MAYFLOWER WIND

Appendix U1. In-Air Acoustic Assessment Report

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MAYFLOWER WIND

Prepared for:
Mayflower Wind Energy LLC

Final In-Air Acoustic Assessment Report

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Table of Contents

Acronyms and Abbreviations v
1.0 Introduction 1-1
1.1 Assessment Objectives 1-1
1.2 Report Organization 1-1
1.3 Noise Descriptors 1-1
1.3.1 Frequency 1-1
1.3.2 Sound Pressure Levels and Decibels 1-1
1.3.3 Addition of Decibels 1-2
1.3.4 A-Weighted Decibels 1-2
1.3.5 Human Response to Changes in Noise Levels 1-3
1.3.6 Noise Descriptors 1-3
1.3.7 Sound Propagation 1-4
1.3.7.1 Geometric Spreading 1-4
1.3.7.2 Ground Absorption 1-4
1.3.7.3 Atmospheric Effects 1-4
1.3.7.4 Shielding by Natural or Human-Made Features 1-4
2.0 Project Description 2-1
2.1 Project Overview 2-1
2.2 Specific Project Details 2-1
3.0 Relevant Regulations and Assessment Approach 3-7
3.1 Relevant Regulations 3-7
3.1.1 Federal 3-7
3.1.2 State 3-7
3.1.3 Local 3-7
3.2 Noise Assessment Approach 3-7
3.2.1 WTGs and OSPs 3-7
3.2.2 Onshore Substation 3-8
3.3 Noise Modeling Methodology 3-8
3.3.1 Offshore Sources 3-8
3.3.2 Onshore Sources 3-8
3.3.3 Construction 3-8
4.0 Existing Conditions/Noise Measurements 4-1
4.1 Noise Measurements 4-1
4.1.1 Monitoring Locations 4-1
4.1.2 Monitoring Results 4-3
5.0 Effects Characterization 5-1
5.1 Future Operations Evaluation 5-1
5.1.1 Primary Noise Sources and Reference Levels 5-1
5.1.2 Noise Modeling Results and Impact Evaluation 5-1
5.1.3 Mitigation Measures 5-4
5.2 Construction Noise Evaluation 5-6
5.2.1 Construction Noise Sources 5-6
5.2.2 Construction Noise Analysis and Mitigation 5-6
5.2.2.1 Offshore Construction 5-7
5.2.2.2 Onshore Construction 5-7
5.2.2.3 Onshore Substation Construction 5-12
5.2.3 Construction Noise Mitigation 5-12

6.0 Conclusions 6-1
7.0 References 7-1

Figures

Figure 2-1. Location of Mayflower Wind Offshore Wind Renewable Energy Generation Project 2-4
Figure 2-2. Location of Mayflower Wind Onshore Project Elements - Falmouth 2-5
Figure 2-3. Location of Mayflower Wind Onshore Project Elements – Brayton Point 2-6
Figure 4-1. Noise Monitoring Locations for the Onshore Substation at Lawrence Lynch (Preferred) 4-2
Figure 4-2. Noise Monitoring Locations for the Onshore Substation at Cape Cod Aggregates (Alternate) 4-3
Figure 4-3. Noise Monitoring Results for the Onshore Substation at Lawrence Lynch at Location LLG-LT1 (Minimum Hourly L_{90} is 38.5 dBA) 4-4
Figure 4-4. Noise Monitoring Locations for the Onshore Substation at Lawrence Lynch at Location LLG-LT2 (Minimum Hourly L_{90} is 44.6 dBA) 4-4
Figure 4-5. Noise Monitoring Locations for the Onshore Substation at Cape Cod Aggregates at Location CCA-LT1 (Minimum Hourly L_{90} is 40.1 dBA) 4-5
Figure 4-6. Noise Monitoring Locations for the Onshore Substation at Cape Cod Aggregates at Location CCA-LT2 (Minimum Hourly L_{90} is 34.9 dBA) 4-5
Figure 5-1. Predicted Noise Contours for the Onshore Substation at Lawrence Lynch (Preferred) 5-2
Figure 5-2. Predicted Noise Contours for the Onshore Substation at Cape Cod Aggregates (Alternate) 5-3
Figure 5-3. Predicted Noise Contours for Lawrence Lynch Site with Mitigation Measures 5-4
Figure 5-4. Predicted Noise Contours for Cape Cod Aggregates with Mitigation Measures 5-5
Figure 5-5. Predicted Noise Contours for Worcester Avenue Landfall (Preferred) 5-8
Figure 5-6. Predicted Noise Contours for Worcester Avenue Landfall (Preferred) with Mitigation Measures 5-9
Figure 5-7. Predicted Noise Contours for Shore Street Landfall (Alternate) 5-10
Figure 5-8. Predicted Noise Contours for Shore Street Landfall (Alternate) with Mitigation Measures 5-11

Tables

Table 1-1. Typical A-Weighted Noise Levels 1-2
Table 2-1. Key Project Details 2-2
Table 5-1. Primary Noise Sources and Reference Levels for Substation Site 5-1
Table 5-2. Construction Noise Sources and Reference Sound Levels 5-6

Attachments

ATTACHMENT 1 – Noise Monitoring Photo Log

Acronyms and Abbreviations

Abbreviation or Acronym	Definition
AIS	Air-insulated substation
ANSI	American National Standards Institute
CMR	Code of Massachusetts Regulations
COP	Construction and Operations Plan
DAQC	Division of Air Quality Control
dB	decibel
dBA	A-weighted decibel
EFSB	Energy Facilities Siting Board
ft	foot/feet
GIS	Gas-insulated substation
ha	hectares
HDD	Horizontal Directional Drilling
HVAC	Heating, Ventilation, and Air Conditioning
Hz	Hertz
ISO	International Organization for Standardization
kHz	kilohertz
km	kilometer
kV	kilovolt
L_{dn}	day-night sound level
L_{eq}	equivalent sound level
$L_{eq[h]}$	1-hour A-weighted equivalent sound level
L_{max}	maximum sound level
L_n	exceedance level
L_wA	A-weighted sound power level
L_{90}	sound pressure level exceeded 90% of the time
m	meter
MassDEP	Massachusetts Department of Environmental Protection
Mayflower Wind	Mayflower Wind Energy LLC
mph	miles per hour
N/A	Not applicable
µPa	micro-Pascal
nm	nautical miles
OBCF	Octave Band Center Frequency
OCS	Outer Continental Shelf
OSP	Offshore Substation Platform
POI	Point of Interconnection
ROW	Right of Way
SPL	Sound Pressure Level
WTG	Wind Turbine Generator

1.0 Introduction

Mayflower Wind Energy LLC (Mayflower Wind) proposes an offshore wind renewable energy generation project (the Project) located in federal waters off the southern coast of Massachusetts in the Outer Continental Shelf (OCS) Lease Area OCS-A 0521 (Lease Area). The Project will deliver electricity to the regionally administered transmission system via export cables with sea-to-shore transitions in Falmouth and Somerset, Massachusetts and onshore transmission system extending to the anticipated points of interconnection (POIs). While the Project includes Falmouth and Somerset (Brayton Point), Massachusetts, the focus of this report is the Falmouth Project components. A separate report for the Brayton Point Project components will be prepared and submitted.

1.1 Assessment Objectives

This assessment determines whether airborne noise impacts would be expected with the currently planned wind turbine generator (WTG) layout and the landing(s), onshore substation, and Falmouth POI. Where impacts are expected, mitigation measures have been evaluated to show how they will reduce noise at affected receptors to acceptable levels.

1.2 Report Organization

This report includes a general Project overview (Section 2.0), identification of the relevant regulations and a description of the noise assessment approach (Section 3.0), a description of existing conditions (Section 4.0), and future noise level calculations and a characterization of effects (Section 5.0). A summary of conclusions is provided in Section 6.0, and references cited in this report are listed in Section 7.0. The remainder of this section provides an explanation of noise concepts.

1.3 Noise Descriptors

Sound can be described as the mechanical energy of a vibrating object transmitted by pressure waves through a liquid or gaseous medium (e.g., air) to a hearing organ, such as a human ear. In the science of acoustics, the fundamental model consists of a sound (or noise) source, a receptor, and the propagation path between the two. The loudness of the noise source and obstructions or atmospheric factors affecting the propagation path to the receptor determine the sound level and characteristics of the noise perceived by the receptor. The following sections present the basic parameters used to describe the environmental sound levels evaluated in this analysis.

1.3.1 Frequency

Continuous sound can be described by frequency (pitch) and amplitude (loudness). A low-frequency sound is perceived as low in pitch. Frequency is expressed in terms of cycles per second, or Hertz (Hz) (e.g., a frequency of 250 cycles per second is referred to as 250 Hz). High frequencies are sometimes more conveniently expressed in kilohertz (kHz), or thousands of Hertz. The audible frequency range for humans is generally between 20 Hz and 20,000 Hz (Cowan, 1994).

1.3.2 Sound Pressure Levels and Decibels

The amplitude of pressure waves generated by a sound source determines the loudness of that source. Sound pressure amplitude is measured in micro-Pascals (μPa). One μPa is approximately one hundred-billionth (0.00000000001) of normal atmospheric pressure. Sound pressure amplitudes for different kinds of noise environments can range from less than 100 to more than 100,000,000 μPa. Because of this large range of values and our sensitivity to changes in these values, sound is rarely expressed in terms of μPa. Instead, a logarithmic scale is used to describe sound pressure level (SPL) in terms of decibels (dB). The threshold of hearing for people less than 20 years old is about 0 dB, which corresponds to 20 μPa. Although this value increases with age, this is the reference used for calculating SPL (Cowan, 1994).

1.3.3 Addition of Decibels

Because decibels are logarithmic units, SPL cannot be added or subtracted through ordinary arithmetic. Under the decibel scale, a doubling of sound energy corresponds to a 3 dB increase. In other words, when two identical sources at the same location are each producing sound of the same loudness, the resulting sound level at a given distance would be 3 dB higher than that for one source under the same conditions. For example, if one automobile produces an SPL of 70 dB when it passes an observer, two cars passing simultaneously would not produce 140 dB; rather, they would combine to produce 73 dB. Under the decibel scale, three sources of equal loudness together produce a sound level 5 dB louder than that for one source.

1.3.4 A-Weighted Decibels

The decibel scale alone does not adequately characterize how humans perceive sound. The dominant frequencies of a sound source have a substantial effect on the human response to that sound. Although the intensity (energy per unit area) of the sound is a purely physical quantity, the loudness or human response is determined by the characteristics of the human hearing mechanism.

Human hearing sensitivity is limited in the range of audible frequencies as well as in the way it perceives the SPL in that range. In general, people are most sensitive to sounds in the frequency range of 1,000 to 4,000 Hz and perceive sounds within that range better than sounds of the same amplitude at higher or lower frequencies (Cowan, 1994). To approximate the response of the human hearing mechanism, sound levels of individual frequency bands are weighted, depending on the human sensitivity to those frequencies. Then, an “A-weighted” sound level (expressed in units of dBA) can be computed based on this information.

The A-weighting network approximates the frequency response of the average healthy human hearing mechanism when listening to sounds at moderate levels. When people make judgments of the relative loudness or annoyance of a sound, their judgments correlate well with the A-weighted levels of those sounds. Noise levels for environmental assessment reports are typically reported in terms of A-weighted decibels or dBA. Table 1-1 describes typical A-weighted noise levels for various noise sources and environments based on field experience.

Table 1-1. Typical A-Weighted Noise Levels

Noise Source (at a Given Distance)	Scale of A-Weighted Sound Level (dB)	Noise Environment	Human Judgment of Noise Loudness (Relative to a Reference Level of 70 dB*)
Military Jet Take-off with After-burner (50 feet [ft], 15 meters [m]) Civil Defense Siren (100 ft [30 m])	140 130	Aircraft Carrier Flight Deck	*128 times as loud *64 times as loud
Commercial Jet Take-off (200 ft [61 m])	120		Threshold of Pain *32 times as loud
Onshore Pile Driver (50 ft [15 m])	110	Rock Music Concert	*16 times as loud
Ambulance Siren (100 ft [30 m]) Newspaper Press (5 ft [1.5 m]) Power Lawn Mower (3 ft [0.9 m])	100		Very Loud *8 times as loud
Motorcycle (25 ft [7.6 m]) Propeller Plane Flyover (1,000 ft [305 m]) Diesel Truck, 40 miles per hour (mph) (64 kilometers [km] per hour) (50 ft [15 m])	90	Boiler Room Printing Press Plant	*4 times as loud
Garbage Disposal (3 ft [0.9 m])	80	High Urban Ambient Sound	*2 times as loud

Noise Source (at a Given Distance)	Scale of A-Weighted Sound Level (dB)	Noise Environment	Human Judgment of Noise Loudness (Relative to a Reference Level of 70 dB*)
Passenger Car, 65 mph (105 km per hour) (25 ft [7.6 m]) Vacuum Cleaner (10 ft [3 m])	70		Moderately loud *70 dB (Reference Loudness)
Normal Conversation (5 ft [1.5 m]) Air Conditioning Unit (100 ft [30 m])	60	Data Processing Center Department Store	*1/2 as loud
Light Traffic (100 ft [30 m])	50	Private Business Office	*1/4 as loud
Bird Calls (distant)	40	Lower Limit of Urban Ambient Sound	Quiet *1/8 as loud
Soft Whisper (5 ft [1.5 m])	30	Quiet Bedroom	
	20	Recording Studio	Very Quiet
	10		
	0		Threshold of Hearing

Source: AECOM

1.3.5 Human Response to Changes in Noise Levels

As discussed above, doubling sound energy results in a 3 dB increase in sound level. However, given a sound level change measured with precise instrumentation, the subjective human perception of a doubling of loudness will usually be different than what is measured. Under controlled conditions in an acoustical laboratory, the trained, healthy human ear is able to discern 1 dB changes in sound levels when exposed to steady, single-frequency (“pure-tone”) signals in the midfrequency (500 to 2,000 Hz) range. In typical environments, changes in noise levels of 1 to 2 dB are generally not perceptible. However, it is widely accepted that people, in general, are able to begin to detect sound level increases of 3 dB in typical environments. Further, a 5 dB increase is generally perceived as a distinctly noticeable increase, and a 10 dB increase is generally perceived as a doubling of loudness. Therefore, a doubling of sound energy (or doubling the number of sources) that would result in a 3 dB increase in sound level, would generally be perceived as barely noticeable.

1.3.6 Noise Descriptors

Noise in our daily environment fluctuates over time. Some fluctuations are minor, but some are substantial. Some noise levels occur in regular patterns, but others are random. Some noise levels fluctuate rapidly, but others slowly. Some noise levels vary widely, but others are relatively constant. Various noise descriptors have been developed to describe time-varying noise levels. The following are the noise descriptors used in this analysis:

- **Equivalent Sound Level (L_{eq})**: L_{eq} represents an average of the sound energy occurring over a specified period. The L_{eq} is the steady-state sound level containing the same acoustical energy as the time-varying sound that actually occurs during the same period. The 1-hour A-weighted equivalent sound level ($L_{eq[h]}$) is the energy-average of A-weighted sound levels occurring during a one-hour period and is the basis for noise abatement criteria for many agencies.

- **Maximum Sound Level (L_{max})**: L_{max} is the highest instantaneous sound level measured during a specified period.
- **Day-Night Level (L_{dn})**: L_{dn} is the energy-average of A-weighted sound levels occurring over a 24-hour period, with a 10 dB increase applied to A-weighted sound levels occurring during normal sleeping hours between 10 p.m. and 7 a.m. to account for the added sensitivity at those times. This metric is often used to assess community noise annoyance from sources that operate constantly at all hours.
- **Exceedance Level (L_n)**: The sound level exceeded "n" percent of a specified time interval. The most common of these is sound pressure exceeded 90% of the time (L_{90}), which is usually used to quantify the residual ambient sound levels in an area.

1.3.7 Sound Propagation

When sound propagates over a distance, it changes in level and frequency content. The manner in which noise reduces with distance depends on the following factors.

1.3.7.1 Geometric Spreading

Sound pressure from a stationary source (i.e., a point source) propagates uniformly outward in a spherical pattern. The sound pressure level attenuates (or decreases) at a rate of 6 dBA for each doubling of distance from a point source. Highways, trains, and power lines consist of several localized noise sources on a defined path, and therefore can be treated as a line source, which approximates the effect of several point sources. Noise from a line source propagates outward in a cylindrical pattern, often referred to as cylindrical spreading. In general, sound pressure levels attenuate at a rate of 3 dBA for each doubling of distance from a line source.

1.3.7.2 Ground Absorption

The propagation path of onshore noise sources to a receptor is usually very close to the ground. Noise attenuation from ground absorption and reflective-wave canceling adds to the attenuation associated with geometric spreading. Traditionally, this excess attenuation has also been expressed in terms of attenuation per doubling of distance. This approximation is usually sufficiently accurate for distances of less than 200 ft (61 m). For acoustically hard sites (i.e., sites with a reflective surface between the source and the receptor, such as a parking lot or body of water) or elevated sources (such as WTGs), no excess ground attenuation is assumed. For acoustically absorptive or soft sites (i.e., those sites with an absorptive ground surface between the source and the receptor, such as soft dirt, grass, or scattered bushes and trees), an excess ground-attenuation value of 1.5 dBA per doubling of distance is normally assumed. This results in drop-off rates of 7.5 dBA per doubling of distance from point sources and 4.5 dBA per doubling of distance from line sources.

1.3.7.3 Atmospheric Effects

Receptors located downwind from a source can be exposed to increased noise levels relative to calm conditions, whereas locations upwind can have lowered noise levels. Sound levels can be increased at large distances (more than 500 ft [152 m]) from a source due to atmospheric temperature inversion (increasing temperature with elevation, as occasionally occurs late at night) and they can decrease at similar distances due to temperature lapse (decreasing temperature with elevation, as typically occurs during a clear day). Other factors, such as humidity and turbulence, can also have significant effects on sound propagation.

1.3.7.4 Shielding by Natural or Human-Made Features

A large object or barrier in the path between a noise source and a receptor can substantially attenuate noise levels at the receptor. The amount of attenuation provided by shielding depends on the size of the object and the frequency content of the noise source. Natural terrain features (e.g., hills and dense woods) and human-made features (e.g., buildings and solid walls) can substantially reduce noise levels. Walls are often constructed between a source and a receptor specifically to reduce noise. A barrier that breaks the line-ofsight between a source and a receptor will typically result in at least 5 dBA of noise reduction. Taller barriers provide increased noise reduction, up to a practical limit of 10 to 15 dBA due to diffraction of sound over and around barriers. Vegetation between the sources and receptors is rarely effective in reducing noise because it does not create a solid barrier. In any case, this kind of noise attenuation is only effective when it is located within 200 ft (61 m) of a source or receptor.

2.0 Project Description

2.1 Project Overview

The Mayflower Wind Project includes a Lease Area located in federal waters south of Martha's Vineyard and Nantucket (Figure 2-1). Wind turbine generators (WTGs) constructed within the Lease Area will deliver power via inter-array cables to the offshore substation platforms (OSPs). Submarine offshore export cables will be installed within offshore export cable corridors (ECCs) to carry the electricity from the OSPs within the Lease Area to the onshore transmission systems via two different ECCs. One ECC will make landfall in Falmouth, Massachusetts and the other will make landfall at Brayton Point, in Somerset, Massachusetts. The offshore export cables will make landfall via horizontal directional drilling (HDD). The proposed Falmouth ECC will extend from the Lease Area through Muskeget Channel into Nantucket Sound to three potential landing location(s) in Falmouth including Shore Street, Central Park, or Worcester Avenue. The proposed Brayton Point ECC will run north and west from the Lease Area through Rhode Island Sound to the Sakonnet River. It will then run north up the Sakonnet River, cross land at Aquidneck Island to Mount Hope Bay, and then north into Massachusetts state waters to Brayton Point. Landfall will be made via HDD at one of two potential landing locations in Somerset on the western side of Brayton Point from the Lee River (preferred) or the eastern side via the Taunton River (alternate).

In Falmouth, the underground onshore export cables will extend from the landfall location(s) to an onshore substation and will be installed within existing paved roadways and shoulder and within a municipal grassy median strip for the Worcester Avenue HDD transition vault (Figure 2-2). The new Falmouth onshore substation will step up the voltage to 345 kilovolts (kV) to enable connection to either an overhead transmission line (preferred) or an underground transmission route (alternate). The selected landfall location will determine the route of the underground onshore export cables between the landfall and the new onshore substation. The proposed Falmouth point of interconnection (POI) to the regional transmission system is an existing switching station (Falmouth Tap). Mayflower Wind anticipates that upgrades to Falmouth Tap will be undertaken by Eversource, as part of a larger reliability project, which is independent of the Mayflower Wind Project. The overhead transmission line will be designed, permitted, and built by Eversource to provide interconnection at Falmouth Tap. The alternate underground transmission route would be constructed within local roadway and/or shoulder extending from the onshore substation to the POI at Falmouth Tap.

As stated above, the Brayton Point ECC includes an overland portion where underground onshore export cables will be installed to cross the northern portion of Aquidneck Island (Figure 2-3). Three route options for the crossing of the island are under consideration, all route options include HDD for entry and exit on/off the island. At Brayton Point, the onshore underground export cables will traverse the site from the landing to the location of a new high voltage direct current (HVDC) converter station (converter station). Underground transmission cable(s) will be constructed from the converter station to the Brayton Point POI, the adjacent existing National Grid substation.

The Falmouth Onshore Project Area includes the landing(s), underground onshore export cables, onshore substation, alternate underground transmission route, and POI at the Falmouth Tap switching station. The Brayton Point Onshore Project Area includes the onshore export cable route options over Aquidneck Island, landing(s) at Aquidneck Island and Brayton Point, the underground onshore export cables, converter station, underground transmission route, and the POI at the National Grid substation. See Figure 2-2 and Figure 2-3 for the Falmouth Onshore Project Area and the Brayton Point Onshore Project Area respectively.

2.2 Specific Project Details

Each primary onshore Project component is briefly described below in Table 2-1. Additional details may be found in the Construction and Operations Plan (COP) Section 3 – Description of Proposed Activities.

Table 2-1. Key Project Details

Project Attribute	Description
Landfall Location(s)	Falmouth, MA Three locations under consideration: Worcester Avenue (preferred), Shore Street, and Central Park Brayton Point, Somerset, MA Two locations under consideration: the western (preferred) and eastern (alternate) shorelines of Brayton Point Aquidneck Island, RI Several locations under consideration for intermediate landfall across the island
Offshore Export Cables	Falmouth ECC Anticipated Cable Type: high voltage alternating current (HVAC) Number of export cables: up to 5 Nominal export cable voltage: 200 – 345 kV Length per export cable beneath seabed: 51.6 – 87.0 mi (83 – 140 km) Cable crossings: up to 9 Target burial depth (below level seabed): 3.2 – 13.1 ft (1 – 4 m) Brayton Point ECC Cable Type: high voltage direct current (HVDC) Number of export cables: up to 6 Up to 4 export power cables and up to 2 communication cables Nominal export cable voltage: ±320 kV Length per export cable beneath seabed: 97 – 124 mi (156 – 200 km) Cable/pipeline crossings: up to 16 (total) Target burial depth (below level seabed): 3.2 – 13.1 ft (1 – 4 m)
Onshore Export Cables	Falmouth, MA HVAC (anticipated); Nominal underground onshore export cable voltage: 200 – 345 kV Up to 12 onshore export power cables and up to five communications cables Length: Up to 6.4 statute miles (mi) (10.3 kilometers [km]) Brayton Point, Somerset, MA HVDC; Nominal underground onshore export cable voltage: ±320 kV Up to 4 export power cables and up to 2 communication cables Length: Up to 3,940 feet (ft) (1,200 m) on Brayton Point Aquidneck Island, RI HVDC; Nominal underground onshore export cable voltage: ±320 kV Up to 4 onshore export power cables and up to 2 communication cables Up to 3 mi (4.8 km) across Aquidneck Island
Onshore Substation/HVDC Converter Station	Falmouth, MA Type: Step up 275-kV to 345-kV; Air-insulated substation (AIS) or gas-insulated substation (GIS) Location: Two locations under consideration: Lawrence Lynch (preferred), and Cape Cod Aggregates (alternate) Area: Up to 26 acres (10.5 hectares [ha]) Brayton Point, Somerset, MA Type: HVDC Converter Station Location: On the Brayton Point property area under consideration Area: Up to 7.5 acres (3.0 ha)

Project Attribute	Description
Transmission from Onshore Substation/Converter Station to POI	Falmouth, MA New, 345-kV overhead transmission line along existing utility right of way (ROW) (preferred) (to be designed, permitted, and built by Eversource) Up to 5.1 mi (8.2 km) in length New, 345-kV underground transmission route (alternate) Up to 2.1 mi (3.4 km) in length Brayton Point, Somerset, MA New 345-kV underground transmission route to National Grid substation HVAC; nominal underground transmission cable voltage: up to 345 kV Up to 2,788 ft (850 m) on Brayton Point property
Point of Interconnection	Falmouth, MA Falmouth Tap (new or upgraded switching station to be designed, permitted, and built by Eversource) Brayton Point, Somerset, MA Existing National Grid substation

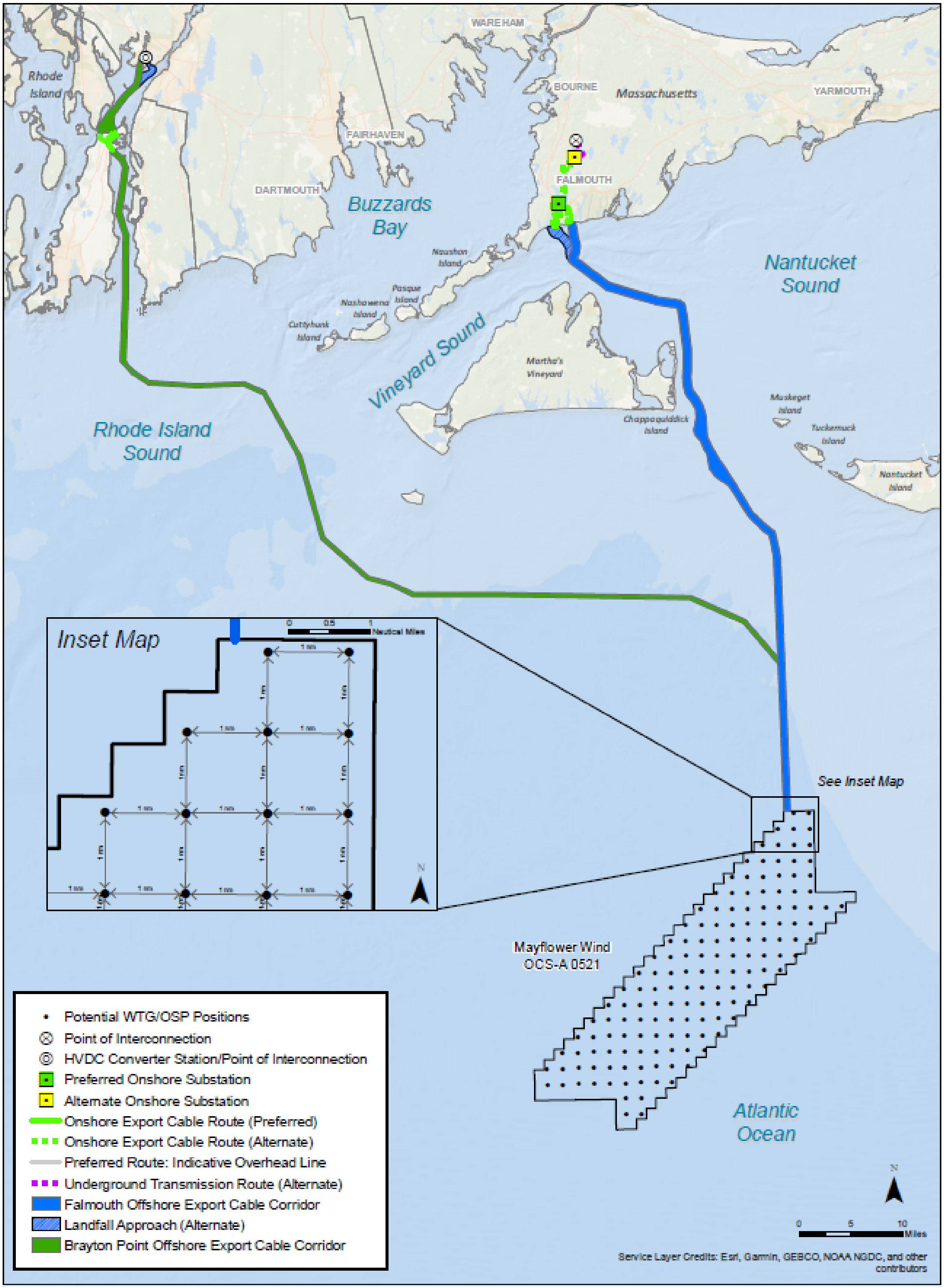


Figure 2-1. Location of Mayflower Wind Offshore Wind Renewable Energy Generation Project

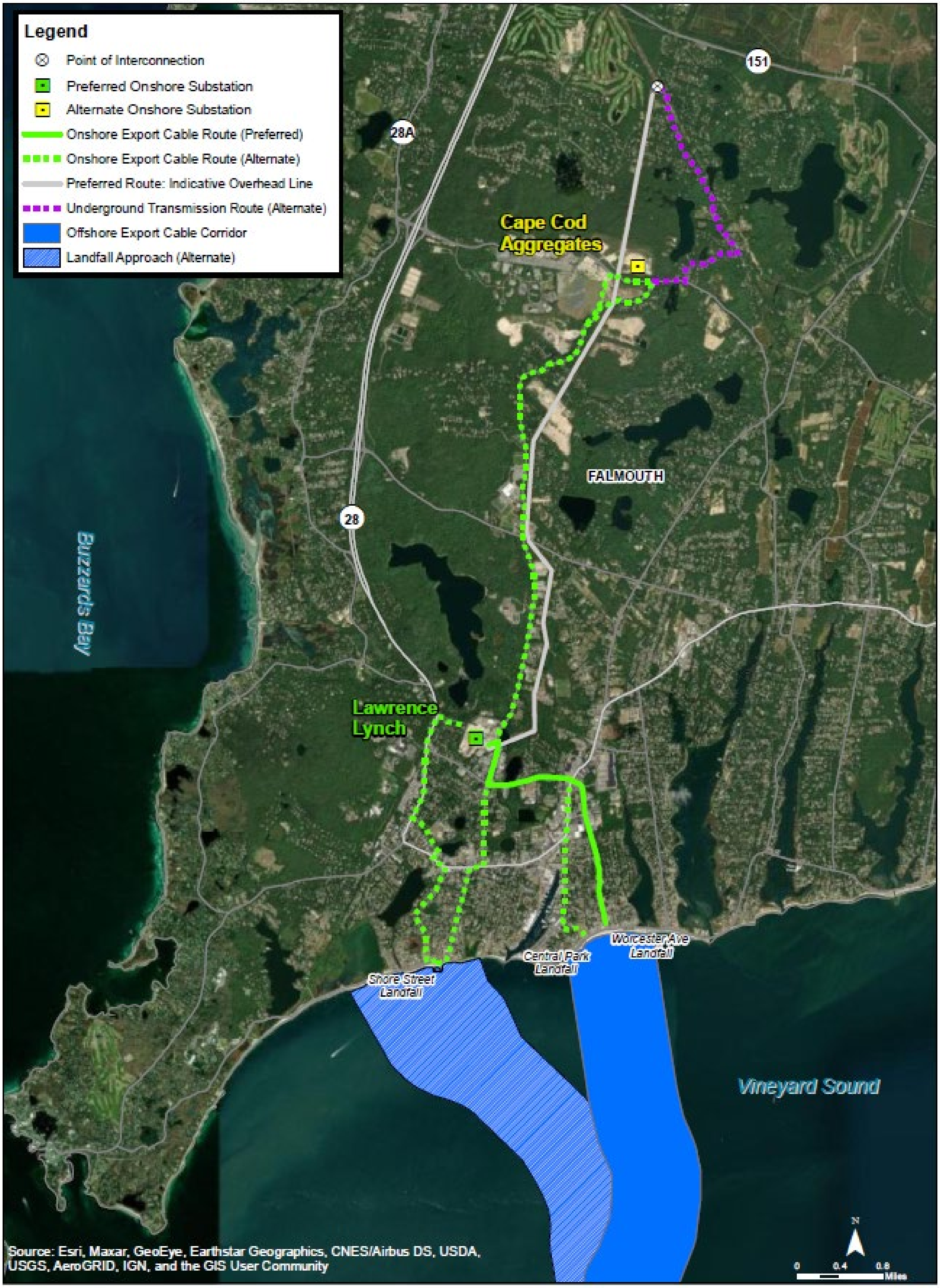


Figure 2-2. Location of Mayflower Wind Onshore Project Elements - Falmouth

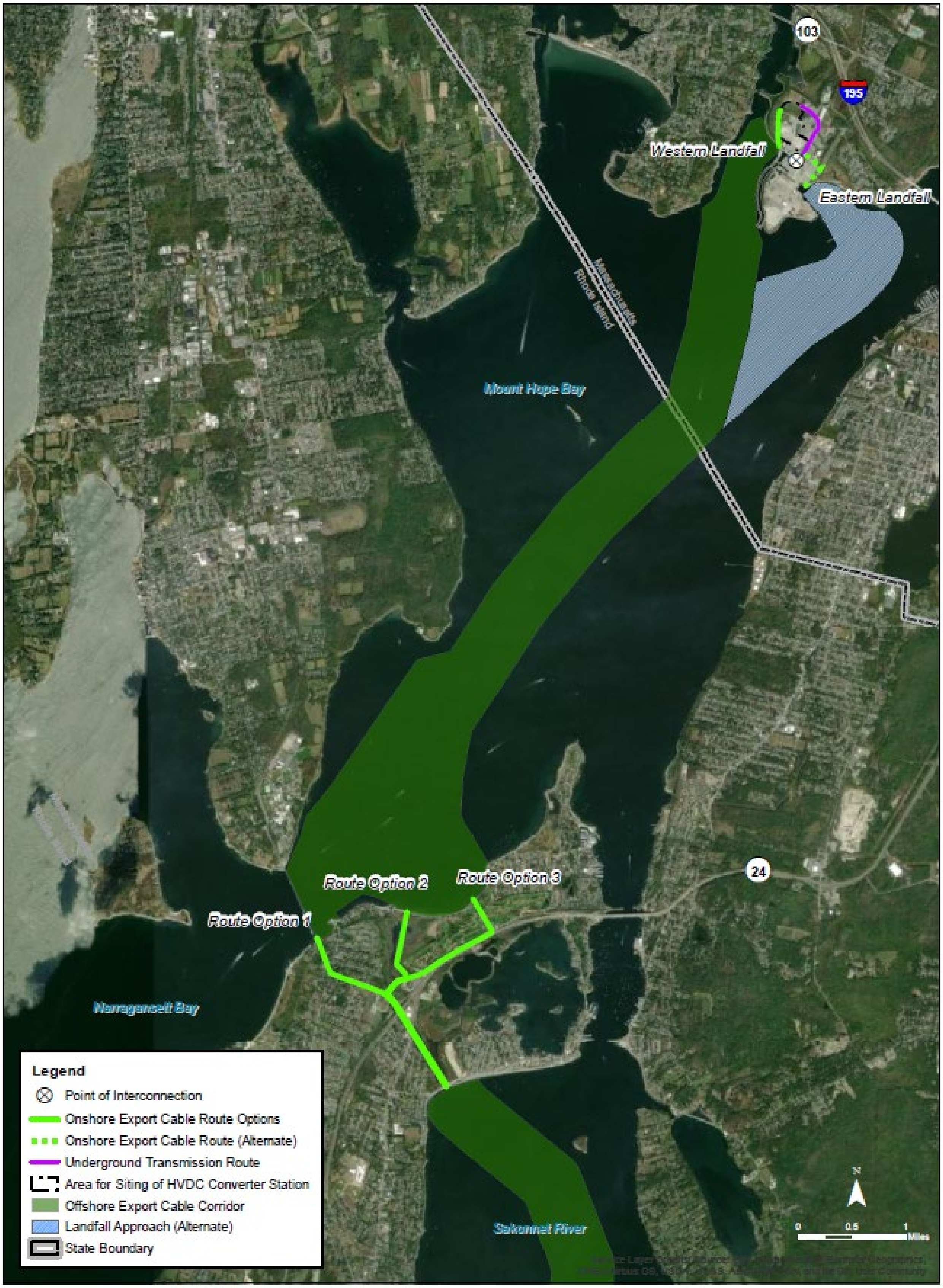


Figure 2-3. Location of Mayflower Wind Onshore Project Elements – Brayton Point

3.0 Relevant Regulations and Assessment Approach

3.1 Relevant Regulations

3.1.1 Federal

There are no federal noise regulations relevant to the in-air acoustic aspect of the Project.

3.1.2 State

The Massachusetts Department of Environmental Protection (MassDEP) administers its noise regulation, 310 Code of Massachusetts Regulations (CMR) 7.10, through a Noise Policy, Division of Air Quality Control (DAQC) Policy 90-001 (MassDEP, 1990). MassDEP regulates any source of “sound of sufficient intensity and/or duration as to cause a condition of air pollution.” The MassDEP Noise Policy is typically used as a basis for review by the Energy Facilities Siting Board and may be used in other state or regional reviews. The Noise Policy states the following:

A source of sound will be considered to be violating the MassDEP’s noise regulation if the source:

1. Increases the broadband sound level by more than 10 dBA above ambient; or
2. Produces a “pure tone” condition – when any octave band center frequency sound pressure level exceeds the two adjacent center frequency sound pressure levels by 3 decibels or more.

These conditions are for both the property line and the closest inhabited residence to the sound source, with the ambient being defined as the lowest hourly L_{90} (in dBA) measured during the period of source operation.

3.1.3 Local

The landfall, onshore substation, and Falmouth POI will be located in the Town of Falmouth. Falmouth has a noise ordinance but, with the exception of a proposed time limit on construction activities that has not yet been passed, the regulations in the noise ordinance do not apply to the Falmouth Project components.

3.2 Noise Assessment Approach

The noise modeling has been performed using the CadnaA computer program, which is a commercially available model that uses International Organization for Standardization (ISO) 9613-2 standard outdoor sound propagation calculation methods to generate noise contours (lines of constant noise level, similar in concept to elevation contours on topographical maps) that are superimposed on aerial photographs. The CadnaA model is accepted internationally by the acoustics professional community for these types of analyses. Manufacturers’ sound power levels for dominant noise sources (such as offshore WTGs and onshore transformers), three-dimensional drawings of site layouts, and topographic maps are used as input to the model to take into account both atmospheric and ground conditions (including water for the offshore sources) in three dimensions. Operation of onshore export cables and alternate underground transmission route are not expected to generate significant noise or pure tones, so these sources are not evaluated further.

3.2.1 WTGs and OSPs

Since the WTGs and OSPs are planned to be more than 20 miles (32 km) from any onshore noise-sensitive location, it is assumed that operational noise generated by these sources will not cause impacts to these locations.

3.2.2 Onshore Substation

One preferred and one alternate onshore substation site are under consideration in the Falmouth Onshore Project Area. Ambient noise levels have been monitored at the closest representative noise-sensitive receptors to each site, to be used as the baseline for the impact analysis. The CadnaA model has been used to generate noise contours around each site to determine the maximum future sound levels expected at each noise-sensitive receptor. Noise mitigation measures were then evaluated for locations predicted to exceed the MassDEP limit to show compliance with these measures in-place.

3.3 Noise Modeling Methodology

3.3.1 Offshore Sources

No in-air noise modeling has been performed for offshore sources.

3.3.2 Onshore Sources

Two candidate substation sites have been evaluated using the CadnaA model, with details included in Section 5.1. All computer models assumed calm winds, a temperature of 50 degrees Fahrenheit (10 degrees Celsius), 70 percent relative humidity, a ground absorption factor of 0.6 (typical for a mixed ground cover), and receivers at an elevation of 4.9 ft (1.5 m) above ground level. This provides a conservative analysis using average atmospheric and ground conditions for the closest noise-sensitive receptors, but more variability in noise levels may be experienced more than 500 feet (150 m) away, where atmospheric effects can either enhance or diminish sound propagation.

The onshore substation has been modelled using a base-case electrical layout, which is a best estimate of the equipment needed at the current stage of engineering. The substation footprint, location, and noise sources are modelled on this basis.

3.3.3 Construction

MassDEP has a longstanding practice of not applying the Noise Policy to temporary construction sound for purposes of air permitting and, instead, MassDEP (and the Energy Facilities Siting Board [EFSB]) require appropriate noise mitigation measures during the construction period.

The most significant construction-related noise sources will be those associated with HDD activities at the landfall location(s). Three landfall location(s) are under consideration, with one preferred location (Worcester Avenue). The CadnaA model was used to generate noise contours around the Worcester Avenue (preferred) and Shore Street (alternate) candidate landfall locations where HDD activities will be conducted to determine the maximum future sound levels expected at each of the closest noise-sensitive receptors. Generally acceptable environmental noise limits are being used for those locations and mitigation measures have been included where those limits are predicted to be exceeded at the closest noise-sensitive receptors. Details associated with this analysis are included in Section 5.2.

4.0 Existing Conditions/Noise Measurements

4.1 Noise Measurements

Two baseline noise monitoring systems were deployed at each of the two candidate substation locations – Lawrence Lynch (the preferred site) and Cape Cod Aggregates – at property line sites representative of the closest noise-sensitive receptors. Secured to existing natural features, these long-term monitors were left unattended until revisited by the investigator 48 hours later for retrieval.

Sound pressure level monitoring was performed with Larson Davis Model LxT sound level meters, rated by the American National Standards Institute (ANSI) as Class 1, per ANSI S1.4-2014. The sound level meter microphones were fitted with standard open-cell foam windscreens and positioned approximately 5 ft (1.5 m) above grade. The sound level meters were set using slow time-response and the A-weighting scale. Sound level meter calibration was field-checked before and after each measurement period with a Larson Davis Model CAL200 acoustic calibrator, and all meters were factory-calibrated within one year of the measurement period. Where not already described, sound level measurements performed for this field survey were conducted in a manner based on guidance from applicable portions of ISO 1996-1 (ISO, 2016) and 1996-2 (ISO, 2017) standards.

A Kestrel Model 3000 handheld weather meter was used to determine or measure average wind speed, temperature, and relative humidity at the beginning of each measurement. There were no adverse weather conditions for monitoring (such as high winds or precipitation) during the measurement period.

4.1.1 Monitoring Locations

Sound level measurements were conducted continuously from September 8 through September 10, 2020, to collect sound pressure level data in the Falmouth Onshore Project Area vicinity. A total of four long-term (48-hour) measurements (two at each site) were conducted at property line locations representative of the closest noise-sensitive receptors to each site.

Observed meteorological data during sound level meter setups showed temperatures ranging from 76 to 83 degrees Fahrenheit (24 to 28 degrees Celsius), humidity ranging from 53 to 70 percent, and wind speeds ranging from 0 to 2 mph (0 to 3.2 km per hour). The sound pressure level measurement locations are described as follows and photographs of the locations are included in Attachment 1 of this report:

Lawrence Lynch (Figure 4-1)

LLG-LT1: Long-term measurement deployment near the northwestern boundary of the candidate substation property. This measurement is representative of baseline noise levels experienced at the nearest noise-sensitive receptor on Rogers Road. The dominant noise sources during the measurement period were heating, ventilation, and air conditioning (HVAC) unit operation from the subject residential property and distant water feature noise generated by a small reservoir at the northern corner of the Lawrence Lynch site. Additional daytime noise sources included intermittent construction vehicle operations and back-up alarms from the Lawrence Lynch site, intermittent bird calls, intermittent chicken calls from a nearby coop, and distant traffic noise.

LLG-LT2: Long-term measurement deployment near the southern boundary of the candidate substation property. This measurement is representative of baseline noise levels experienced at the nearest noise-sensitive receptor on Stephens Lane. The dominant noise source during the measurement period was operation of the existing Falmouth Substation (e.g., transformer hum and other electrical infrastructure). Additional daytime noise sources included intermittent construction vehicle operations and back-up alarms from the Lawrence Lynch site, intermittent bird calls, and distant traffic noise.

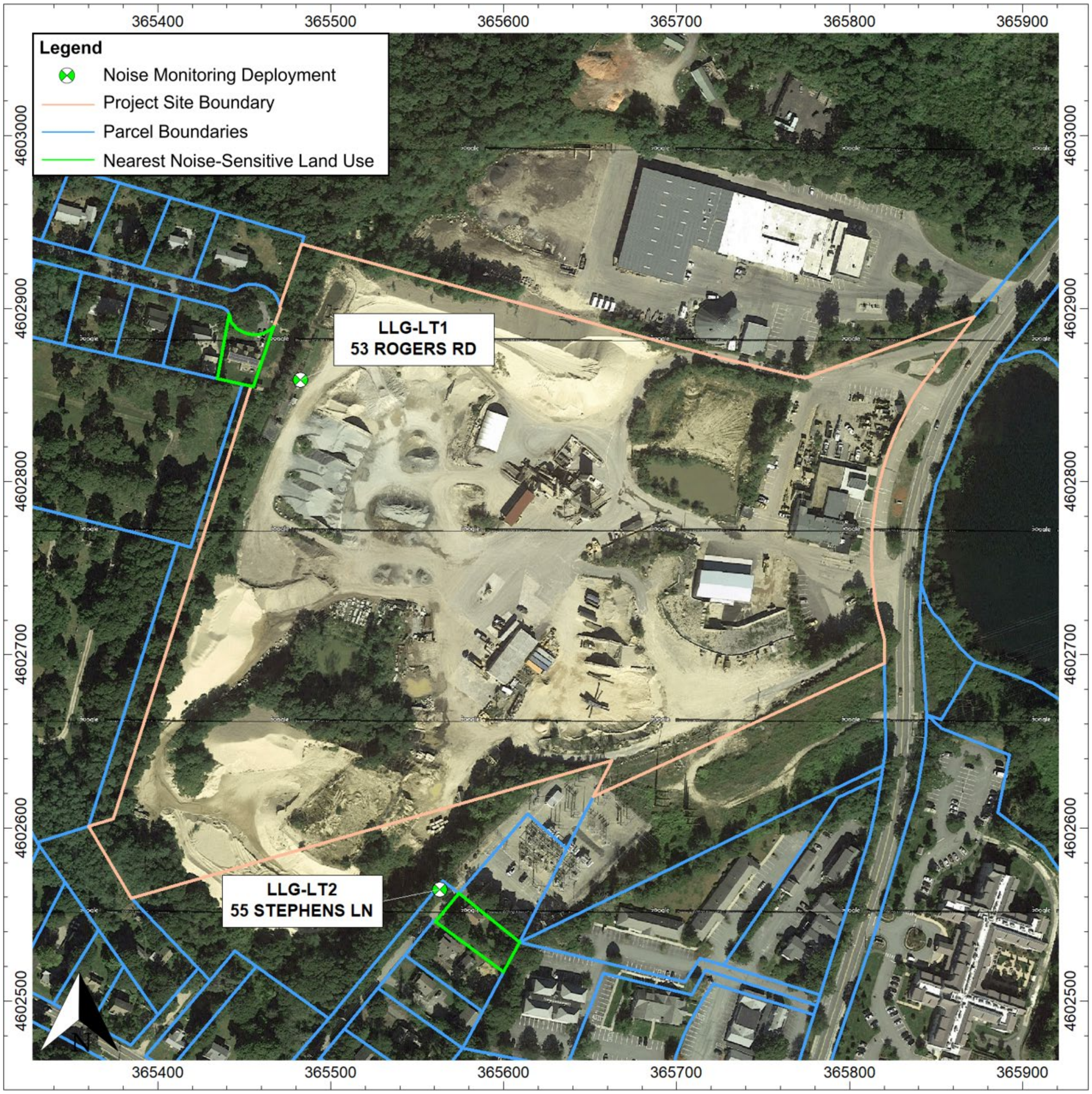


Figure 4-1. Noise Monitoring Locations for the Onshore Substation at Lawrence Lynch (Preferred)

Cape Cod Aggregates (Figure 4-2)

CCA-LT1: Long-term measurement deployment near the southern boundary of the candidate substation property. This measurement is representative of baseline noise levels experienced at the nearest noise-sensitive receptor on Blacksmith Shop Road. The dominant noise source during the measurement period was car and heavy truck traffic along Thomas B. Landers Road and Blacksmith Shop Road. Additional daytime noise sources included intermittent rustling leaves, insects, intermittent bird calls, and distant mechanical noise from the main Cape Cod Aggregates facility.

CCA-LT2: Long-term measurement deployment near the northeastern boundary of the candidate substation property. This measurement is representative of baseline noise levels experienced at the nearest noise-sensitive receptor on Sunfish Lane. The dominant noise source during the measurement period was distant traffic and bird calls. Additional daytime noise sources included intermittent rustling leaves, insects, and distant mechanical noise from the main Cape Cod Aggregates facility.

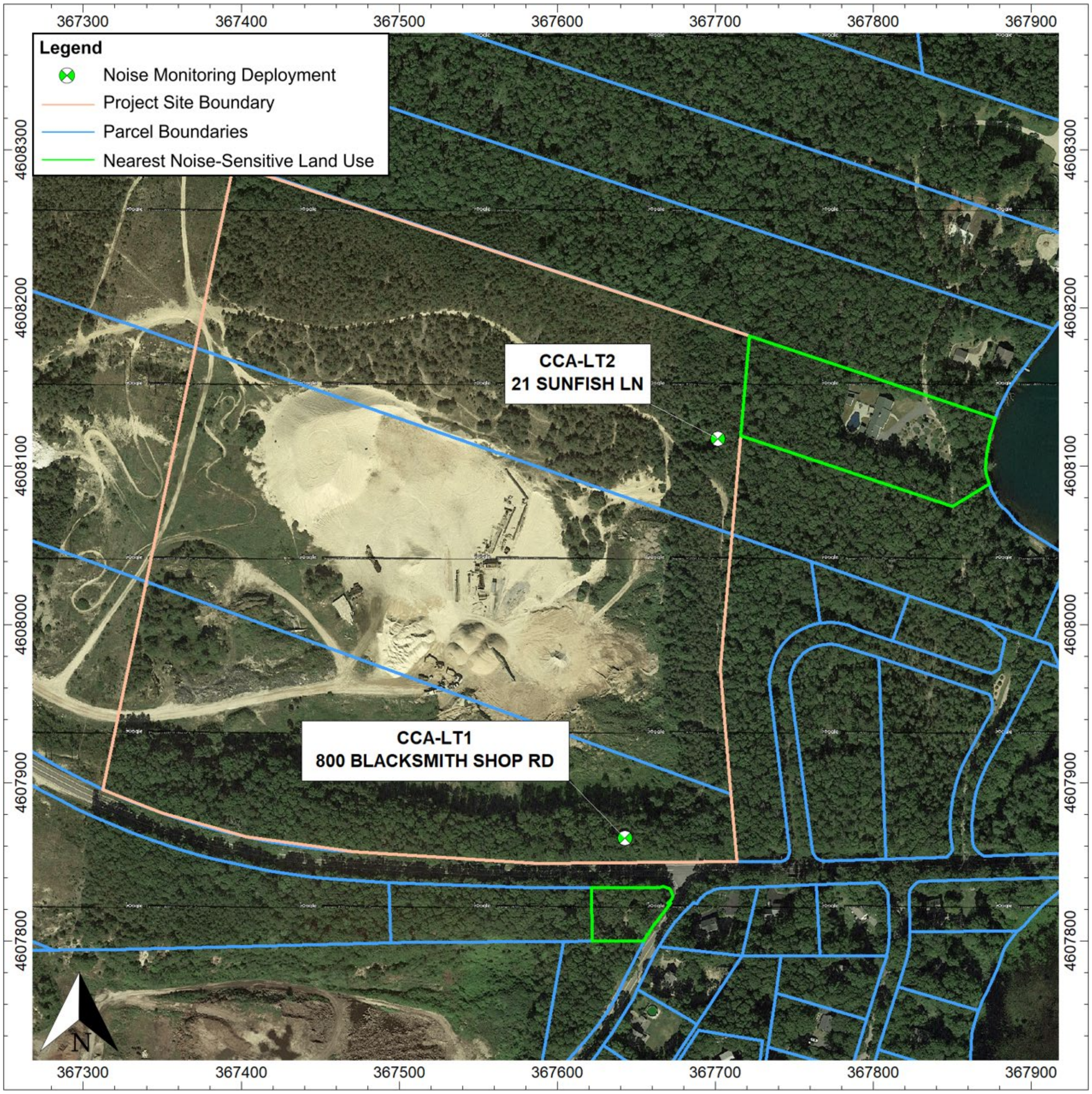


Figure 4-2. Noise Monitoring Locations for the Onshore Substation at Cape Cod Aggregates (Alternate)

4.1.2 Monitoring Results

A summary of the noise monitoring results is shown in Figure 4-3 and Figure 4-4 for the preferred Lawrence Lynch substation site and Figure 4-5 and Figure 4-6 for the alternate Cape Cod Aggregates site. The impact determination is based on a 10-dBA increase over the minimum measured hourly L_{90} at each location. Those values are included in the figure captions. The steady elevated levels recorded during nighttime hours at all sites were most likely caused by insects.

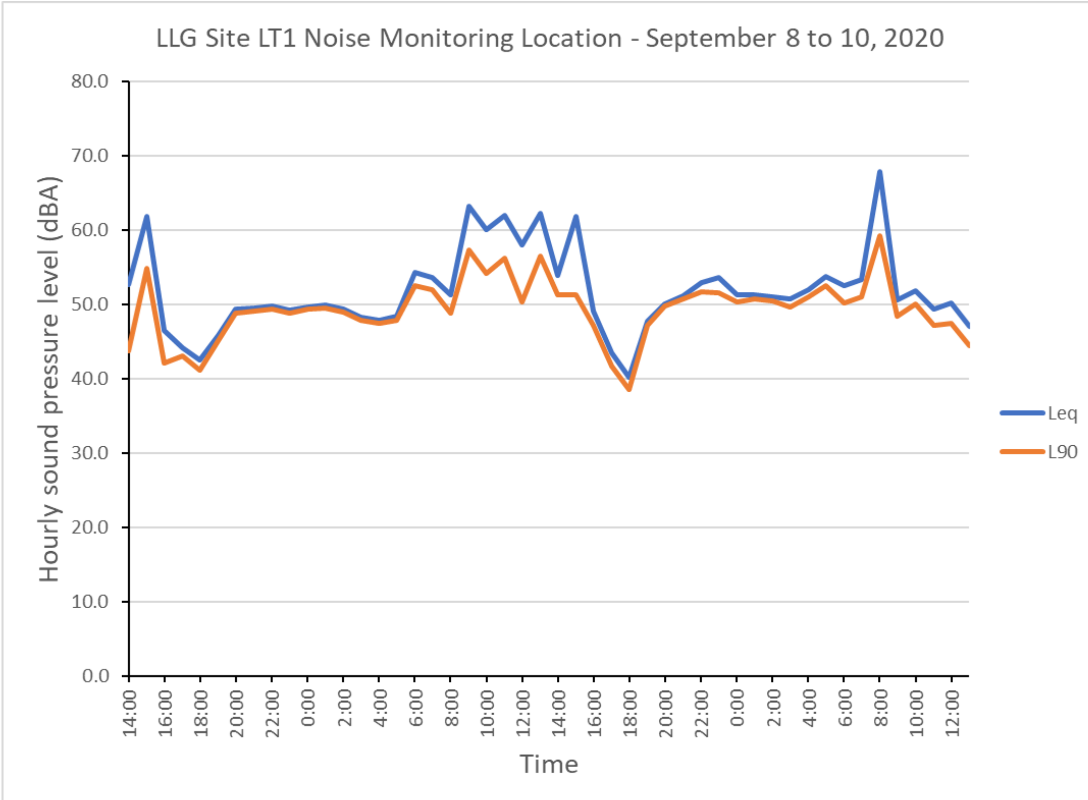


Figure 4-3. Noise Monitoring Results for the Onshore Substation at Lawrence Lynch at Location LLG-LT1 (Minimum Hourly L_{90} is 38.5 dBA)

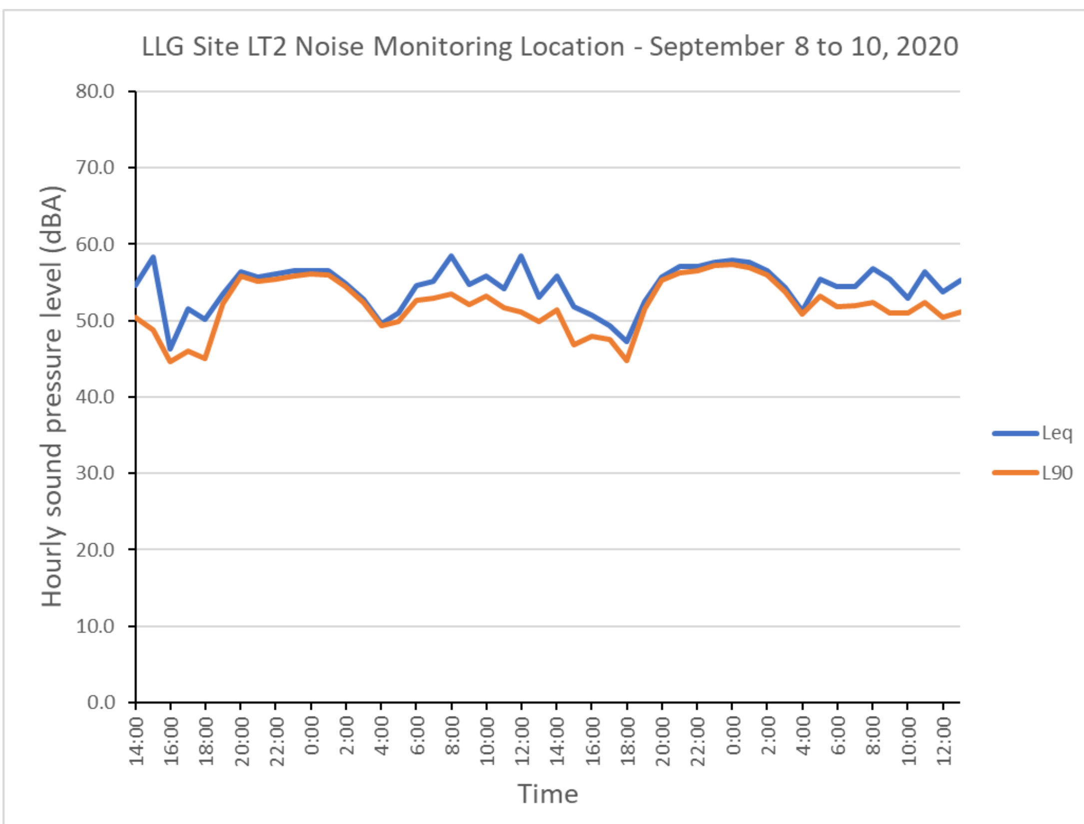


Figure 4-4. Noise Monitoring Locations for the Onshore Substation at Lawrence Lynch at Location LLG-LT2 (Minimum Hourly L_{90} is 44.6 dBA)

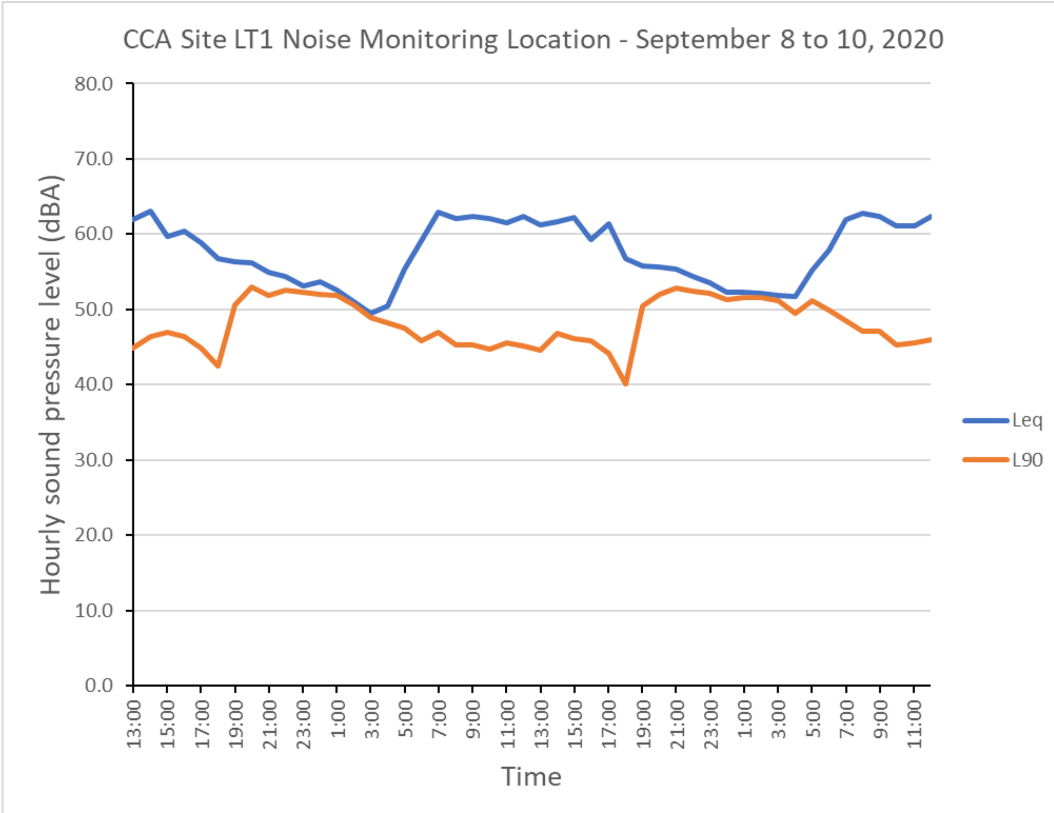


Figure 4-5. Noise Monitoring Locations for the Onshore Substation at Cape Cod Aggregates at Location CCA-LT1 (Minimum Hourly L_{90} is 40.1 dBA)

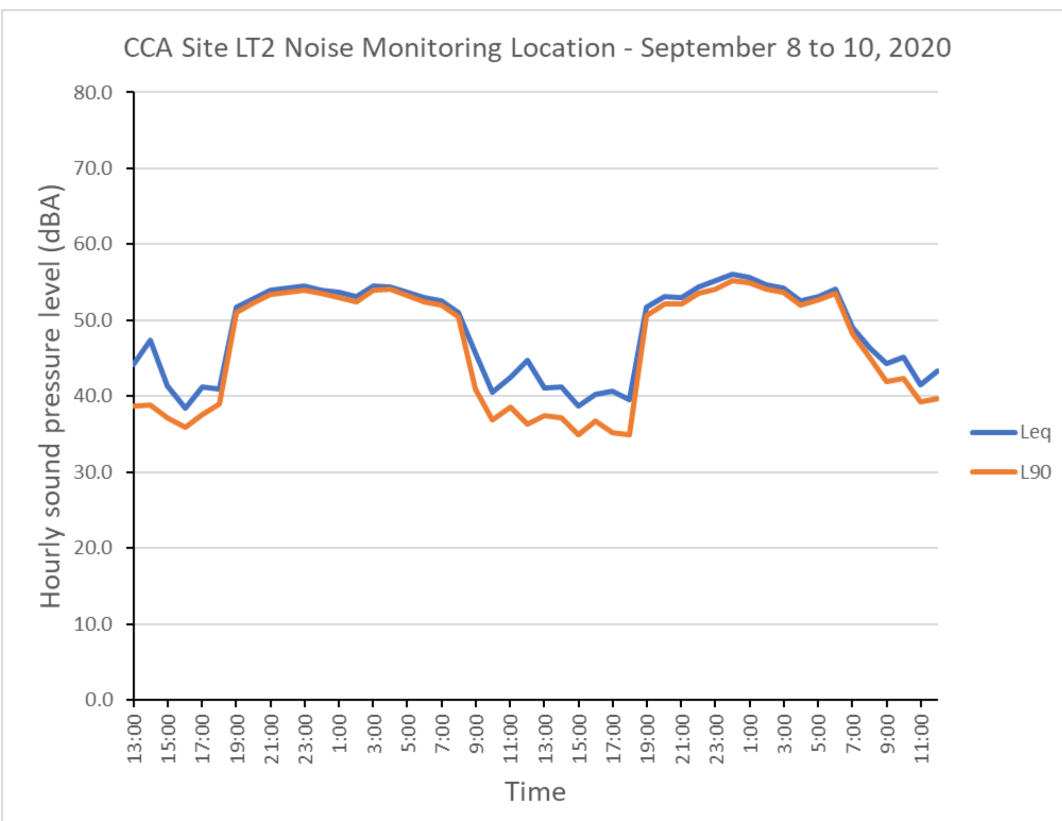


Figure 4-6. Noise Monitoring Locations for the Onshore Substation at Cape Cod Aggregates at Location CCA-LT2 (Minimum Hourly L_{90} is 34.9 dBA)

5.0 Effects Characterization

5.1 Future Operations Evaluation

In the Falmouth Onshore Project Area, the only known operational Project-related noise sources anticipated to generate airborne impacts to noise-sensitive receptors are associated with the substation, depending on the site eventually chosen from the two current candidates.

5.1.1 Primary Noise Sources and Reference Levels

Table 5-1 lists the dominant noise sources associated with the onshore substation (independent of site), along with their referenced sound levels. A-weighted sound power level (L_wA) are sound power levels in dBA, provided by the listed references. Sound power levels, unlike sound pressure levels, are independent of location with respect to a source. The overall A-weighted levels are based on octave band center frequency (OBCF) data from the listed sources.

Table 5-1. Primary Noise Sources and Reference Levels for Substation Site

Source	Quantity in Layout	Relative Height (ft)	L_wA	OBCF Source
Harmonic Filter Capacitor	4 (1 per Filter Trio)	16	79	Harris (1/3) XFMR[1]
Harmonic Filter Reactor	4 (1 per Filter Trio)	12	85	Harris (1/3) XFMR[1]
90 MVAR Reactor	3	8	95	Harris (1/3) XFMR[1]
200 MVAR Reactor	1	8	95	Harris (1/3) XFMR[1]
236 MVAR Reactor	3	8	95	Harris (1/3) XFMR[1]
430 MVA Autotransformer	3	11	95	Harris (1/3) XFMR[1]
150 MVA STATCOM Phase Reactor	18 (6 per STATCOM)	12	85	Harris (1/3) XFMR[1]
STATCOM Heat Exchanger Cooling Fan	3 (1 per STATCOM)	6	97	Wartsila (1/1)[2]
STATCOM Building	3	25[3]	N/A	N/A
Control House Building	1	15[3]	N/A	N/A

Notes:
[1] Harris: Harris, Cyril M. Handbook of Acoustical Measurements and Noise Control, Third Edition, 1998.
[2] Wartsila: Standard-Noise Radiator (6-Fan Array). Wartsila, Data Sheet DBAC307180.
[3] Estimated height
MVA – Megavolt ampere
MVAR – Megavolt ampere (reactive)
N/A – not applicable
STATCOM – Static synchronous compensator
XFMR - Transformer

The site layouts and equipment lists were provided by the Mayflower Wind engineering consultant, Burns & McDonnell.

5.1.2 Noise Modeling Results and Impact Evaluation

The modeling results for each substation site without mitigation are shown in Figure 5-1 for Lawrence Lynch and Figure 5-2 for Cape Cod Aggregates. Both figures demonstrate that noise mitigation is required at each studied substation site to meet the MassDEP limit of 10 dBA above the measured minimum ambient levels at select noise-sensitive receiver locations.

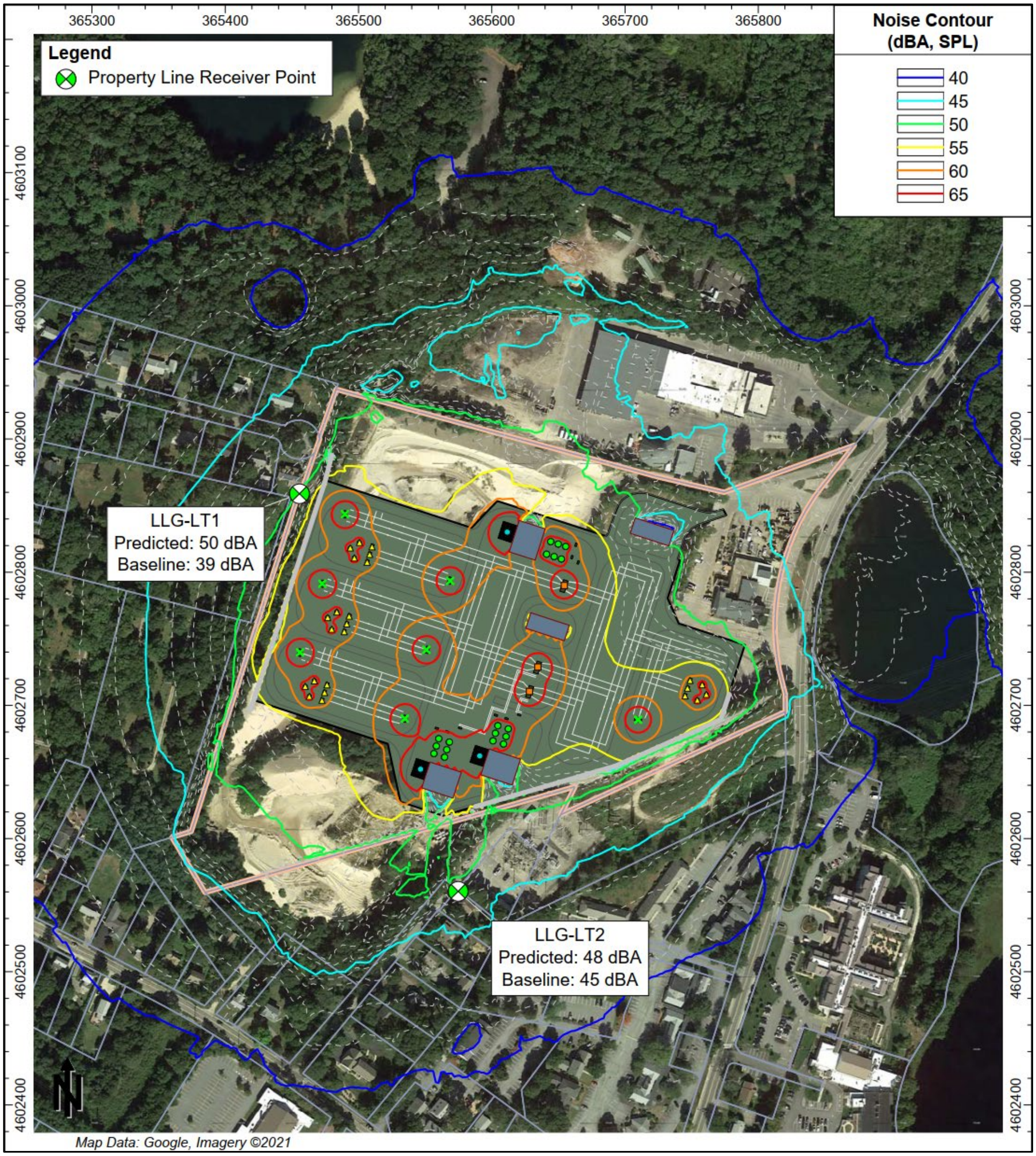


Figure 5-1. Predicted Noise Contours for the Onshore Substation at Lawrence Lynch (Preferred)

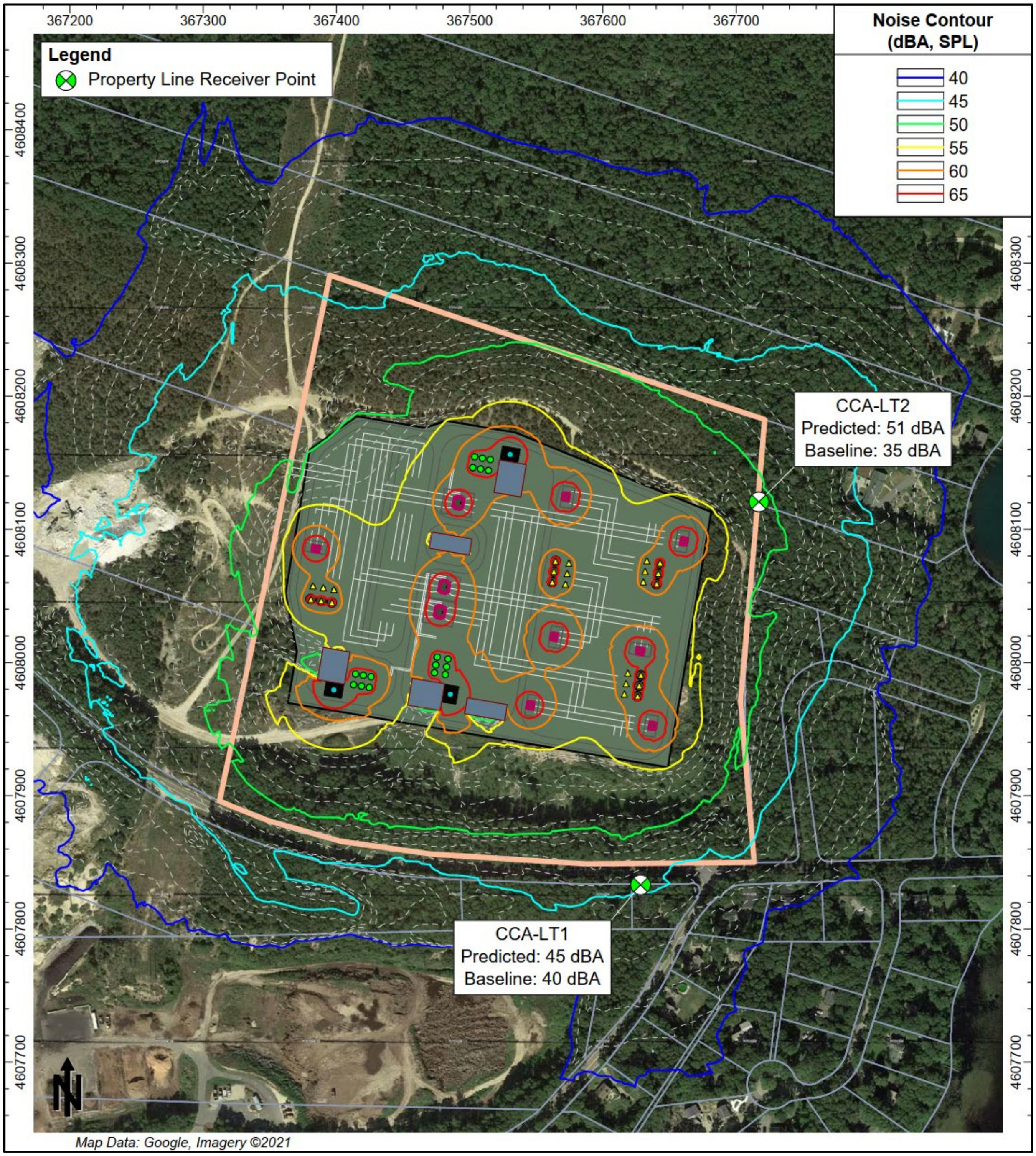


Figure 5-2. Predicted Noise Contours for the Onshore Substation at Cape Cod Aggregates (Alternate)

5.1.3 Mitigation Measures

Mitigation measures in the form of noise barriers were evaluated for both sites shown as purple lines in Figure 5-3 and Figure 5-4. As is shown in the figures, a 6-ft (1.8-m) tall barrier along the northwestern retaining wall of the Lawrence Lynch site and multiple 16-ft (4.9-m) tall and one 22-ft (6.7-m) tall close-in equipment barriers throughout the eastern portion of the Cape Cod Aggregates site will reduce sound levels enough to comply with the MassDEP 10 dBA above ambient limit at the closest residential property lines.

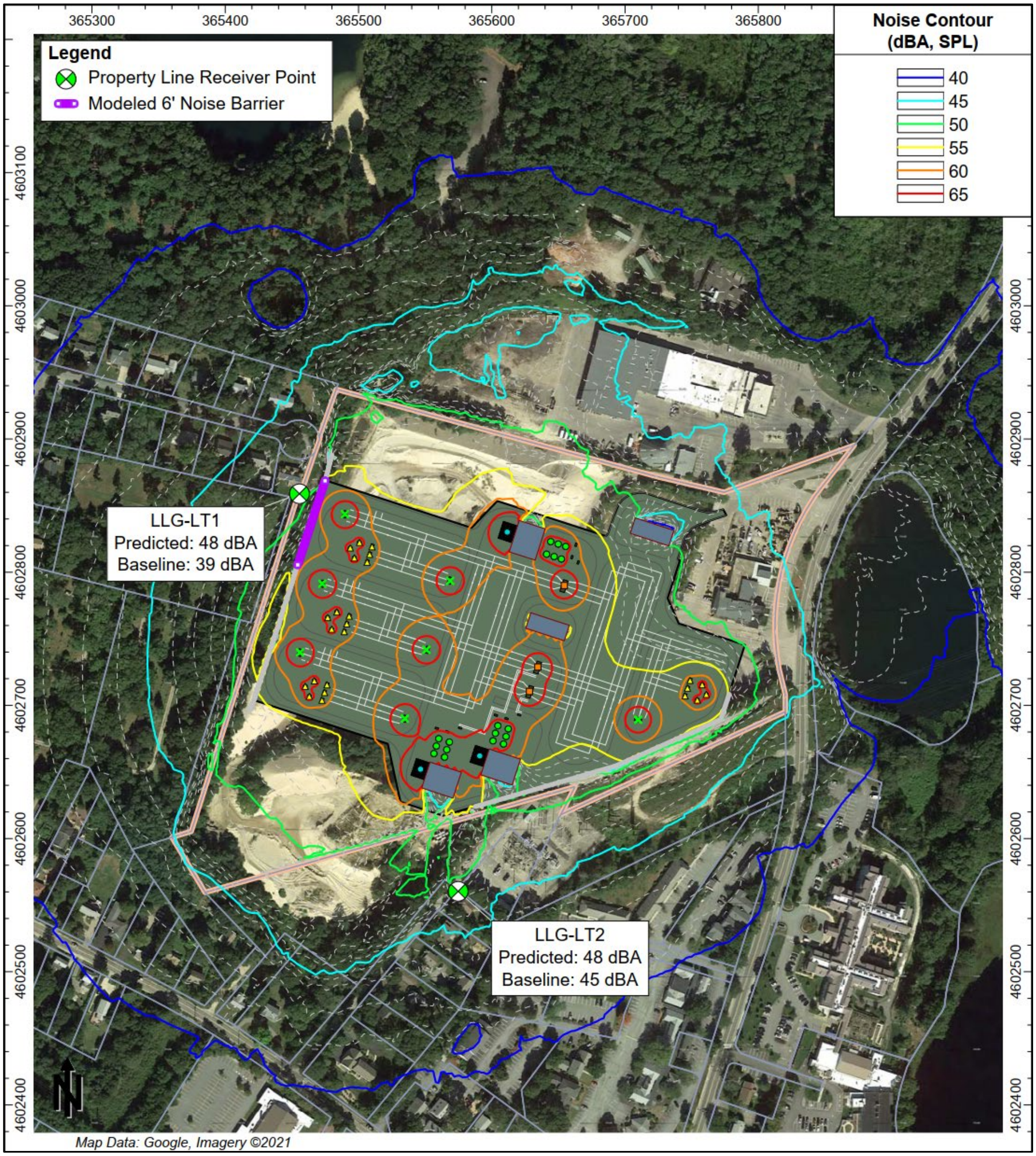


Figure 5-3. Predicted Noise Contours for Lawrence Lynch Site with Mitigation Measures

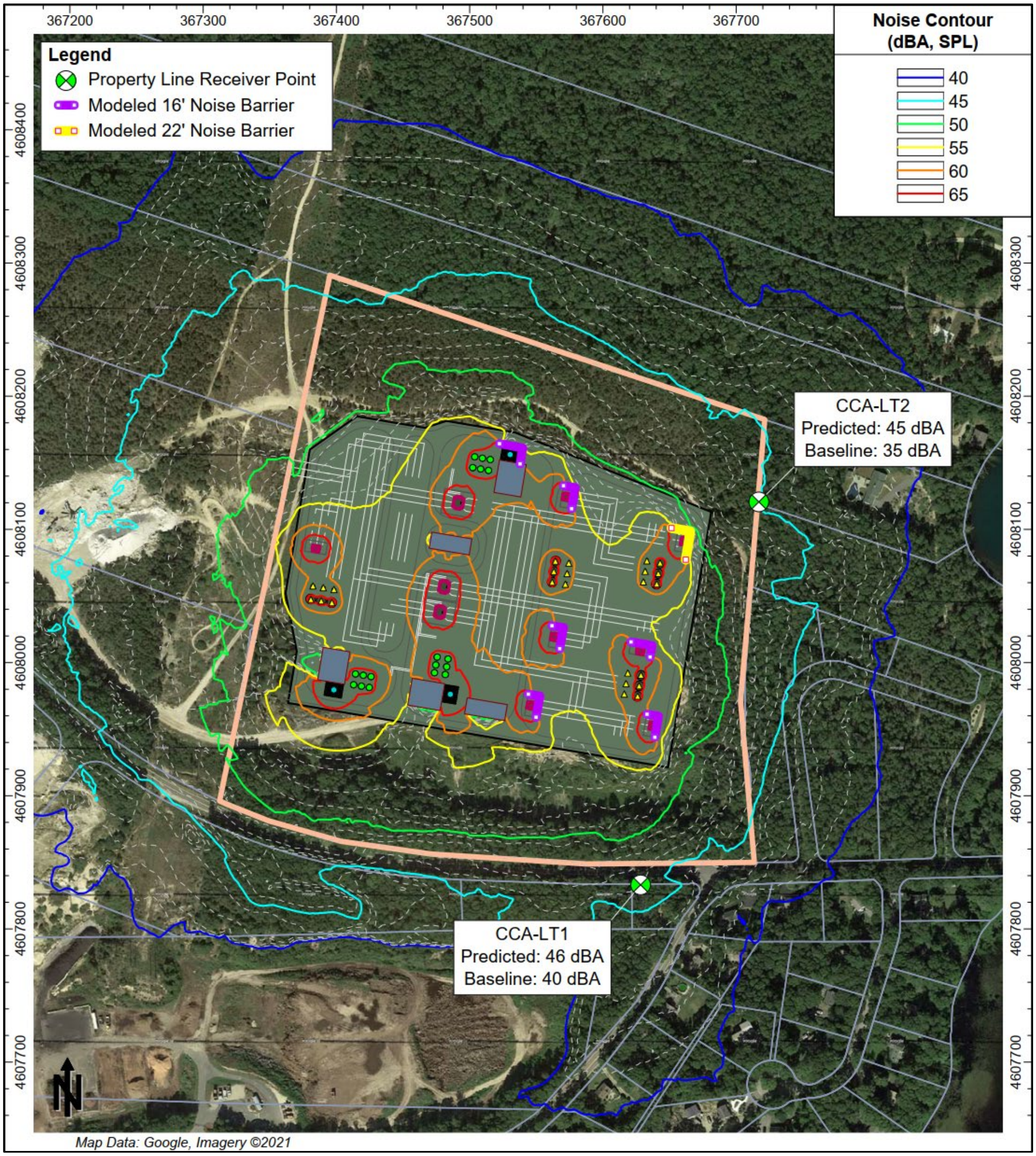


Figure 5-4. Predicted Noise Contours for Cape Cod Aggregates with Mitigation Measures

5.2 Construction Noise Evaluation

5.2.1 Construction Noise Sources

The noise of construction for HDD operations are provided below. The noise sources are applicable to the preferred and two alternate landfall locations. Table 5-2 lists the dominant noise sources associated with the HDD operations (independent of site), along with their referenced sound levels.

Table 5-2. Construction Noise Sources and Reference Sound Levels

Source	Quantity in Layout	Relative Height in ft (m)	L_wA	OBCF Source
Drilling Rig (2 Engines) Mechanical	1	6 (1.8)	113	CAT C-9 "Open Mechanical" at 100% Load
Drilling Rig (2 Engines) Exhaust	1	12 (3.7)	135	CAT C-9 "Open Exhaust" at 100% Load
Mud Cleaner Generator Mechanical	1	6 (1.8)	113	CAT C-9 "Open Mechanical" at 100% Load
Mud Cleaner Generator Exhaust	1	12 (3.7)	135	CAT C-9 "Open Exhaust" at 100% Load
Mud Pump Mechanical	1	6 (1.8)	113	CAT C-9 "Open Mechanical" at 100% Load
Mud Pump Exhaust	1	9 (2.7)	135	CAT C-9 "Open Exhaust" at 100% Load
Light Plant	1	6 (1.8)	93	DEFRA 7.5 kW 3000 RPM Generator
Crane	1	8 (2.4)	95	DEFRA Tracked Crane
Silenced Drilling Rig (2 Engines) Exhaust	1	15 (4.6)	105	CAT C-9 "Open Mechanical" at 100% Load with GT Exhaust "Critical Plus" Grade Silencer
Silenced Mud Cleaner Generator Exhaust	1	15 (4.6)	105	CAT C-9 "Open Mechanical" at 100% Load with GT Exhaust "Critical Plus" Grade Silencer
Silenced Mud Pump Exhaust	1	15 (4.6)	105	CAT C-9 "Open Mechanical" at 100% Load with GT Exhaust "Critical Plus" Grade Silencer

Notes:
CAT C-9: Caterpillar “Package Data” dated 8/13/2018 provided by Mayflower Wind.
GT Exhaust Silencer Product Listing Catalog, 2018.
DEFRA – Department for Environment, Food and Rural Affairs (United Kingdom)

5.2.2 Construction Noise Analysis and Mitigation

There are no relevant quantitative construction noise policy limits for the Falmouth Project components. Therefore, a generally accepted guideline limit of 65 dBA L_{eq} for daytime noise exposures at residential buildings (based on noise ordinances throughout the country) is being used as the goal for these activities (Cowan, 1994). Mayflower Wind will also require that construction equipment be operated such that construction-related noise levels will comply with applicable sections of the MassDEP Air Quality Regulations at 310 CMR 7.10, particularly subsections (1) and (2), which pertain to the use of sound-emitting equipment in a considerate manner so as to reduce unnecessary noise.

5.2.2.1 Offshore Construction

Offshore construction activities will mostly be occurring more than 20 miles (32 km) from any noise-sensitive locations, with the exception of vessel operations to and from the shoreline. The dominant noise sources from these operations would include vessel engines, and these would be close enough to noise-sensitive locations to be audible for short periods of time. The greatest potential for noise impacts from these operations are being addressed in a separate study (COP Appendix U2, Underwater Acoustic Modeling of Construction Sound and Animal Exposure Estimation for Mayflower Wind Energy LLC).

5.2.2.2 Onshore Construction

Onshore Export Cable Installation

The potential for noise impacts from cable installation is a function of the specific receptors along the route as well as the equipment used and proposed hours of operation. Construction is anticipated to occur during typical work hours. However, in specific instances at some locations, or at the request of the Department of Public Works of a given municipality, the Project may seek municipal approval to work at night or outside the normal hours of construction allowed by local bylaw. Nighttime work will be minimized and performed only on an as-needed basis, such as when crossing a busy road, and will be coordinated with the Town of Falmouth. Construction of the alternate underground transmission route would have the same noise characteristics as that of the export cable.

Many potential noise sources will be used for export cable installation, with the loudest expected equipment being excavators and drills. The location and operational duration of each piece of equipment will vary within the Falmouth Onshore Project Area, with no single location having extended periods of noise exposure. Detailed calculations of noise levels will be performed after the equipment and their associated locations have been chosen to determine whether impacts can be expected from these operations but, due to the temporary nature of these operations, impacts are not expected.

In any case, the following best management practices will be used to avoid, minimize, or mitigate any potential negative effects on nearby noise-sensitive locations:

- All equipment will be maintained and, where appropriate, mufflers will be installed;
- Equipment will be used under the lowest operating noise conditions as practical;
- Equipment generating the highest noise levels will be operated as far from noise-sensitive locations as practical;
- Equipment will only be operating when in-use;
- Hours of construction operations will be minimized to the extent practical, especially if nighttime operations are necessary;
- Mayflower Wind will, when possible, use enclosures on continuously-operating equipment such as compressors and generators;
- Where noise levels may be excessive, temporary barriers will be strategically placed between dominant stationary equipment and noise-sensitive locations where practicable and safe; and
- Affected residential communities will be notified before construction activities and a call-in complaint line will be established.

HDD Landfall Installation

Two candidate landfall locations were evaluated quantitatively – Worcester Avenue (the preferred location) and Shore Street (alternate) – assuming all equipment was operating at full load simultaneously to provide the worst case for noise.

Figure 5-5 and Figure 5-7 show noise contours without mitigation, yielding high noise levels at the closest noise-sensitive properties in each case. A combination of 16 ft (4.9 m) tall temporary construction noise barriers and equipment silencers were evaluated as mitigation measures for each location, with the resulting noise level predictions shown in Figure 5-6 and Figure 5-8. In all cases, predicted levels are less than the 65 dBA goal at the closest noise-sensitive properties.

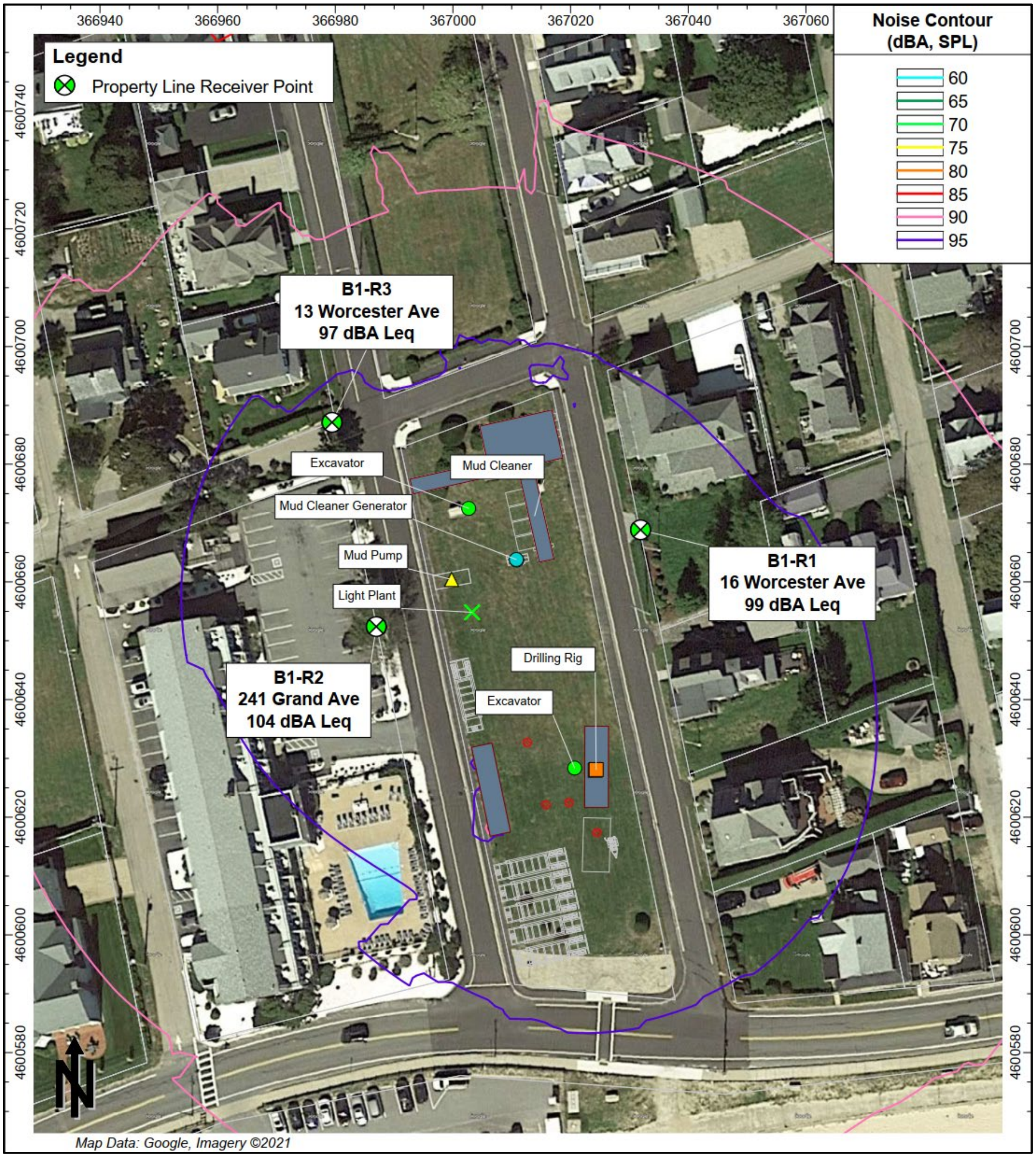


Figure 5-5. Predicted Noise Contours for Worcester Avenue Landfall (Preferred)

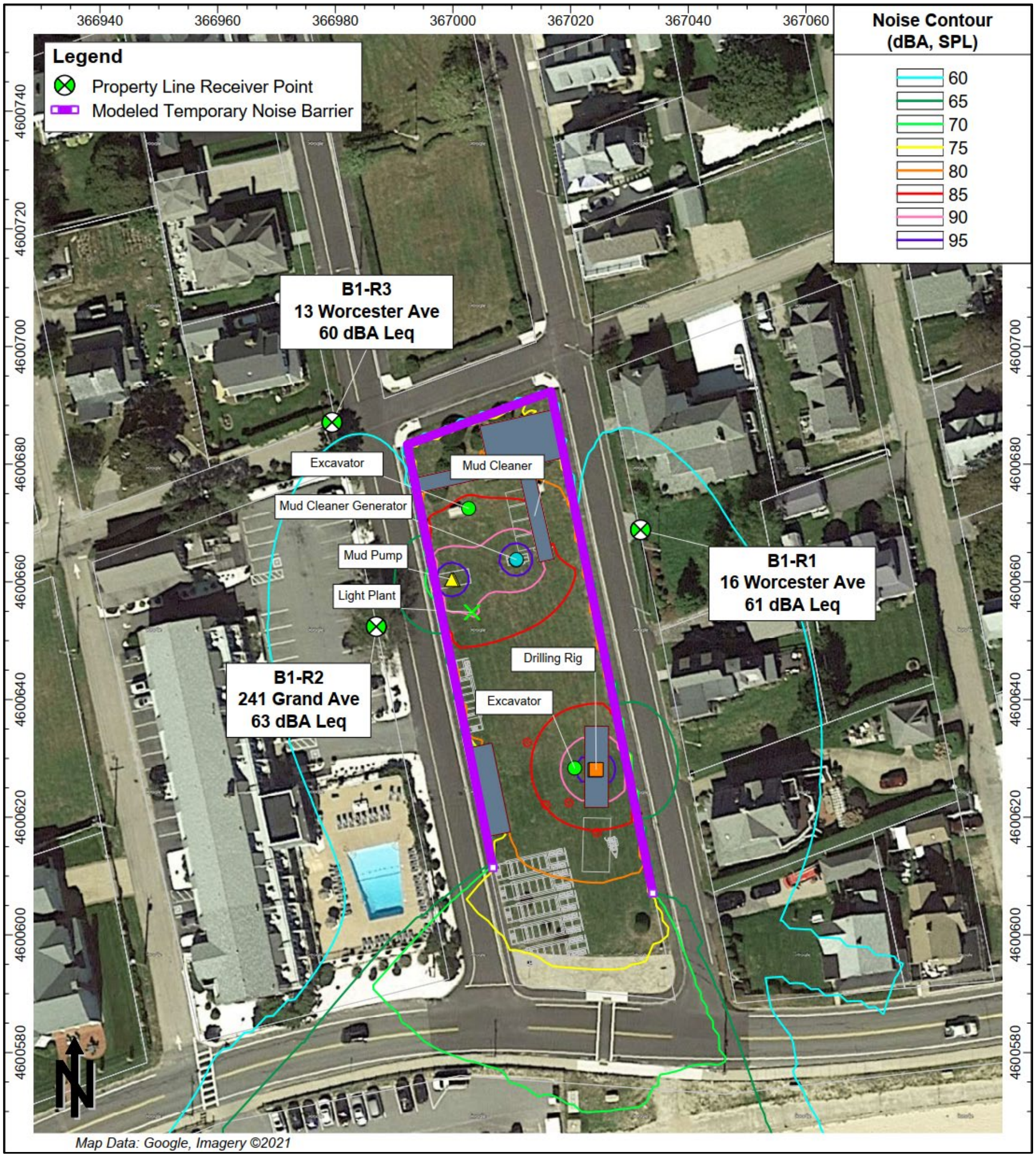


Figure 5-6. Predicted Noise Contours for Worcester Avenue Landfall (Preferred) with Mitigation Measures

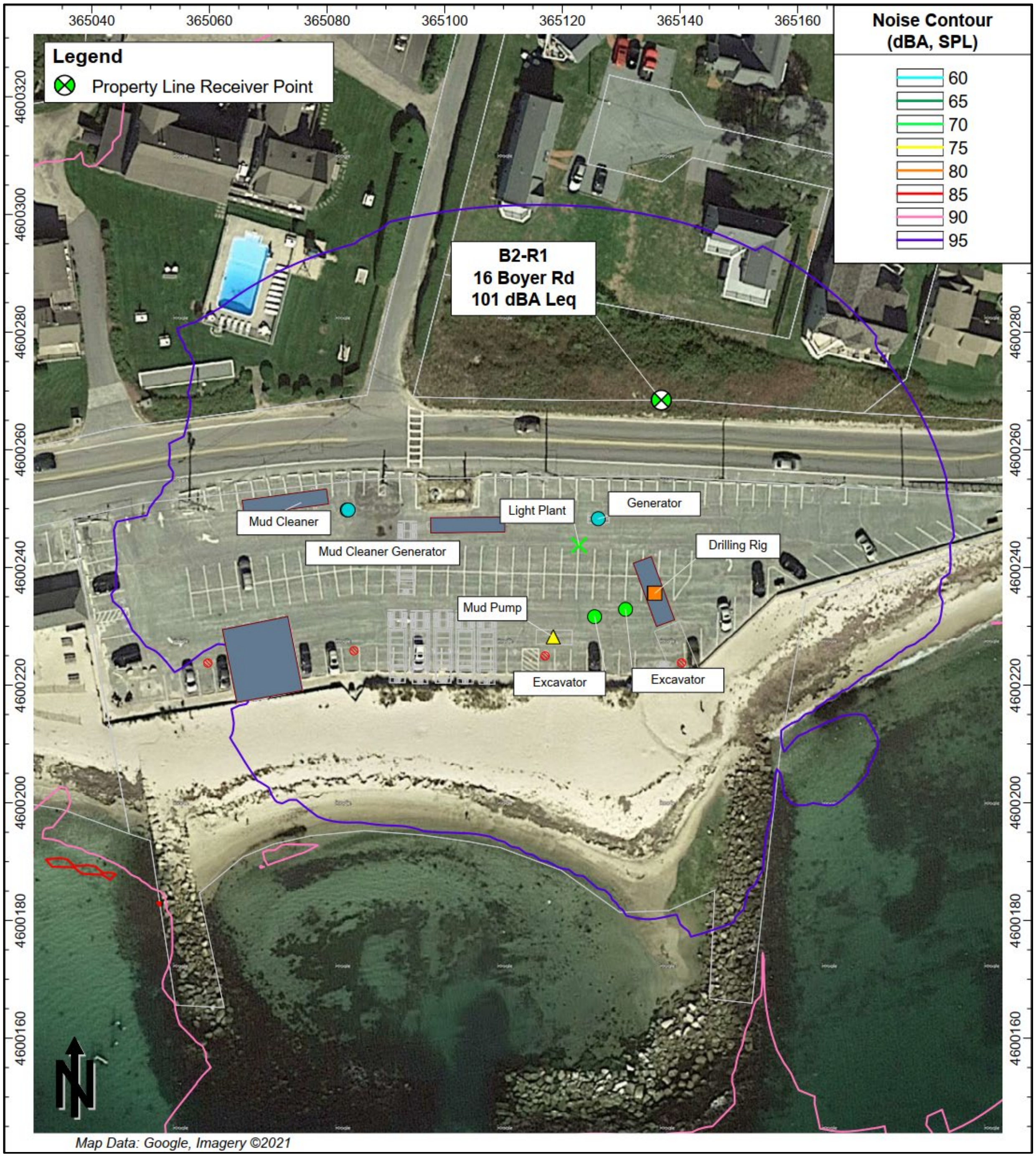


Figure 5-7. Predicted Noise Contours for Shore Street Landfall (Alternate)

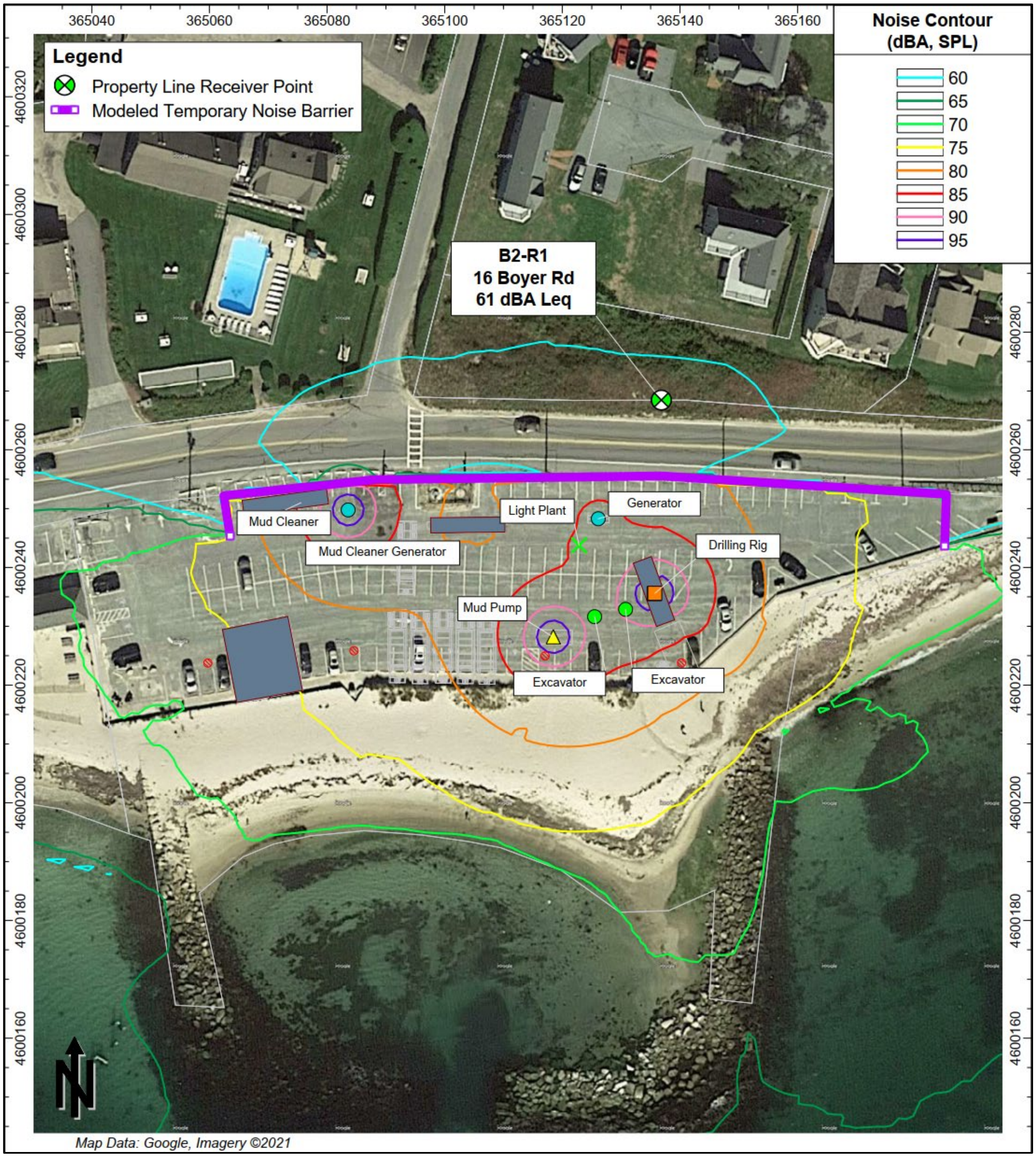


Figure 5-8. Predicted Noise Contours for Shore Street Landfall (Alternate) with Mitigation Measures

5.2.2.3 Onshore Substation Construction

Construction of the onshore substation will take up to 24 months. Substation and construction will include the following activities:

- Site preparation, excavation, and grading;
- Construction of foundations for the control building, transformers, reactors, and switchgear;
- Construction of electrical grounding, duct banks, and underground conduits;
- Installation of appropriate drainage systems, security fence, sound barrier, and station service; and
- Installation of above ground structures including transformers, switchgears, and cable systems.

The potential noise impacts associated with these construction activities will be evaluated after a detailed construction plan has been developed.

5.2.3 Construction Noise Mitigation

While intermittent increases in noise levels are expected during construction activities, Mayflower Wind is committed to avoiding, minimizing, or mitigating these impacts. Mayflower Wind will require that construction equipment be operated such that construction-related noise levels will comply with applicable sections of the MassDEP Air Quality Regulations at 310 CMR 7.10, which pertain to the use of sound-emitting equipment in a considerate manner so as to reduce unnecessary noise to the extent practicable. The Town of Falmouth has no bylaws applicable to construction-related noise.

Noise measures to avoid, minimize, or mitigate effects that are anticipated to be incorporated into the Project include:

- Minimizing the amount of work conducted outside of typical construction hours;
- Installing and maintaining appropriate mufflers on construction equipment;
- Maintaining construction equipment and using newer models to provide the quietest performance;
- Requiring enclosures on continuously operating equipment such as compressors and generators;
- Turning off construction equipment when not in use and minimizing idling times; and
- Mitigating the impact of noisy equipment on sensitive locations by using temporary barriers or buffering distances as practical.

6.0 Conclusions

A preliminary impact assessment was performed for the airborne noise associated with the construction and operation of the Project located in federal waters off the southern coast of Massachusetts, with ancillary facilities to be located in the Town of Falmouth, Massachusetts. Baseline ambient sound levels were measured to characterize the existing ambient sound levels near the two candidate onshore substation sites in Falmouth. Future sound levels were then predicted at the nearest sensitive receptors to evaluate noise impacts due to the Project for the onshore substation sites and two of the three candidate landfall HDD locations in Falmouth.

The results of this analysis demonstrate that with the proposed construction noise barriers for the substation sites, future sound level increases due to the Falmouth Project components are predicted to be less than the MassDEP 10 dBA limit at nearby residences. Also, a proposed combination of noise barriers and equipment silencers for the HDD locations are predicted to result in sound levels at the closest noise-sensitive properties to be within general guideline limits for acceptable daytime construction noise exposures. In addition, no "pure tones" as defined by the MassDEP Noise Policy are expected due to the operation of the Falmouth Project components.

7.0 References

Cowan, J.P. 1994. Handbook of Environmental Acoustics. New York: Wiley.

Harris, C.M. 1998. Handbook of Acoustical Measurements and Noise Control, Third Edition, New York: McGraw-Hill.

ISO, 2016. ISO 1996-1:2016. Acoustics — Description, measurement and assessment of environmental noise — Part 1: Basic quantities and assessment procedures.

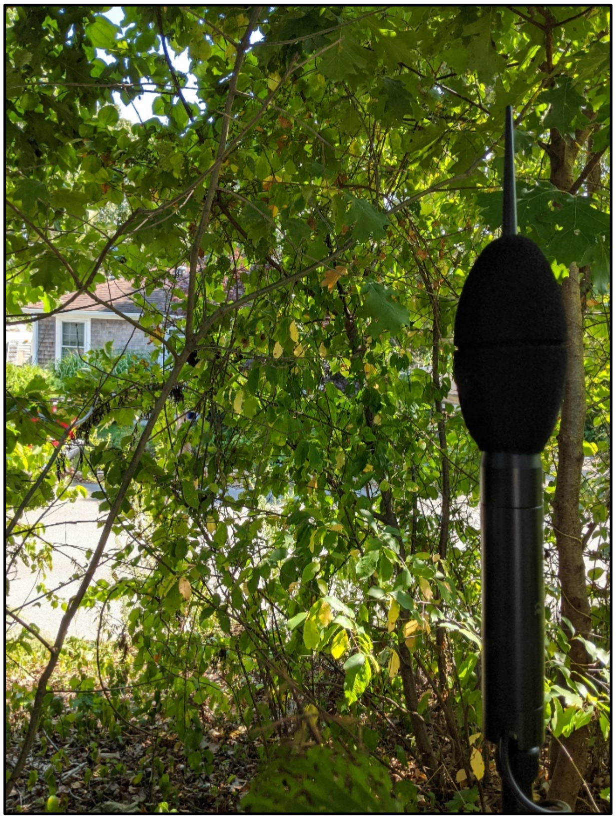
ISO, 2017. ISO 1996-2:2017. Acoustics — Description, measurement and assessment of environmental noise — Part 2: Determination of sound pressure levels.

MassDEP, 1990. Noise Policy, DAQC Policy 90-001. https://www.mass.gov/doc/massdep-noise-policy/download.

Wartsila, 2012. Confidential Radiator Noise Data Sheet W20V32-34DF-34SG. Document DBAC307180 Revision A.

ATTACHMENT 1 – Noise Monitoring Photo Log

	**Photo 1** **Monitoring Site:** LLG-LT1 **Date Taken:** September 8, 2020 **Camera Facing:** West **Description:** View toward nearest noise-sensitive receptor property.
	**Photo 2** **Monitoring Site:** LLG-LT1 **Date Taken:** September 8, 2020 **Camera Facing:** East **Description:** View toward Lawrence Lynch asphalt plant.

	**Photo 3** **Monitoring Site:** LLG-LT2 **Date Taken:** September 8, 2020 **Camera Facing:** Southeast **Description:** View toward nearest noise-sensitive receptor property.
	**Photo 4** **Monitoring Site:** LLG-LT2 **Date Taken:** September 8, 2020 **Camera Facing:** Northwest **Description:** View toward Lawrence Lynch storage piles.

<table>
<tr>
<td></td>
<td>Photo 5

Monitoring Site:
CCA-LT1

Date Taken:
September 8, 2020

Camera Facing:
South

Description:
View toward nearest noise-sensitive receptor property and Thomas B. Landers Road.</td>
</tr>
<tr>
<td></td>
<td>Photo 6

Monitoring Site:
CCA-LT1

Date Taken:
September 8, 2020

Camera Facing:
North

Description:
View toward Cape Cod Aggregates property.</td>
</tr>
</table>

	**Photo 7** **Monitoring Site:** CCA-LT2 **Date Taken:** September 8, 2020 **Camera Facing:** North **Description:** View toward nearest noise-sensitive receptor property.
	**Photo 8** **Monitoring Site:** CCA-LT2 **Date Taken:** September 8, 2020 **Camera Facing:** South **Description:** View toward Cape Cod Aggregates property.