concentration of key air contaminants and their comparison to provincial and federal ambient air quality standards. These standards were obtained from the maximum permissible ground level concentrations outlined in the provincial *Air Quality Regulations* and the *Canadian Ambient Air Quality Standards for Fine Particulate Matter and Ozone* (ECCC, 2013a). The air contaminants reviewed include fine particulate matter – $PM_{2.5}$ (particles having diameters of 2.5 micrometers or smaller), carbon monoxide – CO, sulphur dioxide – SO_2, nitrogen dioxide – NO_2 and ozone – O_3. Ambient air contaminants such as these are monitored by NSE and ECCC through the National Pollutant Surveillance Program (NAPS) via data obtained from monitoring stations located across the province. For each air contaminant of interest in this Project, data from the monitoring station within closest proximity to the Project corridor was obtained. The closest monitoring station that measures CO is downtown Halifax; it is located 135 km southwest of the Project corridor. The Pictou Station is 20 km northwest of the Project corridor and was used to obtain measurements for NO_2, O_3, and $PM_{2.5}$. The Port Hawkesbury station monitors SO_2 and is located 50 km west of the Project corridor. The air quality data stations are presented on Figure 5.1.

Using the 2016 data from the NAPS Program (ECCC, 2013b), the following observations can be made regarding the existing ambient air quality in the Project corridor.

- At the Halifax monitoring station, the monthly average CO concentrations ranged from 0.1 ppm to 0.3 ppm for both 1-hour and 8-hour periods, which are well below the maximum permissible ground level concentrations of 30 ppm and 11 ppm, respectively, as outlined in the provincial *Air Quality Regulations*;
- In Pictou, the reported 1-hour monthly average NO_2 concentration ranged from 1 ppb to 2 ppb, well below the maximum permissible ground level concentration of 210 ppb. The average annual NO_2 concentration was 1 ppb, compared to the 50 ppb limit outlined in the provincial *Air Quality Regulations*;

- In Pictou, the monthly average 1-hour concentration of O_3 ranged from 17 ppb to 30 ppb, well below the maximum permissible ground level concentration for O_3 of 82 ppb for a 1-hour testing period;
- The Port Hawkesbury monthly average concentration of SO_2 ranged from 0.3 ppb to 1.4 ppb for both the 1-hour and 24-hour tests, well below the maximum permissible ground level concentration of 340 ppb and 110 ppb for 1-hour and 24-hour, respectively; and
- The Pictou station reported a monthly for $PM_{2.5}$ of 3 µg/m^3 to 6 µg/m^3 for a 24-hour period, well below the of 28 µg/m^3 limit imposed by the *Canadian Ambient Air Quality Standards for Fine Particulate Matter and Ozone* (ECCC, 2013).

The ambient air quality of the Project corridor is expected to be good. All key air contaminants reported from the Pictou station fall well below provincial and federal air emission standards. The CO concentration of the Project corridor may even be lower than the concentration reported at the Halifax station, as it is located in more urban environment while the project corridor is in a rural area.

Air contaminants of interest for the current Project for which 2016 annual emissions in Nova Scotia are known are presented in

Table 5.1. These emissions originated from industrial, commercial, residential, mobile transportation, and incineration sources, among others, as reported by the Government of Canada (2018a).

Table 5.1 Air Contaminant Emissions in Nova Scotia (2016)

Air Contaminant	2016 Emissions (tonnes/year)
Particulate Matter less than 2.5 microns ($PM_{2.5}$)	2,391
Sulphur Dioxide (SO_x as SO_2)	923
Nitrogen Oxides (NO_x as NO_2)	15,088
Carbon Monoxide (CO)	8,083

Local Assessment Area

Monitoring Type

Air Quality Station

Climate Station

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HIGHWAY 104 - Sutherlands River to Antigonish

FIGURE 5.1
Air Quality and Climate Data Stations in Nova Scotia
Sheet 1 of 1

0 3 6 12 18 24 Km
Scale @ 11"x17" - 1:600,000

Z:\151046.14 - NSTIR CORRIDOR 4 EA\20 CAD\08 GIS\151046.14 - FIG 5.1 - MXD-009 EA FIGURES - CLIMATE & AIR QUALITY.mxd | Coordinate System: NAD 1983 CSRS UTM Zone 20N | Drawn: BH | Checked: MR | Approved: IB | Date: 04/10/2018

5.1.2 Noise

According to the *Guidelines for Environmental Noise Measurement and Assessment* developed by the formerly named Nova Scotia Department of Environment and Labour (NSDEL, 1990), noise is defined as unwanted sound. Noise pollution can disrupt normal daily activities, thereby reducing the quality of the surrounding environment. Several factors affect the way sound is perceived and its effects on humans, such as the frequency, duration, loudness, and variability of noise levels with exposure. Frequency refers to the number of vibrational cycles per second; it is perceived by the ear as 'pitch' (high and low sounds), and its unit of measurement is Hertz (Hz). Duration is the length of time that a sound persists and is often referred to as 'impulse' or 'continuous'. Intensity is the level of noise (loudness or 'sound pressure level') and is measured in logarithmic units called decibels (dB). Since the human ear cannot perceive all pitches or frequencies, the A-weighted decibel (dBA) is used to compensate for the varying ability for humans to detect very high and low pitched sounds, giving these frequencies less weight than the standard dB scale. As such, dBA is used to evaluate ambient or community noise, such as noise from traffic or construction equipment, and its effects on humans. A dBA of 0 coincides with the threshold of human hearing, while a dBA of 130 coincides with the threshold of human pain; normal human conversation is detected at approximately 60 dBA (Department of the Army, 2015). Examples of daily activities which contribute to ambient noise levels and associated human perceptions of these sounds based on the aforementioned scale are outlined in Table 5.2.

Table 5.2 The Effects of Sound Sources and Intensities on Human Perception and Health

Sound Source	Sound Intensity (dBA)	Effects to Humans
Airplane (taking off)	140	Harmfully loud
Stock car races Jet takeoff at 100-200 ft. (30.5 – 60.1 m)	130	Threshold of pain
Heavy machinery Chainsaw	120	Threshold of sensation or feeling
Jet flyover (1,000 ft.) Car horn	110	Regular exposure > 1 min. risks permanent hearing loss.
Snow mobile Garbage truck	100	1 hr / day risks hearing loss Unprotected exposure at ≥ 95 dBA is not recommended for >15 min / day
Diesel truck (50 ft. at 50 miles/hr)	90	Very annoying
Heavy traffic Industrial workplace	85	Hearing damage can begin after 8 hours of exposure.
Noisy Urban area (daytime)	80	Annoying; interferes with conversation

Sound Source	Sound Intensity (dBA)	Effects to Humans
Commercial area Freeway traffic (50 ft.) Gas lawnmower (100 ft.)	70	Interferes with telephone conversation
Heavy traffic (300 ft.) Normal conversation	60	Intrusive; Interference with human speech begins at approximately 60 dBA
Quiet urban area (daytime)	50	Quiet
Quiet urban and suburban areas (nighttime)	40	Sleep disturbance may occur at < 50 dBA
Soft whisper (15 ft.)	30	Very quiet
Quiet rural area (nighttime)	20	Very quiet
Normal Breathing	10	Just audible
Lowest threshold of human hearing	0	Lowest threshold of human hearing

Source: Department of the Army (2003, 2015); U.S. Dept. of the Interior Bureau of Reclamation (2008).

Noise emission levels associated with construction equipment which may be used during construction of the proposed Highway 104 twinning between Sutherlands River and Antigonish are outlined in Table 5.3.

Table 5.3 Construction Equipment Noise Emissions

Equipment	Typical Noise Level (dBA) *50 feet from Source
Air Compressor	81
Backhoe	80
Compactor	82
Concrete Mixer	85
Concrete Pump	82
Concrete Vibrator	76
Dozer	85
Generator	81
Grader	85
Loader	85
Paver	89
Pile Driver (Impact)	101
Pile Driver (Sonic)	96
Truck	88

Source: U.S. Department of Transportation Federal Transit Administration (2006); U.S. Department of Transportation Federal Highway Administration (2017).

Based on the noise emission levels outlined in Table 5.2 and Table 5.3, sound quality within 50 feet of the construction area may be similar to noise levels associated with an urban, commercial or industrial area. It is important to note that sound intensity levels are approximate values as actual values will vary depending on numerous factors, including distance of the receiver from the sound source and the time of day. As indicated in Table 5.2, noise levels generally vary with time. For example, daytime noise levels in an urban area differ relative to nighttime noise levels in the same area. To account for the time varying characteristics of noise, the continuous sound level measurement (L_{eq}) is used in community noise evaluations to calculate the average sound level over a period of time. L_{eq} is measured in dBA and should be collected at a minimum of two continuous representative hours in one period (NSDEL, 1990). Noise guidelines within Nova Scotia have been established within the *Guidelines for Environmental Noise Measurement and Assessment* for three periods (NSDEL, 1990):

- $L_{eq} \leq$ 65 dBA between 0700 and 1900 hours (day);
- $L_{eq} \leq$ 60 dBA between 1900 and 2300 hours (evening); and
- $L_{eq} \leq$ 55 dBA between 2300 and 700 hours (night).

Within the Municipality of the County of Antigonish, the following noise criteria has been established under the regional 'Noise By-Law':

- $L_{eq} \leq$ 90 dBA between 7:00 am and 7:00 pm (day);
- $L_{eq} \leq$ 90 dBA between 7:00 pm and 10:00 pm (evening); and
- $L_{eq} \leq$ 70 dBA between 10:00 pm and 7:00 am (night).

To characterize the existing ambient sound levels in the proposed Project Area, CBCL Limited completed baseline noise measurements at 16 receptor locations (Figure 5.2) in April, 2018. Data was collected over a 24-hour period at each station. Data was then compared to the NSDEL guidelines and municipal 'Noise By-Law'. As indicated in Table 5.4, ambient noise levels which exceeded the NSDEL guidelines were detected at 12 monitoring stations, while measurements at 4 stations (Stations 8 through 11) did not exceed guidelines. Noise measurements did not exceed by-law criteria at any of the 16 monitoring stations where data was collected. Further information on methodology and results of the 2018 noise monitoring study conducted by CBCL is provided in Appendix D (CBCL, 2018a).

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- Noise Survey Locations
- Local Assessment Area
- Municipal Boundaries
- NSGC - 1: 10 000 Waterbodies
- NSGC - 1: 10 000 Rivers/ Streams

Roads

- TCH
- Arterial
- Collector
- Paved Road
- Unpaved Road
- Railroad
- Lanes / Driveways

Environmental Assessment
HIGHWAY 104 - Sutherlands River to Antigonish

FIGURE 5.2
Noise Monitoring Station Locations
Within the Project Area
Sheet 1 of 1

0 0.5 1 1.5 2 2.5 3 3.5 km
Scale @ 11"x17" - 1:97,747

Z:\151046.14 - NSTIR CORRIDOR 4 EA\20 CAD\08 GIS\151046.14 - FIG 5.2 - MXD-010 EA FIGURES - NOISE MONITORING.mxd | Coordinate System: NAD 1983 CSRS UTM Zone 20N | Drawn: BH | Checked: MR | Approved: IB | Date: 05/10/2018

Table 5.4 2018 Baseline Noise Monitoring Results – Hourly Leq Averages

Time (hour)	NSE Guideline (dBA)	Municipal Noise By-Law (dBA)	Monitoring Station ID															
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
10:00	65	90	64.1	60.1	60.4	-	-	-	-	-	-	-	-	-	-	-	-	-
11:00	65	90	63.6	60.6	60.6	59.7	62.6	63.8	-	-	-	-	-	-	-	-	-	-
12:00	65	90	64.5	63.2	63.2	58.8	65.2	64.2	67.7	-	-	-	-	-	-	-	-	-
13:00	65	90	63.6	63.7	63.7	61.2	65.4	65.2	67.6	56.6	46.3	42.7	44.7	-	-	-	-	-
14:00	65	90	64.4	59.1	59.1	58.7	66.0	64.5	70.0	57.0	43.6	41.7	46.2	67.4	64.9	61.5	60.0	62.4
15:00	65	90	64.8	60.0	60.0	57.1	66.7	65.2	68.9	54.8	42.7	39.9	44.3	66.8	63.8	59.8	57.3	59.0
16:00	65	90	63.4	60.0	60.0	60.1	65.2	65.9	67.8	58.5	45.0	40.7	46.0	66.3	65.4	61.2	58.0	60.1
17:00	65	90	64.2	58.0	58.0	58.9	64.6	67.0	68.4	57.4	40.6	37.9	43.5	68.0	63.2	62.2	59.8	62.4
18:00	65	90	60.7	56.9	56.9	58.8	59.6	64.4	64.3	53.0	39.4	35.8	43.3	63.9	63.0	61.5	57.5	59.6
19:00	60	90	55.6	53.9	53.9	53.2	57.5	61.2	61.8	52.5	38.1	36.9	42.6	65.1	57.5	59.8	55.7	57.1
20:00	60	90	54.0	53.7	53.7	52.6	55.8	57.6	59.4	50.1	38.1	36.2	42.2	62.7	59.0	61.2	56.6	53.3
21:00	60	90	51.7	49.8	49.8	51.1	55.6	56.2	56.0	46.9	38.3	38.1	42.1	61.7	52.1	62.2	50.7	49.4
22:00	60	70	45.4	44.5	44.5	50.0	51.4	53.3	52.7	44.8	38.4	37.4	42.0	51.7	49.5	61.5	47.5	49.1
23:00	55	70	43.7	42.5	42.5	48.7	46.7	47.9	46.0	38.8	38.0	38.1	41.6	45.8	57.6	59.8	55.5	56.3
0:00	55	70	44.9	41.6	41.6	48.5	46.6	47.3	47.0	37.9	38.5	39.1	41.6	47.4	51.1	61.2	50.7	49.0
1:00	55	70	44.7	41.1	41.1	48.3	42.3	45.2	44.2	38.3	38.5	37.0	41.4	45.3	48.2	62.2	48.2	45.8
2:00	55	70	45.0	42.9	42.9	50.7	45.1	43.0	42.6	38.6	39.1	39.1	41.5	46.3	46.4	61.5	47.1	47.7
3:00	55	70	50.7	41.8	41.8	49.9	47.2	47.4	46.3	39.0	39.3	39.9	41.6	46.8	51.3	59.8	51.6	51.8
4:00	55	70	55.9	47.5	47.5	52.7	48.5	46.5	48.2	39.3	38.5	38.6	41.3	48.2	51.4	61.2	51.4	52.4
5:00	55	70	62.1	53.3	53.4	54.1	55.9	52.7	56.3	39.3	38.7	38.2	41.3	51.3	51.5	62.2	51.9	54.7
6:00	55	70	66.0	60.1	57.7	59.9	61.6	58.2	63.2	40.6	39.5	41.7	42.0	64.5	58.3	61.5	55.5	59.0
7:00	65	90	66.6	63.3	63.3	64.4	63.6	63.9	63.2	42.0	40.5	41.7	42.1	64.6	62.6	59.8	60.7	60.1
8:00	65	90	66.3	66.2	66.2	66.0	63.7	65.1	66.0	42.8	39.6	40.8	41.3	66.2	64.4	61.2	59.8	60.2
9:00	65	90	-	67.8	67.6	65.8	63.2	59.8	66.2	39.6	38.4	42.3	42.2	64.6	64.5	62.2	59.8	64.5
10:00	65	90	-	-	-	65.5	63.1	62.2	62.0	41.9	38.8	40.8	41.7	65.7	65.7	61.5	65.6	64.1
11:00	65	90	-	-	-	-	-	-	68.0	46.6	40.0	43.2	41.5	66.9	66.6	59.8	61.8	63.1
12:00	65	90	-	-	-	-	-	-	-	42.3	40.9	41.1	42.1	64.6	70.2	61.2	63.6	65.6
13:00	65	90	-	-	-	-	-	-	-	-	-	-	-	67.7	67.5	62.2	64.4	67.1

Notes: 0.1 Denotes NSE exceedance

5.1.3 Climate Normals

The Project corridor is located in Northeastern Nova Scotia and extends eastward from Sutherlands River to Antigonish. This area generally has cold, snowy winters and warm, humid summers. The Collegeville Environment Canada weather station is closest to the Project corridor; it is located 10 km south of Brierly Brook. Table 5.5 provides temperature and precipitation normals for Collegeville from 1981-2010 along with monthly averages (Government of Canada, 2018b). Wind normals are presented from the Halifax Stanfield International Airport, the closest wind data station (Government of Canada, 2018c). The climate station locations are depicted on Figure 5.1.

Table 5.5 Historic Climate data from Environment Canada Weather Station Nearest the Highway 104 Project Area (1981-2010)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Temperature Normals for Collegeville, NS (1981 - 2010)													
Daily Average (°C)	-6.5	-6.1	-2.1	3.5	9.3	14.2	18.3	18.1	13.9	8.3	3.2	-2.6	6.0
Daily Maximum (°C)	-1.5	-1.2	2.6	8.2	15.2	20.4	24.1	23.8	19.5	13.1	7.1	1.6	11.1
Daily Minimum (°C)	-11.4	-11.0	-6.8	-1.3	3.4	7.9	12.4	12.5	8.4	3.4	-0.7	-6.7	0.8
Precipitation Normals for Collegeville, NS (1981 - 2010)													
Rainfall (mm)	63.0	45.3	75.2	81.4	102.6	102.5	86.7	97.6	114.8	139.8	130.2	85.3	1124.4
Snowfall (cm)	47.8	42.6	33.2	12.8	0.9	0.0	0.0	0.0	0.0	0.8	10.0	42.7	190.7
Precipitation (mm)	110.9	87.9	108.3	94.2	103.5	102.5	86.7	97.6	114.8	140.6	140.2	127.9	1315.1
Wind Normals for Halifax Stanfield International Airport, NS (1981 - 2010)													
Most Frequent Direction	NW	NW	N	N	S	S	S	S	S	W	NW	NW	S
Maximum Gust Speed (km/h)	117	127	126	115	92	97	130	91	120	109	113	132	--
Direction of Maximum Gust	SE	SW	SW	SE	SE	N	SE	S	SE	SE	SE	SE	--
Days with Winds >= 52 km/h	2.4	1.9	1.9	1.3	0.4	0.3	0.2	0.2	0.5	0.6	1.7	2.2	13.3
Days with Winds >= 63 km/h	0.7	0.5	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.7	2.9
Wind Speeds for Halifax Stanfield International Airport, NS (1981 - 2010)													
Average Speed (All Directions, km/h)	17.7	18.3	18.5	18.3	16.5	15.2	14.2	13.2	14.4	16.0	17.5	18.3	16.5

The data presented in Table 5.5 illustrates that October and November have the highest precipitation, with a yearly average accumulation of 1,315.1 mm. July and August are the warmest months with average temperatures of 18.3°C and 18.1°C, respectively; the coldest months are January and February, with an average temperature of -6.5°C and -6.1°C, respectively. The yearly average temperature is 6°C with a daily average maximum of 11.1°C and a daily average minimum of 0.8°C.

From May to September, the winds prevail from the South and shift to North, Northwest, and West for the remainder of the year. Throughout the year there are an average of 13.3 days with winds greater than or equal to 52 km/h and 2.9 days with winds greater than or equal to 63 km/h. The average annual wind speed is 16.5 km/h.

5.1.4 Greenhouse Gas Emissions

Provincial and national greenhouse gas (GHG) emissions at intervals between 1990 and 2016 are presented in Table 5.6. Provincial and national GHG emissions were extracted from the *National Inventory Report 1990-2016: Greenhouse Gas Sources and Sinks in Canada – Executive Summary 2018* (ECCC, 2018a). Since Canada has indicated its intent to reduce GHG emissions by 30% below 2005 levels by the year 2030, 2005 is used as the base year for comparisons to current GHG emissions. This data indicates that between 2005 and 2016, Canada and Nova Scotia have reduced greenhouse gas emissions by 3.8% and 33%, respectively. Based on these data, Nova Scotia has already reduced GHG emissions by 10%, a goal established for the year 2020 under the *Environmental Goals and Prosperity Act* (2007). Nova Scotia has also achieved Canada's 2030 goal to reduce GHG emissions by 30% below 2005 levels (ECCC, 2018a).

Table 5.6 Provincial and National GHG Emissions

Region	GHG Emissions (Mt CO_2 eq)								Change (%)
	1990	2005	2011	2012	2013	2014	2015	2016	2005-2016
Canada	603	732	700	707	716	716	714	704	-3.8
Nova Scotia	19.6	23.2	20.9	19.2	18.2	16.4	16.6	15.6	-33%

ECCC (2018) also reports annual GHG emissions among Intergovernmental Panel on Climate Change (IPCC) Sectors in Canada (i.e., Energy; Industrial Processes and Product Use; Agriculture; Waste; Land Use, Land-use Change and Forestry) for selected years. The IPCC Sector that applies to this Project is 'Energy'. Select components which comprise this category and their annual GHG emissions for the years reported by ECCC (2018) are outlined in Table 5.7. GHG emissions resulting from construction and road transportation contribute to the total GHG emissions reported for the Energy sector by ECCC (2018a). These emission volumes, measured in megatonnes of carbon dioxide equivalent (Mt CO_2 eq), are among those highlighted in Table 5.7. For further information on GHG emissions per IPCC Sector and respective components, please refer to the *National Inventory Report 1990-2016: Greenhouse Gas Sources and Sinks in Canada – Executive Summary 2018* (ECCC, 2018a).

Table 5.7 National GHG Emissions for Select Components within the Energy IPCC Sector

IPCC Sector	GHG Emissions (Mt CO_2 eq)						
	2005	2011	2012	2013	2014	2015	2016
Total Energy	732	700	707	716	716	714	704
a. Total Stationary Combustion Sources	342	320	319	322	325	322	317
Public Electricity and Heat Production	125	94	91	87	84	87	84
Manufacturing Industries	48	44	44	45	45	44	42
Construction	1	1	1	1	1	1	1
b. Total Transport	192	197	197	202	200	202	199
Road Transport	129	139	140	144	141	142	143
Domestic Aviation	8	6	7	8	7	7	7
Railways	7	8	8	7	8	7	7
c. Total Fugitive Sources	61	55	58	60	63	61	56
Oil and Natural Gas	59	54	57	59	62	60	55

Based on the above GHG emissions, construction contributes <1% to total stationary combustion sources, whereas road transport contributes >50% of total transportation GHG emissions.

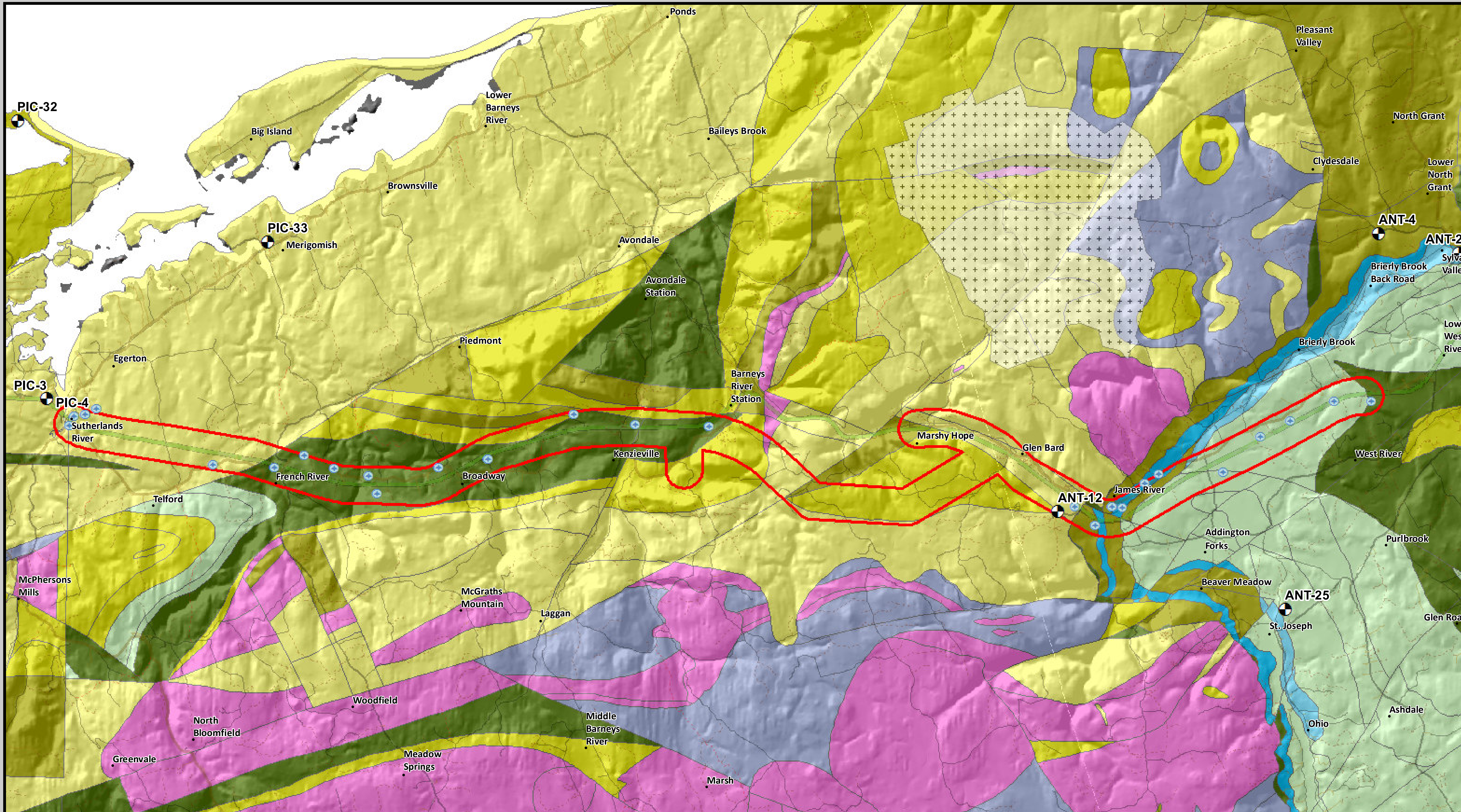
5.2 Physical Environment

5.2.1 Terrain, Geology, and Soils

The proposed highway corridor traverses a broad range of rock types from the Mabou, Arisaig, Georgeville, and Windsor Groups. Figure 5.3 shows bedrock formations in the Project Area, grouped by rock type. Coarse-grained sedimentary rock (e.g. sandstone, conglomerate) predominates in the western-most part of the corridor, and occurs over shorter intervals in the centre of the corridor. Finer-grained sedimentary and metamorphic rock predominate through much of the central part of the corridor (siltstone, mudstone, shale, quartzite, metasandstone and slate). The material underlying the eastern part of the corridor is primarily evaporite deposits of the Antigonish Basin. This material comprises limestone, gypsum, and anhydrite, interbedded in places with sandstone, siltstone, and mudstone. Karst formation has been documented in the Antigonish Basin.

Quaternary material in the highway corridor is predominantly silty or stony till, deposited over plains of thicknesses generally varying from 3 to 30 metres (shown in Figure 5.4). Water well records in the region indicate that the till thickness is generally 5 to 11 metres. Bedrock is exposed in three limited zones of the corridor. Glaciofluvial deposits intersect the eastern end of the corridor, indicating potential for a significant thickness of granular material. Topographic features identified from LiDAR mapping of this area indicate the presence of several borrow-pits.

Previous work to map karst features has focused on areas to the northeast of the proposed highway corridor, and on the eastern side of Antigonish Harbour. Expanses of collapsed topography have been identified, in addition to more isolated occurrences of sink holes and folding features (DeMont and Utting, 2010; DeMont et al., 2009; Boehner et al., 2002; Boehner, 2002). Mapped features tend to be concentrated along bedrock contact and fault lines. One analysis (Chisholm, 2014) mapped the likelihood of Karst activity within the highway corridor as predominantly moderate, increasing at contacts between limestone and anhydrite-gypsum material (Macumber and Bridgeville Formations) shown on Figure 5.5. Figure 5.5 shows detailed LiDAR mapping within the proposed corridor. Several topographic features were identified, suggesting the potential for minor Karst activity within 500 metres of the proposed corridor. Follow-up field reconnaissance and geotechnical work would be required to confirm and assess these features further.



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- Antigonish Protected Water Area (PWA)
- Aquifer Test
- NSE Record of Drilled Well
- 500 m from Highway Centreline

Bedrock Lithology

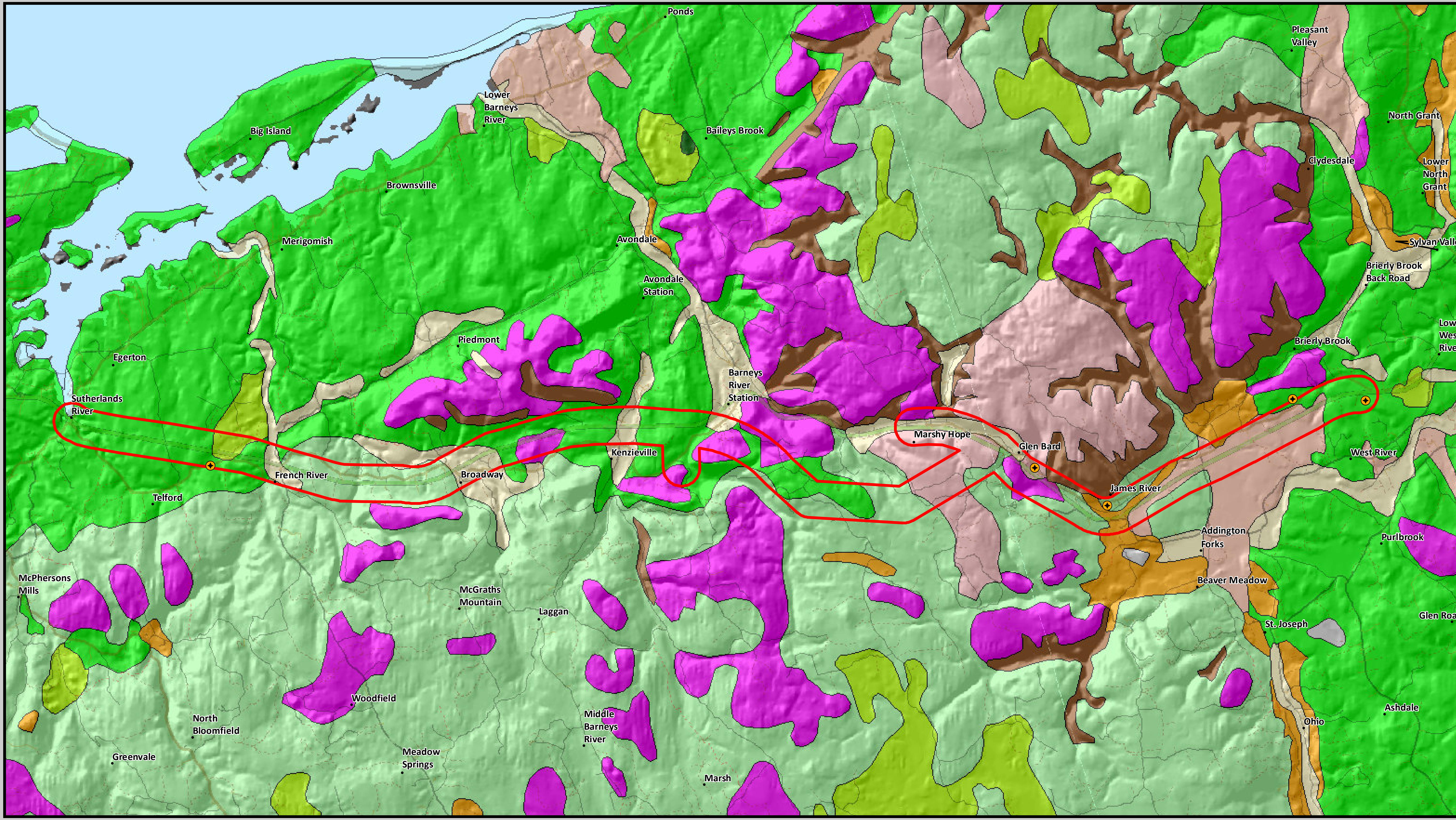
- Limestone
- Anhydrite-Gypsum
- Sedimentary-Evaporite
- Coarse-Grained Sedimentary
- Fine-Grained Sedimentary
- Meta-Sedimentary
- Metamorphic
- Volcanic / Basalt
- Plutonic

Environmental Assessment
HIGHWAY 104 - Sutherlands River to Antigonish

FIGURE 5.3
Bedrock Geology Within the Regional Assessment Area
Sheet 1 of 1

0 0.5 1 1.5 2 2.5 3 3.5 4 km
Scale @ 11"x17" - 1:100,000

Z:\151046.14 - NSTIR CORRIDOR 4 EA\20 CAD\08 GIS\151046.14 - FIG 5.3 - MXD-015 EA FIGURES- GEOLOGY- BEDROCK.mxd | Coordinate System: NAD 1983 CSRS UTM Zone 20N | Drawn: BH | Checked: XX | Approved: IB | Date: 04/10/2018



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- NSE Record of Dug Well
- 500 m from Highway Centreline

Quaternary Type

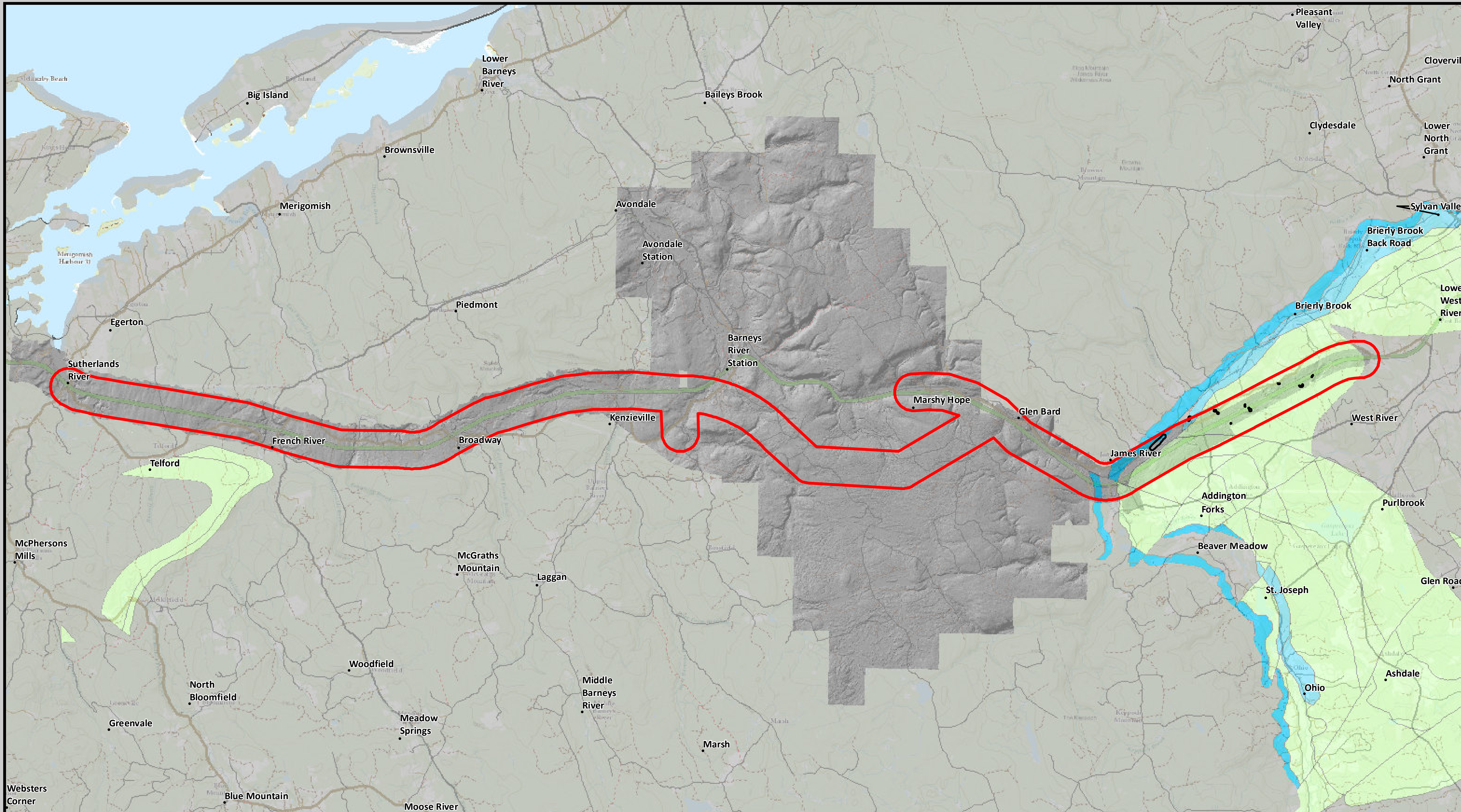
- Organi Deposits
- Colluvial Deposits
- Alluvial Deposits
- Marine Deposits
- Glaciolacustrine Deposits
- Glaciomarine Deposits
- Glaciofluvial Deposits (Outwash Fans)
- Glaciofluvial Deposits (Kames and Eskers)
- Hummocky Ground Morraine
- Stony Till Plain (Ground Moraine)
- Stony Drumlin (Drumlin Facies)
- Silty Till Plain (Ground Moraine)
- Silty Drumlin (Drumlin Facies)
- Residuum
- Bedrock
- Lakes

Environmental Assessment
HIGHWAY 104 - Sutherlands River to Antigonish

Figure 5.4
Surficial Geology Within the Regional Assessment Area

0 0.5 1 1.5 2 2.5 3 3.5 4 km
Scale @ 11"x17" - 1:100,000

Z:\151046.14 - NSTIR CORRIDOR 4 EA\20 CAD\08 GIS\151046.14 - FIG 5.4 - MXD-015 EA FIGURES- GEOLOGY- QUARTERNARY SURIFICIAL.mxd | Coordinate System: NAD 1983 CSRS UTM Zone 20N | Drawn: BH | Checked: XX | Approved: IB | Date: 04/10/2018



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500 m from Highway Centreline
Potential Karst Feature
No Karst Potential

Bedrock Lithology

Limestone
Anhydrite-Gypsum
Sedimentary-Evaporite

Environmental Assessment
HIGHWAY 104 - Sutherlands River to Antigonish

FIGURE 5.5
Evaporite Deposits Within the Regional Assessment Area

0 0.5 1 1.5 2 2.5 3 3.5 4 km
Scale @ 11"x17" - 1:100,000

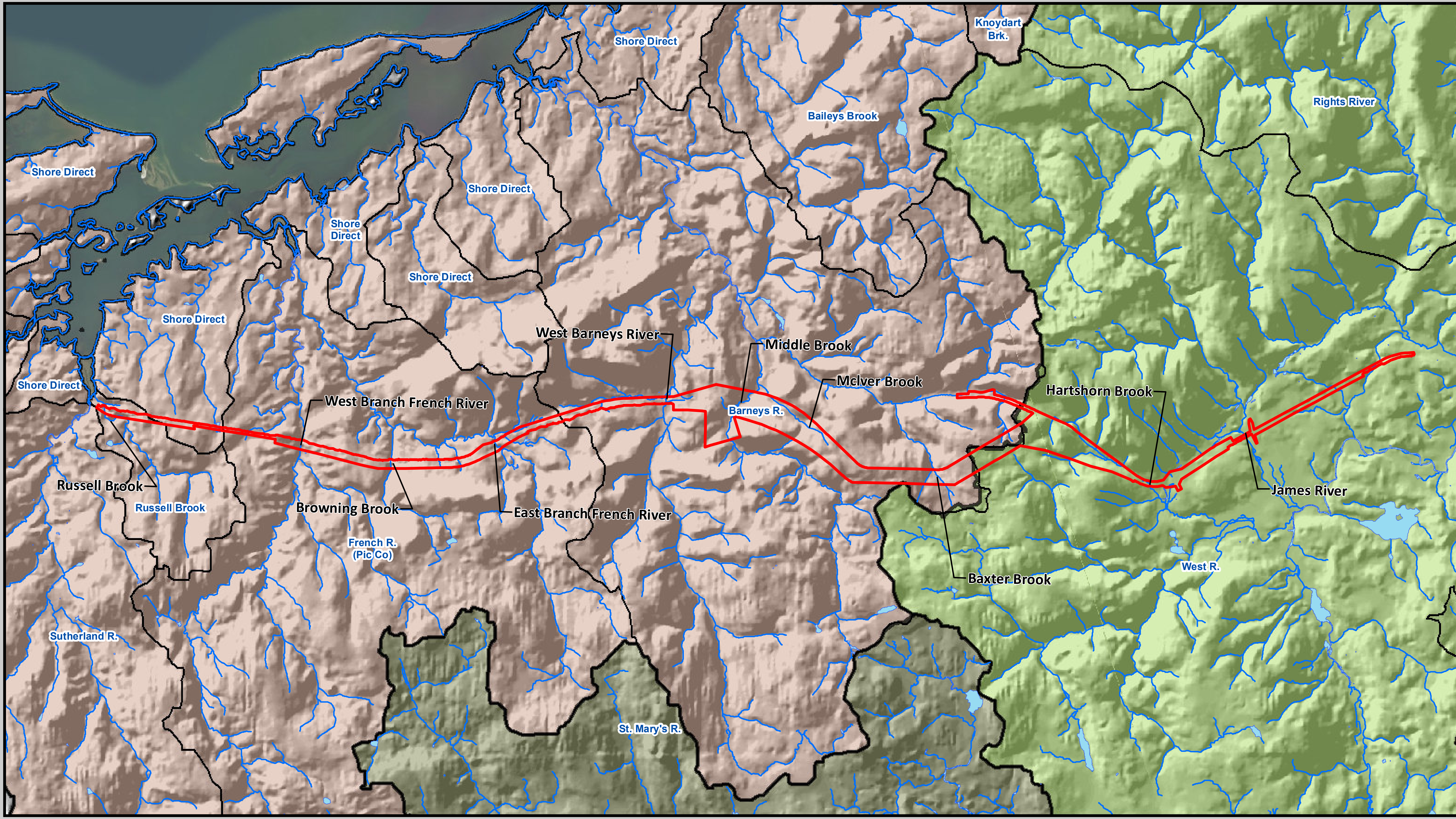
Z:\151046.14 - NSTIR CORRIDOR 4 EA\20 CAD\08 GIS\151046.14 - FIG 5.5 - MXD-015 EA FIGURES- GEOLOGY- EVAPORITE DETAIL.mxd | Coordinate System: NAD 1983 CSRS UTM Zone 20N | Drawn: BH | Checked: XX | Approved: IB | Date: 04/10/2018

5.2.2 Surface Water Quality

The LAA for the Highway 104 Twinning Project falls within two separate watersheds. Watercourses in the eastern third of the Project Area fall within the South River and West River primary watershed (Table 5.8). The majority of the LAA falls within the French River, Barneys' River, and West River secondary watersheds (Figure 5.6). All the watercourses occurring within the LAA are summarized in Table 5.8. All surface water within the LAA eventually drains into the Gulf of St. Lawrence.

The eastern portion of the Highway 104 Twinning Project LAA occurs within the South River and West River primary watershed, which is composed of three secondary watersheds, the West River, Rights River, and South River secondary watersheds. Of these three, the LAA falls only within the West River secondary watershed (Figure 5.6). The West River secondary watershed drains northwards towards the Gulf of St. Lawrence. A total of 47 watercourses occur within this secondary watershed, of which only 9 are considered to be permanent (Table 5.8). These are James River, West Branch French River, Browning Brook, Middle Brook, McIver Brook, Baxter Brook, Hartshorn Brook, East Branch French River, and West Barneys River. The majority of watercourses within these watersheds are unnamed streams or surface drainage flows.

Watercourses located within the central and western portions of the LAA are part of the French River primary watershed which is composed of 12 secondary watersheds (Figure 5.6). Of these, only four are actually located wholly or partially within the LAA. These are the Russell Brook, French River, and Barneys River secondary watersheds, as well as a small unnamed coastal secondary watershed labelled as 'Shore Direct' (Figure 5.6).



- Local Assessment Area
- NSGC - 1: 10 000 Waterbodies
- NSGC - 1: 10 000 Rivers/ Streams
- Primary Watershed Boundary
- Secondary Watershed Boundary

Primary Watershed: Defining River

- French River
- South River and West River
- St. Marys River

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HIGHWAY 104 - Sutherlands River to Antigonish

FIGURE 5.6
Primary and Secondary Watersheds Overlapping the Local Assessment Area

0 0.5 1 1.5 2 2.5 3 3.5 km
Scale @ 11"x17" - 1:97,747

Z:\151046.14 - NSTIR CORRIDOR 4 EA\20 CAD\08 GIS\151046.14 - FIG 5.6 - MXD-020 EA FIGURES -WATERSHEDS.mxd | Coordinate System: NAD 1983 CSRS UTM Zone 20N | Drawn: BH | Checked: XX | Approved: IB | Date: 04/10/2018

Table 5.8 Summary of Watercourses within the Highway 104 Twinning Local Assessment Area, By Watershed

Primary Watershed	Secondary Watershed	Watercourse Size Category	Name and Number within PA
French River	Barneys River	Ephemeral	10
		Intermittent	12
		Intermittent, Ephemeral	41
		Large Permanent	3
		Small Permanent	5
		Small Permanent, Intermittent	2
	French River	Ephemeral	4
		Intermittent	5
		Intermittent, Ephemeral	17
		Large Permanent	3
		Small Permanent	6
		Small Permanent, Intermittent	3
	Russell Brook	Ephemeral	4
		Intermittent	1
		Intermittent, Ephemeral	1
		Large Permanent	1
	Shore Direct	Ephemeral	2
		Intermittent	2
		Intermittent, Ephemeral	1
South River and West River	West River	Ephemeral	5
		Intermittent	12
		Intermittent, Ephemeral	21
		Large Permanent	2
		Small Permanent	3
		Small Permanent, Intermittent	4
Total			**170**

The Russell Brook secondary watershed drains north into the southern extent of Merigomish Harbour. It encompasses one permanent watercourse (Russell Brook), and 7 ephemeral to intermittent watercourses (Figure 5.6). The Project Area crosses Russell Brook twice shortly before it flows into the Harbour (Figure 5.6).

The Barneys River secondary watershed is drained by 73 watercourses, of which 10 are considered permanent (Table 5.8). This secondary watershed flows northward into Merigomish Harbour at Lower Barneys River (Figure 5.6).

The French River secondary watershed contains 38 watercourses, of which 12 are considered permanent (Table 5.8). This secondary watershed flows north into Merigomish Harbour (Figure 5.6).

A small unnamed small secondary watershed (labeled as Shore Direct) also drains northward into the upper reaches of Merigomish Harbour (Figure 5.6). The LAA crosses this watershed approximately five km south of the Harbour. This secondary watershed contains no watercourses considered to be permanent (Table 5.8).

It should be noted that the Sutherlands River secondary watershed is also part of the French River primary watershed, but its eastern boundary meets the western boundary of the LAA and no portion of the Sutherland River secondary watershed actually occurs within the Project Area (Figure 5.6).

In 2016 and 2018, the CBCL team assessed a total of 170 watercourses within the LAA, ranging from large permanent rivers to small ephemeral watercourses. These are summarized by watershed and size category in Table 5.8.

For all watercourses, except those categorized as ephemeral, a suite of water quality parameters (temperature, pH, conductivity, dissolved oxygen (DO), turbidity, and/or total dissolved solids (TDS)) was measured in-situ during the watercourse assessment programs in 2016 and 2018. Some watercourses classified as ephemeral with intermittent characteristics were also measured, if sufficient water was present at the time of sampling. In 2016, a YSI 556 or a YSI Professional Plus multi-parameter unit was used to measure parameters, while in 2018 a Horiba U-52 Multiparameter (which also measured turbidity) was used. Flow values were also calculated manually in-situ at all watercourses with sufficient water present at the time of survey.

Results for all the watercourses measured during field work in 2016 and 2018 are provided in Table 5.9, along with applicable CCME FWAL guidelines (pH and DO only). All watercourses sampled are depicted on Figure 5.8.

Table 5.9 Summary of Surface Water Quality Parameters Measured in Watercourses in 2016 and 2018. (Freshwater Aquatic Life (FWAL) Guideline Exceedances in Bold)

Watercourse ID	Year Measured	Watercourse Size Category	Velocity m/s	pH*	Temp. (ºC)	DO **(mg/L)	Cond. (µm/cm)	Turbidity (NTU)	TDS g/L
WC-4-02	2018	Intermittent, Ephemeral	0.07	**5.47**	15.84	**1.41**	637.00		0.50
WC-4-03	2018	Intermittent		**5.08**	11.72	7.21	39.00	3.60	0.03
WC-4-04	2016	Intermittent		**6.41**	14.02	8.15	243.00		0.20
WC-4-05	2016	Small Permanent	0.05	6.83	15.53	7.59	448.00	*n/a*	0.37
WC-4-06	2016	Intermittent	0.04	6.68	15.64	0.69	1437.00		1.14
WC-4-07	2016	Intermittent		7.38	18.94	7.32	572.00		0.42
WC-4-08	2018	Intermittent	0.02	**6.47**	16.82	**3.75**	526.00		0.41
WC-4-09	2018	Large Permanent	0.50	**6.11**	11.54	11.80	65.00	0.70	0.04
WC-4-10	2016	Intermittent		**5.91**	16.81	**5.08**	919.00		0.71
WC-4-100	2018	Intermittent, Ephemeral		7.74	10.81	10.47	44.00	0.00	0.03

Watercourse ID	Year Measured	Watercourse Size Category	Velocity m/s	pH*	Temp. (ºC)	DO **(mg/L)	Cond. (µm/cm)	Turbidity (NTU)	TDS g/L
WC-4-102	2018	Small Permanent	0.91	**5.41**	9.31	*n/a*	43.00	0.00	0.03
WC-4-11	2018	Intermittent, Ephemeral	0.11	6.62	15.52	9.51	342.00		0.27
WC-4-12	2018	Intermittent, Ephemeral	0.13	7.36	16.50	8.96	272.00		0.21
WC-4-13	2018	Small Permanent	0.48	6.59	9.23	12.90	450.00	0.00	0.29
WC-4-14	2018	Small Permanent, Intermittent	0.06	7.22	15.17	9.82	172.00	*n/a*	0.14
WC-4-15	2018	Intermittent, Ephemeral	0.04	7.04	15.16	9.72	43.00		0.03
WC-4-16	2018	Intermittent, Ephemeral	0.19	6.70	15.45	8.53	87.00	2.50	0.07
WC-4-17	2018	Intermittent, Ephemeral	0.07	7.59	15.63	7.56	144.00		0.09
WC-4-18	2018	Small Permanent, Intermittent	0.20	6.74	12.94	10.76	38.00	1.80	0.03
WC-4-19	2018	Small Permanent	0.12	6.59	12.64	10.73	38.00	0.00	0.03
WC-4-20	2018	Intermittent		6.75	14.70	7.83	294.00		0.24
WC-4-21	2018	Large Permanent	0.31	6.52	8.22	12.07	32.00	0.60	0.40
WC-4-22	2018	Small Permanent	0.40	6.71	14.71	10.30	119.00	0.00	0.08
WC-4-23	2018	Small Permanent	0.27	6.50	10.30	10.22	236.00	2.90	0.15
WC-4-23-A	2018	Small Permanent	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*
WC-4-23-B	2018	Intermittent, Ephemeral		6.60	9.74	8.88	41.00	1.60	0.03
WC-4-25	2018	Intermittent, Ephemeral	0.11	7.69	9.35	9.98	177.00	0.10	0.12
WC-4-26	2018	Intermittent	0.16	7.34	8.77	9.68	76.00	0.50	0.05
WC-4-27	2018	Small Permanent, Intermittent	0.21	7.19	9.78	7.80	131.00	0.50	0.09
WC-4-28	2018	Intermittent	0.11	7.44	9.13	8.12	210.00	0.10	0.13
WC-4-29	2018	Large Permanent	0.28	8.07	10.25	11.58	60.00	0.00	0.04
WC-4-30	2018	Intermittent, Ephemeral	*n/a*	7.92	15.15	9.31	173.00	*n/a*	0.11
WC-4-31	2018	Intermittent, Ephemeral	0.21	6.92	10.60	11.25	219.00	0.90	0.14
WC-4-31-A	2018	Intermittent, Ephemeral	*n/a*	6.63	8.63	10.30	38.00	1.90	0.03
WC-4-32	2016	Intermittent	*n/a*	**6.22**	16.78	**5.14**	78.00	*n/a*	0.05
WC-4-32-A	2018	Intermittent, Ephemeral	0.50	**4.19**	12.72	18.00	25.00	0.00	0.02
WC-4-33	2018	Large Permanent	0.44	6.58	12.77	11.51	38.00	0.10	0.03
WC-4-33-A	2018	Small Permanent	0.23	6.84	10.81	10.09	56.00	0.10	0.36

Watercourse ID	Year Measured	Watercourse Size Category	Velocity m/s	pH*	Temp. (ºC)	DO **(mg/L)	Cond. (µm/cm)	Turbidity (NTU)	TDS g/L
WC-4-33-B	2018	Intermittent, Ephemeral	*n/a*	7.66	7.57	9.91	570.00	2.80	0.37
WC-4-33-C	2018	Intermittent, Ephemeral	*n/a*	7.54	7.45	7.95	61.00	3.00	0.04
WC-4-33-H	2018	Intermittent, Ephemeral	0.18	**5.04**	16.44	15.26	96.00	0.00	0.06
WC-4-35	2018	Intermittent, Ephemeral	*n/a*	7.97	9.20	10.25	41.00	2.20	0.03
WC-4-35-D	2018	Intermittent	*n/a*	7.95	10.22	9.39	41.00	7.40	0.03
WC-4-36	2018	Intermittent, Ephemeral	*n/a*	**4.95**	7.45	17.15	31.00	0.00	0.02
WC-4-37	2018	Intermittent, Ephemeral	0.29	**5.63**	7.61	*n/a*	39.00	8.40	0.03
WC-4-37-B	2018	Intermittent, Ephemeral	0.30	**5.29**	7.92	*n/a*	35.00	3.40	0.02
WC-4-39	2018	Intermittent, Ephemeral	0.22	**5.76**	6.64	*n/a*	43.00	2.80	0.03
WC-4-40	2018	Small Permanent	0.41	7.76	8.79	11.07	43.00	1.50	0.03
WC-4-41	2018	Intermittent, Ephemeral	0.35	**5.41**	8.26	*n/a*	31.00	0.00	0.20
WC-4-43	2018	Small Permanent, Intermittent	0.52	7.96	12.82	9.22	39.00	0.00	0.03
WC-4-44	2018	Intermittent, Ephemeral	0.04	**6.10**	13.64	**3.90**	42.00	*n/a*	0.03
WC-4-47	2018	Intermittent, Ephemeral	0.56	**5.88**	12.94	*n/a*	35.00	0.00	0.02
WC-4-48	2018	Intermittent, Ephemeral	0.32	7.88	11.87	9.60	36.00	0.70	0.02
WC-4-49	2018	Intermittent	*n/a*	**4.28**	14.24	9.00	45.00	*n/a*	0.03
WC-4-50	2018	Small Permanent	0.32	7.70	7.78	11.71	39.00	0.00	0.03
WC-4-50-A	2018	Intermittent	0.24	7.85	14.20	10.75	39.00	0.00	0.03
WC-4-52	2018	Intermittent	0.24	8.02	15.84	8.16	37.00	0.00	0.02
WC-4-55	2018	Intermittent	*n/a*	7.62	11.42	10.03	0.05	0.00	0.03
WC-4-56	2018	Intermittent	0.37	7.62	6.84	12.58	44.00	0.00	0.03
WC-4-56-A	2018	Intermittent, Ephemeral	0.16		8.86	11.20	0.05	3.80	0.03
WC-4-57	2018	Small Permanent	0.32	7.36	7.76	12.29	105.00	0.00	0.07
WC-4-57-B	2018	Intermittent, Ephemeral	0.00	7.33	9.90	8.84	104.00	0.00	0.07
WC-4-58	2018	Intermittent	0.18	7.49	15.90	9.14	39.00	*n/a*	0.03
WC-4-34	2018	Intermittent, Ephemeral	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*
WC-4-59	2018	Intermittent, Ephemeral	0.19	**4.24**	15.34	9.50	0.05	*n/a*	0.03
WC-4-60	2018	Intermittent	*n/a*	7.52	8.79	10.95	36.00	4.50	0.02
WC-4-61	2016	Small Permanent, Intermittent	0.19	**5.69**	14.50	9.45	143.00	*n/a*	0.09
WC-4-38	2018	Intermittent, Ephemeral	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*
WC-4-62	2016	Intermittent	*n/a*	7.88	16.50	8.94	143.00	*n/a*	0.09
WC-4-63	2016	Intermittent	0.47	7.55	15.93	9.60	284.00	*n/a*	0.19

Watercourse ID	Year Measured	Watercourse Size Category	Velocity m/s	pH*	Temp. (ºC)	DO **(mg/L)	Cond. (µm/cm)	Turbidity (NTU)	TDS g/L
WC-4-64	2018	Intermittent	0.16	8.00	16.01	7.14	434.00	*n/a*	0.28
WC-4-42	2016	Intermittent	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*
WC-4-65	2018	Large Permanent	0.23	7.80	11.48	11.21	148.00	0.00	0.10
WC-4-65-F	2018	Small Permanent, Intermittent	0.15	7.48	11.00	9.58	43.00	0.00	0.03
WC-4-45	2016	Intermittent, Ephemeral	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*
WC-4-46	2018	Intermittent, Ephemeral	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*
WC-4-65-G	2018	Small Permanent	0.58	7.37	10.07	10.61	34.00	0.30	0.02
WC-4-66	2018	Intermittent	0.08	7.43	6.79	8.81	319.00	0.30	0.21
WC-4-66-A	2018	Small Permanent, Intermittent	0.33	7.61	7.73	10.84	194.00	0.00	0.13
WC-4-66-B	2018	Small Permanent, Intermittent	*n/a*	7.33	10.01	7.42	68.00	3.40	0.04
WC-4-51	2016	Intermittent	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*
WC-4-67	2018	Intermittent	*n/a*	8.68	12.90	9.40	559.00	0.00	0.36
WC-4-53	2016	Intermittent, Ephemeral	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*
WC-4-54	2018	Intermittent, Ephemeral	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*
WC-4-68	2016	Intermittent, Ephemeral	*n/a*	**6.45**	12.89	7.30	252.00	*n/a*	0.16
WC-4-69	2016	Large Permanent	0.19	8.03	15.09	10.01	209.00	*n/a*	*n/a*
WC-4-70	2018	Intermittent	*n/a*	7.84	12.67	**5.47**	229.00	3.50	0.15
WC-4-71	2018	Intermittent	0.14	7.91	12.37	**5.58**	5.94	0.00	0.32
WC-4-72	2018	Small Permanent	0.22	8.79	13.13	10.52	207.00	0.90	0.13
WC-4-73	2018	Intermittent	*n/a*	8.27	12.50	7.19	462.00	*n/a*	*n/a*
WC-4-74	2016	Intermittent	*n/a*	7.98	15.47	**6.09**	689.00	*n/a*	*n/a*
WC-4-75	2018	Large Permanent	0.49	**5.43**	10.88	11.64	80.00	0.85	0.052
WC-4-77	2018	Intermittent	0.36	**6.32**	10.86	10.25	300.00	0.90	0.237
WC-4-84	2018	Intermittent, Ephemeral	0.24	**6.49**	13.74	9.70	357.00	0.20	0.23
WC-4-85	2018	Large Permanent	0.21	**6.01**	12.75	11.30	49.00	1.50	0.03
WC-4-86	2018	Small permanent, Intermittent	0.12	7.70	6.16	12.84	106.00	7.70	0.06
WC-4-90-A	2018	Intermittent, Ephemeral	0.16	**6.37**	10.25	11.05	173.00	1.20	0.11
WC-4-91	2018	Intermittent, Ephemeral	0.13	**6.45**	8.66	12.58	580.00	2.20	0.38
WC-4-94	2018	Intermittent, Ephemeral	0.16	**5.61**	14.80	16.65	328.00	2.70	0.21
WC-4-94-B	2018	Intermittent, Ephemeral	0.35	**5.39**	12.94		139.00	0.00	0.09
WC-4-95	2018	Intermittent	0.19	7.99	11.50	10.53	115.00	0.70	0.08

Watercourse ID	Year Measured	Watercourse Size Category	Velocity m/s	pH*	Temp. (°C)	DO **(mg/L)	Cond. (µm/cm)	Turbidity (NTU)	TDS g/L
WC-4-95-A	2018	Small Permanent	0.19	7.99	11.50	10.53	115.00	0.70	0.08
WC-4-95-B	2018	Large Permanent	0.28	7.99	11.50	10.53	115.00	0.70	0.08
WC-4-97	2018	Intermittent, Ephemeral	0.11	8.35	11.55	8.35	400.00	1.70	0.26

**CCME FWAL Guideline for pH is 6.5 to 9. 5*
***CCME FWAL Guideline for dissolved oxygen is 9.5 mg/L for early life stages for cold-water biota, and 6.5 mg/L for other life stages*

Brief summaries of the water quality parameters listed in Table 5.9 are provided below by parameter.

Velocity: Velocity values were generally variable, which is not surprising, given the range of watercourse sizes observed (Table 5.9). Recorded values ranged from 0 to 0.91 m/s, with an average velocity of 0.25 m/s.

pH: The majority (64 of 87, or 73.5 %) of the watercourses measured in 2016 and 2018 had pH readings within the 'suitable' range for aquatic life per CCMH guidelines. The balance of watercourses were acidic, ranging from 4.28 – 6.47. Overall, pH values ranged from 4.19 to 8.79, with an average value of 6.91.

Temperature: The average value of the 96 temperatures readings recorded at watercourses within the LAA in 2016 and 2018 was 12.01°C, with values ranging from 6.16 to 18.94°C. Of these, 48 were within the range (11-16 mg/L) considered optimal for brook trout (Raleigh, 1982).

Dissolved Oxygen: Dissolved oxygen levels were generally variable, which is to be expected, given the range of watercourse sizes and flow velocities observed (Table 5.9). Recorded values ranged from 0.69 to 18.00 mg/L, with an average dissolved oxygen reading of 9.60 mg/L. The CCME guideline for Freshwater Aquatic Life for dissolved oxygen cites a minimum acceptable dissolved oxygen concentration of 9.5 mg/L for early life stages for cold-water biota, and a concentration of 6.5 mg/L for other life stages (CCME, 1999). Of the 89 watercourses for which DO was measured, 79 (89%) met the minimum guideline of 6.5 mg/L, and 50 (56%) also met the guideline of 9.5 mg/L for early life stages. A total of 83 watercourses (93%) met Raleigh's tolerance value of 5 mg/L for Brook trout (Raleigh, 1982).

Conductivity: Conductivity values were generally variable, which is to be expected, given the range of watercourse sizes and flow velocities observed (Table 5.9). Recorded values (n=96) ranged from 0.05 to 1437 µS/cm, with an average conductivity value of 193.6 µS/cm. There are no CCME guidelines for conductivity values for freshwater aquatic life.

Turbidity: Turbidity values were generally variable, which is to be expected, given the range of watercourse sizes and flow velocities observed (Table 5.9). Recorded values (*n*=68) ranged from 0 to 8.4 NTU, with an average turbidity value of 1.29 NTU. The turbidity values collected during the aquatic sampling programs could be used for comparison purposes if future turbidity monitoring is required during watercourse crossing installations. The CCME guidelines for turbidity state maximum increases above background levels for freshwater aquatic life as follows (CCME, 1999):

- *"Clear Flow: Maximum increase of 8 NTUs from background levels for a short-term exposure (e.g., 24-h period). Maximum average increase of 2 NTUs from background levels for a longer term exposure (e.g., 30-d period); and*
- *High flow or turbid waters: Maximum increase of 8 NTUs from background levels at any one time when background levels are between 8 and 80 NTUs. Should not increase more than 10% of background levels when background is > 80 NTUs."*

Total Dissolved Solids (TDS): The average value of the 93 TDS readings recorded at watercourses in 2016 and 2018 was 0.14 g/L, with values ranging from 0.02 to 1.14 g/L. There are no CCME guidelines for total dissolved solid values for freshwater aquatic life.

Further discussion of these watercourses with regards to fish and fish habitat is provided in Section 5.6. Wetlands are discussed in Section 5.5.

5.2.3 Hydrogeology and Groundwater Quality

The proposed highway corridor passes through at least two distinct regional flow systems. The western part of the corridor passes through the French River Watershed (1DQ), which discharges northward to Merigomish Harbour. The eastern part of the corridor passes through the Southwest River Watershed (1DR), discharging to Antigonish Harbour. The highway corridor traverses a regional flow divide, which is expected to correspond to a regional groundwater flow divide.

In the western part of the corridor, regional flow is expected to be predominantly from south to north, discharging to the north and northwest coastal areas of Merigomish Harbour. The recharge area for this flow system would be via plutonic and volcanic rock 5 to 10 km to the south of the corridor. In the eastern part of the corridor, regional flow is expected to be predominantly northeastward, discharging to Antigonish Harbour. The corridor traverses a part of the headwater for this system, with components of flow predominantly through evaporite rock of the Antigonish Basin.

Groundwater flow systems at intermediate depths may interact with the larger streams and valley features located within the proposed corridor. In the west, these flow systems may originate on topographic ridges to the south and north of the corridor valley, transmitted toward and potentially discharging to the corridor valley as fracture flow. In the eastern part of the corridor, intermediate flow systems are expected to be predominantly eastward, transmitted parallel to the corridor alignment, through fractures and/or karst features in the evaporite rock. These systems may interact with surface water or continue as subsurface flow toward Antigonish Harbour.

Shallow groundwater flow paths local to the highway corridor will tend to originate in local topographic high areas and discharge to small streams and wetlands. Water features are aligned both perpendicular and parallel to various sections of the corridor. Local flow directions will be determined by topographic and sub-surface conditions specific to each flow system. Quaternary geology mapping identified glaciofluvial material at James River. This feature may act as a shallow aquifer, receiving recharge from the north, west, and south, and discharging eastward to the Beaver Meadow wetland and West River system.

NSE records show up to nine water well records in the James River area. Although only one of these wells is listed as a dug well, wells in this area may rely on local sand and gravel features. Up to 58 water well records are mapped as located within 500 metres of the highway corridor, however, the georeferencing accuracy/resolution for 47 of these records exceeds 500 metres. Mapped records indicate that well depths are generally between 30 and 60 metres, exhibiting yields on the order of 6 to 45 L/min. Lower well yields are generally associated with lower expected ambient groundwater flow rates. Aquifer transmissivity data for the region is summarized as follows:

- Evaporite rock: 3 to 44 m^3/day (low to moderate well yields);
- Sedimentary rock, Antigonish basin: 4 to 15 m^3/d (low well yields); and
- Sedimentary rock, Merigomish basin: 3 to 30 m^3/d (low to moderate well yields).

Water quality data are available for five registered or public water supplies mapped as being located within 500 metres of the highway corridor. Concentrations of dissolved solids are generally low, with moderate hardness. Manganese concentrations were below 30 µg/L, and iron concentrations varied from 40 to 200 µg/L. Arsenic (1 µg/L) and uranium (0.2 µg/L) data were available for one water supply. Elevated concentrations of dissolved solids, hardness, and odour are common for wells that draw gypsum-anhydrite contacted water, which could apply to water wells in the eastern parts of the corridor.

5.3 Biological Environment – Flora

5.3.1 Project Ecological Land Classification (P-ELC)

A component of the vegetation studies for the Project was the development of a Project Ecological Land Classification (P-ELC). The purpose of the P-ELC was to provide a landscape-level analysis of major vegetation communities and habitat within the defined P-ELC study area. It is intended that the P-ELC serve as an over-arching component of the vegetation baseline information to be used in the Environmental Assessment (EA) process.

More specifically, the goals of the P-ELC are to:

- Conduct a rigorous field assessment of the terrestrial environment;
- Generate a remote-sensing-based mapped inventory of P-ELC Units, which represent umbrella categories for the major vegetation communities encountered during the field surveys (see ‘Community Classification’ in previous sections) and other non-vegetated areas; and the provision of Geographic Information System (GIS) map layers of same;
- Provide a product which serves as the basis for other studies reliant on habitat mapping, i.e., avifauna, mammals, wetlands and rare vegetation; and
- Provide an effects assessment tool for quantifying interactions between the Project and the natural environment, as required for various taxa.

The P-ELC Units generated in the present study represent a range of conditions which are equally identifiable both through field surveys and remote sensing. These conditions are:

- Major vegetation associations;
- Vegetation structure; and
- Potential wetland status.

5.3.1.1 Desktop Study – National and Provincial Frameworks for Ecological Land Classification

National and provincial frameworks for ELC were reviewed, and include:

- The National Ecological Framework for Canada (Ecological Stratification Working Group, 1995); and
- Ecological Land Classification for Nova Scotia (Neily et al., 2003; Neily et al., 2010; Neily et al., 2015).

These frameworks reference a nested hierarchy of ecological subdivisions, as follows, with a scale of applicability and definitions per the Ecological Stratification Working Group (1995):

- **Ecozone** (1:7.5M scale): *"An area of the earth's surface representative of large and very generalized ecological units characterized by interactive and adjusting abiotic and biotic factors."*
- **Ecoregion** (1: 5M to 1:2M scale): *"a part of a province characterized by distinctive regional ecological factors, including climatic, physiography, vegetation, soil, water, fauna, and land use."*
- **Ecodistrict:** (1: 3M to 1:1M scale): "*a part of an ecoregion characterized by distinctive assemblages of relief, geology, landforms and soils, vegetation, water, fauna, and land use."*

More refined levels of ecological stratification exist in Nova Scotia, and include the following:

- **Ecosection** (1:50k to 1:100k scale): These are a subdivision of Ecodistricts that are described by unique combinations of enduring landscape features such as soil drainage, soil texture and topographic pattern (Neily et al., 2003); and
- **Ecosite** (1:10k to 1:50k scale): These are subdivisions of Ecosections that are described by site conditions such as elevation, aspect, slope, slope position, soil drainage and texture (Neily et al., 2003). Ecosites have a finite range of soil and site conditions which in turn give rise to a predictable cohort of vegetation types which grow naturally under those conditions (Keys et al., 2010).

The proposed section of Highway 104 twinning intersects with the Pictou Antigonish Highlands (west of Antigonish), St. George's Bay (surrounding Antigonish), and the Northumberland Lowlands (east of Sutherlands River) ecodistricts (Neily et al., 2015). Ecoregion and Ecodistrict boundaries intersecting the highway corridor can be seen in Figure 5.7.

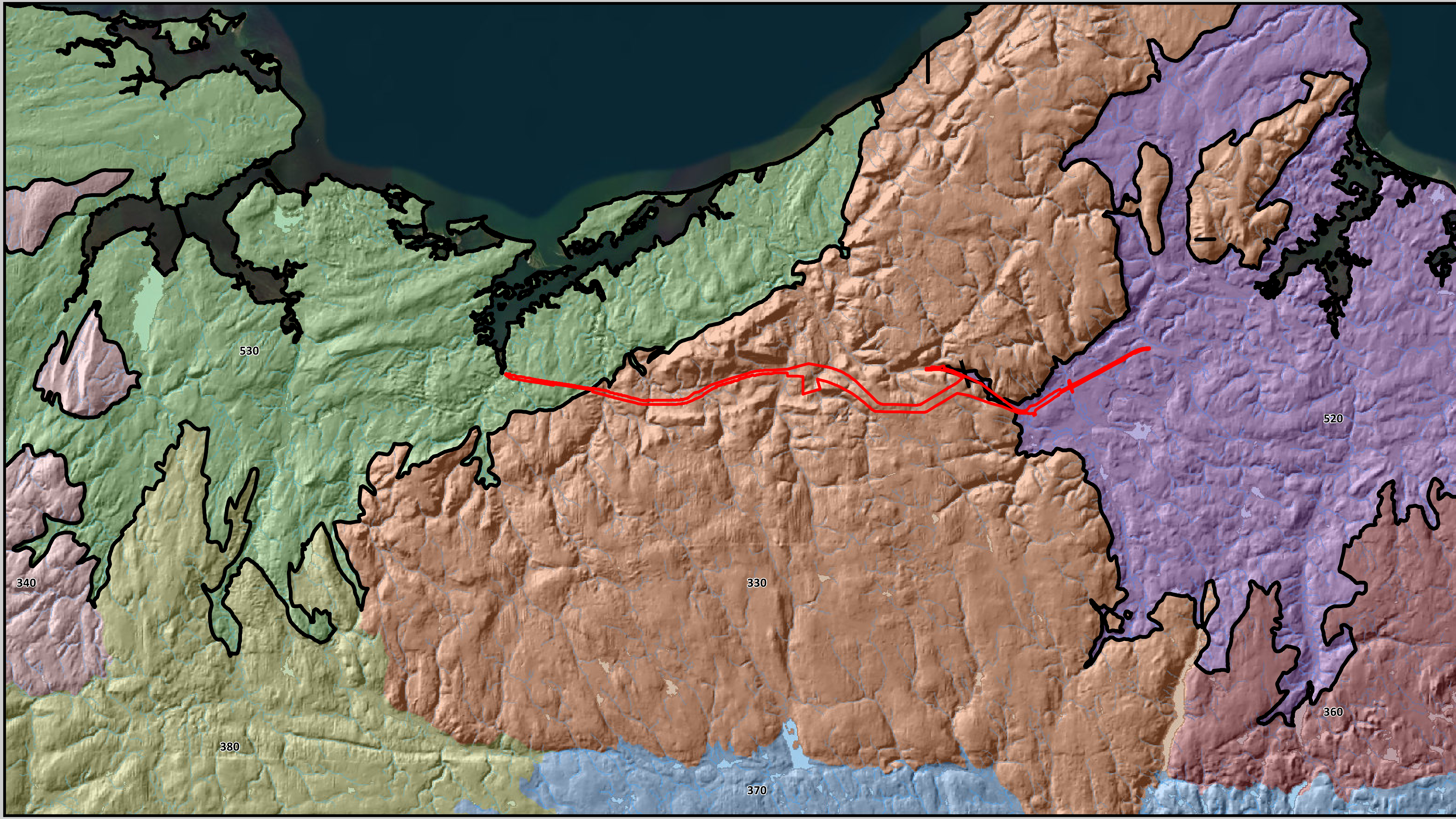
The Pictou Antigonish Highlands ecodistrict is defined tolerant hardwood and mixedwood forests consisting of American beech (*Fagus grandifolia*), sugar maple (*Acer saccharum*), yellow birch (*Betula alleghaniensis*), red spruce (*Picea rubens*) and sporadic eastern hemlock (*Tsuga canadensis*), which can be located along the crests and the upper and middle reaches of hills and larger hummocks. Eastern hemlock is often associated with steep slopes along the banks of watercourses. Red spruce and eastern hemlock are predominantly located in the low-lying areas with black spruce (*Picea mariana*) occupying poorly drained sites. Coarser soils that were deposited during the melting of the glaciers, often found along stream banks, will support stands of white pine (*Pinus strobus*). Old fields that were once tolerant hardwood stands are reclaimed by white spruce (*Picea glauca*).

The St. George's Bay ecodistrict includes most of Antigonish County and extends towards the Cape Breton Hills. This low-lying area is characterised by cool springs, and warm, moist summers. These climatic conditions produce prime growing conditions as seen by the abundance of agricultural lands amongst the rolling hills. Soils are primarily imperfectly drained to moderately drained gravel to gravelly clay loams. Well drained gravelly sand loams are often associated with major tributaries. Gypsum outcrops and karst topography, areas that often support the growth for rare species, are found along the cliffs of St. George's Bay. Natural forest stand compositions are infrequent due to the extensive agricultural disturbance. Abandoned agricultural lands have been reclaimed primarily by white spruce. Under normal conditions, it is likely that tolerant hardwoods including beech, sugar maple, and yellow birch would be present along the upper hillslopes, while tolerant softwoods including red spruce, eastern hemlock, and white pine would be found along the low-lying areas. Black spruce and tamarack (*Larix laricina*) could be common amongst imperfect to poorly drained soil types.

The Northumberland Lowlands ecodistrict extends along the Northumberland Strait into New Brunswick, seldom exceeding 50 m above sea level. This area is bounded and sheltered by the Cobequid Mountains, Pictou Antigonish Highlands, and the Cumberland Hills. This area consists primarily of black and red spruce. After a disturbance, either natural (i.e., fire) or anthropogenic (i.e., forest harvesting), early successional species including balsam fir (*Abies balsamea*), red maple (*Acer rubrum*), white birch (*Betula papyrifera*), trembling aspen (*Populus tremuloides*), and largetooth aspen (*Populus grandidentata*) will likely become established. Tolerant hardwood stands are uncommon to rare in this ecodistrict but can occur along the upper hillslopes with better drained soils.

5.3.1.2 P-ELC Analysis Methodology

General Concepts: The purpose of image classification is to iteratively organize imagery pixels into land-cover information classes, which in this instance are related directly to vegetation communities sampled on the ground. Imagery pixels are placed into these defined classes based on their spectral signature, which is derived from the multiple bands contained in the image. These spectral signatures are generated through the delineation of training areas within a GIS, which are polygons of known vegetation characteristics, as determined by field surveys or other reference data. Using the spectral signature data, the image classification algorithm in turn performs a pixel-by-pixel analysis of the remaining portions of the imagery in order to assign these remaining pixels to the defined land-cover classes.



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- Local Assessment Area
- NSGC - 1: 10 000 Waterbodies
- NSGC - 1: 10 000 Rivers/ Streams
- Ecoregion Boundary

Nova Scotia Uplands Ecoregion

- 330 Pictou Antigonish Highlands Ecodistrict
- 340 Cobequid Hills Ecodistrict
- 360 Mulgrace Plateau Ecodistrict
- 370 St. Marys River Ecodistrict
- 380 Central Uplands Ecodistrict

Northumberland/ Bras d'Or Ecoregion

- 520 St. George's Bay Ecodistrict
- 530 Northumberland Lowlands Ecodistrict

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HIGHWAY 104 - Sutherlands River to Antigonish

FIGURE 5.7
Ecozones and Ecodistricts Encompassing the Local Assessment Area

0 1 2 4 6 8 Km
Scale @ 11"x17" - 1:200,000

Z:\151046.14 - NSTIR CORRIDOR 4 EA\20 CAD\08 GIS\151046.14 - FIG 5.7 - MXD-008 EA FIGURES - ECODISTRICTS.mxd | Coordinate System: NAD 1983 CSRS UTM Zone 20N | Drawn: BH | Checked: MR | Approved: IB | Date: 04/10/2018

Data Sources and Image Processing: The primary source of land-cover imagery for this study was RapidEye multispectral satellite imagery (5 m spatial resolution), The RapidEye product consists of 5 bands of spectral data with ranges as follows:

- Blue (440-510 nm);
- Green (520-590 nm);
- Red (630-685 nm);
- Red Edge (690-730 nm); and
- Near Infrared (760-850 nm).

Using the RapidEye data, a Normalized Differential Vegetation Index (NDVI) layer was generated using the Near Infrared (NIR) and Red bands, per the following equation: NDVI = (NIR – Red) / (NIR + Red).

The five RapidEye spectral bands, plus the NDVI were composited into a multiband raster for the purposes of a 'supervised' image classification. 'Training areas' for this classification were developed using the network ecosystem classification field sample locations, and visual interpretation of high resolution imagery. The ecosystem classification points assisted in identifying major vegetation groups such as coniferous, deciduous, and mixed forest, as well as vegetated and un-vegetated non-forest areas (e.g., low herbaceous vegetation, gravel, asphalt, and water). These training areas were in turn used to generate class signatures for each of the defined land-cover classes in the training area dataset. These class signatures are statistical clusters based on the spectral attributes of the various input layers in the multiband raster being classified (ESRI, 2018a). Using the class signature files, a Maximum Likelihood image classification algorithm (ESRI, 2018b) was performed, wherein each cell in the multiband raster is placed into one of the land-cover classes defined in the signature file. Upon execution of the RapidEye land-cover classification, a focal majority filter (ESRI, 2018c) was applied to reduce noise within the classification and to generalize the habitat regions. During this process, each classified image pixel was assigned the majority value found in its immediate 3x3 pixel neighbourhood.

The RapidEye data was supplemented by Light Detecting and Ranging (LiDAR) topographic data (1 m spatial resolution), to introduce various topographic and structural (i.e., vegetation height) parameters to the analysis. LiDAR was acquired from a variety of sources including the Nova Scotia Geomatics Centre Elevation Explorer (NSGC, 2018), and directly from NSTIR. LiDAR data was imported into the GIS as point clouds from raw LAS files from the various data sources. Using these data, a series of seamless raster datasets were generated along the entire length and breadth of the Project corridor, including:

- Digital Surface Model (DSM): An elevation surface derived from interpolation of all ground, and above ground elevation features;
- Digital Elevation Model (DEM): An elevation surface derived from interpolation of ground elevation features only; and
- Canopy Height Model (CHM): Defined as the arithmetic difference between the DSM and DEM, and representing the height of all above ground features (predominantly vegetation).

All analysis was performed using ESRI ArcGIS Desktop and ArcGIS Pro (with 3D and Spatial Analyst extensions). Additional topographic analysis was conducted within SAGA GIS.

5.3.1.3 P-ELC Outputs

The P-ELC output layer comprises three-digit codes describing the various permutations of the input layers as follows.

- '100' level codes – Major Land-cover Class
    - 100: Coniferous
    - 200: Deciduous
    - 300: Mixed Wood
    - 400: Herbaceous
    - 500: Herbaceous/Gravel-Soil
    - 600: Gravel or Asphalt
    - 700: Water
- '10' level codes – Height Class
    - 10: <0.5 m
    - 20: 0.5–2 m
    - 30: 2-5 m
    - 40: 5-10 m
    - 50: > 10 m
- '1' level codes – Wetness Class (expressed as height above modelled water table)
    - 0: >20 m
    - 1: 10-20 m
    - 2: 5-10 m
    - 3: 2-5 m
    - 4: 1-2 m
    - 5: 0.5-1 m
    - 6: 0.25-0.5 m
    - 7: 0.1-0.25 m
    - 9: 0.05-0.1 m
    - 9: < 0.05 m

As specific examples of P-ELC code interpretation based on the above:

- P-ELC code '250' represents potential for mature, well drained, deciduous forest;
- P-ELC code '139' represents potential for coniferous shrub wetland;
- P-ELC code '429' represents potential for tall herbaceous-dominated wetland, such as a cattail marsh; and
- P-ELC code '344' represents potential for a moderately well drained, immature mixed forest.

Due to the high number of permutations of three-digit codes, discrete mapping of the individual P-ELC codes can be challenging to visually interpret. This P-ELC does, however, enable the extraction of very specific landscape parameters and is well suited to analytical mapping within GIS, especially for specific habitat studies. For visual interpretation purposes, a rendering consisting of major land-cover classes ('100' series codes), overlain with Wetness classes 6 through 9 (high wetland potential) is provided in Figure 5.8.

5.3.2 Vascular Plants

Vascular plants have been selected as a VEC because of their crucial roles in local ecosystems and biodiversity, as well as the potential for interactions with the Project. CBCL's methodologies and the resulting findings of the desktop and field studies are described in detail in the following subsections.

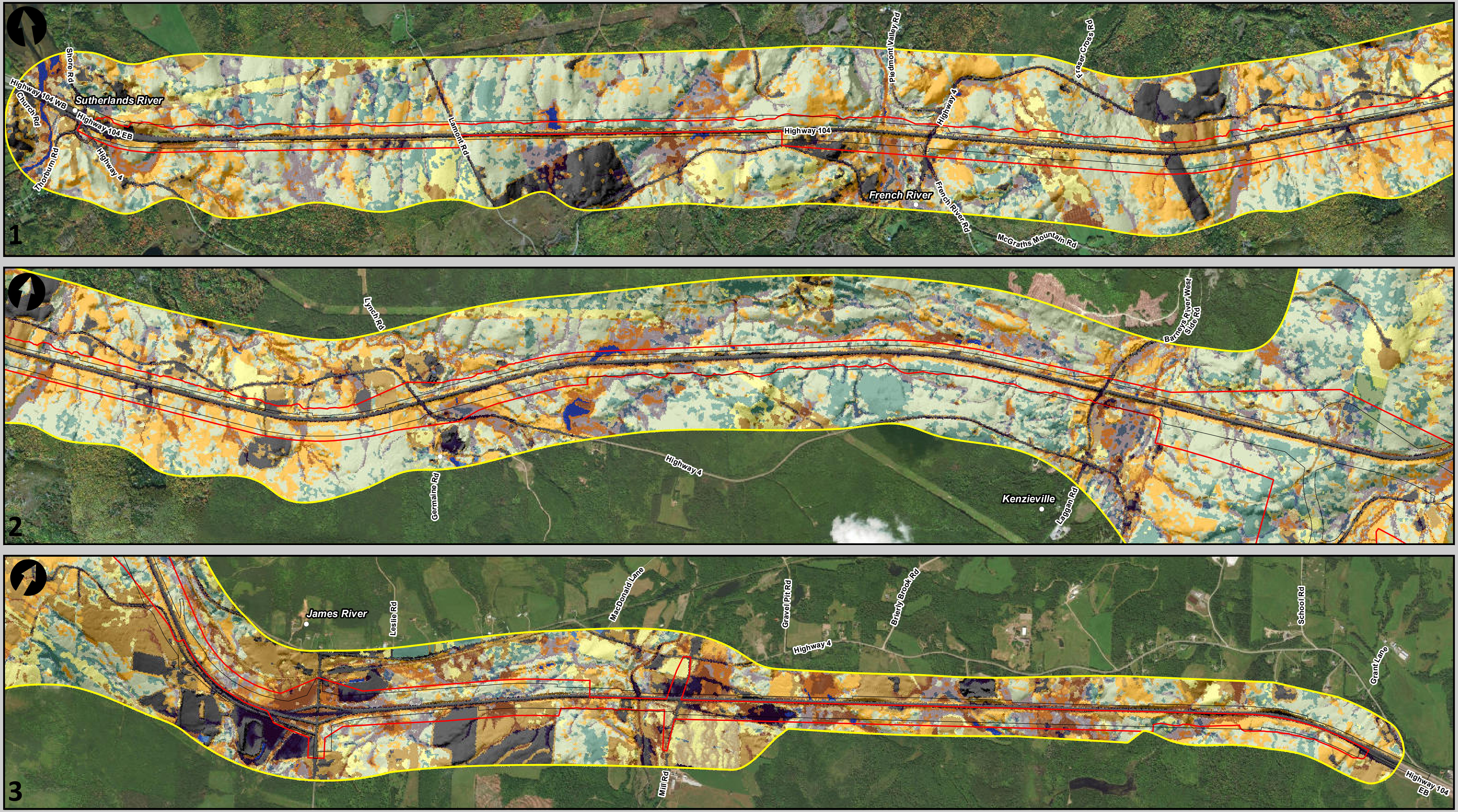
5.3.2.1 Desktop Study

Prior to field surveys, basic information on vascular plant communities and species occurring in the Project Area was obtained from a variety of sources, such as the *Natural History of Nova Scotia* (Davis & Browne, 1996), and *Nova Scotia Plants* (Munro, 2014). Additional specialized references used during the vegetation community and species assessments are listed in their relevant subsections below.

Information on potential rare or uncommon plant species was obtained from the Atlantic Canada Conservation Data Centre (ACCDC), which did not report any vascular or non-vascular plant Species at Risk (SAR) from within the Project Area or 5 km buffer (ACCDC, 2018c). The ACCDC report did list a total of 17 vascular plant Species of Conservation Concern (SOCC) from within the Project Area or 5 km buffer (Table 5.10). Some of these are considered to have suitable habitat within the LAA (Table 5.10). Several of these species (*Cystopteris bulbifera, Carex eburnea, Erigeron hyssopifolius, Cypripedium parviflorum, Packera paupercula)* are calcareous species which occur in areas of exposed gypsum. Exposed areas of gypsum are present near, but not within the LAA or Project Area.

Table 5.10 Vascular Plant SOCC Reported by ACCDC (2018) from Within 5 km of the Project Area

Common Name	Scientific Name	COSEWIC	ACCDC	Suitable Habitat Within LAA?
Hyssop-leaved Fleabane	*Erigeron hyssopifolius*	-	S3	No
Marsh Bellflower	*Campanula aparinoides*	-	S3	Possible
Hayden's Sedge	*Carex haydenii*	-	S1	Possible
Canada Lily	*Lilium canadense*	-	S2	Yes
Fragrant Green Orchid	*Platanthera huronensis*	-	S1S2	Possible
Blunt-leaved Pondweed	*Potamogeton obtusifolius*	-	S3	Possible
White-stemmed Pondweed	*Potamogeton praelongus*	-	S3	Possible
Ground-Fir	*Lycopodium sabinifolium*	-	S3?	Possible
Dwarf Clearweed	*Pilea pumila*	-	S1	Possible
Shortawned Foxtail	*Alopecurus aequalis*	-	S3	Yes
Yellow Lady's-slipper	*Cypripedium parviflorum*	-	S2S3	No
Hop Sedge	*Carex lupulina*	-	S3	Yes
Gmelin's Water Buttercup	*Ranunculus gmelinii*	-	S3	Yes
Woodland Strawberry	*Fragaria vesca ssp. americana*	-	S3	Yes
Balsam Groundsel	*Packera paupercula*	-	S3S4	No
Bulblet Bladder Fern	*Cystopteris bulbifera*	-	S3	No
Bristle-leaved Sedge	*Carex eburnea*	-	S3S4	No



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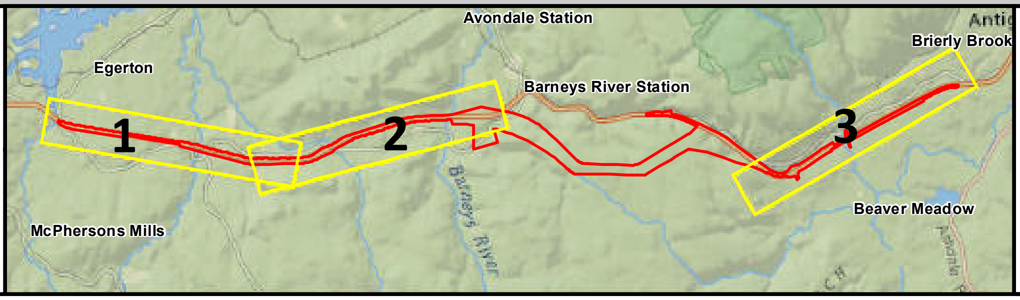
- P-ELC Boundary
- Local Assessment Area
- Project Area

P-ELC Cover Class
- 100 - Coniferous
- 200 - Deciduous
- 300 - Mixed
- 400 - Herbaceous
- 500 - Herbaceous / Gravel-Soil
- 600 - Gravel-Soil / Asphalt / Cutover
- 700 - Water

P-ELC Wetness Class
- 0-5 - Well Drained
- 6: 0.25-0.5 m
- 7: 0.1-0.25 m
- 8: 0.05 - 0.1 m
- 9: <0.05 m

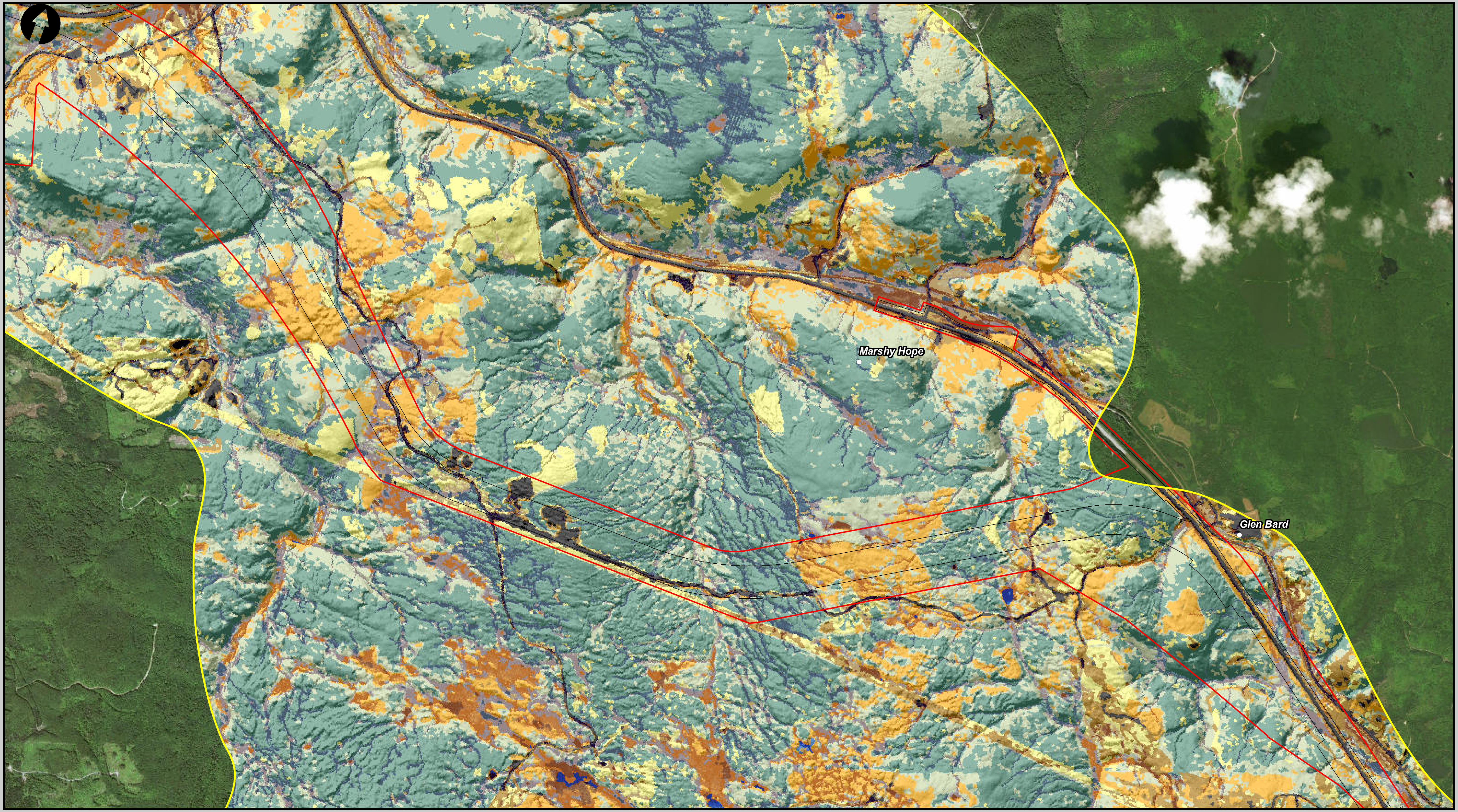


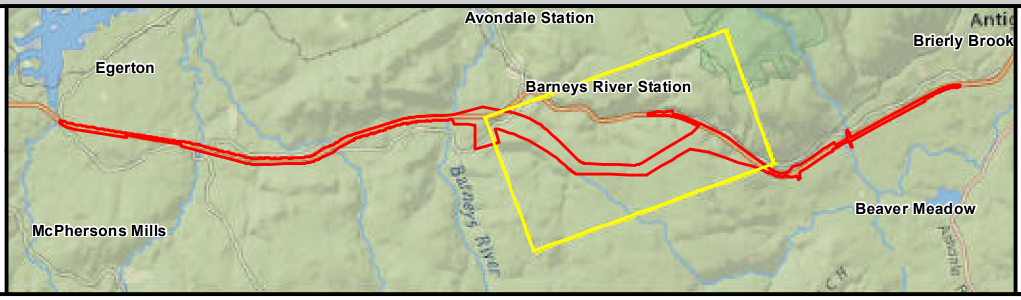
Environmental Assessment
HIGHWAY 104 - Sutherlands River to Antigonish

FIGURE 5.8
Project Ecological Land Classification (P-ELC)
Sheet 1 of 2 (Twinning Portions)

0 0.5 1 km
Scale @ 11"x17" - 1:25,000

Z:\151046.14 - NSTIR CORRIDOR 4 EA\20 CAD\08 GIS\151046.14 - FIG 5.8 - MXD-014 EA FIGURES- P-ELC- Page1.mxd | Coordinate System: NAD 1983 UTM Zone 20N | Drawn: BH | Checked: IB | Approved: IB | Date: 14/11/2018





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- P-ELC Boundary
- Local Assessment Area
- Project Area

P-ELC Cover Class

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- 300 - Mixed
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- 600 - Gravel-Soil / Asphalt / Cutover
- 700 - Water

P-ELC Wetness Class

- 0-5 - Well Drained
- 6: 0.25-0.5 m
- 7: 0.1-0.25 m
- 8: 0.05 - 0.1 m
- 9: <0.05 m

Environmental Assessment
HIGHWAY 104 - Sutherlands River to Antigonish

FIGURE 5.8
Project Ecological Land Classification (P-ELC)
Sheet 2 of 2 (New Alignment Portion)

0 0.25 0.5 1 km
Scale @ 11"x17" - 1:25,000

Z:\151046.14 - NSTIR CORRIDOR 4 EA\20 CAD\08 GIS\151046.14 - FIG 5.8 - MXD-014 EA FIGURES- P-ELC- Page2.mxd | Coordinate System: NAD 1983 UTM Zone 20N | Drawn: BH | Checked: IB | Approved: IB | Date: 14/11/2018