APPENDIX A
MLS CERTIFICATE OF INCORPORATION

Nova Scotia

CERTIFICATE OF INCORPORATION

Companies Act

Registry Number

3302278

Name of Company

MARITIME LAUNCH SERVICES LTD.

I hereby certify that the above-mentioned company was incorporated this date under the Companies Act and that the company is limited.

Stewart McKelvey

Agent of the Registrar of Joint Stock Companies

October 21, 2016

Date of Incorporation

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LAUNCH NOISE STUDY

Blue Ridge Research and Consulting, LLC

Technical Report

Launch Noise Study for the Nova Scotia Environmental Assessment

December 2017 (Final)

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Acronyms and Abbreviations

The following acronyms and abbreviations are used in the report:

BRRC	Blue Ridge Research and Consulting, LLC
CCOHS	Canadian Centre for Occupational Health and Safety
dB	Decibel
dBA	A-weighted Decibel Level
DI	Directivity Indices
DSM-1	Distributed Source Method 1
EA	Environmental Assessment
kg	Kilogram
km	Kilometer
kN	Kilonewton
$L_{A,max}$	Maximum A-weighted Sound Level In Decibels
L_{max}	Maximum Unweighted Sound Level in Decibels
L_{pk}	Peak Sound Pressure Level in Decibels
m	Meter
MCLV	Medium Class Launch Vehicle
NEF	Noise Exposure Forecast
NIHL	Noise-induced Hearing Loss
NIOSH	National Institute for Occupational Safety and Health
OSHA	Occupational Safety and Health Administration
P_k	Peak Pressure
psf	Pounds per Square Foot
RUMBLE	The Launch Vehicle Acoustic Simulation Model
TA	Time Above
µPa	Micropascal

1 Introduction

This report documents the noise study performed as part of Maritime Launch Services (MLS) efforts to perform an environmental assessment (EA) for the proposed launch operations of a Medium Class Launch Vehicle (MCLV) from Nova Scotia, Canada. The proposed launch site, hereafter referred to as the Canso launch site, is located in Guysborough County near the community of Canso, on the north-eastern tip of mainland Nova Scotia, Canada. The proposed launch operations include polar orbit missions of the MCLV.

The potential for launch vehicle noise and sonic boom impacts is evaluated on a single-event and cumulative basis in relation to human annoyance, hearing conservation, and structural damage criteria. Section 2 summarizes the basics of sound and describes the noise metrics and impact criteria discussed throughout this report. Section 3 describes the general methodology of the launch vehicle noise and sonic boom modeling. Section 4 describes the acoustical modeling input parameters for MCLV operations. Section 5 presents the launch vehicle noise and sonic boom modeling results. Lastly, Section 6 provides a summary of the notable findings of this noise study.

2 Acoustics Overview

An overview of sound-related terms, metrics, and effects, which are pertinent to this study, is provided to assist the reader in understanding the terminology used in this noise study.

2.1 Fundamentals of Sound

Any unwanted sound that interferes with normal activities or the natural environment is defined as noise. Three principal physical characteristics are involved in the measurement and human perception of sound: intensity, frequency, and duration [1].

- **Intensity** is a measure of a sound's acoustic energy and is related to sound pressure. The greater the sound pressure, the more energy is carried by the sound and the louder the perception of that sound.
- **Frequency** determines how the pitch of the sound is perceived. Low-frequency sounds are characterized as rumbles or roars, while high-frequency sounds are typified by sirens or screeches.
- **Duration** is the length of time the sound can be detected.

The loudest sounds that can be comfortably detected by the human ear have intensities a trillion times higher than those of sounds barely audible. Because of this vast range, using a linear scale to represent the intensity of sound can become cumbersome. As a result, a logarithmic unit known as the decibel (abbreviated dB) is used to represent sound levels. A sound level of 0 dB approximates the threshold of human hearing and is barely audible under extremely quiet listening conditions. Normal speech has a sound level around 60 dB. Sound levels above 120 dB begin to be felt inside the human ear as discomfort. Sound levels between 130 and 140 dB are experienced as pain [2].

Because of the logarithmic nature of the decibel unit, sound levels cannot be simply added or subtracted and are somewhat cumbersome to handle mathematically. However, there are some useful rules when

dealing with sound levels. First, if a sound's intensity is doubled, the sound level increases by 3 dB, regardless of the initial sound level. For example:

50 dB + 50 dB = 53 dB, and 70 dB + 70 dB = 73 dB.

Second, the total sound level produced by two sounds with different levels is usually only slightly more than the higher of the two. For example:

50.0 dB + 60.0 dB = 60.4 dB.

In the community, "it is unlikely that the average listener would be able to correctly identify at a better than chance level the louder of two otherwise similar events which differed in maximum sound level by < 3 dB" [3]. On average, a person perceives a change in sound level of about 10 dB as a doubling (or halving) of the sound's loudness. This relation holds true for both loud and quiet sounds. A decrease in sound level of 10 dB actually represents a 90% decrease in sound intensity but only a 50% decrease in perceived loudness because the human ear does not respond linearly [1].

Sound frequency is measured in terms of cycles per second or hertz (Hz). Human hearing ranges in frequency from 20 Hz to 20,000 Hz, although perception of these frequencies is not equivalent across this range. Human hearing is most sensitive to frequencies in the 1,000 to 4,000 Hz range. Frequency-based adjustments are applied to mimic the sensitives of human ears. An "A-weighting" filter, as shown in Figure 2-1, adjusts sound levels at lower and higher frequencies to match the reduced sensitivity of human hearing for moderate sound levels. For this reason, the A-weighted decibel level (dBA) is commonly used to assess community sound.

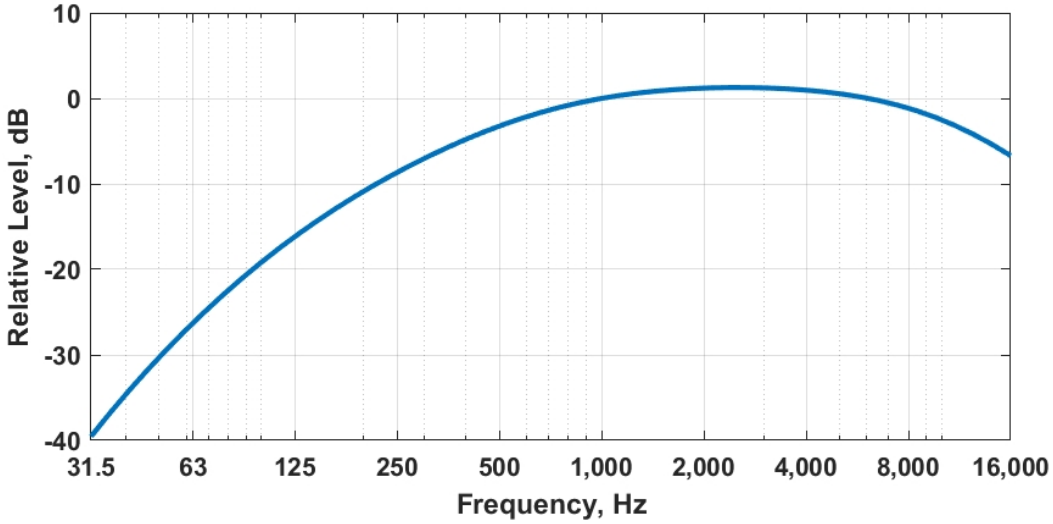

Figure 2-1. Frequency adjustments for A-weighting [4]

Sound sources can contain a wide range of frequency (pitch) content as well as variations in extent from short-durations to continuous, such as back-up alarms and ventilation systems, respectively. Figure 2-2 is a chart of A-weighted sound levels from typical sounds [5]. Some sound sources (air conditioners, generators, lawn mowers) are continuous with levels that are constant for a given duration; others (vehicles passing by) are the maximum sound during an event, and some (urban day and nighttime) are averages over extended periods [6]. Per the US Environmental Protection Agency, "Ambient noise in urban areas typically varies from 60 to 70 dB, but can be as high as 80 dB in the center of a large city. Quiet suburban neighborhoods experience ambient noise levels around 45-50 dB" [7].

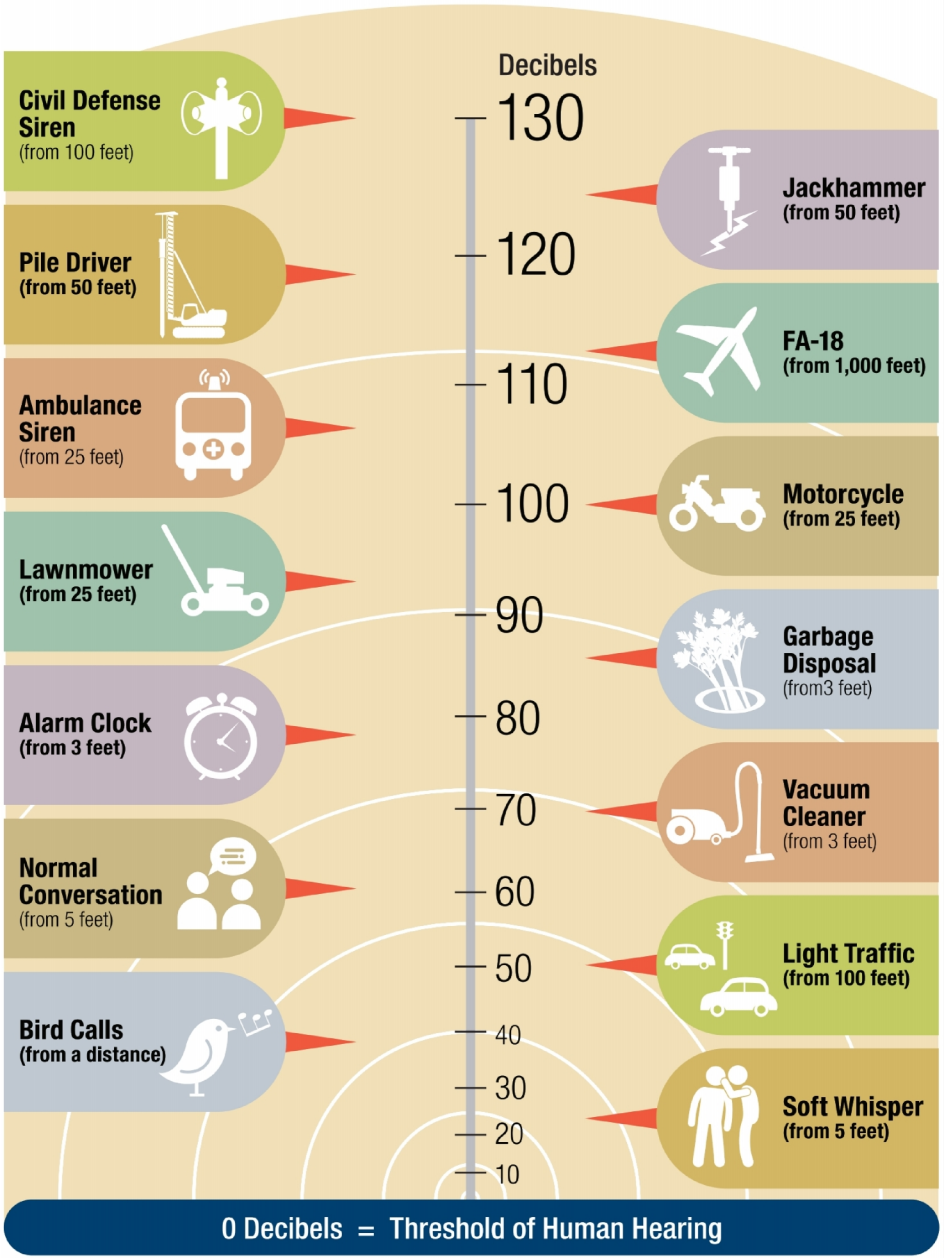

Figure 2-2. Typical A-weighted Sound Levels of Common Sounds [8]

The intensity of sonic booms is quantified with physical pressure units rather than levels. Intensities of sonic booms are traditionally described by the amplitude of the front shock waves, referred to as the overpressure, in pounds per square foot (psf), where 1 psf = 47.88 Pascals (Pa). The amplitude is particularly relevant when assessing structural effects as opposed to loudness or cumulative community response. In this study, sonic booms are quantified by either dB or psf, as appropriate for the particular impact being assessed [9].

2.2 Noise Metrics

A variety of acoustical metrics have been developed to describe sound events and to identify any potential impacts to receptors within the environment. These metrics are based on the nature of the event and who or what is affected by the sound. A brief description of the noise metrics used in this noise study are provided below.

Maximum Sound Level (L_{max})

The highest sound level measured during a single event, in which the sound changes with time, is called the Maximum Sound Level (abbreviated as L_{max}). The highest A-weighted sound level measured during a single event is called the Maximum A-weighted Sound Level (abbreviated as $L_{A,max}$). Although it provides some measure of the event, L_{max} (or $L_{A,max}$) does not fully describe the sound because it does not account for how long the sound is heard.

Peak Sound Level (L_{pk})

For impulsive sounds, the true instantaneous peak sound pressure level, which lasts for only a fraction of a second, is important in determining impacts. The peak pressure of the front shock wave is used to describe sonic booms and it is usually presented in psf. Peak sound levels are not frequency weighted.

Noise Exposure Forecast (NEF)

The NEF metric is based on the perceived noise level (PNL) and effective perceived noise level (EPNL). NEF is used to predict the community's response to a long-term noise environment. PNL is a measure of the perceived noisiness of a noise event by an observer, and EPNL consists of instantaneous PNL corrected for tones and flyover duration. EPNL evaluates four factors of a noise event: level, broadband frequency distribution, maximum tone, and duration [10]. The NEF is also a function of the number of annual daytime and nighttime events, where a 16.7 factor is applied to nighttime events (occurring between the hours of 10:00 p.m. and 7:00 a.m.) to account for increased human sensitivity to noise at night.

Time Above (TA)

The TA metric is the total time that the A-weighted sound level is at or above a threshold. TA is a supplemental metric that is used to help understand noise exposure.

2.3 Noise Effects

Noise criteria have been developed to protect the public health and welfare of the surrounding communities. The impacts of launch vehicle noise and sonic booms are evaluated on a cumulative basis in terms of human annoyance. In addition, the launch vehicle noise and sonic boom impacts are evaluated on a single-event basis in relation to hearing conservation and potential structural damage.

2.3.1 Human Annoyance

Transport Canada uses a NEF system to predict a community's response to aircraft noise. During the development of NEF, case histories of aircraft noise complaints were analyzed as to severity, frequency of complaint, and distribution around aerodromes. The results of this work, shown in Table 2-1, have been used for relating land use recommendations to NEF contour levels [11].

Table 2-1. Community response prediction [12]

Area	Response Prediction
1 (> 40 NEF)	Repeated and vigorous individual complaints are likely. Concerted group and legal action might be expected.
2 (35-40 NEF)	Individual complaints may be vigorous. Possible group action and appeals to authorities.
3 (30-35 NEF)	Sporadic to repeated individual complaints. Group action is possible.
4 (< 30 NEF)	Sporadic complaints may occur. Noise may interfere occasionally with certain activities of the resident.

Transport Canada recommends that below 25 NEF, all noise sensitive land uses are permissible without restrictions or limitations. Above 25 NEF, no new noise sensitive land uses (i.e. residential, schools, day care centers, nursing homes, and hospitals) are permitted [11].

Although Transport Canada does not currently have regulations that govern the methods used to evaluate the potential impacts of rocket noise, NEF is used in this report to be consistent with the current practices related to aircraft noise. However, noise studies used in the development of the NEF metric did not include rocket noise, which are historically irregularly occurring events. Thus, the suitability of NEF for infrequent rocket noise and sonic boom events is uncertain.

2.3.2 Speech Interference

Speech interference from environmental noise is a primary cause of annoyance for communities. Disruption of routine activities at home, at work, or other settings leads to frustrations and annoyance. One measure of speech comprehension is sentence intelligibility, which is the percent of sentences spoken and understood. A sentence intelligibility of 95% usually permits reliable communication between adults because of the redundancy in normal conversation. For a given level of vocal effort and distance between a speaker and listener, Table 2-2 presents the maximum steady background noise levels that permit satisfactory outdoor speech intelligibility of 95%. If the background noise levels increase above the levels presented in Table 2-2, the speaker will have to raise their voice appreciably or move closer to maintain the same intelligibility.

Table 2-2. Maximum background noise levels that permit outdoor speech intelligibility of 95% [7]

	Communication Distance (meters)					
Voice Level	0.5	1	2	3	4	5
Normal Voice (dBA)	72	66	60	56	54	52
Raised Voice (dBA)	78	72	66	62	60	58

2.3.3 Hearing Conservation

Launch Vehicle Noise

Government agencies provide guidelines on permissible noise exposure limits to protect human hearing from long-term continuous daily exposures to high noise levels and to aid in the prevention of noise-induced hearing loss (NIHL). A number of federal agencies have set exposure limits on non-impulsive noise levels including the Canadian Centre for Occupational Health and Safety (CCOHS) [12], U.S. Occupational Safety and Health Administration (OSHA) [13], and the U.S. National Institute for Occupational Safety and Health (NIOSH) [14]. The most conservative of these upper noise level limits has been set by OSHA at 115 dBA. At a sound level of 115 dBA, the allowable exposure duration is 15 minutes for OSHA and 28 seconds for CCOHS (in Nova Scotia) and NIOSH. $L_{A,max}$ contours are used to identify potential locations where hearing protection should be considered for rocket operations.

Sonic Booms

A sonic boom is the sound associated with the shock waves created by a vehicle traveling through the air faster than the speed of sound. Multiple federal government agencies have provided guidelines on permissible noise exposure limits on impulsive noise such as a sonic boom. These documented guidelines are in place to protect one's hearing from exposures to high noise levels and to aid in the prevention of NIHL. In terms of upper limits on impulsive or impact noise levels; CCOHS [12], NIOSH [14] and OSHA [13] have stated that levels should not exceed a L_{pk} of 140 dB, which equates to a sonic boom level of approximately 4 psf (192 Pa). Note, the CCOHS guidelines for L_{pk} in the Canadian jurisdiction of Nova Scotia are not defined. However, in jurisdictions that do define a L_{pk}, it is 140 dB.

2.3.4 Structural Damage

Launch Vehicle Noise

Typically, the most sensitive components of a structure to launch vehicle noise are windows, and infrequently, the plastered walls and ceilings. The potential for damage to a structure is unique interaction among the incident sound, the condition of the structure, and the material of each element and its respective boundary conditions. A report from the National Research Council on the "Guidelines for Preparing Environmental Impact Statements on Noise" [15] states that one may conservatively consider all sound lasting more than one second with levels exceeding 130 dB (unweighted) as potentially damaging to structures.

A NASA technical memo found a relationship between structural damage claims and overall sound pressure level, where "the probability of structural damage [was] proportional to the intensity of the low frequency sound" [16]. This relationship estimated that one damage claim in 100 households exposed is expected at an average continuous sound level of 120 dB, and one in 1,000 households at 111 dB. The study was based on community responses to 45 ground tests of the first and second stages of the Saturn V rocket system conducted in Southern Mississippi over a period of five years. The sound levels used to develop the criteria were mean, modeled sound levels.

It is important to highlight the difference between the static ground tests on which the rate of structural damage claims is based on, and the dynamic events modeled in this noise study. During ground tests, the engine/motor remains in one position, which results in a longer exposure duration to continuous levels as opposed to the transient noise occurring from the moving vehicle during a launch event. Regardless of this difference, Guest and Slone's (1972) damage claim criteria represents the best available dataset regarding the potential for structural damage resulting from rocket noise. Thus, L_{max} values of 120 dB and 111 dB are used in this report as conservative thresholds for potential risk of structural damage claims.

Sonic Booms

Sonic booms are also commonly associated with structural damage. Most damage claims are for brittle objects, such as glass and plaster. Table 2-3 summarizes the threshold of damage that may be expected at various overpressures [17]. A large degree of variability exists in damage experience, and much of the damage depends on the pre-existing condition of a structure. Breakage data for glass, for example, spans a range of two to three orders of magnitude at a given overpressure. The probability of a window breaking at 1 psf ranges from one in a billion [18] to one in a million [19]. These damage rates are associated with a combination of boom load and window pane condition. At 10 psf, the probability of breakage is between one in 100 and one in 1,000. Laboratory tests involving glass [20] have shown that properly installed window glass will not break at overpressures below 10 psf, even when subjected to repeated booms. However, in the real world, installed window glass is not always in pristine condition.

Damage to plaster occurs at similar ranges to glass damage. Plaster has a compounding issue in that it will often crack due to shrinkage while curing or from stresses as a structure settles, even in the absence of outside loads. Sonic boom damage to plaster often occurs when internal stresses are high as a result of these factors. In general, for well-maintained structures, the threshold for damage from sonic booms is 2 psf [17]; below 2 psf, damage is unlikely.

Table 2-3. Possible damage to structures from sonic booms [17]

Sonic Boom Overpressure Nominal (psf)	Type of Damage	Item Affected
0.5 - 2	Plaster	Fine cracks; extension of existing cracks; more in ceilings; over doorframes; between some plasterboards.
	Glass	Rarely shattered; either partial or extension of existing.
	Roof	Slippage of existing loose tiles/slates; sometimes new cracking of old slates at nail holes.
	Damage to Outside Walls	Existing cracks in stucco extended.
	Bric-a-brac	Those carefully balanced or on edges can fall; fine glass, such as large goblets, can fall and break.
	Other	Dust falls in chimneys.
2 - 4	Glass, Plaster, Roofs, Ceilings	Failures occur that would have been difficult to forecast (in terms of their existing localized condition). Nominally in good condition.
4 - 10	Glass	Regular failures within a population of well-installed glass; industrial as well as domestic greenhouses.
	Plaster	Partial ceiling collapse of good plaster; complete collapse of very new, incompletely cured, or very old plaster.
	Roofs	High probability rate of failure in nominally good condition, slurry-wash; some chance of failures in tiles on modern roofs; light roofs (bungalow) or large area can move bodily.
	Walls (out)	Old, free standing walls in fairly good condition can collapse.
	Walls (in)	Inside (“party”) walls known to move at 10 psf.
Greater than 10	Glass	Some good glass will fail regularly to sonic booms from the same direction. Glass with existing faults could shatter and fly. Large window frames move.
	Plaster	Most plaster affected.
	Ceilings	Plasterboards displaced by nail popping.
	Roofs	Most slate/slurry roofs affected, some badly; large roofs having good tile can be affected; some roofs bodily displaced causing gale-end and will-plate cracks; domestic chimneys dislodged if not in good condition.
	Walls	Internal party walls can move even if carrying fittings such as hand basins or taps; secondary damage due to water leakage.
	Bric-a-brac	Some nominally secure items can fall; e.g., large pictures, especially if fixed to party walls.

3 Noise Modeling

Launch vehicle propulsion systems, such as solid rocket motors and liquid-propellant rocket engines, generate high amplitude, broadband noise. Most of the noise is created by the rocket plume interacting with the atmosphere, and the combustion noise of the propellants. Although rocket noise radiates in all directions, it is highly directive, meaning that a significant portion of the source's acoustic power is concentrated in specific directions.

In addition to the rocket noise, a launch vehicle creates sonic booms during its supersonic flight. The potential for the boom to intercept the ground depends on the trajectory and speed of the vehicle as well as the atmospheric profile. The sonic boom is shaped by the physical characteristics of the vehicle and the atmospheric conditions through which it propagates. These factors affect the perception of a sonic boom. The noise is perceived as a deep boom, with most of its energy concentrated in the low frequency range. Although sonic booms generally last less than one second, their potential for impact may be considerable.

3.1 Launch Vehicle Noise

The Launch Vehicle Acoustic Simulation Model (RUMBLE), developed by Blue Ridge Research and Consulting, LLC (BRRC), is the noise model used to predict the noise associated with the proposed operations. The core components of the model are visualized in Figure 3-1 and are described in the following sub sections.

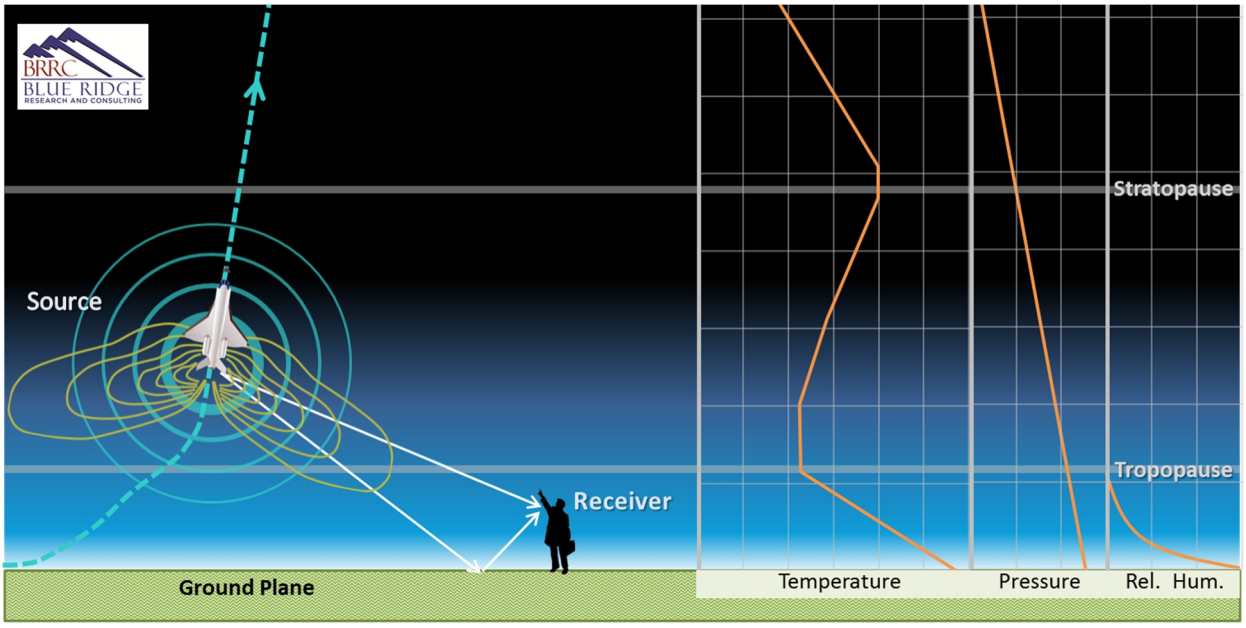

Figure 3-1. Conceptual overview of rocket noise prediction model methodology

3.1.1 Source

The rocket noise source definition considers the acoustic power of the rocket, forward flight effects, directivity, and the Doppler effect.

Acoustic Power

Eldred's Distributed Source Method 1 (DSM-1) [21] is utilized for the source characterization. The DSM-1 model determines the launch vehicle's total sound power based on its total thrust, exhaust-velocity, and the engine/motor's acoustic efficiency. BRRC's recent validation of the DSM-1 model showed very good agreement between full-scale rocket noise measurements and the empirical source curves [22]. The acoustic efficiency of the rocket engine/motor specifies the percentage of the mechanical power converted into acoustic power. The acoustic efficiency of the rocket engine/motor was modeled using Guest's variable acoustic efficiency [23]. Typical acoustic efficiency values range from 0.2% to 1.0% [21]. In the far-field, distributed sound sources are modeled as a single compact source located at the nozzle exit with an equivalent total sound power. Therefore, launch vehicle propulsion systems with multiple tightly clustered equivalent engines can be modeled as a single engine with an effective exit diameter and total thrust [21]. Additional boosters or cores (that are not considered to be tightly clustered) are handled by summing the noise contribution from each booster/core.

Forward Flight Effect

A rocket in forward flight radiates less noise than the same rocket in a static environment. A standard method to quantify this effect reduces overall sound levels as a function of the relative velocity between the jet plume and the outside airflow [24, 25, 26, 27]. This outside airflow travels in the same direction as the rocket exhaust. At the onset of a launch, the rocket exhaust travels at far greater speeds than the ambient airflow. As the differential between the forward flight velocity and exhaust velocity decreases, jet plume mixing is reduced, which reduces the corresponding noise emission. Notably, the maximum sound levels are normally generated before the vehicle reaches the speed of sound. Thus, the modeled noise reduction is capped at a forward flight velocity of Mach 1.

Directivity

Rocket noise is highly directive, meaning the acoustic power is concentrated in specific directions, and the observed sound pressure will depend on the angle from the source to the receiver. NASA's Constellation Program has made significant improvements in determining launch vehicle directivity of the reusable solid rocket motor (RSRM) [28]. The RSRM directivity indices (DI) incorporate a larger range of frequencies and angles then previously available data. Subsequently, improvements were made to the formulation of the RSRM DI [29] accounting for the spatial extent and downstream origin of the rocket noise source. These updated DI are used for this analysis.

Doppler Effect

The Doppler effect is the change in frequency of an emitted wave from a source moving relative to a receiver. The frequency at the receiver is related to the frequency generated by the moving sound source and by the speed of the source relative to the receiver. The received frequency is higher (compared to the emitted frequency) if the source is moving towards the receiver, it is identical at the instant of passing by, and it is lower if the source is moving away from the receiver. During a rocket launch, an observer on the ground will hear a downward shift in the frequency of the sound as the distance from the source to receiver increases. The relative changes in frequency can be explained as follows: when the source of the waves is moving toward the observer, each successive wave crest is emitted from a position closer to the

observer than the previous wave. Therefore, each wave takes slightly less time to reach the observer than the previous wave, and the time between the arrivals of successive wave crests at the observer is reduced, causing an increase in the frequency. While they are traveling, the distance between successive wave fronts is reduced such that the waves "bunch together." Conversely, if the source of waves is moving away from the observer, then each wave is emitted from a position farther from the observer than the previous wave; the arrival time between successive waves is increased, reducing the frequency. Likewise, the distance between successive wave fronts increases, so the waves "spread out." Figure 3-2 illustrates this spreading effect for an observer in a series of images, where a) the source is stationary, b) the source is moving less than the speed of sound, c) the source is moving at the speed of sound, and d) the source is moving faster than the speed of sound. As the frequency is shifted lower, the A-weighting filtering on the spectrum results in a decreased A-weighted sound level. For unweighted overall sound levels, the Doppler effect does not change the levels since all frequencies are accounted for equally.

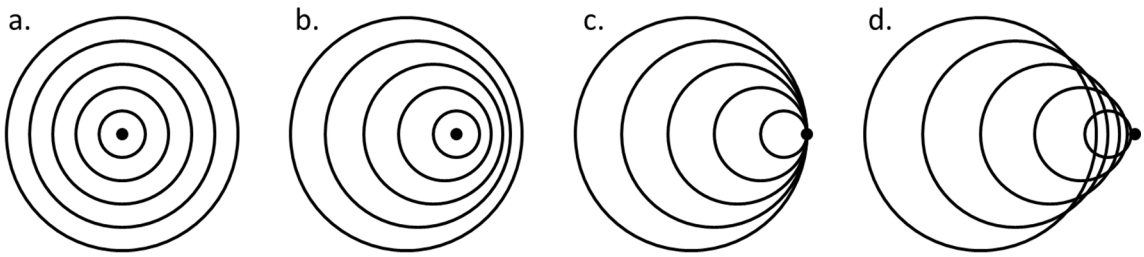

Figure 3-2. Effect of expanding wavefronts (decrease in frequency) that an observer would notice for higher relative speeds of the rocket relative to the observer for: a) stationary source b) source velocity < speed of sound c) source velocity = speed of sound d) source velocity > speed of sound

3.1.2 Propagation

The sound propagation from the source to receiver considers the ray path, atmospheric absorption, and ground interference.

Ray Path

The model assumes straight line propagation between the source and receiver to determine propagation effects. For straight rays, sound levels decrease as the sound wave propagates away from a source uniformly in all directions. The launch vehicle noise model components are calculated based on the specific geometry between source (launch vehicle trajectory point) to receiver (grid point). The position of the launch vehicle, described by the trajectory, is provided in latitude and longitude, defined relative to a reference system (e.g. World Geodetic System 1984) that approximates the Earth's surface by an ellipsoid. The receiver grid is also described in geodetic latitude and longitude, referenced to the same reference system as the trajectory data, ensuring greater accuracy than traditional flat earth models.

Atmospheric Absorption

Atmospheric absorption is a measure of the sound attenuation from the excitation of vibration modes of air molecules. Atmospheric absorption is a function of temperature, pressure and relative humidity of the air. Figure 3-1 shows an example atmospheric profile. The atmospheric absorption is calculated using formulas found in ANSI Standard S1.26-1995 (R2004). The result is a sound-attenuation coefficient, which is a function of frequency, atmospheric conditions, and distance from the source. The amount of absorption depends on the parameters of the atmospheric layer and the distance that the sound travels through the layer. The total sound attenuation is the sum of the absorption experienced from each atmospheric layer.

Nonlinear propagation effects can result in distortions of high-amplitude sound waves [30] as they travel through the medium. These nonlinear effects are counter to the effect of atmospheric absorption [31, 32]. However, recent research shows that nonlinear propagation effects change the perception of the received sound [33, 34], but the standard acoustical metrics are not strongly influenced by nonlinear effects [35, 36]. The overall effects of nonlinear propagation on high-amplitude sound signatures and their perception is an on-going area of research, and it is not currently included in the propagation model.

Ground Interference

The calculated results of the sound propagation using DSM-1 provide a free-field sound level (i.e. no reflecting surface) at the receiver. However, sound propagation near the ground is most accurately modeled as the combination of a direct wave (source to receiver) and a reflected wave (source to ground to receiver) as shown in Figure 3-1. The ground will reflect sound energy back toward the receiver and interfere both constructively and destructively with the direct wave. Additionally, the ground may attenuate the sound energy causing the reflected wave to propagate a smaller portion of energy to the receiver. RUMBLE accounts for the attenuation of sound by the ground [37, 38] when estimating the received noise. The model assumes a five-foot receiver height and a homogeneous grass ground surface. However, it should be noted that noise levels may be 3 dB louder over water surfaces compared to the predicted levels over the homogeneous grass ground surfaces assumed in the modeling. To account for the random fluctuations of wind and temperature on the direct and reflected wave, the effect of atmospheric turbulence is also included [37, 39].

3.1.3 Receiver

The received noise is estimated by combining the source and propagation components. The basic received noise is modeled as overall and spectral level time histories. This approach enables a range of noise metrics relevant to environmental noise analysis to be calculated and prepared as output.

3.2 Sonic Booms

When a vehicle moves through the air, it pushes the air out of its way. At subsonic speeds, the displaced air forms a pressure wave that disperses rapidly. At supersonic speeds, the vehicle is moving too quickly for the wave to disperse, so it remains as a coherent wave. This wave is a sonic boom. When heard at ground level, a sonic boom consists of two shock waves (one associated with the forward part of the vehicle, the other with the rear part) of approximately equal strength and (for fighter aircraft) separated by 100 to 200 milliseconds. For launch vehicles, the separation can be extended because of the volume of the plume. Thus, their waveform durations can be as large as one second. When plotted, this pair of shock waves and the expanding flow between them has the appearance of a capital letter “N,” so a sonic boom pressure wave is usually called an “N-wave.” An N-wave has a characteristic "bang-bang" sound that can be startling. Figure 3-3 shows the generation and evolution of a sonic boom N-wave under the vehicle. Figure 3-4 shows the sonic boom pattern for a vehicle in steady, level supersonic flight. The boom forms a cone that is said to sweep out a “carpet” under the flight track. The boom levels vary along the lateral extent of the “carpet” with the highest levels directly underneath the flight track and decreasing as the lateral distance increases to the cut-off edge of the “carpet.” When the vehicle is maneuvering, the sonic boom energy can be focused in highly localized areas on the ground.

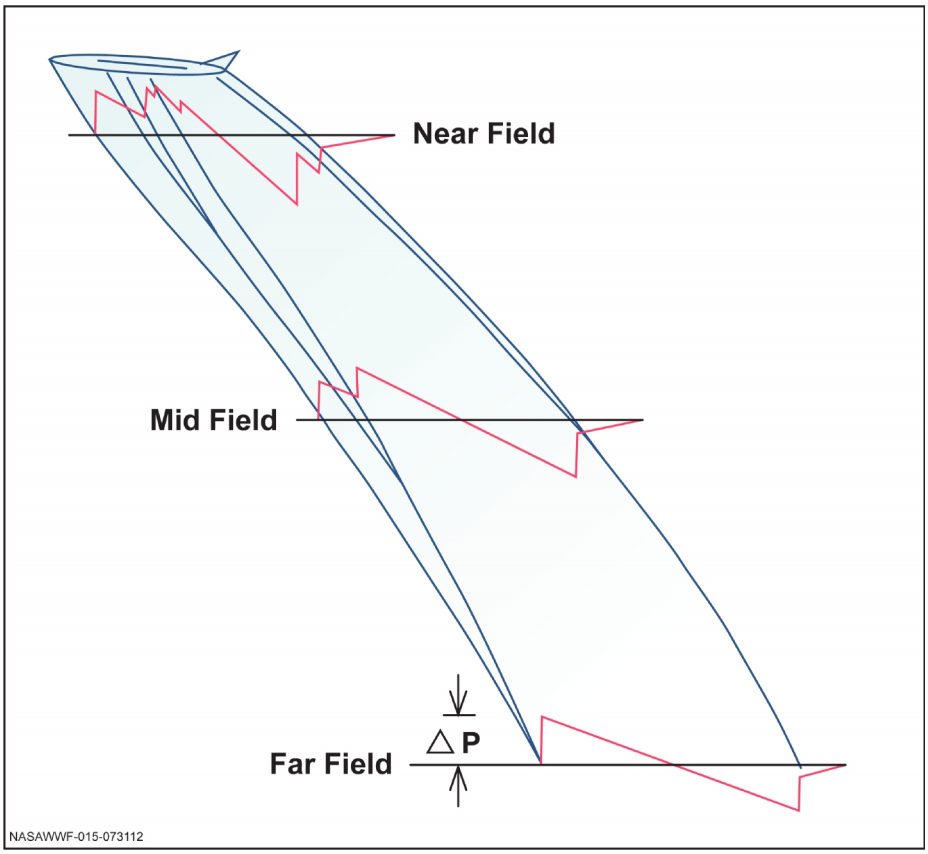

Figure 3-3. Sonic boom generation and evolution to N-wave [40]

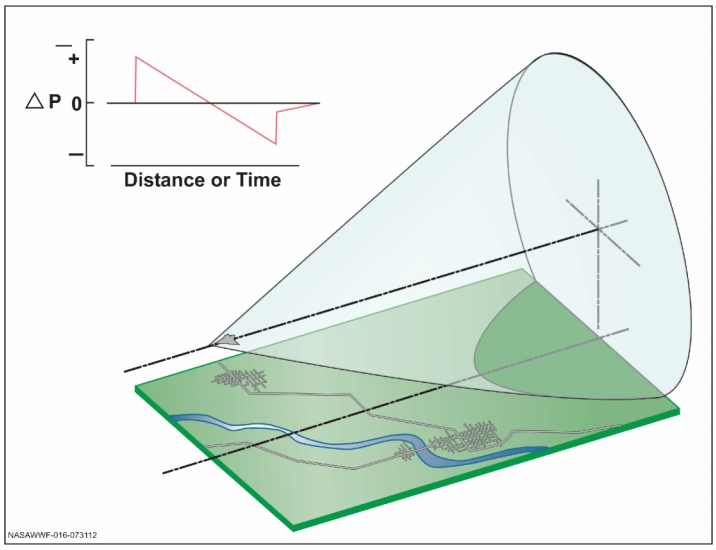

Figure 3-4. Sonic boom carpet for a vehicle in steady flight [41]

The complete ground pattern of a sonic boom depends on the size, weight, shape, speed, and trajectory of the vehicle. Since aircraft fly supersonically with relatively low horizontal angles, the boom is directed toward the ground. However, for rocket trajectories, the boom is directed laterally until the rocket rotates significantly away from vertical, as shown in Figure 3-5. This difference causes a sonic boom from a rocket to propagate much further downrange compared to aircraft sonic booms. This extended propagation usually results in relatively lower sonic boom levels from rocket launches. For aircraft, the front and rear shock are generally the same magnitude. However, for a rocket the plume provides a smooth decrease in the vehicle volume, which diminishes the strength of the rear shock.

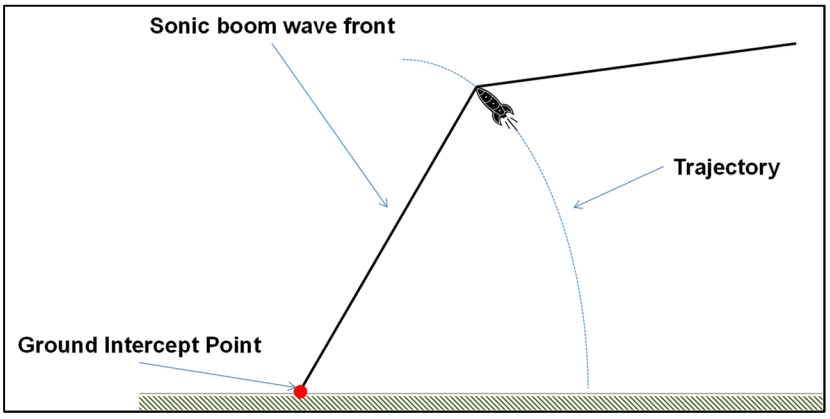

Figure 3-5. Sonic boom propagation for rocket launch

The single-event prediction model, PCBoom4 [42, 43, 44] is used to predict the sonic boom footprint. PCBoom4 calculates the magnitude, waveform, and location of sonic boom overpressures on the ground from supersonic flight. Several inputs are required to calculate the sonic boom impact, including the aircraft model, the trajectory path, the atmospheric conditions and the ground surface height. Predicted sonic boom footprints are in the form of constant pressure contours.

4 Canso Launch Site Modeling Input

4.1 Launch Site Description

The proposed Canso launch site is located in Guysborough County near the community of Canso, on the north-eastern tip of mainland Nova Scotia, Canada. The coordinates of the Canso launch site are 45.3033°N, 60.9823°W, as shown in Figure 4-1. The models utilize an atmospheric profile, which describes the variation of temperature, pressure and relative humidity with respect to the altitude. Standard atmospheric data sources [45, 46, 47] were used to create a composite atmospheric profile for altitudes up to 100 km.

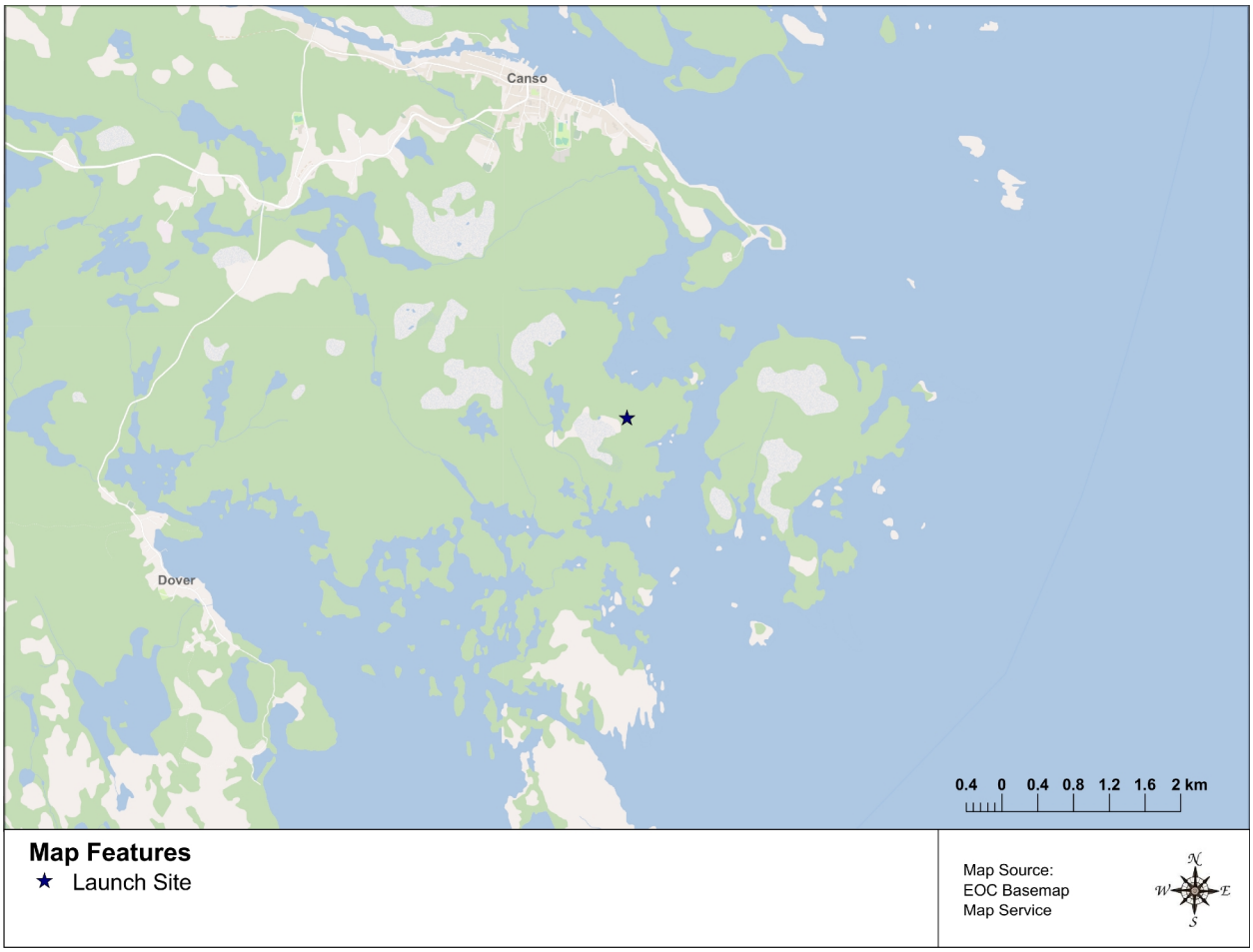

Figure 4-1. Canso launch pad location

4.2 Vehicle and Engine Modeling Parameters

The RUMBLE model requires specific vehicle/engine input parameters to determine the noise exposure resulting from the proposed polar orbit missions of the MCLV from the Canso launch site. The parameters of the representative MCLV and its engine are presented in Table 4-1.

Table 4-1. Vehicle and engine parameters used in acoustic modeling

MCLV Parameters	Values
Vehicle Length	38.9 m
Gross Vehicle Weight	261,813 kg
Number of Engines	2
Maximum Net Thrust Per Engine	1,824 kN
Nozzle Exit Diameter	1.3 m
Propellant Description	LOX/RP-1

4.3 Flight Trajectory Data

Launch trajectories departing from the Canso launch site will be unique to each mission and the environmental conditions. However, for the purpose of assessing potential noise impacts from MCLV launches, a nominal trajectory has been designed by Yuzhnoye. The provided trajectory has a flight path heading of approximately 181° relative to true north.

4.4 Operational Data

The proposed MCLV annual operations, summarized in Table 4-2, consist of eight launches. Of the eight total annual operations, two occur during acoustic nighttime hours (0200 – 0700).

Table 4-2. Proposed annual MCLV operations at the Canso launch site

		Annual Operations		
Operation	Location	Acoustic Day 0700 to 2200	Acoustic Night 2200 to 0700	Total
Launch	Canso Launch Pad	6	2	8

5 Results

The following sections present the study results of the environmental noise and sonic boom impacts associated with the proposed MCLV operations at the Canso launch site. Single event launch vehicle noise and sonic boom results are presented in Section 5.1 and cumulative noise results are presented in Section 5.2. To provide more detail on potential impacts to the communities of Canso and Little Dover, specific point metric results are provided in Section 5.3. It should be noted that noise levels may be 3 dB louder over water because of the acoustical hardness of the water surface.

5.1 Single Event Results

Launch vehicle noise and sonic boom impacts are evaluated on a single-event basis in relation to hearing conservation and structural damage criteria. Noise and sonic boom modeling was conducted for the proposed MCLV launch.

5.1.1 Launch vehicle noise

Maximum A-weighted Sound Level ($L_{A,max}$)

The maximum A-weighted sound level ($L_{A,max}$) indicates the maximum sound level achieved over the duration of the event. An upper limit noise level of 115 dBA is used as a guideline to protect human hearing from long-term continuous daily exposures to high noise levels and to aid in the prevention of noise-induced hearing loss. At a sound level of 115 dBA, the allowable exposure duration is 28 seconds for CCOHS (in Nova Scotia). A single MCLV launch event may generate levels at or above an $L_{A,max}$ of 115 dBA within 1.1 km of the launch pad, as shown by the orange contour in Figure 5-1.

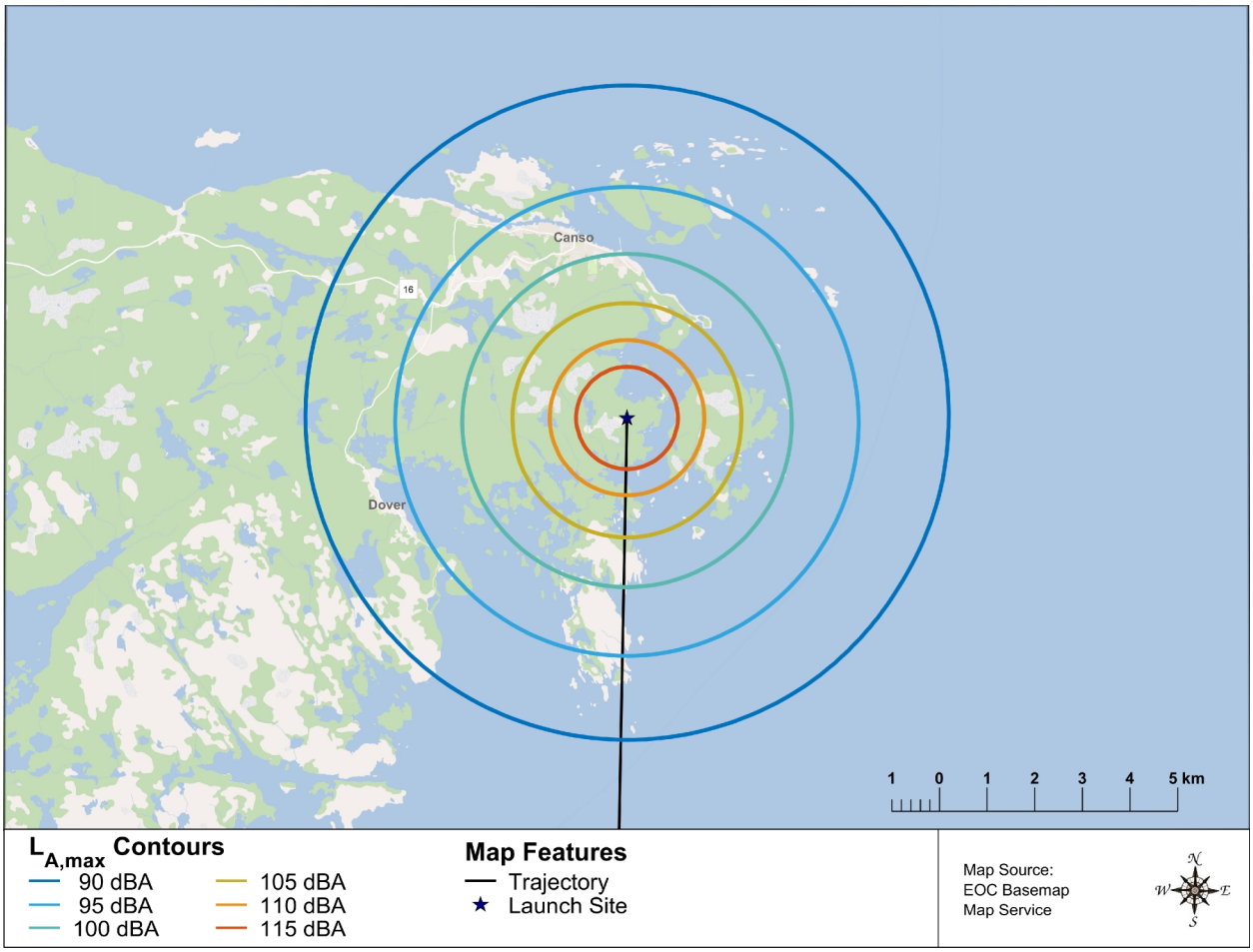

Figure 5-1. $L_{A,max}$ contours for a MCLV launch

Maximum Unweighted Sound Level (L_{max})

To assess the potential risk to structural damage claims, the 111 dB and 120 dB L_{max} contours generated by a MCLV launch event are presented in Figure 5-2. The potential for structural damage claims is approximately one damage claim per 100 households exposed at 120 dB and one in 1,000 households at 111 dB [16]. For launch events, L_{max} in excess of 120 dB and 111 dB would be limited to a radius of 3.0 km and 7.8 km from the launch pad, respectively.

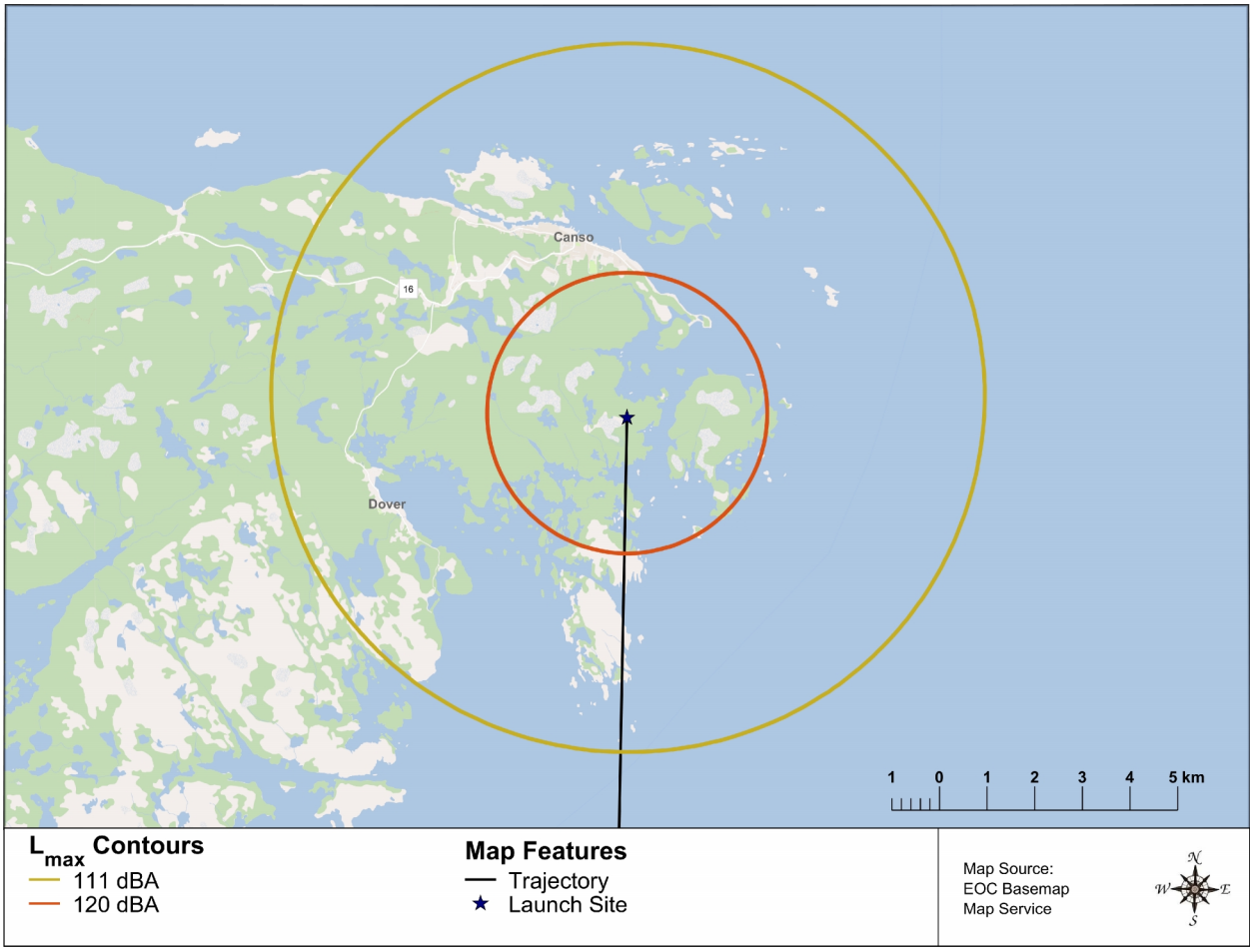

Figure 5-2. L_{max} contours for a MCLV launch

5.1.2 Sonic Booms

The presence and/or location of sonic boom regions is highly dependent on the actual trajectory and atmospheric conditions at the time of flight. The sonic boom contours generated by a MCLV launch event, represented by peak overpressure in psf, are shown in Figure 5-3.

For the nominal MCLV launch event, sonic booms intercept the ground during the supersonic portion of the ascent because the flight path angle deviates from vertical with increasing altitude. The modeled overpressure contour values between 0.25 and 4 psf are shown in Figure 5-3 for the nominal MCLV launch event. The maximum overpressure is 6.9 psf, is located over water, and covers an area too small to be seen in the figures. The boom footprint falls in the Atlantic Ocean, approximately 60 km from the launch pad along the launch azimuth. The nominal sonic boom from a MCLV launch operation is not predicted to intercept the mainland of Nova Scotia, and as such, will not exceed the hearing conservation and structural damage criteria.

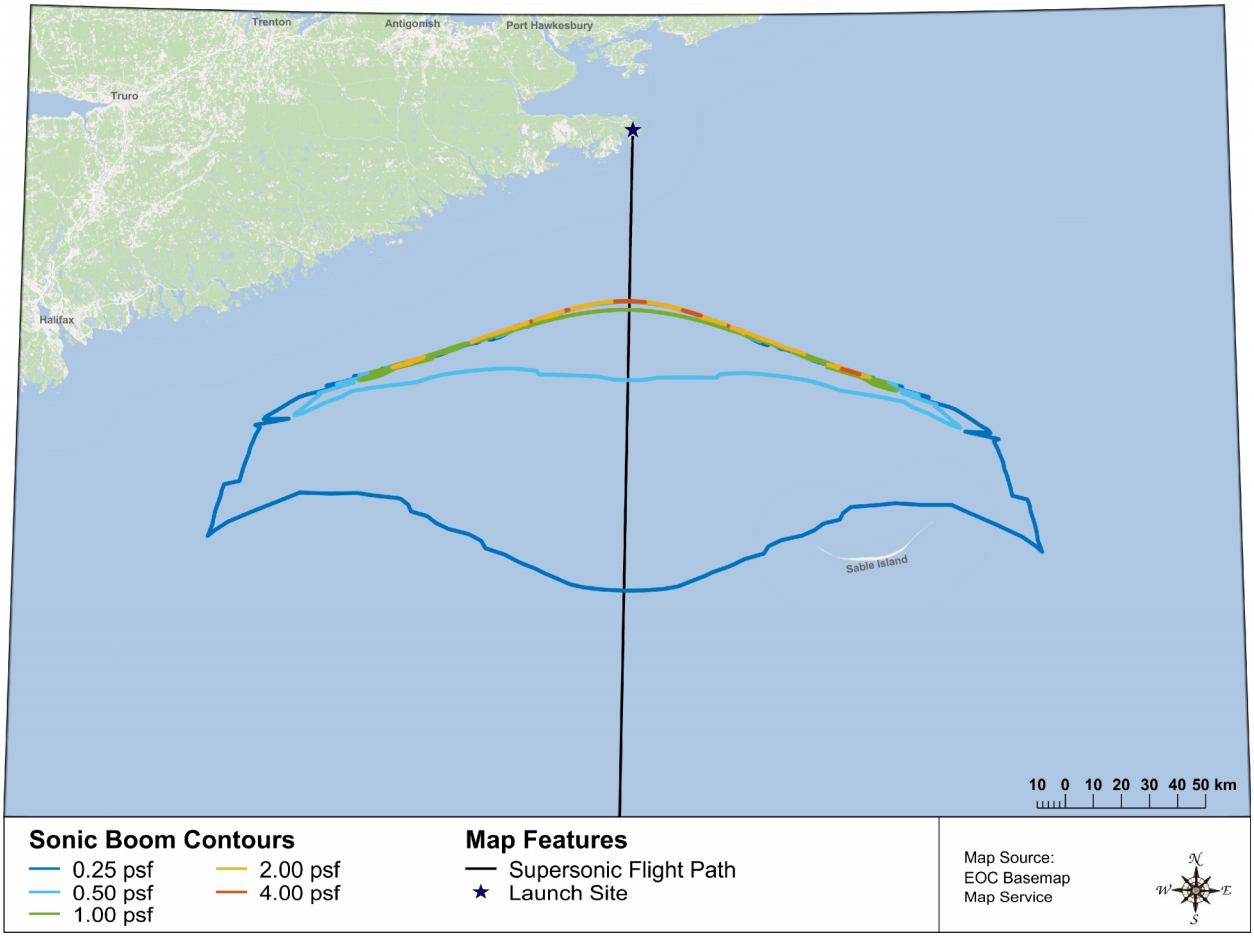

Figure 5-3. Sonic boom peak overpressure contours for a MCLV launch

5.2 Cumulative Noise Results

NEF is used to predict a community's response to the proposed launch operations of the MCLV by providing an estimate of the total noise environment arising from the forecasted operations. Levels below 30 NEF will likely generate sporadic complaints and the noise may interfere occasionally with certain activities of residents [12]. The 30 NEF contour generated by the proposed operations of the MCLV extends approximately 1.6 km from the launch pad. This area does not appear to include any permanent residents, therefore NEF in the community will be below 30. Furthermore, the communities of Canso and Dover will be exposed to levels less than 25 NEF, which is associated with no restrictions or limitations to noise sensitive land uses [11]. The sonic boom footprint for the nominal launch azimuth does not intercept land, and, thus, it would not contribute to the NEF contours.

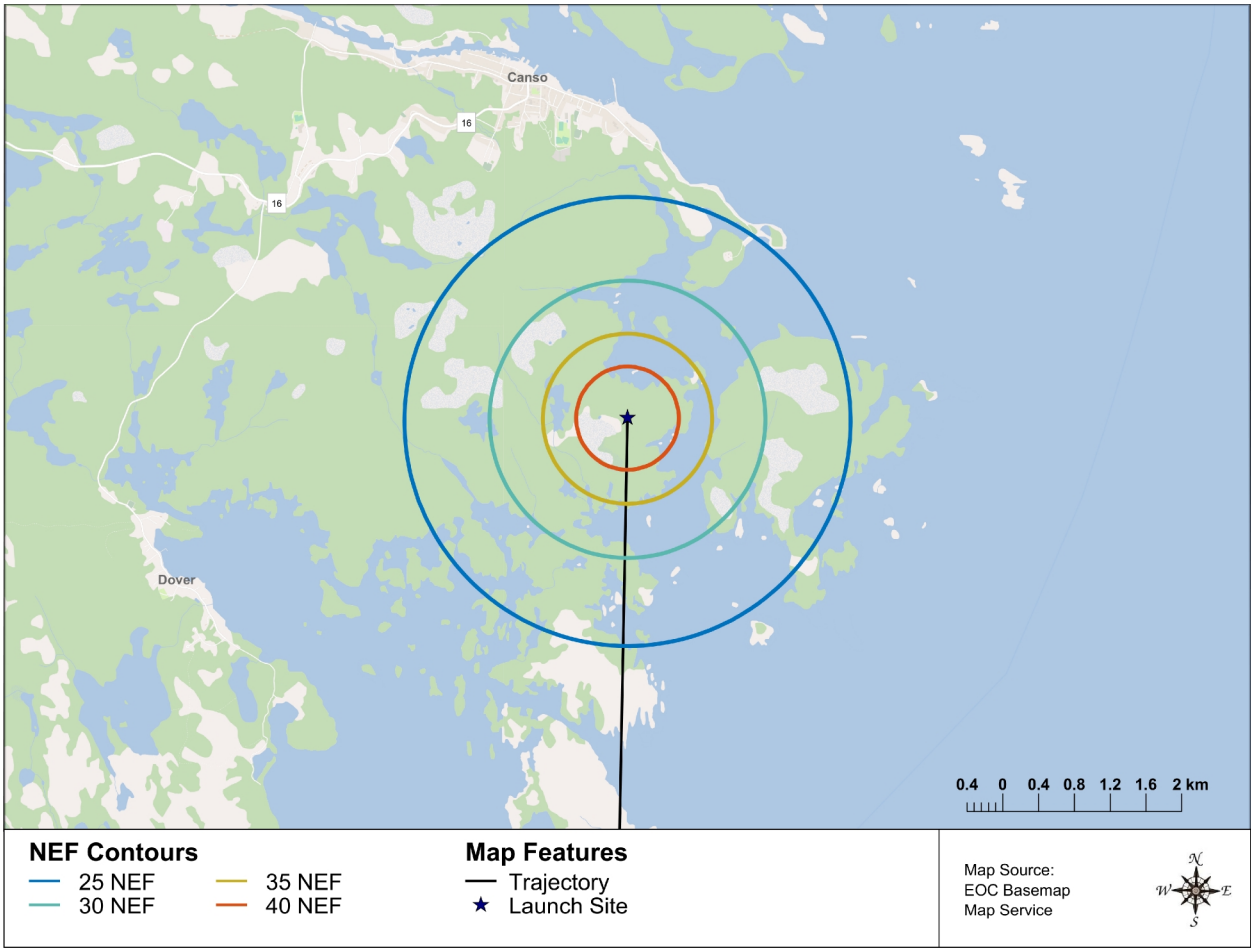

Figure 5-4. NEF contours for MCLV operations at the Canso launch site

5.3 Specific Point Analysis

To provide more detail on potential impacts, two specific points of interest were selected:

1. The Canso Site located south of Canso at the end of Whitman Street along the east side of the road leading to the wind turbines, and
2. The Little Dover Site located north of Little Dover along Dover Road on the west side of Dover Basin.

Figure 5-5. Locations of the two selected specific points of interest near the Canso Launch Site

Although the launch noise is generated at T-0, the noise propagation time is not instantaneous. Therefore, some residents with a clear view of the launch site will see the launch before they hear it. Once audible, the launch noise will steadily increase until the maximum sound level is reached, after which the launch noise will slowly decrease as the rocket moves farther away. The maximum sound level will occur for less than a second, and depends on the thrust profile, peak directivity angle, and distance between the source and the receiver. The duration that the launch event is audible above the ambient noise levels will depend on the location; however, it is likely to be on the order of 5 minutes.

The results of the specific point analysis are presented in Table 5-1 and include the NEF, time above 66 dBA, $L_{A,max}$, and L_{max} received at the Canso and Little Dover sites from a MCLV launch. The NEF levels at the two specific points are less than 30 NEF, which is associated with sporadic community complaints. The TA 66 dBA, associated with 95% outdoor speech intelligibility at 1 m, is less than two minutes at the two specific points. The $L_{A,max}$ at the specific points is less than the 115 dBA upper limit noise level associated with protecting human hearing. The L_{max} at the specific points is between 111 and 120 dB, which is associated with a potential risk of generating structural damage claims at a rate between 1 per 1,000 households and 1 per 100 households.

Table 5-1. Specific point noise analysis results

Name	Location	NEF	TA 66 dBA	$L_{A,max}$	L_{max}
Canso	45.329133°N 60.996417°W	22 NEF	~ 90 seconds	102 dBA	120 dB
Little Dover	45.300276°N 61.055549°W	15 NEF	~ 110 seconds	92 dBA	114 dB

6 Summary

This report documents the noise study performed as part of MLS efforts on the EA for the proposed polar orbit missions of a MCLV from the Canso Launch Site in Nova Scotia, Canada. Noise and sonic boom modeling and analyses were performed for the launch operations of a MCLV. The potential for launch vehicle noise and sonic boom impacts was evaluated on a single-event and cumulative basis in relation to human annoyance, hearing conservation and structural damage criteria.

NEF is used to predict a community's response to the proposed launch operations of the MCLV by providing an estimate of the long-term noise environment arising from the forecasted operations. While repeated vigorous complaints are associated with levels above 30 NEF, there are no known permanent residences within the 30 NEF contour, which extends 1.6 km from the launch site. Outside of the 30 NEF contour, sporadic complaints may occur. However, the communities of Canso and Little Dover will be exposed to levels below 25 NEF where Transport Canada has no restrictions or limitations to noise sensitive land uses.

The single event launch vehicle noise and sonic boom results are related to hearing conservation and structural damage claims. Predicted noise levels are less than the 115 dBA upper noise limit guideline at distances greater than 1.1 km from the launch pad. The potential for structural damage claims from launch vehicle noise is approximately one damage claim per 100 households exposed at 120 dB and one in 1,000 households at 111 dB [16]. L_{max} in excess of 120 dB would be limited to a radius of 3.0 km from the launch pad, and L_{max} in excess of 111 dB would be limited to a radius of 7.8 km from the launch pad. L_{max} at the communities of Canso and Little Dover is between 111 and 120 dB. The nominal sonic boom from a MCLV launch operation is not predicted to intercept the mainland of Nova Scotia, and as such, will not exceed the hearing conservation and structural damage criteria.

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APPENDIX D
VEGETATION SURVEY

Table 1. Vegetative Survey Results ***Project # 16-5903***

Scientific Name	Common Name	SARA	COSEWIC	NS SAR	S-Rank	NSDNR
Abies balsamea	Balsam Fir	Not Listed	Not Listed	Not Listed	S5	Secure
Acer pensylvanicum	Striped Maple	Not Listed	Not Listed	Not Listed	S5	Secure
Acer rubrum	Red Maple	Not Listed	Not Listed	Not Listed	S5	Secure
Acer spicatum	Mountain Maple	Not Listed	Not Listed	Not Listed	S5	Secure
Achillea millefolium	Common Yarrow	Not Listed	Not Listed	Not Listed	S5	Secure
Alnus viridis	Green Alder	Not Listed	Not Listed	Not Listed	S5	Secure
Andromeda polifolia	Bog Rosemary	Not Listed	Not Listed	Not Listed	S5	Secure
Aralia hispida	Bristly Sarsaparilla	Not Listed	Not Listed	Not Listed	S5	Secure
Aralia nudicaulis	Wild Sarsaparilla	Not Listed	Not Listed	Not Listed	S5	Secure
Arethusa bulbosa	Arethusa	Not Listed	Not Listed	Not Listed	S4	Secure
Argentina anserina	Common Silverweed	Not Listed	Not Listed	Not Listed	S5	Secure
Argentina anserina	Silverweed Cinquefoil	Not Listed	Not Listed	Not Listed	S5	Secure
Photinia pyrifolia	Red Chokeberry	Not Listed	Not Listed	Not Listed	S4	Secure
Betula alleghaniensis	Yellow Birch	Not Listed	Not Listed	Not Listed	S5	Secure
Betula papyrifera	Paper Birch	Not Listed	Not Listed	Not Listed	S5	Secure
Betula populifolia	Gray Birch	Not Listed	Not Listed	Not Listed	S5	Secure
Calamagrostis canadensis	Bluejoint Reed Grass	Not Listed	Not Listed	Not Listed	S5	Secure
Calamagrostis stricta	**Slim-stemmed Reed Grass**	**Not Listed**	**Not Listed**	**Not Listed**	**S2**	**Sensitive**
Calopogon tuberosus	Tuberous Grass Pink	Not Listed	Not Listed	Not Listed	S4	Secure
Calystegia sepium	Hedge False Bindweed	Not Listed	Not Listed	Not Listed	S5	Secure
Camelina sativa	Large-seeded False-flax	Not Listed	Not Listed	Not Listed	SNA	Exotic
Carex adusta	**Lesser Brown Sedge**	**Not Listed**	**Not Listed**	**Not Listed**	**S2S3**	**Sensitive**
Carex atlantica	Atlantic Sedge	Not Listed	Not Listed	Not Listed	S4	Secure
Carex brunnescens	Brownish Sedge	Not Listed	Not Listed	Not Listed	S5	Secure
Carex canescens	Silvery Sedge	Not Listed	Not Listed	Not Listed	S5	Secure
Carex crawfordii	A Sedge	Not Listed	Not Listed	Not Listed	S5	Secure
Carex cumulata	Dense Sedge	Not Listed	Not Listed	Not Listed	S4S5	Secure
Carex debilis	White-Edge Sedge	Not Listed	Not Listed	Not Listed	S5	Secure
Carex echinata	Star Sedge	Not Listed	Not Listed	Not Listed	S5	Secure
Carex exilis	A Sedge	Not Listed	Not Listed	Not Listed	S4	Secure
Carex houghtoniana	**Houghton's Sedge**	**Not Listed**	**Not Listed**	**Not Listed**	**S2S3**	**Sensitive**
Carex lurida	Sallow Sedge	Not Listed	Not Listed	Not Listed	S5	Secure
Carex nigra	Smooth Black Sedge	Not Listed	Not Listed	Not Listed	S5	Secure
Carex paleacea	Chaffy Sedge	Not Listed	Not Listed	Not Listed	S5	Secure
Carex pauciflora	Few-flowered Sedge	Not Listed	Not Listed	Not Listed	S4S5	Secure
Carex silicea	Seabeach Sedge	Not Listed	Not Listed	Not Listed	S4	Secure
Carex stricta	Tussock Sedge	Not Listed	Not Listed	Not Listed	S5	Secure
Carex trisperma	Three-seeded Sedge	Not Listed	Not Listed	Not Listed	S5	Secure

Scientific Name	Common Name	SARA	COSEWIC	NS SAR	S-Rank	NSDNR
Carex atlantica	Prickly Bog Sedge	Not Listed	Not Listed	Not Listed	S4	Secure
Chamaedaphne calyculata	Leatherleaf	Not Listed	Not Listed	Not Listed	S5	Secure
Chamerion angustifolium	Fireweed	Not Listed	Not Listed	Not Listed	S5	Secure
Cinna latifolia	Drooping Wood Reed Grass	Not Listed	Not Listed	Not Listed	S5	Secure
Clintonia borealis	Yellow Bluebead Lily	Not Listed	Not Listed	Not Listed	S5	Secure
Comptonia peregrina	Sweet-fern	Not Listed	Not Listed	Not Listed	S5	Secure
Coptis trifolia	Goldthread	Not Listed	Not Listed	Not Listed	S5	Secure
Corema conradii	Broom Crowberry	Not Listed	Not Listed	Not Listed	S4	Secure
Cornus canadensis	Dwarf Dogwood	Not Listed	Not Listed	Not Listed	S5	Secure
Cypripedium acaule	Pink Lady's-slipper	Not Listed	Not Listed	Not Listed	S5	Secure
Dalibarda repens	Robin Runaway	Not Listed	Not Listed	Not Listed	S4S5	Secure
Daucus carota	Wild Carrot	Not Listed	Not Listed	Not Listed	SNA	Exotic
Dennstaedtia punctilobula	Eastern Hay-scented Fern	Not Listed	Not Listed	Not Listed	S5	Secure
Diervilla lonicera	Northern Bush-Honeysuckle	Not Listed	Not Listed	Not Listed	S5	Secure
Doellingeria umbellata	Hairy Flat-topped Aster	Not Listed	Not Listed	Not Listed	S5	Secure
Drosera intermedia	Spoon-leaved Sundew	Not Listed	Not Listed	Not Listed	S5	Secure
Drosera rotundifolia	Round-leaved Sundew	Not Listed	Not Listed	Not Listed	S5	Secure
Dryopteris cristata	Crested Shield-Fern	Not Listed	Not Listed	Not Listed	S5	Secure
Eleocharis obtusa	Blunt Spikerush	Not Listed	Not Listed	Not Listed	S5	Secure
Eleocharis ovata	**Ovate Spikerush**	**Not Listed**	**Not Listed**	**Not Listed**	**S2?**	**Sensitive**
Eleocharis robbinsii	Robbins' Spikerush	Not Listed	Not Listed	Not Listed	S4	Secure
Empetrum nigrum	Black Crowberry	Not Listed	Not Listed	Not Listed	S5	Secure
Epigaea repens	Trailing Arbutus	Not Listed	Not Listed	Not Listed	S5	Secure
Chamerion angustifolium	Fireweed	Not Listed	Not Listed	Not Listed	S5	Secure
Equisetum arvense	Field Horsetail	Not Listed	Not Listed	Not Listed	S5	Secure
Eriophorum virginicum	Tawny Cottongrass	Not Listed	Not Listed	Not Listed	S5	Secure
Oclemena nemoralis	Bog Aster	Not Listed	Not Listed	Not Listed	S5	Secure
Euphrasia nemorosa	Common Eyebright	Not Listed	Not Listed	Not Listed	S5	Secure
Festuca ovina	Ovina Fescue	Not Listed	Not Listed	Not Listed	SNA	Not Listed
Fragaria virginiana	Virginia Strawberry	Not Listed	Not Listed	Not Listed	S5	Secure
Gaultheria hispidula	Creeping Snowberry	Not Listed	Not Listed	Not Listed	S5	Secure
Gaultheria procumbens	Eastern Teaberry	Not Listed	Not Listed	Not Listed	S5	Secure
Gaylussacia baccata	Black Huckleberry	Not Listed	Not Listed	Not Listed	S5	Secure
Gaylussacia bigeloviana	Dwarf Huckleberry	Not Listed	Not Listed	Not Listed	S5	Secure
Glaux maritima	Sea Milkwort	Not Listed	Not Listed	Not Listed	S5	Secure
Hieracium x floribundum	Yellow Hawkweed	Not Listed	Not Listed	Not Listed	SNA	Exotic
Hypericum canadense	Canada St. John's-wort	Not Listed	Not Listed	Not Listed	S5	Secure
Ilex verticillata	Common Winterberry	Not Listed	Not Listed	Not Listed	S5	Secure

Scientific Name	Common Name	SARA	COSEWIC	NS SAR	S-Rank	NSDNR
Iris versicolor	Harlequin Blue Flag	Not Listed	Not Listed	Not Listed	S5	Secure
Juncus balticus	Baltic Rush	Not Listed	Not Listed	Not Listed	S5	Secure
Juncus effusus	Soft Rush	Not Listed	Not Listed	Not Listed	S5	Secure
Juncus gerardii	Black-grass Rush	Not Listed	Not Listed	Not Listed	S5	Secure
Juncus tenuis	Slender Rush	Not Listed	Not Listed	Not Listed	S5	Secure
Juniperus communis	Common Juniper	Not Listed	Not Listed	Not Listed	S5	Secure
Kalmia angustifolia	Sheep Laurel	Not Listed	Not Listed	Not Listed	S5	Secure
Kalmia polifolia	Pale Bog Laurel	Not Listed	Not Listed	Not Listed	S5	Secure
Larix laricina	Tamarack	Not Listed	Not Listed	Not Listed	S5	Secure
Ledum groenlandicum	Common Labrador Tea	Not Listed	Not Listed	Not Listed	S5	Secure
Linnaea borealis	Twinflower	Not Listed	Not Listed	Not Listed	S5	Secure
Listera australis	Southern Twayblade	Not Listed	Not Listed	Not Listed	S3	Secure
Lotus corniculatus	Garden Bird's-foot Trefoil	Not Listed	Not Listed	Not Listed	SNA	Exotic
Luzula acuminata	Hairy Woodrush	Not Listed	Not Listed	Not Listed	S5	Secure
Luzula multiflora	Common Woodrush	Not Listed	Not Listed	Not Listed	S5	Secure
Lycopodium obscurum	Ground Pine	Not Listed	Not Listed	Not Listed	S4S5	Secure
Lysimachia maritima	Sea Milkwort	Not Listed	Not Listed	Not Listed	Not Listed	Not Listed
Lysimachia terrestris	Swamp Yellow Loosestrife	Not Listed	Not Listed	Not Listed	S5	Secure
Maianthemum canadense	Wild Lily-of-the-valley	Not Listed	Not Listed	Not Listed	S5	Secure
Maianthemum trifolium	Three-leaved False Soloman's Seal	Not Listed	Not Listed	Not Listed	S5	Secure
Melampyrum lineare	American Cow Wheat	Not Listed	Not Listed	Not Listed	S5	Secure
Mitchella repens	Partridgeberry	Not Listed	Not Listed	Not Listed	S5	Secure
Myrica gale	Sweet Gale	Not Listed	Not Listed	Not Listed	S5	Secure
Morella pensylvanica	Northern Bayberry	Not Listed	Not Listed	Not Listed	S5	Secure
Nemopanthus mucronatus	Mountain Holly	Not Listed	Not Listed	Not Listed	S5	Secure
Nuphar lutea ssp. variegata	Variegated Pond-lily	Not Listed	Not Listed	Not Listed	S5	Secure
Oclemena acuminata	Whorled Wood Aster	Not Listed	Not Listed	Not Listed	S5	Secure
Oclemena nemoralis	Bog Aster	Not Listed	Not Listed	Not Listed	S5	Secure
Osmunda cinnamomea	Cinnamon Fern	Not Listed	Not Listed	Not Listed	S5	Secure
Osmunda claytoniana	Interrupted Fern	Not Listed	Not Listed	Not Listed	S5	Secure
Oxalis montana	Common Wood Sorrel	Not Listed	Not Listed	Not Listed	S5	Secure
Phegopteris connectilis	Northern Beech Fern	Not Listed	Not Listed	Not Listed	S5	Secure
Phleum pratense	Meadow Timothy	Not Listed	Not Listed	Not Listed	SNA	Exotic
Photinia pyrifolia	Red Chokeberry	Not Listed	Not Listed	Not Listed	S4	Secure
Picea glauca	White Spruce	Not Listed	Not Listed	Not Listed	S5	Secure
Picea mariana	Black Spruce	Not Listed	Not Listed	Not Listed	S5	Secure
Pinus banksiana	Jack Pine	Not Listed	Not Listed	Not Listed	S4	Secure
Plantago major	Common Plantain	Not Listed	Not Listed	Not Listed	SNA	Exotic

Table 1. Vegetative Survey Results ***Project # 16-5903***

Scientific Name	Common Name	SARA	COSEWIC	NS SAR	S-Rank	NSDNR
Plantago maritima	Seaside Plantain	Not Listed	Not Listed	Not Listed	S5	Secure
Platanthera blephariglottis	White-fringed Orchid	Not Listed	Not Listed	Not Listed	S4	Secure
Platanthera clavellata	Little Club-Spur Orchid	Not Listed	Not Listed	Not Listed	S5	Secure
Platanthera lacera	Ragged Fringed Orchid	Not Listed	Not Listed	Not Listed	S4S5	Secure
Pogonia ophioglossoides	Rose Pogonia	Not Listed	Not Listed	Not Listed	S4	Secure
Polygonum sagittatum	Arrow-leaved Smartweed	Not Listed	Not Listed	Not Listed	S5	Secure
Populus tremuloides	Quaking Aspen	Not Listed	Not Listed	Not Listed	S5	Secure
Potentilla simplex	Old-Field Cinquefoil	Not Listed	Not Listed	Not Listed	S5	Secure
Prenanthes trifoliolata	Three-leaved Rattlesnakeroot	Not Listed	Not Listed	Not Listed	S5	Secure
Prunella vulgaris	Self-Heal	Not Listed	Not Listed	Not Listed	S5	Secure
Prunus pensylvanica	Fire Cherry	Not Listed	Not Listed	Not Listed	S5	Secure
Pteridium aquilinum	Bracken Fern	Not Listed	Not Listed	Not Listed	S5	Secure
Rhinanthus minor	Little Yellow Rattle	Not Listed	Not Listed	Not Listed	SNA	Secure
Rhododendron canadense	Rhodora	Not Listed	Not Listed	Not Listed	S5	Secure
Rhynchospora alba	White Beakrush	Not Listed	Not Listed	Not Listed	S5	Secure
Rosa virginiana	Virginia Rose	Not Listed	Not Listed	Not Listed	S5	Secure
Rubus allegheniensis	Common Blackberry	Not Listed	Not Listed	Not Listed	S5	Secure
Rubus chamaemorus	Cloudberry	Not Listed	Not Listed	Not Listed	S4	Secure
Rubus idaeus	Red Raspberry	Not Listed	Not Listed	Not Listed	S5	Secure
Sarracenia purpurea	Northern Pitcher Plant	Not Listed	Not Listed	Not Listed	S5	Secure
Schizaea pusilla	**Little Curlygrass Fern**	**Not Listed**	**Not Listed**	**Not Listed**	**S3S4**	**Secure**
Trichophorum caespitosum	Tufted Clubsedge	Not Listed	Not Listed	Not Listed	S5	Secure
Scirpus cyperinus	Common Woolly Bulrush	Not Listed	Not Listed	Not Listed	S5	Secure
Senecio robinsii	Swamp Ragwort	Not Listed	Not Listed	Not Listed	SNA	Exotic
Sibbaldiopsis tridentata	Three-toothed Cinquefoil	Not Listed	Not Listed	Not Listed	S5	Secure
Solidago sempervirens	Seaside Goldenrod	Not Listed	Not Listed	Not Listed	S5	Secure
Solidago uliginosa	Northern Bog Goldenrod	Not Listed	Not Listed	Not Listed	S5	Secure
Sorbus americana	American Mountain Ash	Not Listed	Not Listed	Not Listed	S5	Secure
Spartina alterniflora	Smooth Cord Grass	Not Listed	Not Listed	Not Listed	S5	Secure
Spergularia canadensis	Canadian Sandspurry	Not Listed	Not Listed	Not Listed	S4	Secure
Spiraea alba	Narrow-Leaved Meadow-Sweet	Not Listed	Not Listed	Not Listed	S5	Secure
Symphyotrichum novi-belgii	New Belgium American-Aster	Not Listed	Not Listed	Not Listed	S5	Secure
Symphyotrichum puniceum	Purple-stemmed Aster	Not Listed	Not Listed	Not Listed	S5	Secure
Tetraplodon mnioides	**Entire-leaved nitrogen moss**	**Not Listed**	**Not Listed**	**Not Listed**	**S2S3**	**Secure**
Thalictrum pubescens	Tall Meadow-rue	Not Listed	Not Listed	Not Listed	S5	Secure
Thelypteris noveboracensis	New York Fern	Not Listed	Not Listed	Not Listed	S5	Secure
Triadenum virginicum	Marsh St. John's Wort	Not Listed	Not Listed	Not Listed	S5	Secure
Trientalis borealis	Northern Starflower	Not Listed	Not Listed	Not Listed	S5	Secure

Table 1. Vegetative Survey Results ***Project # 16-5903***

Scientific Name	Common Name	SARA	COSEWIC	NS SAR	S-Rank	NSDNR
Trifolium pratense	Red Clover	Not Listed	Not Listed	Not Listed	SNA	Exotic
Trifolium repens	White Clover	Not Listed	Not Listed	Not Listed	SNA	Exotic
Trillium undulatum	Painted trillium	Not Listed	Not Listed	Not Listed	S5	Secure
Utricularia cornuta	Horned Bladderwort	Not Listed	Not Listed	Not Listed	S5	Secure
Vaccinium angustifolium	Late Lowbush Blueberry	Not Listed	Not Listed	Not Listed	S5	Secure
Vaccinium myrtilloides	Velvet-leaved Blueberry	Not Listed	Not Listed	Not Listed	S5	Secure
Vaccinium oxycoccos	Small Cranberry	Not Listed	Not Listed	Not Listed	S5	Secure
Vaccinium vitis-idaea	Foxberry	Not Listed	Not Listed	Not Listed	S5	Secure
Veronica officinalis	Gypsy-Weed	Not Listed	Not Listed	Not Listed	S5	Exotic
Viburnum nudum	Northern Wild Raisin	Not Listed	Not Listed	Not Listed	S5	Secure
Vicia cracca	Tufted Vetch	Not Listed	Not Listed	Not Listed	SNA	Exotic

APPENDIX E
WETLAND SURVEY

WETLAND ID	PROJECT COMPONENT	ALTERATION AREA (sq.m)	WETLAND TYPE	LANDSCAPE POSITION	LANDFORM	WATER FLOW	SOIL TYPE	SURFACE/HYDROLOGIC CONDITIONS	WETLAND BOUNDARY	WETLAND COMPONENT	DOMINANT VEGETATION			Notes
											Herbs	Shrubs	Trees	
1	N/A	0.0	Treed and Shrub Swamp - Bog Complex	Terrene/ Riparian	Basin	Throughflow	A1: Histosol	Surface saturation Standing water	Moderate/ Gentle	Treed Swamp	*Aralia nudicaulis, Osmunda cinnamomea, Cornus canadensis, Trientalis borealis, Carex trisperma,*	*Picea mariana, Acer rubrum, Viburnum nudum, Nemopanthus mucronatus, Kalmia angustifolia, Myrica gale*	*Acer rubrum, Abies balsamea, Picea mariana*	Associated with Winter's Creek.
										Shrub Swamp	*Ledum groenlandicum, Osmunda cinnmomea, Eriophorum virginicum, Oclemena nemoralis, Cornus canadensis, Sarracenia purpurea*	*Nemopanthus mucronata, Gaylussacia baccata, Kalmia angustifolia, Myrica gale, Chamaedaphne calyculata, Picea mariana, Rhododendron canadensis*	*Picea Mariana, Abies balsamea*	Hummocky with little herbaceous vegetation visible. Hummocky with occasional granite boulders.
										Bog	*Eriophorum virginicum, Tricophorum caespitosum, Sarracenia purpurea, Rubus chamaemorus, Andromeda polifolia, Oxycoccos microcarpus*	*Picea mariana, Rhodora canadensis, Ledum groenlandicum, Larix laricina, Gaylussacia bigelovania, Kalmia angustifolia*	*None*	Gentle transition from barren outcrops to bog. Steep slope between bog down to Treed Swamp portion (and Winter's Creek).
2	LCC	159.7	Treed Swamp - Bog Complex	Terrene	Basin	Outflow	A1: Histosol	Surface saturation	Moderate/ Gentle	Treed Swamp	*Osmunda cinnamomea, Aralia nudicaulis, Cornus canadensis, Trientalis borealis, Carex trisperma*	*Nemopanthus mucronatus, Abies balsamea, Sorbus americanus, Picea mariana, Viburnum nudum, Kalmia angustifolium, Acer rubrum*	*Acer rubrum, Abies balsamea, Picea mariana, Betula papyrifera*	Dense and well developed subcanopy
										Bog	*Eriophorum virginicum, Trichophorum caespitosum, Sarracenia purpurea, Andromeda polifolia, Rubus chamaemorus, Oxycoccos microcarpus*	*Kalmia angustifolia, Rhodora canadensis, Ledum groenlandicum, Nemopanthus mucronatus, Chamaedaphne calyculatta, Picea mariana, Larix laricina*	*Picea mariana, Larix laricina*	N/A
3	LCC	585.8	Treed Swamp	Terrene	Basin	Isolated	A1: Histosol	Surface saturation	Gentle	N/A	*Osmunda cinnamomea, Carex trisperma, Oclemena acuminata, Aralia nudicaulis, Doellingeria umbellata, Rubus hispidus, Mitchella repens, Coptis trifolia, Prenanthes trifoliolata*	*Abies balsmea, Nemopanthus mucronatus, Picea mariana*	*Abies balsamea, Picea mariana, Acer rubrum, Betula papyrifera*	High amount of *Sphagnum* cover; moderate amount of downed wood and snags; high level of microtopography
4	LCC/ Access Road	2256.7	Treed Swamp	Terrene	Basin	Isolated	A1: Histosol	Surface saturation	Moderate/ Gentle	N/A	*Osmunda cinnamomea, Carex trisperma, Aralia nudicualis, Cornus canadensis, Trientalis borealis, Oclemena acuminata*	*Nemopanthus mucronatus, Abies balsamea, Viburnum nudum, Sorbus americana, Picea mariana, Acer rubrum, Kalmia angustifolium*	*Abies balsamea, Acer rubrum*	Dense woody understory; moderate amount of downed wood; moderate amount of microtopography
5	Access Road	369.7	Treed and Shrub Swamp Complex	Terrene	Basin	Outflow	A1: Histosol	Surface saturation Intermittent standing water	Moderate/ Gentle	Treed Swamp	*Osmunda cinnamomea, Aralia nudicaulis, Cornus canadensis, Trientalis borealis, Carex trisperma*	*Nemopanthus mucronatus, Abies balsamea, Sorbus americanus, Picea mariana, Viburnum nudum, Kalmia angustifolium, Acer rubrum*	*Abies balsamea, Acer rubrum, Picea mariana*	Dense woody understory; abundant fallen woody debris
										Shrub Swamp	*Osmunda cinnmomea, Eriophorum virginicum, Oclemena nemoralis*	*Nemopanthus mucronatus, Rhodora canadensis, Picea mariana, Kalmia angustifolia, Gaylusaccia baccata, Chamaedaphne calyculata*	*None*	Dense shrub canopy, with Sphagnum substrate.

WETLAND ID	PROJECT COMPONENT	ALTERATION AREA (sq.m)	WETLAND TYPE	LANDSCAPE POSITION	LANDFORM	WATER FLOW	SOIL TYPE	SURFACE/HYDROLOGIC CONDITIONS	WETLAND BOUNDARY	WETLAND COMPONENT	DOMINANT VEGETATION			Notes
											Herbs	Shrubs	Trees	
6	HIF/ Access Road	12721.2	Treed and Shrub Swamp - Bog Complex	Terrene/ Riparian	Basin	Throughflow/ Outflow	A1: Histosol	Surface saturation, Intermittent standing water	Gentle	Treed Swamp	*Osmunda cinnamomea, Eriophorum virginicum, Aralia nudicaulis, Carex trisperma, Viburnum nudum, Coptis trifolia, Trientalis borealis, Oclemena acuminata, Mitchella repens*	*Viburnum nudum, Larix laricina, Sorbus americana, Picea mariana, Nemopanthus mucronatus, Abies balsamea*	*Abies balsamea, Picea mariana, Larix laricina*	Abundant deadfall. Sphagnum covered substrate
										Shrub Swamp	*Osmunda cinnamomea, Sarracenia purpurea, Trichophorum caespitosum*	*Picea mariana, Rhododendron canadense, Gaylusaccia baccata, Kalmia angustifolia, Myrica gale, Chamaedaphne calyculata, Pinus banksiana*	*None*	Hummocky areas, little herbaceous vegetation visible
										Bog	*Trichophorum caespitosum, Sarracenia purpurea, Ledum groenlandicum, Gaylussacia bigeloviana, Vaccinium oxycoccos, Mitchella repens*	*Picea mariana, Larix laricina, Kalmia angustifolia*	*None*	Very deep peat accumulation in certain areas (> 2 m)
7	N/A	N/A	Treed Swamp	Terrene	Basin	Throughflow	A1: Histosol	Surface saturation	Moderate	Treed Swamp	*Cornus canadensis, Maianthemum trifolium, Osmunda cinnamomea, Aralia nudicaulis, Coptis trifolia, Mitchella repens*	*Abies balsamea, Picea mariana, Viburnum nudum, Kalmia Angustifolia*	*Abies balsamea, Picea mariana*	Ephemeral inflow channel.
8	Access Road	160.3	Shrub Swamp	Terrene	Basin	Throughflow	A1: Histosol	Intermittent standing water, Surface saturation	Moderate/ Steep	Shrub Swamp	*Osmunda cinnamomea, Oclemena nemoralis, Myrica gale*	*Viburnum nudum, Abies balsamea, Picea mariana, Nemopanthus mucronatus*	*None*	Sharp transition to surrounding granite outcropping.
9	Access Road	159.5	Treed and Shrub Swamp - Bog Complex	Terrene	Basin	Outflow/ Throughflow	A1: Histosol on rock	Surface saturation	Moderate/ Steep	Treed Swamp	*Maianthemum canadensis, Osmunda cinnamomea, Cornus canadensis, Onoclea sensibilis, Carex trisperma, Oclemena acuminata*	*Viburnum nudum, Nemopanthus mucronatus, Picea mariana, Abies balsamea*	*Picea mariana, Abies balsamea*	Dense sphagnum cover, minor herbaceous cover.
										Shrub Swamp	*Cornus canadensis, Oclemena nemoralis, Ledum groenlandicum, Gaultheria procumbens, Eriophorum virginicum*	*Myrica gale, Gaylussacia baccata, Ledum groenlandicum, Rhododendron canadense, Nemopanthus mucronatus, Picea mariana, Viburnum nudum, Larix laricina*	*None*	Little herbaceous stratrum visible between dense shrub growth. Lots of leaf detritus on ground.
										Bog	*Kalmia polifolia, Andromeda polifolia, Chamaedaphne calyculata, Kalmia angustifolia, Oclemena nemoralis, Vaccinium macrocarpon, Ledum groenlandicum, Eriophorum virginicum, Myrica gale, Gaylussacia baccata*	*Picea mariana, Myrica gale, Gaylussacia baccata, Nemopanthus mucronatus*	*None*	Basin within granite outcropping, abrupt transitions in some areas and gentle in others.
10	Launch Pad/ Access Road	4323.9	Bog	Terrene	Basin	Outflow	A1: Histosol	Surface saturation Intermittent surface water	Gentle	Bog	*Eriophorum virginicum, Trichophorum caespitosum, Sarracenia purpurea, Oclemena nemoralis, Vaccinium oxycoccos, Rubus chamaemorus, Andromeda polifolia, Kalmia polifolia, Gaylusaccia bigeloviana, Ledum groenlandicum, Coremi conradii*	*Picea mariana, Kalmia angustifolia, Juniperus communis, Larix laricina, Ledum groenlandicum, Chamaedaphne calyculata*	*None*	Perched bog.

WETLAND ID	PROJECT COMPONENT	ALTERATION AREA (sq.m)	WETLAND TYPE	LANDSCAPE POSITION	LANDFORM	WATER FLOW	SOIL TYPE	SURFACE/HYDROLOGIC CONDITIONS	WETLAND BOUNDARY	WETLAND COMPONENT	DOMINANT VEGETATION			Notes
											Herbs	Shrubs	Trees	
11	Launch Pad/ Access Road	599.2	Shrub Swamp	Terrene	Basin	Throughflow	A1: Histosol (30 cm on rock)	Surface saturation	Moderate	N/A	*Osmunda cinnamomea, Maianthemum canadensis, Ledum groenlandicum, Maianthemum trifolium*	*Ledum groenlandicum, Viburnum nudum, Nemopanthus mucronatus, Gaylusaccia baccata, Myrica gale, Alnus incana*	*Baies balsamea, Picea mariana*	Basin within granite outcrops.
12	Launch Pad/ Access Road	8067.1	Shrub Bog	Terrene	Basin	Outflow	A1: Histosol (30 cm on rock)	Surface saturation	Moderate	N/A	*Trichophorum caespitosum, Sarracenia purpurea, Ledum groenlandicum, Gaylussacia bigeloviana, Vaccinium oxycoccos, Kalmia angustifolium, Cornus canadensis, Andromeda polifolia, Abies balsamea*	*Picea mariana, Gaylussacia baccata, Pinus banksiana, Nemopanthus mucronata, Viburnum nudum*	*None*	N/A
13	Access Road	269.7	Shrub Swamp	Riparian	Basin	Outflow	A1: Histosol	Saturated within 5 cm, Water table within 20 cm.	Moderate	N/A	*Gaultheria procumbens, Ledum groenlandicum*	*Kalmia angustifolia, Ledum groenlandicum, Chamaedaphne calyculata, Rhododendron canadensis, Alnus incana*	*Picea mariana, Abies balsamea*	Associated with Watercourse 2
14	HIF	757.6	Treed Swamp	Terrene	Basin	Isolated	A1: Histosol (35 cm on rock)	Surface saturation	Gentle	N/A	*Cornus canadensis, Oclemena acuminata, Ledum groenlandicum, Osmunda cinnmomea, Kalmia angustifolia, Trientalis borealis, Vaccinium angustifolium*	*Abies balsamea, Picea mariana, Nemopanthus mucronatus, Kalmia angustifolia*	*Abies balsamea, Picea mariana*	N/A

APPENDIX F
BIRD SURVEY

Common Name	Scientific Name	*SARA* Status[1]	NS *ESA* Status[2]	COSEWIC Status[3]	NSDNR Status[4]	NS S-Rank
American Bittern	*Botaurus lentiginosus*	Not Listed	Not Listed	Not Listed	Sensitive	S3S4B
American Golden-Plover	*Pluvialis dominica*	Not Listed	Not Listed	Not Listed	Sensitive	S1S2M
American Kestrel	*Falco sparverius*	Not Listed	Not Listed	Not Listed	Secure	S3B
American Oystercatcher	*Haematopus palliatus*	Not Listed	Not Listed	Not Listed	Undetermined	S1B
American Three-toed Woodpecker	*Picoides dorsalis*	Not Listed	Not Listed	Not Listed	Undetermined	S1?
Arctic Tern	*Sterna paradisaea*	Not Listed	Not Listed	Not Listed	May Be At Risk	S3B
Baltimore Oriole	*Icterus galbula*	Not Listed	Not Listed	Not Listed	May Be At Risk	S2S3B
Bank Swallow	*Riparia riparia*	Not Listed	Not Listed	Threatened	May Be At Risk	S2S3B
Barn Swallow	*Hirundo rustica*	Not Listed	Endangered	Threatened	At Risk	S3B
Bay-breasted Warbler	*Dendroica castanea*	Not Listed	Not Listed	Not Listed	Sensitive	S3S4B
Bicknell's Thrush	*Catharus bicknelli*	Special Concern	Endangered	Threatened	At Risk	S1S2B
Black-backed Woodpecker	*Picoides arcticus*	Not Listed	Not Listed	Not Listed	Sensitive	S3S4
Black-bellied Plover	*Pluvialis squatarola*	Not Listed	Not Listed	Not Listed	Secure	S3M
Black-billed Cuckoo	*Coccyzus erythropthalmus*	Not Listed	Not Listed	Not Listed	May Be At Risk	S3B
Black-crowned Night-heron	*Nycticorax nycticorax*	Not Listed	Not Listed	Not Listed	May Be At Risk	S1B
Black-legged Kittiwake	*Rissa tridactyla*	Not Listed	Not Listed	Not Listed	Sensitive	S3B,S5N
Blackpoll Warbler	*Dendroica striata*	Not Listed	Not Listed	Not Listed	Sensitive	S3S4B
Blue-winged Teal	*Anas discors*	Not Listed	Not Listed	Not Listed	May Be At Risk	S3S4B
Bobolink	*Dolichonyx oryzivorus*	Not Listed	Vulnerable	Threatened	Sensitive	S3S4B
Boreal Chickadee	*Poecile hudsonica*	Not Listed	Not Listed	Not Listed	Sensitive	S3
Boreal Owl	*Aegolius funereus*	Not Listed	Not Listed	Not At Risk	Undetermined	S2?B
Brant	*Branta bernicla*	Not Listed	Not Listed	Not Listed	Sensitive	S2M
Brown Thrasher	*Toxostoma rufum*	Not Listed	Not Listed	Not Listed	Undetermined	S1B
Brown-headed Cowbird	*Molothrus ater*	Not Listed	Not Listed	Not Listed	Secure	S2B
Buff-breasted Sandpiper	*Tryngites subruficollis*	Not Listed	Not Listed	Special Concern	Accidental	SNA
Bufflehead	*Bucephala albeola*	Not Listed	Not Listed	Not Listed	Secure	S3S4N
Canada Warbler	*Wilsonia canadensis*	Threatened	Endangered	Threatened	At Risk	S3S4B
Cape May Warbler	*Dendroica tigrina*	Not Listed	Not Listed	Not Listed	Sensitive	S2B
Chimney Swift	*Chaetura pelagica*	Threatened	Endangered	Threatened	At Risk	S2B,S1M
Cliff Swallow	*Petrochelidon pyrrhonota*	Not Listed	Not Listed	Not Listed	May Be At Risk	S2S3B
Common Eider	*Somateria mollissima*	Not Listed	Not Listed	Not Listed	Secure	S3S4
Common Goldeneye	*Bucephala clangula*	Not Listed	Not Listed	Not Listed	Secure	S2B,S5N

Common Name	Scientific Name	*SARA* Status[1]	NS *ESA* Status[2]	COSEWIC Status[3]	NSDNR Status[4]	NS S-Rank
Common Nighthawk	*Chordeiles minor*	Threatened	Threatened	Threatened	At Risk	S2S3B
Common Tern	*Sterna hirundo*	Not Listed	Not Listed	Not At Risk	Sensitive	S3B
Eastern Bluebird	*Sialia sialis*	Not Listed	Not Listed	Not At Risk	Sensitive	S3B
Eastern Kingbird	*Tyrannus tyrannus*	Not Listed	Not Listed	Not Listed	Sensitive	S3B
Eastern Meadowlark	*Sturnella magna*	Not Listed	Not Listed	Threatened	Sensitive	SHB
Eastern Wood-Pewee	*Contopus virens*	Not Listed	Vulnerable	Special Concern	Sensitive	S3S4B
Evening Grosbeak	*Coccothraustes vespertinus*	Not Listed	Not Listed	Not Listed	Secure	S3S4B,S3N
Fox Sparrow	*Passerella iliaca*	Not Listed	Not Listed	Not Listed	Secure	S3S4B
Gadwall	*Anas strepera*	Not Listed	Not Listed	Not Listed	May Be At Risk	S2B
Gray Catbird	*Dumetella carolinensis*	Not Listed	Not Listed	Not Listed	May Be At Risk	S3B
Gray Jay	*Perisoreus canadensis*	Not Listed	Not Listed	Not Listed	Sensitive	S3
Great Cormorant	*Phalacrocorax carbo*	Not Listed	Not Listed	Not Listed	Sensitive	S2S3
Greater Yellowlegs	*Tringa melanoleuca*	Not Listed	Not Listed	Not Listed	Sensitive	S3B,S3S4M
Harlequin Duck - Eastern pop.	*Histrionicus histrionicus pop. 1*	Special Concern	Endangered	Special Concern	At Risk	S2N
Hudsonian Godwit	*Limosa haemastica*	Not Listed	Not Listed	Not Listed	Sensitive	S1S2M
Hudsonian Whimbrel	*Numenius phaeopus hudsonicus*	Not Listed	Not Listed	Not Listed	Sensitive	S2S3M
Indigo Bunting	*Passerina cyanea*	Not Listed	Not Listed	Not Listed	Undetermined	S1?B
Killdeer	*Charadrius vociferus*	Not Listed	Not Listed	Not Listed	Sensitive	S3B
Leach's Storm-Petrel	*Oceanodroma leucorhoa*	Not Listed	Not Listed	Not Listed	Secure	S3B,S5M
Least Sandpiper	*Calidris minutilla*	Not Listed	Not Listed	Not Listed	Secure	S1B,S3M
Lesser Yellowlegs	*Tringa flavipes*	Not Listed	Not Listed	Not Listed	Secure	S3M
Long-eared Owl	*Asio otus*	Not Listed	Not Listed	Not Listed	May Be At Risk	S2S3
Nelson's Sparrow	*Ammodramus nelsoni*	Not Listed	Not Listed	Not At Risk	Secure	S3S4B
Northern Gannet	*Morus bassanus*	Not Listed	Not Listed	Not Listed	Secure	SHB,S5M
Northern Goshawk	*Accipiter gentilis*	Not Listed	Not Listed	Not At Risk	Secure	S3S4
Northern Harrier	*Circus cyaneus*	Not Listed	Not Listed	Not At Risk	Secure	S3S4B
Northern Mockingbird	*Mimus polyglottos*	Not Listed	Not Listed	Not Listed	Secure	S1B
Northern Pintail	*Anas acuta*	Not Listed	Not Listed	Not Listed	May Be At Risk	S1B
Olive-sided Flycatcher	*Contopus cooperi*	Threatened	Threatened	Threatened	At Risk	S3B
Pectoral Sandpiper	*Calidris melanotos*	Not Listed	Not Listed	Not Listed	Secure	S2S3M
Peregrine Falcon - anatum/tundrius	*Falco peregrinus pop. 1*	Special Concern	Vulnerable	Special Concern	Sensitive	S1B,SNAM
Philadelphia Vireo	*Vireo philadelphicus*	Not Listed	Not Listed	Not Listed	Undetermined	S2?B
Pine Grosbeak	*Pinicola enucleator*	Not Listed	Not Listed	Not Listed	May Be At Risk	S2S3B,S5N

Common Name	Scientific Name	*SARA* Status[1]	NS *ESA* Status[2]	COSEWIC Status[3]	NSDNR Status[4]	NS S-Rank
Pine Siskin	*Carduelis pinus*	Not Listed	Not Listed	Not Listed	Sensitive	S2S3
Piping Plover melodus ssp	*Charadrius melodus melodus*	Endangered	Endangered	Endangered	At Risk	S1B
Purple Martin	*Progne subis*	Not Listed	Not Listed	Not Listed	May Be At Risk	SHB
Purple Sandpiper	*Calidris maritima*	Not Listed	Not Listed	Not Listed	Sensitive	S3?N
Red Crossbill	*Loxia curvirostra*	Not Listed	Not Listed	Not Listed	Secure	S3S4
Red Knot rufa ssp	*Calidris canutus rufa*	Not Listed	Endangered	Endangered	At Risk	S2M
Red-breasted Merganser	*Mergus serrator*	Not Listed	Not Listed	Not Listed	Secure	S3S4B,S5N
Red-breasted Nuthatch	*Sitta canadensis*	Not Listed	Not Listed	Not Listed	Secure	S3
Roseate Tern	*Sterna dougallii*	Endangered	Endangered	Endangered	At Risk	S1B
Rose-breasted Grosbeak	*Pheucticus ludovicianus*	Not Listed	Not Listed	Not Listed	Sensitive	S2S3B
Rough-legged Hawk	*Buteo lagopus*	Not Listed	Not Listed	Not At Risk	Secure	S3N
Ruby-crowned Kinglet	*Regulus calendula*	Not Listed	Not Listed	Not Listed	Sensitive	S3S4B
Ruddy Duck	*Oxyura jamaicensis*	Not Listed	Not Listed	Not Listed	Secure	S1B
Ruddy Turnstone	*Arenaria interpres*	Not Listed	Not Listed	Not Listed	Secure	S3M
Rusty Blackbird	*Euphagus carolinus*	Special Concern	Endangered	Special Concern	May Be At Risk	S2B
Sanderling	*Calidris alba*	Not Listed	Not Listed	Not Listed	Secure	S3M,S2N
Savannah Sparrow (Ipswich)	*Passerculus sandwichensis princeps*	Special Concern	Not Listed	Special Concern	Sensitive	S1B
Scarlet Tanager	*Piranga olivacea*	Not Listed	Not Listed	Not Listed	Undetermined	S2B
Semipalmated Plover	*Charadrius semipalmatus*	Not Listed	Not Listed	Not Listed	Secure	S1B,S3S4M
Semipalmated Sandpiper	*Calidris pusilla*	Not Listed	Not Listed	Not Listed	Sensitive	S3M
Short-billed Dowitcher	*Limnodromus griseus*	Not Listed	Not Listed	Not Listed	Secure	S3M
Short-eared Owl	*Asio flammeus*	Special Concern	Not Listed	Special Concern	May Be At Risk	S1S2B
Spotted Sandpiper	*Actitis macularius*	Not Listed	Not Listed	Not Listed	Sensitive	S3S4B
Swainson's Thrush	*Catharus ustulatus*	Not Listed	Not Listed	Not Listed	Secure	S3S4B
Tennessee Warbler	*Vermivora peregrina*	Not Listed	Not Listed	Not Listed	Sensitive	S3S4B
Veery	*Catharus fuscescens*	Not Listed	Not Listed	Not Listed	Secure	S3S4B
Vesper Sparrow	*Pooecetes gramineus*	Not Listed	Not Listed	Not Listed	May Be At Risk	S2B
Virginia Rail	*Rallus limicola*	Not Listed	Not Listed	Not Listed	Undetermined	S2S3B
Warbling Vireo	*Vireo gilvus*	Not Listed	Not Listed	Not Listed	Undetermined	S1B
Whip-Poor-Will	*Caprimulgus vociferus*	Threatened	Threatened	Threatened	At Risk	S1?B
White-rumped Sandpiper	*Calidris fuscicollis*	Not Listed	Not Listed	Not Listed	Secure	S3M
Willet	*Tringa semipalmata*	Not Listed	Not Listed	Not Listed	May Be At Risk	S2S3B

Common Name	Scientific Name	*SARA* Status[1]	NS *ESA* Status[2]	COSEWIC Status[3]	NSDNR Status[4]	NS S-Rank
Willow Flycatcher	*Empidonax traillii*	Not Listed	Not Listed	Not Listed	Sensitive	S2B
Wilson's Snipe	*Gallinago delicata*	Not Listed	Not Listed	Not Listed	Sensitive	S3B
Wilson's Warbler	*Wilsonia pusilla*	Not Listed	Not Listed	Not Listed	Sensitive	S3B
Wood Thrush	*Hylocichla mustelina*	Not Listed	Not Listed	Threatened	Undetermined	SUB
Yellow-bellied Flycatcher	*Empidonax flaviventris*	Not Listed	Not Listed	Not Listed	Sensitive	S3S4B

Source: ACCDC 2017

[1]Government of Canada 2016; [2]NS ESA 2015; [3]COSEWIC 2015; [4]NSDNR 2015; [5]ACCDC 2017

Table F2: Conservation Status of Species Observed During the Avian Assessment *Project # 16-5903*

Common Name	Scientific Name	Observed During Passerine Surveys	Observed During Shorebird Surveys	Observed During Avian Acoustic Assessment	SARA Status	COSEWIC Status	NSESA Status	NS S-Rank	NSDNR (Categorical)
Alder Flycatcher	*Empidonax alnorum*	Yes			Not Listed	Not Listed	Not Listed	S5B	Secure
American Black Duck	*Anas rubripes*	Yes	Yes	Yes	Not Listed	Not Listed	Not Listed	S5	Secure
American Crow	*Corvus brachyrhynchos*	Yes	Yes	Yes	Not Listed	Not Listed	Not Listed	S5	Secure
American Goldfinch	*Carduelis tristis*	Yes		Yes	Not Listed	Not Listed	Not Listed	SNR	Secure
American Redstart	*Setophaga ruticilla*	Yes			Not Listed	Not Listed	Not Listed	S4S5B	Secure
American Robin	*Turdus migratorius*	Yes		Yes	Not Listed	Not Listed	Not Listed	S5B,S3N	Secure
Bald eagle	*Haliaeetus leucocephalus*	Yes	Yes	Yes	Not Listed	Not at Risk	Not Listed	S5	Secure
Belted Kingfisher	*Megaceryle alcyon*	Yes	Yes	Yes	Not Listed	Not Listed	Not Listed	S5B	Secure
Black-and-white Warbler	*Mniotilta varia*	Yes		Yes	Not Listed	Not Listed	Not Listed	S5B	Secure
Black-capped Chickadee	*Poecile atricapillus*	Yes		Yes	Not Listed	Not Listed	Not Listed	SNR	Secure
Black-throated Green Warbler	*Dendroica virens*	Yes		Yes	Not Listed	Not Listed	Not Listed	S5B	Secure
Blue Jay	*Cyanocitta cristata*	Yes		Yes	Not Listed	Not Listed	Not Listed	S5	Secure
Blue-headed Vireo	*Vireo solitarius*	Yes		Yes	Not Listed	Not Listed	Not Listed	S5B	Secure
Bonaparte's Gull	*Chroicocephalus philadelphia*	Yes			Not Listed	Not Listed	Not Listed	S5M	Secure
Boreal Chickadee	*Poecile hudsonica*	Yes		Yes	Not Listed	Not Listed	Not Listed	S3	Sensitive
Brown Creeper	*Certhia americana*			Yes	Not Listed	Not Listed	Not Listed	S5	Secure
Canada Goose	*Branta canadensis*		Yes	Yes	Not Listed	Not Listed	Not Listed	SNAB,S4N	Secure
Cedar Waxwing	*Bombycilla cedrorum*	Yes			Not Listed	Not Listed	Not Listed	S5B	Secure
Chestnut-sided Warbler	*Dendroica pensylvanica*	Yes			Not Listed	Not Listed	Not Listed	S5B	Secure
Cliff Swallow	*Petrochelidon pyrrhonota*		Yes		Not Listed	Not Listed	Not Listed	S2S3B	May Be At Risk
Common Eider	*Somateria mollissima*	Yes	Yes		Not Listed	Not Listed	Not Listed	S3S4	Secure
Common Grackle	*Quiscalus quiscula*	Yes			Not Listed	Not Listed	Not Listed	S5B	Secure
Common Loon	*Gavia immer*	Yes	Yes		Not Listed	Not at Risk	Not Listed	S4B,S4N	May Be At Risk
Common Raven	*Corvus corax*	Yes	Yes	Yes	Not Listed	Not Listed	Not Listed	S5	Secure
Common Tern	*Sterna hirundo*	Yes	Yes	Yes	Not Listed	Not at Risk	Not Listed	S3B	Sensitive
Common Yellowthroat	*Geothlypis trichas*	Yes		Yes	Not Listed	Not Listed	Not Listed	S5B	Secure
Dark-eyed Junco	*Junco hyemalis*	Yes		Yes	Not Listed	Not Listed	Not Listed	S4S5	Secure
Double-crested Cormorant	*Phalacrocorax auritus*	Yes	Yes		Not Listed	Not at Risk	Not Listed	S4B	Secure
Golden-crowned Kinglet	*Regulus satrapa*	Yes		Yes	Not Listed	Not Listed	Not Listed	S5	Sensitive
Gray Jay	*Perisoreus canadensis*			Yes	Not Listed	Not Listed	Not Listed	S3	Sensitive
Great Black-backed Gull	*Larus marinus*	Yes	Yes	Yes	Not Listed	Not Listed	Not Listed	S4S5	Secure
Great Blue Heron	*Ardea herodias*		Yes		Not Listed	Not Listed	Not Listed	S4B	Secure
Greater Scaup	*Aythya marila*		Yes		Not Listed	Not Listed	Not Listed	S4N	Secure
Greater Yellowlegs	*Tringa melanoleuca*	Yes	Yes	Yes	Not Listed	Not Listed	Not Listed	S3B,S3S4M	Sensitive
Hairy woodpecker	*Picoides villosus*	Yes			Not Listed	Not Listed	Not Listed	S5	Secure
Harlequin Duck - Eastern pop.	*Histrionicus histrionicus pop. 1*		Yes		Special Concern	Special Concern	Endangered	S2N	At Risk
Hermit Thrush	*Catharus guttatus*	Yes		Yes	Not Listed	Not Listed	Not Listed	S5B	Secure
Herring Gull	*Larus argentatus*	Yes	Yes	Yes	Not Listed	Not Listed	Not Listed	S5	Secure
Killdeer	*Charadrius vociferus*	Yes			Not Listed	Not Listed	Not Listed	S3B	Sensitive
Least Flycatcher	*Empidonax minimus*	Yes			Not Listed	Not Listed	Not Listed	S4S5B	Secure
Least sandpiper	*Calidris minutilla*		Yes		Not Listed	Not Listed	Not Listed	S1B,S3M	Secure
Lesser Black-backed Gull	*Larus fuscus*	Yes			Not Listed	Not Listed	Not Listed	SNA	Accidental
Lesser Yellowlegs	*Tringa flavipes*		Yes	Yes	Not Listed	Not Listed	Not Listed	S3M	Secure
Lincoln's Sparrow	*Melospiza lincolnii*	Yes			Not Listed	Not Listed	Not Listed	S4B	Secure
Magnolia Warbler	*Dendroica magnolia*	Yes			Not Listed	Not Listed	Not Listed	S5B	Secure
Mallard	*Anas platyrhynchos*		Yes	Yes	Not Listed	Not Listed	Not Listed	S5	Secure
Mourning Dove	*Zenaida macroura*	Yes			Not Listed	Not Listed	Not Listed	S5	Secure
Northern Flicker	*Colaptes auratus*	Yes		Yes	Not Listed	Not Listed	Not Listed	S5B	Secure

Table F2: Conservation Status of Species Observed During the Avian Assessment *Project # 16-5903*

Common Name	Scientific Name	Observed During Passerine Surveys	Observed During Shorebird Surveys	Observed During Avian Acoustic Assessment	SARA Status	COSEWIC Status	NSESA Status	NS S-Rank	NSDNR (Categorical)
Orange-crowned Warbler	*Vermivora celata*	Yes			Not Listed	Not Listed	Not Listed	SNA	Secure
Osprey	*Pandion haliaetus*	Yes	Yes		Not Listed	Not Listed	Not Listed	S4B	Secure
Palm Warbler	*Dendroica palmarum*	Yes			Not Listed	Not Listed	Not Listed	S5B	Secure
Pine Siskin	*Carduelis pinus*	Yes		Yes	Not Listed	Not Listed	Not Listed	S2S3	Sensitive
Purple Finch	*Carpodacus purpureus*	Yes		Yes	Not Listed	Not Listed	Not Listed	S4S5B,S3S4N	Secure
Red-breasted Nuthatch	*Sitta canadensis*	Yes		Yes	Not Listed	Not Listed	Not Listed	S3	Secure
Red-eyed Vireo	*Vireo olivaceus*	Yes		Yes	Not Listed	Not Listed	Not Listed	S5B	Secure
Red-tailed Hawk	*Buteo jamaicensis*		Yes		Not Listed	Not at Risk	Not Listed	S5	Secure
Ring-billed Gull	*Larus delawarensis*		Yes	Yes	Not Listed	Not Listed	Not Listed	SUB,S5N	Secure
Ring-necked Pheasant	*Phasianus colchicus*	Yes			Not Listed	Not Listed	Not Listed	SNA	Exotic
Ruby-crowned Kinglet	*Regulus calendula*	Yes			Not Listed	Not Listed	Not Listed	S3S4B	Sensitive
Ruffed Grouse	*Bonasa umbellus*	Yes			Not Listed	Not Listed	Not Listed	S5	Secure
Savannah Sparrow	*Passerculus sandwichensis*	Yes		Yes	Not Listed	Not Listed	Not Listed	S4S5B	Secure
Savannah Sparrow (Ipswich)	*Passerculus sandwichensis princeps*	Yes			Special Concern	Special Concern	Not Listed	S1B	Secure
Semipalmated Plover	*Charadrius semipalmatus*	Yes	Yes	Yes	Not Listed	Not Listed	Not Listed	S1B,S3S4M	Secure
Semipalmated Sandpiper	*Calidris pusilla*	Yes	Yes		Not Listed	Not Listed	Not Listed	S3M	Sensitive
Snow Bunting	*Plectrophenax nivalis*		Yes		Not Listed	Not Listed	Not Listed	S5N	Secure
Snowy Egret	*Egretta thula*		Yes		Not Listed	Not Listed	Not Listed	SNA	Undetermined
Song Sparrow	*Melospiza melodia*	Yes		Yes	Not Listed	Not Listed	Not Listed	S5B	Secure
Spotted Sandpiper	*Actitis macularius*	Yes	Yes	Yes	Not Listed	Not Listed	Not Listed	S3S4B	Sensitive
Surf Scoter	*Melanitta perspicillata*		Yes		Not Listed	Not Listed	Not Listed	S4N	Secure
Swainson's Thrush	*Catharus ustulatus*	Yes		Yes	Not Listed	Not Listed	Not Listed	S3S4B	Secure
Whimbrel	*Numenius phaeopus*		Yes		Not Listed	Not Listed	Not Listed	SNR	Sensitive
White-breasted Nuthatch	*Sitta carolinensis*	Yes			Not Listed	Not Listed	Not Listed	S4	Secure
White-throated Sparrow	*Zonotrichia albicollis*	Yes			Not Listed	Not Listed	Not Listed	S5B	Secure
White-throated Sparrow	*Zonotrichia albicollis*			Yes	Not Listed	Not Listed	Not Listed	S5B	Secure
White-winged Crossbill	*Loxia leucoptera*	Yes		Yes	Not Listed	Not Listed	Not Listed	S4S5	Secure
Willet	*Tringa semipalmata*	Yes	Yes		Not Listed	Not Listed	Not Listed	S2S3B	May Be At Risk
Winter Wren	*Troglodytes troglodytes*	Yes			Not Listed	Not Listed	Not Listed	S5B	Secure
Wood Duck	*Aix sponsa*		Yes		Not Listed	Not Listed	Not Listed	S5B	Secure
Yellow Warbler	*Dendroica petechia*	Yes			Not Listed	Not Listed	Not Listed	S5B	Secure
Yellow-rumped Warbler	*Dendroica coronata*	Yes		Yes	Not Listed	Not Listed	Not Listed	S5B	Secure
Shorebird spp.			Yes	Yes	Unknown	Unknown	Unknown	Unknown	Unknown
Sandpiper spp.			Yes	Yes	Unknown	Unknown	Unknown	Unknown	Unknown
Passerine spp.		Yes		Yes	Unknown	Unknown	Unknown	Unknown	Unknown
Gull spp.			Yes	Yes	Unknown	Unknown	Unknown	Unknown	Unknown
Duck spp.			Yes	Yes	Unknown	Unknown	Unknown	Unknown	Unknown

Table F3: Passerine Survey Results ***Project # 16-5903***

Common Name	Number of Birds Observed by Season			
	Winter	Spring Migration	Breeding	Fall Migration
Alder Flycatcher	-	-	3	-
American Black Duck	-	2	1	13
American Crow	48	48	33	48
American Goldfinch	-	-	-	2
American Redstart	-	-	3	-
American Robin	-	2	8	17
Bald eagle	8	-	-	4
Belted Kingfisher	-	1	2	2
Black-and-white Warbler	-	2	6	1
Black-capped Chickadee	31	22	15	13
Black-throated Green Warbler	-	-	5	-
Blue Jay	-	-	-	11
Blue-headed Vireo	-	4	2	6
Bonaparte's Gull	-	1	-	-
Boreal Chickadee	-	1	14	8
Cedar Waxwing	-	-	-	2
Chestnut-sided Warbler	-	-	3	
Common Eider	-	-	-	1
Common Grackle	-	1	-	-
Common Loon	-	-	2	-
Common Raven	6	1	2	5
Common Tern	-	23	-	-
Common Yellowthroat	-	39	99	3
Dark-eyed Junco	-	35	60	14
Double-crested Cormorant	-	1	5	1
Golden-crowned Kinglet	-	1	3	-
Great Black-backed Gull	-	-	3	1
Greater Yellowlegs	-	1	1	-
Hairy woodpecker	2	2	-	-
Hermit Thrush	-	7	74	4
Herring Gull	-	41	26	12
Killdeer	-	-	-	1
Least Flycatcher	-	-	8	-
Lesser Black-backed Gull	-	9	5	-
Lincoln's Sparrow	-	-	-	4
Magnolia Warbler	-	10	22	-
Mourning Dove	-	5	-	1
Northern Flicker	-	2	1	4
Orange-crowned Warbler	-	-	-	7
Osprey	-	-	-	1
Palm Warbler	-	14	37	1
Pine Siskin	-	-	-	66
Purple Finch	-	6	5	3
Red-breasted Nuthatch	-	1	-	3
Red-eyed Vireo	-	-	10	10
Ring-necked Pheasant	-	3	-	-
Ruby-crowned Kinglet	-	1	5	-
Ruffed Grouse	-	2	-	-
Savannah Sparrow	-	6	48	10
Savannah Sparrow (Ipswich)	-	1	-	-
Semipalmated Plover	-	-	-	1
Semipalmated Sandpiper	-	-	-	1
Song Sparrow	-	10	13	14

Table F3: Passerine Survey Results ***Project # 16-5903***

Common Name	Number of Birds Observed by Season			
	Winter	Spring Migration	Breeding	Fall Migration
Spotted Sandpiper	-	-	-	2
Swainson's Thrush	-	2	-	-
White-breasted Nuthatch	-	-	-	1
White-throated Sparrow	-	14	27	2
White-winged Crossbill	-		-	7
Willet	-	-	19	-
Winter Wren	-	2	1	-
Yellow Warbler	-	-	2	-
Yellow-rumped Warbler	-	17	37	-
Number of Birds Observed	**95**	**340**	**610**	**307**
Number of Species Observed	**5**	**37**	**37**	**39**

Table F4: Breeding Passerine Survey Results ***Project # 16-5903***

Common Name	Scientific Name	Number Observed	Breeding Evidence	Breeding Code
Alder Flycatcher	*Empidonax alnorum*	3	Possible	H, S
American Black Duck	*Anas rubripes*	1	Possible	H, S
American Crow	*Corvus brachyrhynchos*	33	Possible	H, S
American Redstart	*Setophaga ruticilla*	3	Probable	P
American Robin	*Turdus migratorius*	8	Probable	P
Belted Kingfisher	*Megaceryle alcyon*	2	Possible	H, S
Black-and-white Warbler	*Mniotilta varia*	6	Possible	H, S
Black-capped Chickadee	*Poecile atricapillus*	15	Possible	H, S
Black-throated Green Warbler	*Dendroica virens*	5	Possible	H, S
Blue-headed Vireo	*Vireo solitarius*	2	Possible	H, S
Boreal Chickadee	*Poecile hudsonica*	14	Probable	P
Chestnut-sided Warbler	*Dendroica pensylvanica*	3	Possible	H, S
Common Loon	*Gavia immer*	2	Possible	H, S
Common Raven	*Corvus corax*	2	Possible	H, S
Common Yellowthroat	*Geothlypis trichas*	99	Probable	P
Dark-eyed Junco	*Junco hyemalis*	60	Probable	P
Double-crested Cormorant	*Phalacrocorax auritus*	5	Possible	H, S
Golden-crowned Kinglet	*Regulus satrapa*	3	Possible	H, S
Great Black-backed Gull	*Larus marinus*	3	Possible	H, S
Greater Yellowlegs	*Tringa melanoleuca*	1	Possible	H, S
Hermit Thrush	*Catharus guttatus*	74	Probable	P
Herring Gull	*Larus argentatus*	26	Possible	H, S
Least Flycatcher	*Empidonax minimus*	8	Possible	H, S
Lesser Black-backed Gull	*Larus fuscus*	5	Possible	H, S
Magnolia Warbler	*Dendroica magnolia*	22	Probable	P, T
Northern Flicker	*Colaptes auratus*	1	Possible	H, S
Palm Warbler	*Dendroica palmarum*	37	Probable	P
Purple Finch	*Carpodacus purpureus*	5	Possible	H, S
Red-eyed Vireo	*Vireo olivaceus*	10	Possible	H, S
Ruby-crowned Kinglet	*Regulus calendula*	5	Possible	H, S
Savannah Sparrow	*Passerculus sandwichensis*	48	Probable	P
Song Sparrow	*Melospiza melodia*	13	Probable	P
White-throated Sparrow	*Zonotrichia albicollis*	27	Confirmed	NB, P
Willet	*Tringa semipalmata*	19	Probable	P, T
Winter Wren	*Troglodytes troglodytes*	1	Possible	H, S
Yellow Warbler	*Dendroica petechia*	2	Possible	H, S
Yellow-rumped Warbler	*Dendroica coronata*	37	Probable	P, T

Number of Species Observed	37
Number of Birds Observed	610
Breeding Status	**Number Of Birds**
Possible	24
Probable	12
Confirmed	1

Table F5. Shorebird Survey Results ***Project # 16-5903***

Common Name	Guild	Winter			
		Spinny Gully	Chapel Gully	Blackduck Cove	Glasgow Head
American Black Duck	Seaducks and Waterfowl	-	-	3	-
American Crow	Passerines	-	-	-	-
Bald Eagle	Raptors	-	-	1	-
Belted Kingfisher	Passerines	-	-	-	-
Canada Goose	Seaducks and Waterfowl	-	-	-	-
Cliff Swallow	Passerines	-	-	3	-
Common Eider	Seaducks and Waterfowl	8	-	-	-
Common Loon	Seaducks and Waterfowl	-	-	-	-
Common Raven	Passerines	-	-	-	-
Common Tern	Seabirds and Seagulls	-	-	-	-
Double-crested Cormorant	Seaducks and Waterfowl	-	-	-	-
Great Black-backed Gull	Seabirds and Seagulls	-	-	4	-
Great Blue Heron	Shorebirds	-	-	-	-
Greater Scaup	Seaducks and Waterfowl	-	-	36	-
Greater Yellowlegs	Shorebirds	-	-	-	-
Harlequin Duck - Eastern pop.	Seaducks and Waterfowl	-	-	-	-
Herring Gull	Seabirds and Seagulls	-	-	1	-
Least sandpiper	Shorebirds	-	-	-	-
Lesser Yellowlegs	Shorebirds	-	-	-	-
Mallard	Seaducks and Waterfowl	-	-	-	-
Osprey	Raptors	-	-	-	-
Red-tailed Hawk	Raptors	-	-	-	-
Ring-billed Gull	Seabirds and Seagulls	-	-	-	-
Semipalmated Plover	Shorebirds	-	-	-	-
Semipalmated Sandpiper	Shorebirds	-	-	-	-
Snow Bunting	Passerines	-	-	-	-
Snowy Egret	Shorebirds	-	-	-	-
Spotted sandpiper	Shorebirds	-	-	-	-
Surf Scoter	Seaducks and Waterfowl	-	-	42	-
Whimbrel	Shorebirds	-	-	-	-
Willet	Shorebirds	-	-	-	-
Wood Duck	Seaducks and Waterfowl	-	-	-	-

Table F5. Shorebird Survey Results ***Project # 16-5903***

Common Name	Guild	Spring			
		Spinny Gully	Chapel Gully	Blackduck Cove	Glasgow Head
American Black Duck	Seaducks and Waterfowl	-	4	11	-
American Crow	Passerines	-	-	-	-
Bald Eagle	Raptors	-	-	-	-
Belted Kingfisher	Passerines	-	-	1	-
Canada Goose	Seaducks and Waterfowl	-	24	4	-
Cliff Swallow	Passerines	-	-	-	-
Common Eider	Seaducks and Waterfowl	-	-	-	-
Common Loon	Seaducks and Waterfowl	-	-	-	-
Common Raven	Passerines	-	-	-	-
Common Tern	Seabirds and Seagulls	-	-	-	-
Double-crested Cormorant	Seaducks and Waterfowl	-	-	4	-
Great Black-backed Gull	Seabirds and Seagulls	1	-	-	-
Great Blue Heron	Shorebirds	-	-	1	-
Greater Scaup	Seaducks and Waterfowl	-	-	-	-
Greater Yellowlegs	Shorebirds	-	3	-	-
Harlequin Duck - Eastern pop.	Seaducks and Waterfowl	-	4	-	-
Herring Gull	Seabirds and Seagulls	2	1	7-	-
Least sandpiper	Shorebirds	-	-	-	-
Lesser Yellowlegs	Shorebirds	-	-	-	-
Mallard	Seaducks and Waterfowl	-	4	-	-
Osprey	Raptors	-	-	1	-
Red-tailed Hawk	Raptors	-	-	1	-
Ring-billed Gull	Seabirds and Seagulls	-	-	-	-
Semipalmated Plover	Shorebirds	-	-	5	-
Semipalmated Sandpiper	Shorebirds	-	-	-	-
Snow Bunting	Passerines	-	-	-	-
Snowy Egret	Shorebirds	-	1	-	-
Spotted sandpiper	Shorebirds	-	-	-	-
Surf Scoter	Seaducks and Waterfowl	-	-	2	-
Whimbrel	Shorebirds	-	1	-	-
Willet	Shorebirds	-	-	-	-
Wood Duck	Seaducks and Waterfowl	-	-	-	-

Table F5. Shorebird Survey Results ***Project # 16-5903***

Common Name	Guild	Summer			
		Spinny Gully	Chapel Gully	Blackduck Cove	Glasgow Head
American Black Duck	Seaducks and Waterfowl	-	-	-	-
American Crow	Passerines	-	1	-	-
Bald Eagle	Raptors	-	-	-	-
Belted Kingfisher	Passerines	-	-	1	-
Canada Goose	Seaducks and Waterfowl	-	-	12	-
Cliff Swallow	Passerines	-	-	-	-
Common Eider	Seaducks and Waterfowl	-	-	-	-
Common Loon	Seaducks and Waterfowl	-	-	-	-
Common Raven	Passerines	-	-	-	-
Common Tern	Seabirds and Seagulls	6	2	24	-
Double-crested Cormorant	Seaducks and Waterfowl	-	5	6	-
Great Black-backed Gull	Seabirds and Seagulls	-	2	57	-
Great Blue Heron	Shorebirds	-	-	-	-
Greater Scaup	Seaducks and Waterfowl	-	-	-	-
Greater Yellowlegs	Shorebirds	-	-	-	-
Harlequin Duck - Eastern pop.	Seaducks and Waterfowl	-	-	-	-
Herring Gull	Seabirds and Seagulls	6	3	6-	-
Least sandpiper	Shorebirds	-	-	-	-
Lesser Yellowlegs	Shorebirds	-	-	-	-
Mallard	Seaducks and Waterfowl	-	-	-	-
Osprey	Raptors	-	-	-	-
Red-tailed Hawk	Raptors	-	-	-	-
Ring-billed Gull	Seabirds and Seagulls	2	2	-	-
Semipalmated Plover	Shorebirds	-	-	-	-
Semipalmated Sandpiper	Shorebirds	-	-	5	-
Snow Bunting	Passerines	-	-	-	-
Snowy Egret	Shorebirds	-	-	-	-
Spotted sandpiper	Shorebirds	-	-	1	-
Surf Scoter	Seaducks and Waterfowl	-	-	-	-
Whimbrel	Shorebirds	-	-	-	-
Willet	Shorebirds	1	6	3	-
Wood Duck	Seaducks and Waterfowl	-	-	-	-

Table F5. Shorebird Survey Results ***Project # 16-5903***

Common Name	Guild	Fall			
		Spinny Gully	Chapel Gully	Blackduck Cove	Glasgow Head
American Black Duck	Seaducks and Waterfowl	-	8	12	16
American Crow	Passerines	-	4	-	4
Bald Eagle	Raptors	-	-	-	-
Belted Kingfisher	Passerines	-	-	-	-
Canada Goose	Seaducks and Waterfowl	-	12	-	-
Cliff Swallow	Passerines	-	-	-	-
Common Eider	Seaducks and Waterfowl	-	-	5	-
Common Loon	Seaducks and Waterfowl	-	-	3	-
Common Raven	Passerines	2	-	-	-
Common Tern	Seabirds and Seagulls	-	-	-	3
Double-crested Cormorant	Seaducks and Waterfowl	8	2	2	9
Great Black-backed Gull	Seabirds and Seagulls	-	3	35	2
Great Blue Heron	Shorebirds	-	2	-	-
Greater Scaup	Seaducks and Waterfowl	-	-	-	-
Greater Yellowlegs	Shorebirds	-	2	-	-
Harlequin Duck - Eastern pop.	Seaducks and Waterfowl	-	-	-	-
Herring Gull	Seabirds and Seagulls	11	3	56	9
Least sandpiper	Shorebirds	-	-	-	1
Lesser Yellowlegs	Shorebirds	1	-	-	-
Mallard	Seaducks and Waterfowl	-	-	27	1-
Osprey	Raptors	-	-	-	-
Red-tailed Hawk	Raptors	-	-	-	-
Ring-billed Gull	Seabirds and Seagulls	3	-	-	1
Semipalmated Plover	Shorebirds	-	-	1-	-
Semipalmated Sandpiper	Shorebirds	-	-	-	2
Snow Bunting	Passerines	-	-	-	2-
Snowy Egret	Shorebirds	-	1	-	-
Spotted sandpiper	Shorebirds	-	-	1	-
Surf Scoter	Seaducks and Waterfowl	-	-	-	-
Whimbrel	Shorebirds	-	-	-	-
Willet	Shorebirds	-	-	-	-
Wood Duck	Seaducks and Waterfowl	6	-	-	-

Table F5. Shorebird Survey Results ***Project # 16-5903***

Common Name	Guild	All Seasons			
		Spinny Gully	Chapel Gully	Blackduck Cove	Glasgow Head
American Black Duck	Seaducks and Waterfowl	-	12	26	16
American Crow	Passerines	-	5	-	4
Bald Eagle	Raptors	-	-	1	-
Belted Kingfisher	Passerines	-	-	2	-
Canada Goose	Seaducks and Waterfowl	-	36	16	-
Cliff Swallow	Passerines	-	-	3	-
Common Eider	Seaducks and Waterfowl	8	-	5	-
Common Loon	Seaducks and Waterfowl	-	-	3	-
Common Raven	Passerines	2	-	-	-
Common Tern	Seabirds and Seagulls	6	2	24	3
Double-crested Cormorant	Seaducks and Waterfowl	8	7	12	9
Great Black-backed Gull	Seabirds and Seagulls	1	5	96	2
Great Blue Heron	Shorebirds	-	2	1	-
Greater Scaup	Seaducks and Waterfowl	-	-	36	-
Greater Yellowlegs	Shorebirds	-	5	-	-
Harlequin Duck - Eastern pop.	Seaducks and Waterfowl	-	4	-	-
Herring Gull	Seabirds and Seagulls	19	7	187	9
Least sandpiper	Shorebirds	-	-	-	1
Lesser Yellowlegs	Shorebirds	1	-	-	-
Mallard	Seaducks and Waterfowl	-	4	27	1-
Osprey	Raptors	-	-	1	-
Red-tailed Hawk	Raptors	-	-	1	-
Ring-billed Gull	Seabirds and Seagulls	5	2	-	1
Semipalmated Plover	Shorebirds	-	-	15	-
Semipalmated Sandpiper	Shorebirds	-	-	5	2
Snow Bunting	Passerines	-	-	-	2-
Snowy Egret	Shorebirds	-	2	-	-
Spotted sandpiper	Shorebirds	-	-	2	-
Surf Scoter	Seaducks and Waterfowl	-	-	44	-
Whimbrel	Shorebirds	-	1	-	-
Willet	Shorebirds	1	6	3	-
Wood Duck	Seaducks and Waterfowl	6	-	-	-

Table F6: Avian Acoustic Assessment Results ***Project # 16-5903***

Common Name	Guild	Spinney Gully	Glasgow Head
American Black Duck	Seaducks and Waterfowl	2	0
American Crow	Passerines	124	100
American Goldfinch	Passerines	14	3
American Robin	Passerines	36	0
Bald Eagle	Raptors	5	4
Belted Kingfisher	Passerines	4	1
Black-and-white Warbler	Passerines	2	0
Black-capped Chickadee	Passerines	29	40
Black-throated-green Warbler	Passerines	1	0
Blue Jay	Passerines	6	3
Blue-headed Vireo	Passerines	3	1
Boreal Chickadee	Passerines	1	2
Brown Creeper	Passerines	4	0
Canada Goose	Seaducks and Waterfowl	4	0
Common Raven	Passerines	15	13
Common Tern	Seabirds and Gulls	43	32
Common Yellowthroat	Passerines	2	0
Dark-eyed Junco	Passerines	14	1
Duck spp.	Seaducks and Waterfowl	3	1
Golden-crowned Kinglet	Passerines	1	0
Gray Jay	Passerines	1	0
Great Blackbacked Gull	Seabirds and Gulls	7	3
Greater Yellowlegs	Shorebirds	4	2
Gull spp.	Seabirds and Gulls	1	0
Hermit Thrush	Passerines	1	0
Herring Gull	Seabirds and Gulls	35	15
Lesser Yellowlegs	Passerines	0	2
Mallard	Seaducks and Waterfowl	0	7
Northern Flicker	Passerines	4	2
Passerine spp.	Passerines	10	49
Pine Siskin	Passerines	3	0
Purple Finch	Passerines	3	0
Red-breasted Nuthatch	Passerines	0	2
Red-eyed Vireo	Passerines	2	0
Ring-billed Gull	Seabirds and Gulls	3	3
Sandpiper spp.	Shorebirds	2	4
Savannah Sparrow	Passerines	11	10
Semi-palmated Plover	Shorebirds	0	1
Shorebird spp.	Shorebirds	10	11
Song Sparrow	Passerines	22	17
Spotted Sandpiper	Shorebirds	4	13
Swainon's Thrush	Passerines	2	0
White-throated Sparrow	Passerines	11	0
White-winged Crossbill	Passerines	26	11
Willet	Shorebirds	2	0
Yellow-rumped Warbler	Passerines	13	7
Number of Birds Observed		**490**	**360**
Number of Species Observed		**42**	**29**