Raven Farm Substation Sound Study

Central Maine Power Company

Raven Farm Substation Sound Study
Project No. 99382

Revision 0
5/17/2018

Raven Farm Substation Sound Study

prepared for

Central Maine Power Company
Raven Farm Substation Sound Study
Cumberland, Maine

Project No. 99382

Revision 0
5/17/2018

prepared by

Burns & McDonnell Engineering Company, Inc.
Kansas City, Missouri

TABLE OF CONTENTS

Page No.

LIST OF TABLES

Page No.

LIST OF FIGURES

Page No.

LIST OF ABBREVIATIONS

Abbreviation	**Term/Phrase/Name**
ANSI	American National Standards Institute
Burns & McDonnell	Burns & McDonnell Engineering Company, Inc.
CadnaA	Computer Aided Design for Noise Abatement model
CMP	Central Maine Power Company
dB	decibels
dBA	A-weighted decibels
FHWA	Federal Highway Administration
Hz	Hertz
ISO	International Organization for Standardization
kV	kilovolt
L_{90}	Ninety percentile exceedance sound level
L_{eq}	equivalent sound level
MDEP	Maine Department of Environmental Protection
MVA	megavolt-ampere
NECEC	New England Clean Energy Connect
SPL	sound pressure level
Substation	Raven Farm Substation
STC	Sound Transmission Class
SWL	sound power level

1.0 EXECUTIVE SUMMARY

Burns & McDonnell Engineering Company, Inc. (Burns & McDonnell) conducted a sound study for the existing Raven Farm Substation (Substation), owned and operated by Central Maine Power Company (CMP) in Cumberland, Maine. CMP is proposing to expand the terminal at the existing Substation to add a 345-/115-kV, 448-megavolt ampere (MVA) auto-transformer and a breaker-and-one-half, 115-kilovolt (kV) bus. The upgrades to the Substation are required as part of the New England Clean Energy Connect (NECEC) Project. Improvements will require the addition of circuit breakers, disconnect switches, instrument transformers, surge arrestors, buswork, support structures, and foundations, as well as modifications to the existing protection and control system. There is currently no significant sound-emitting equipment at the Raven Farm Substation.

Study objectives:

- identify state and local regulations applicable to the Substation;
- measure existing ambient noise levels near the Substation;
- develop an operational noise model;
- determine if the Substation will meet the applicable sound level regulations, and
- analyze potential sound mitigation options for the new equipment.

Ambient noise monitoring was completed for the Substation from August 15 to 16, 2017. The measurements established daytime and nighttime ambient sound levels at the Substation site in the directions of neighboring residences.

The Maine Department of Environmental Protection (MDEP) regulates and limits noise at and beyond the property boundaries (at “protected locations”) produced by a source or activity, based on the existing ambient noise levels and adjacent land use or zoning classification. The MDEP requires that 5-A-weighted decibel (dBA) penalty be added to the measured total sound level when pure tones or tonal sounds are measured, as defined by the standard. This Substation transformer will emit tonal sounds; therefore, when analyzing the Substation for compliance, the 5-dBA penalty was added to the modeled sound levels to account for the possibility of tonal sounds being measurable at the property line.

Noise modeling was completed for the Substation to estimate offsite sound levels with the Substation transformer energized. Predictive modeling results were analyzed for compliance with the MDEP sound level limits. Based on the ambient measurements collected and the predictive modeling results, the design of the Substation, as submitted in the September 27, 2017 application to the MDEP, would be in compliance with the MDEP noise regulations and its applicable sound level limits.

At the request of CMP, additional noise modeling scenarios were run to determine if additional noise mitigation could reasonably help reduce sound levels offsite. There are various mitigation techniques that could be used to reduce sound impacts to the neighboring residences. Multiple options were analyzed as a part of this study. The mitigation options include the use of a quieter transformer and/or structures around the equipment constructed of sound absorptive panels. The options were analyzed for effectiveness both individually and in combination to provide multiple levels of mitigation and mitigation options. The costs associated with the various mitigation options were not determined as part of this analysis.

This analysis has identified mitigation options that could reduce the expected far-field sound levels generated by the Substation to a range from 20 dBA to 33 dBA at the nearest residences. Determining actual Substation sound levels with the transformer energized would be completed through a combination of near-field measurements and modeling to estimate sound levels at the property line and beyond. With the expected Substation-generated sound levels, there would be no practical way to measure sound related to Substation operation at the residential locations, because of the existing background sound levels. Long-term monitoring could also be used to establish any changes in far-field sound levels. The model predicted sound levels for the base design and the mitigation options are shown in Table 1-1.

Table 1-1: Modeled Sound Levels

Modeled Receptor	Base Design (dBA)	Mitigation Option 1 (dBA)	Mitigation Option 2 (dBA)	Mitigation Option 3 (dBA)
PL1 – Property Line	39.6	31.1	29.6	21.1
PL2 – Property Line	39.5	32.6	29.5	22.6
PL3 – Property Line	39.1	30.4	29.1	20.4

Noise from construction equipment will be emitted during construction of the Substation. The impacts that various construction-related activities might have will vary considerably based on the proximity to the fenceline. Construction noise will be addressed during construction, and sound dampening material could be used if necessary. The construction contractor should complete all construction activities in a manner that will meet applicable construction noise limits.

This report demonstrates that the proposed design of the Raven Farm Substation will comply with the applicable MDEP noise standards, and that additional mitigation options could reduce sound impacts to well below the applicable MDEP standards.

2.0 ACOUSTICAL TERMINOLOGY

The term “sound level” is often used to describe two different sound characteristics: sound power and sound pressure. Every source that produces sound has a sound power level (SWL). The sound power level is the acoustical energy emitted by a sound source and is an absolute number that is not affected by the surrounding environment. The acoustical energy produced by a source propagates through media as pressure fluctuations. These pressure fluctuations, also called sound pressure levels (SPL), are what human ears hear and microphones measure.

Sound is physically characterized by amplitude and frequency. The amplitude of sound is measured in decibels (dB) as the logarithmic ratio of a sound pressure to a reference sound pressure (20 micropascals). The reference sound pressure corresponds to the typical threshold of human hearing. To the average listener, a 3-dB change in a continuous broadband sound is generally considered “just barely perceptible”; a 5-dB change is generally considered “clearly noticeable”; and a 10-dB change is generally considered a doubling (or halving, if the sound is decreasing) of the apparent loudness.

Sound waves can occur at many different wavelengths, also known as frequencies. Frequency is measured in hertz (Hz) and is the number of wave cycles per second that occur. The typical human ear can hear frequencies ranging from approximately 20 to 20,000 Hz. Normally, the human ear is most sensitive to sounds in the middle frequencies (1,000 to 8,000 Hz) and is less sensitive to sounds in the lower and higher frequencies. As such, the A-weighting scale was developed to simulate the frequency response of the human ear to sounds at typical environmental levels. The A-weighting scale emphasizes sounds in the middle frequencies and de-emphasizes sounds in the low and high frequencies. Any sound level to which the A-weighting scale has been applied is expressed in A-weighted decibels, or dBA. For reference, the A-weighted sound pressure level and subjective loudness associated with some common sound sources are listed in Table 2-1.

Sound in the environment is constantly fluctuating, as when a car drives by, a dog barks, or a plane passes overhead. Therefore, sound metrics have been developed to quantify fluctuating environmental sound levels. These metrics include the exceedance sound level. The exceedance sound level, L_x, is the sound level exceeded during “x” percent of the sampling period and is also referred to as a statistical sound level. One common L_x value is the 90-percentile exceedance sound level (L_{90}), which commonly represents background sound levels. The equivalent-continuous sound level (L_{eq}) is the arithmetic average of the varying sound over a given time period and is the most common metric used to describe sound.

Table 2-1: Typical Sound Pressure Levels Associated with Common Sound Sources

Sound Pressure Level (dBA)	Subjective Evaluation	Environment	
		Outdoor	Indoor
140	Deafening	Jet aircraft at 75 feet	--
130	Threshold of pain	Jet aircraft during takeoff at a distance of 300 feet	--
120	Threshold of feeling	Elevated train	Hard rock band
110	--	Jet flyover at 1,000 feet	Inside propeller plane
100	Very loud	Power mower, motorcycle at 25 feet, auto horn at 10 feet, crowd sound at football game	--
90	--	Propeller plane flyover at 1,000 feet, noisy urban street	Full symphony or band, food blender, noisy factory
80	Moderately loud	Diesel truck (40 mph) at 50 feet	Inside auto at high speed, garbage disposal, dishwasher
70	Loud	B-757 cabin during flight	Close conversation, vacuum cleaner
60	Moderate	Air-conditioner condenser at 15 feet, near highway traffic	General office
50	Quiet	--	Private office
40	--	Farm field with light breeze, birdcalls	Soft stereo music in residence
30	Very quiet	Quiet residential neighborhood	Inside average residence (without TV and stereo)
20	--	Rustling leaves	Quiet theater, whisper
10	Just audible	--	Human breathing
0	Threshold of hearing	--	--

Source: Adapted from *Architectural Acoustics*, M. David Egan, 1988, and *Architectural Graphic Standards*, Ramsey and Sleeper, 1994.

3.0 APPLICABLE REGULATIONS

The MDEP noise standard limits noise at protected locations, which are defined as any area accessible on foot containing a residence, house of worship, school, library, hospital, nursing home, etc. Limits are provided for protected locations based on the existing ambient noise levels and existing land use or zone.

At protected locations where the existing zoning or the existing use is predominantly commercial, transportation, or industrial, the Project sound levels are limited to 70 dBA during the day (7:00 AM to 7:00 PM) and 60 dBA at night (7:00 PM to 7:00 AM), measured at the property line of the receiver. For protected locations where the zoning or the existing use is not predominantly commercial, transportation, or industrial, the Project sound levels are limited to 60 dBA during the day and 50 dBA at night. Further, if the existing all-encompassing ambient levels (L_{eq}) are at or below 45 dBA during the day or 35 dBA at night, then the area would be considered a quiet area, and the allowable Project levels would be limited to 55 dBA during the day and 45 dBA at night. The State noise standard further allows that when a physical residence is greater than 500 feet from the property line, the noise standard at that portion of the property line be relaxed to the daytime limit of 55 dBA at all hours of the day.

Absent other factors, the Substation could have nighttime property line sound level limits of 45 dBA, 50 dBA, or 55 dBA, depending on zoning classification of the adjacent property, location of residence on the adjacent property, and/or existing ambient sound levels. The MDEP requires a 5-dBA penalty be added to the measured total sound level when pure tones are observed, as defined by the standard. If a tone is measured at the protected area, 5 dBA would be added to the measured overall sound level when compared to the limits. This would effectively lower the sound the Substation is allowed to emit by 5 dBA since transformers often emit pure tones. In this analysis, the modeled results were increased by 5 dBA when compared to the MDEP sound level limits to account for the possibility of a tonal sounds at the property line and beyond. The generated sound level contours do not reflect this increase.

The MDEP provides sound level limits for construction activities. The sound from construction activities between 7:00 PM and 7:00 AM is subject to the nighttime sound level limits applicable to normal operation at the site. Sound from construction activities between 7:00 AM and 7:00 PM shall not exceed the limits provided in Table 3-1 at any protected location.

Table 3-1: Construction Sound Pressure Level Limits at Protected Locations

Duration of Activity	Hourly Sound Level Limit
12 hours	87 dBA
8 hours	90 dBA
6 hours	92 dBA
4 hours	95 dBA
3 hours	97 dBA
2 hours	100 dBA
1 hour or less	105 dBA

Source: MDEP Chapter 375.10 (2)(b)

4.0 AMBIENT NOISE MEASUREMENTS

Burns & McDonnell personnel took short-term (5-minute) measurements multiple times from August 15 to 16, 2017 around the existing Raven Farm Substation to establish ambient sound levels in the Substation area. The locations of the short-term measurement points are shown in Figure 4-1. The short-term measurements were taken during times when meteorological conditions were favorable for conducting sound measurements. Temperatures varied, ranging from around 65 to 80 degrees Fahrenheit. Skies were partly cloudy to clear. Winds also varied, with mostly light winds.

Measurements were taken using an American National Standards Institute (ANSI) type 1 sound-level meter (Larson-Davis Model 831). The sound level meter was calibrated before and after each set of measurements. None of the calibration level changes exceeded ± 0.5 dB. A windscreen was used at all times on the microphone, and the meter was mounted on a tripod. The microphone was located approximately 5 feet above ground with the microphone angled per the manufacturer's recommendation.

The ambient sound level measurement periods were 5 minutes long, and measured values were logged by the sound meter at each measurement location. The sound levels varied at each measurement point due to the extraneous sounds that occurred during each measurement. Extraneous sounds during the measurement periods included vehicular traffic from nearby roads, airplanes flying overhead, birds and insects. The average measured, A-weighted L_{eq} and L_{90} sound levels are presented in Table 4-1.

Table 4-1: Average Short-Term Existing Sound Levels

Monitor Location	Average Daytime Sound Level[a]		Average Nighttime Sound Level[a]	
	L_{eq} (dBA)	L_{90} (dBA)	L_{eq} (dBA)	L_{90} (dBA)
MP1	50.2	46.3	42.4	39.9
MP2	47.8	45.3	46.4	45.6
MP3	46.4	43.0	43.5	40.7
MP4	45.6	42.7	44.4	37.5
MP5	45.3	42.8	46.1	40.7

(a) Daytime is 7:00 AM to 7:00 PM, nighttime is 7:00 PM to 7:00 AM

Path: Z:\Clients\ENS\CMP\99382_QMIPermitSOW\Studies\Permitting\Noise\Modeling\Noise\GIS\Figure 4-1 Raven Farm Substation Monitoring Locations.mxd gweger 5/7/2018

Raven Farm Measurement Points

NORTH

500 250 0 500

Scale in Feet

BURNS McDONNELL

Figure 4-1

CMP NECEC
Raven Farm Substation
Monitoring Locations

Source: Burns & McDonnell Engineering Company, Inc.

Issued: 5/7/2018

The data shows that the area surrounding the Raven Farm Substation would not be considered a quiet area according to the MDEP criteria (Substation is currently inaudible). In addition to the short-term measurements, the MDEP allows the use of the nomograph method of the Federal Highway Administration (FHWA) Traffic Noise Prediction Model to estimate highway traffic noise. Based on the distance from Interstate 295 (I-295), approximately 1,700 feet, and the traffic counts from the 2010 I-295 Corridor Study prepared by the Maine Department of Transportation, it is estimated that the existing highway noise near the Substation is between 45 and 50 dBA on average depending on the time of day and variations in traffic flow. These levels are consistent with those measured and showed in Table 4-1.

The sound level limits per the MDEP would be 50 dBA and 60 dBA at residential property lines during the night and day, respectively. The MDEP regulations apply a 5-dBA penalty to measured sources that emit tonal noise. The Substation transformer will emit tonal noise; therefore, the Substation will be designed to meet 45 dBA at all adjacent residential property lines that have residential living spaces within 500 feet (i.e., measure 45 dBA, then add a 5-dBA penalty to stay below 50 dBA). If the residential living space is located outside of 500 feet from the property line, the Substation would only need to meet 55 dBA (i.e., measure 55 dBA, then add 5 dBA to stay below 60 dBA), provided a tone is present. The nearest residential receiver is located 200 feet east of the Substation. There are residential properties on all sides of the Substation.

5.0 NOISE MODELING

To estimate offsite sound emitted by the Substation, Burns & McDonnell modeled the sound sources included as part of the Substation. The Substation was modeled based on estimated octave band sound data for transformers rated at the specific sound level. The model was then used to estimate project-related sound levels at the nearest property lines for both industrial and residential properties.

5.1 Noise Modeling Methodology

Noise modeling was performed using the industry-accepted sound modeling software Computer Aided Design for Noise Abatement (CadnaA), version 2018. The software is a scaled, three-dimensional program, which considers air absorption, terrain, ground absorption, and reflections and shielding for each piece of noise-emitting equipment, and then predicts sound pressure levels at discrete locations and over a gridded area. The model calculates sound propagation based on International Organization for Standardization (ISO) 9613-2:1996, General Method of Calculation. ISO 9613-2 assesses the sound level propagation based on the octave band center-frequency range from 31.5 to 8,000 Hz.

The ISO standard considers sound propagation and directivity. The sound-modeling software calculates omnidirectional, downwind sound propagation using worst-case directivity factors. In other words, the model assumes that each piece of equipment propagates its maximum sound level in all directions at all times. Empirical studies accepted within the industry have demonstrated that modeling may over-predict sound levels in certain directions, and as a result, the modeling results in this evaluation should be considered a conservative measure of the Substation’s actual sound level.

The modeled atmospheric conditions were assumed to be calm, and the temperature and relative humidity were left at the program’s default values. Reflections and shielding were considered for sound waves encountering physical structures. Sound levels around the site can be influenced by the sound reflections from physical structures onsite. Obstacles onsite were modeled with structured facades, which accounts for sound reflected and the amount of sound absorbed by the structure itself. The area surrounding the Project has mild elevation changes, which scatter and absorb the sound waves. Thus, terrain was included to account for surface effects such as ground absorption. Ground absorption was set to half the available value (G = 0.5) for areas surrounding the Substation and no foliage was included in the model. Taking this approach, the modeled results are expected to be conservative. The modeling assumptions are outlined in Table 5-1.

Table 5-1: Sound Modeling Parameters

Model Input	Parameter Value
Ground Absorption Coefficient	0.5
Number of Reflections	2
Receptor Height	5 feet above grade
Terrain	USGS topographic land data
Temperature	50 °F
Humidity	70%

5.2 Noise Modeling Results

The octave band sound levels of the Raven Farm Substation transformer are expected to be similar to existing transformers of comparable size and rating at other CMP substations. Predicted sound pressure levels for the Substation were estimated by scaling measured transformer sound profiles to an average sound pressure level of 75 dBA at 6 feet from the equipment envelope. This is the specified sound level of the transformer CMP has proposed to install at the Raven Farm Substation in its initial application to the MDEP.

The modeled Substation sound levels at nearby protected locations are provided in Table 5-2. Review of the data reveals that sound levels from the Substation would not exceed the applicable noise level standards at any of the adjacent residential property lines. The modeling layout is presented in Figure 5-1.

Table 5-2: Modeled Operational Sound Levels

Modeled Receptor	Modeled Sound Level (dBA)	Modeled Sound Level with Penalty Added [a] (dBA)	Sound Level Requirement [b] (dBA)
PL1 – Property Line	39.6	44.6	50
PL2 – Property Line	39.5	44.5	50
PL3 – Property Line	39.1	44.1	50

(a) Values in this column represent the modeled sound level of the Substation with a 5-dBA tonal penalty added.
(b) The sound level requirement is compared to the modeled sound level with a penalty added, as a conservative measure.

In addition to the tabular data presented in the table above, noise contour maps are shown in Figure 5-2 that depict the expected noise levels in the area and the locations of the modeled receptors. Noise contours do not reflect the 5-dBA penalty. This figure shows that all of the protected locations are outside of the limiting noise contour, 45 dBA, which with the addition of the 5 dBA “penalty” would correspond to the 50-dBA nighttime limit.

Path: Z:\Clients\ENS\CMP\99382_QMIPermitSOW\Studies\Permitting\Noise\Modeling\Noise\GIS\Figure 5-1 Raven Farm Substation Modeling Layout.mxd gweger 5/7/2018

Service Layer Credits: Esri, HERE, DeLorme, MapmyIndia, ' OpenStreetMap contributors, and the GIS user community

Property Line Receptors

Transformer

Property Line

NORTH

500 250 0 500

Scale in Feet

BURNS McDONNELL

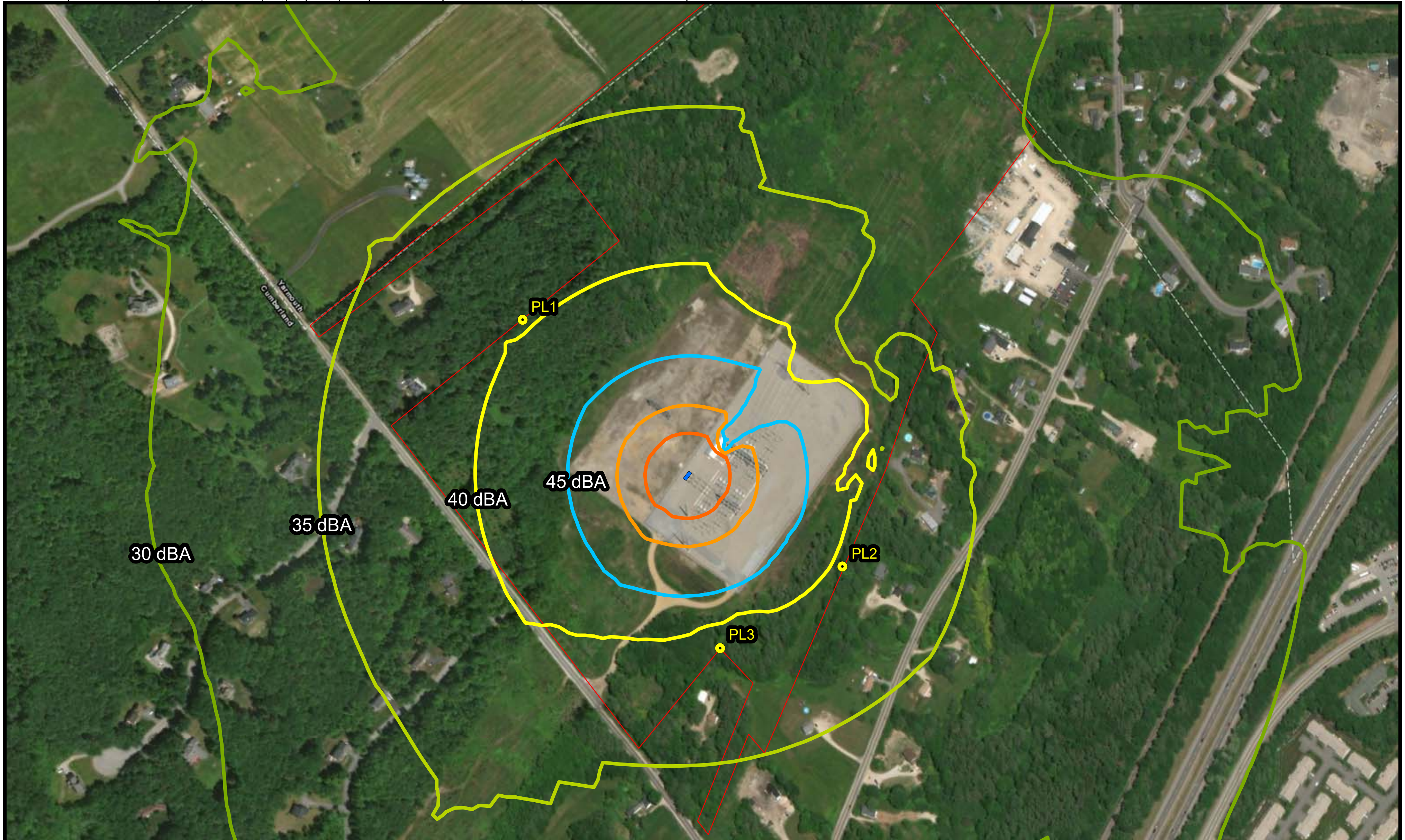
Figure 5-1

CMP NECEC
Raven Farm Substation
Modeling Layout

Source: Burns & McDonnell Engineering Company, Inc.

Issued: 5/7/2018

Path: Z:\Clients\ENS\CMP\99382_QMIPermitSOW\Studies\Permitting\Noise\Modeling\Noise\GIS\Figure 5-2 Raven Farm Substation Base Sound Level Contours.mxd gweger 5/7/2018



- 20 dBA
- 25 dBA
- 30 dBA
- 35 dBA
- 40 dBA
- 45 dBA
- 50 dBA
- 55 dBA
- Property Line

Note: 5-dBA tonal sound penalty is not depicted on this figure

NORTH

500 250 0 500

Scale in Feet

BURNS McDONNELL

Figure 5-2

CMP NECEC
Raven Farm Substation
Base Sound Level Contours

Source: Burns & McDonnell Engineering Company, Inc.

Issued: 5/7/2018

6.0 NOISE MITIGATION ANALYSIS

Burns & McDonnell modeled the Raven Farm Substation transformer with a sound level comparable to similar transformers in the CMP system, and demonstrated the Substation would comply with applicable, State regulations. At the request of CMP, additional noise modeling scenarios have been run to determine what steps could be taken to reduce sound levels offsite.

Without mitigation, the transformer would meet the MDEP noise level requirements, but it may be audible to neighboring residents during times of low background sound. The base modeling scenario used a typical noise transformer rated at 75 dBA at 6 feet. Burns & McDonnell has analyzed low-noise transformers and transformer sound walls to determine the reduction in Substation-generated noise at the property line for each option. Table 6-1 describes each mitigation option analyzed.

Table 6-1: Mitigation Options

Mitigation Option	Description
Base	Transformer 75 dBA at 6 feet
Mitigation Option 1	Transformer 75 dBA at 6 feet and sound wall
Mitigation Option 2	Transformer 65 dBA at 6 feet
Mitigation Option 3	Transformer 65 dBA at 6 feet and sound wall

6.1 Sound Wall Design

Sound walls can be effective at reducing sound levels near a source. Acoustic wall systems can be made of a variety of materials to address specific sound emission and aesthetic concerns. Burns & McDonnell has recently installed removable systems that use metal panels at similar substations.

This type of wall panel system is typically supported by steel, wide-flanged posts installed at approximately 10- to 15-foot spacing. The posts are supported by concrete foundations or other structural framing to support the post and panel assembly. The panels are inserted between adjacent posts to create the wall. Systems of this type permit removal of panels and posts allow unrestricted personnel access should equipment replacement or major work be necessary.

The sound performance of these types of walls is a function of the wall’s transmission loss properties (sound reduction through the material), height, and distance from the noise source and the receiver. As the transmission loss value of a barrier increases, the overall height can be reduced, to achieve similar overall noise reduction. The sound wall analyzed for this Substation was of the same size (23 feet tall) and acoustical properties as the sound walls recently built at the CMP Maguire Road Substation in Kennebunk.

The proposed layout of the barrier wall is shown in Figure 6-1. The barrier would fully enclose the transformer, and access doors would be needed for routine maintenance and inspections. As noted, the panels would be removable for major maintenance requirements. Table 6-2 depicts the transmission loss values of the wall system used for the Maguire Road Substation and subsequently modeled for the Raven Farm Substation. The wall panels for Maguire Road were supplied by Aeroacoustics, but other vendors can provide similar sound wall options which could be used in place of the Aeroacoustics wall system.

Table 6-2: Acoustical Barrier Transmission Loss Properties

Sound Reductions	STC [a]	Octave Band Frequency (Hz) Transmission Loss (dB)								
		31.5	63	125	250	500	1000	2000	4000	8000
Aeroacoustics Wall Panels	44	--	22	24	31	42	52	61	66	66

(a) Sound Transmission Class (STC) is a single value decibel rating of the transmission properties of a partition.

The barrier, as modeled, would be an approximately 45 x 75 feet rectangle, be approximately 23 feet tall, and include a six-inch air gap at the base to allow for cooling. The support steel would be attached to concrete foundations and the walls would be constructed of the Aeroacoustics sound absorptive panels.

Path: Z:\Clients\ENS\CMP\99382_QMIPermitSOW\Studies\Permitting\Noise\Modeling\Noise\GIS\Figure 6-1 Raven Farm Substation Base Sound Wall Location.mxd gweger 5/7/2018

Sound Wall
Transformer

NORTH

100 50 0 100
Scale in Feet

BURNS McDONNELL

Figure 6-1

CMP NECEC
Raven Farm Substation
Sound Wall Location

Source: Burns & McDonnell Engineering Company, Inc.

Issued: 5/7/2018

6.2 Low Noise Transformer Design

The transformer produces noise through core noise, load noise, and cooling equipment noise. The core noise is caused by magnetostriction effects and inter-laminar magnetic forces. It is influenced by the flux density, core material, core geometry, and excitation voltage waveform. The load sound is caused by electromagnetic forces resulting from leakage fields. The sound is proportional to the load current and is predominately produced by the axial and radial vibrations of the windings. The sound from cooling equipment is generally caused by the cooling fans and oil pumps. The fan noise is influenced by the blade-tip speed, blade design, and the number of fans. Pump noise is typically insignificant when fans are running. The overall noise of a transformer is characterized as a humming sound, and this type of tonal sound can often be distinguishable at lower overall sound levels than broadband noise in general.

Installation of a standard-sound level transformer was demonstrated to meet the MDEP property line sound level limits, as designed. Low-noise transformer technology is available for the required type of unit, that would produce 65 dBA at 6 feet from the unit versus 75 dBA at 6 feet as is characteristic of the typical unit. Reducing the near-field sound levels of the transformer, would equate to similar reductions in the far-field (beyond the property line) impacts from the transformer.

6.3 Noise Mitigation Results

6.3.1 Mitigation Option 1 – Transformer (75 dBA at 6 Feet) and Sound Wall

Predictive modeling was completed for Mitigation Option 1. The expected sound levels from the installation of a four-sided absorptive sound wall around the Raven Farm transformer can be seen in Figure A-1 of Appendix A, which shows a graphical representation in 5-dB contours of the sound generated from the Substation. The model utilized sound levels determined from field measurements, calibrated to 75 dBA at 6 feet, and a four-sided absorptive barrier. Table 6-3 shows the impacts of installing a sound wall around the standard sound level transformer. The Substation-generated sound levels for Option 1 at the property line receivers would decrease by 7-9 dBA below the Base option, depending on location.

Table 6-3: Modeled Operational Sound Levels – Option 1

Modeled Receptor	Base (75 dBA at 6 feet)	Option 1 (75 dBA at 6 feet with Wall)	Sound Reduction with Option 1 (dBA)
PL1	39.6	31.1	8.5
PL2	39.5	32.6	6.9
PL3	39.1	30.4	8.7

Note: Modeled sound levels do not include the 5-dBA tonal penalty which would be added to each level when comparing to the 50-dBA nighttime sound level limit, provided a pure tone is measured.

6.3.2 Mitigation Option 2 – Low-Noise Transformer (65 dBA at 6 Feet)

Predictive modeling was completed for Mitigation Option 2. The expected sound levels from the installation of a low-noise transformer at the Raven Farm Substation can be seen in Figure A-2 of Appendix A, which shows a graphical representation in 5-dB contours of the sound generated from the Substation. The model utilized sound levels determined from field measurements, calibrated to 65 dBA at 6 feet. Table 6-4 shows the impacts of installing a low-noise transformer at the Substation. The Substation-generated sound levels for Option 2 at the property line receivers would decrease by 10 dBA below the Base option.

Table 6-4: Modeled Operational Sound Levels – Option 2

Modeled Receptor	Base (75 dBA at 6 feet)	Option 2 (65 dBA at 6 feet)	Sound Reduction with Option 2 (dBA)
PL1	39.6	29.6	10.0
PL2	39.5	29.5	10.0
PL3	39.1	29.1	10.0

Note: Modeled sound levels do not include the 5-dBA tonal penalty which would be added to each level when comparing to the 50-dBA nighttime sound level limit, provided a pure tone is measured.

6.3.3 Mitigation Option 3 – Low-Noise Transformer (65 dBA at 6 Feet) and Sound Wall

Predictive modeling was completed for Mitigation Option 3, which combines a low-noise transformer and a sound wall. The expected sound levels from the installation of a low-noise transformer and a four-sided absorptive sound wall at the Substation can be seen in Figure A-3 of Appendix A, which shows a graphical representation in 5-dB contours of the sound generated from the Substation. The model utilized sound levels determined from field measurements, calibrated to 65 dBA at 6 feet, and a four-sided absorptive barrier. Table 6-5 shows the impacts of installing a low-noise transformer and a sound wall at the Substation. The Substation-generated sound levels for Option 3 at the property line receivers would decrease by 17-19 dBA below the Base option, depending on location.

Table 6-5: Modeled Operational Sound Levels – Option 3

Modeled Receptor	Base (75 dBA at 6 feet)	Option 3 (65 dBA at 6 feet with Wall)	Sound Reduction with Option 3 (dBA)
PL1	39.6	21.1	18.5
PL2	39.5	22.6	16.9
PL3	39.1	20.4	18.7

Note: Modeled sound levels do not include the 5-dBA tonal penalty which would be added to each level when comparing to the 50-dBA nighttime sound level limit, provided a pure tone is measured.

7.0 CONSTRUCTION NOISE

The noise impacts from various construction-related activities will vary considerably based on the proximity to the Substation fenceline. Generic sound data ranges are available for various types of equipment at certain distances. Impact levels from the construction activities are compared to the local and State regulations. Table 7-1 lists generic activities and their minimum and maximum instantaneous sound levels at 50 feet.

Table 7-1: Range of Typical Construction Equipment Noise Levels[a]

Generic Construction Equipment	Minimum Noise at 50 feet (dBA)	Maximum Noise at 50 feet (dBA)
Backhoes	74	92
Compressors	73	86
Concrete Mixers	76	88
Cranes (movable)	70	94
Dozers	65	95
Front Loaders	77	96
Generators	71	83
Graders	72	91
Jack Hammers and Rock Drills	80	98
Pumps	69	71
Scrapers	76	95
Trucks	83	96

(a) Values taken from FHWA Highway Construction Noise and the HEARS database

The types of equipment listed in the table above may be used at various times and for various periods of time. Equipment noise would be addressed during construction by the construction contractor, and sound dampening material may be used if applicable sound level limits are exceeded. Most construction activities will not occur simultaneously. There will be periods in which concrete needs to cure and no construction will occur. Sound levels are expected to be lower in areas where activities are occurring at distances greater than 50 feet from the construction zone. The construction contractor will complete all construction activities in a manner that will satisfy the construction noise limits provided in MDEP Ch. 375(10)(C)(2).

Sound from construction activities between 7:00 PM and 7:00 AM is limited to the nighttime sound level limit of 50 dBA at all protected locations, as applicable to normal operation at the site without a tonal penalty. Sound from daytime construction activities, between 7:00 AM and 7:00 PM, is limited to the limits provided in Table 7-2 at any protected location.

Construction is expected to involve site clearing, excavation, placement of concrete and other typical utility construction practices. Construction activities will be limited in the area to the extent necessary. The construction contractor will take the necessary steps to address elevated construction sound levels.

Table 7-2: Construction Sound Pressure Level Limits at Protected Locations

Duration of Activity	Hourly Sound Level Limit
12 hours	87 dBA
8 hours	90 dBA
6 hours	92 dBA
4 hours	95 dBA
3 hours	97 dBA
2 hours	100 dBA
1 hour or less	105 dBA

Source: MDEP Chapter 375.10 (2)(b)

8.0 CONCLUSION

Burns & McDonnell prepared a detailed sound study on behalf of CMP to assess the potential noise impacts associated with operation of the Raven Farm Substation after modifications are made. The study included identification of state and local regulatory sound level limits (Cumberland's land use ordinances contain no sound level limits), an ambient noise monitoring program to identify baseline conditions, detailed computer noise modeling, analysis of noise mitigation measures, and a determination of whether CMP's proposal would comply with MDEP noise standards. For this project, the MDEP limits sound at protected areas to 50 dBA at night and requires a 5-dBA penalty be applied to measured tonal sounds.

The site is bordered by residential properties in all directions. However, the ambient noise monitoring program revealed that the daytime hourly average sound levels (the existing Substation site has no noise sources and was not audible) were greater than 45 dBA and nighttime sound levels were greater than 35 dBA. As such, the areas surrounding the Substation are protected areas, but are not defined as quiet areas under MDEP's noise standard. Ambient noise in the area is dominated by the nearby I-295, which is located approximately 1,700 feet from the Substation.

Predictive modeling demonstrated that the Base Substation design sound levels would be below the MDEP sound level limits. At the request of CMP, multiple noise modeling scenarios were run to analyze noise mitigation options to reduce sound levels offsite. Various mitigation techniques could be used to reduce sound impacts to the neighboring residences.

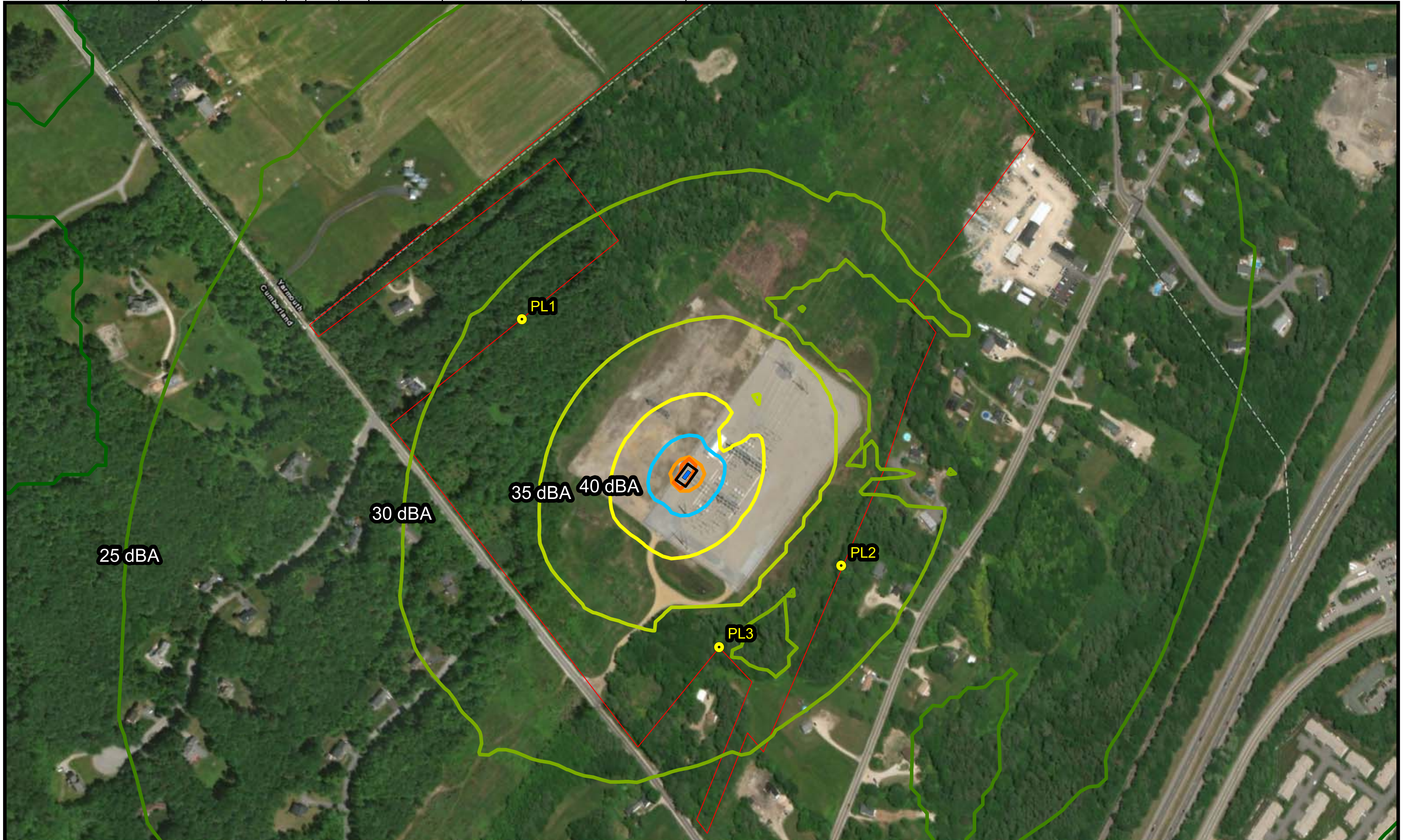
The expected far-field sound levels generated by the Substation with mitigation applied ranged from 20 dBA to 33 dBA at the nearest residences, depending on the level of mitigation applied. Substation sound levels with the transformer energized would be determined through a combination of near-field measurements and modeling to estimate sound levels at the property line and beyond. Within the expected Substation sound levels, there would be no practical way to measure sound related to the Substation operation at the residential locations, because existing background sound levels between 45 and 50 dBA would exceed sounds generated by the Substation offsite. Long-term monitoring could also be used to establish any changes in far-field sound levels.

Noise from construction equipment will vary by construction-related activity, proximity to the fenceline and residences, and the duration of activity. The construction contractor will complete all construction activities in a manner that will satisfy the MDEP construction noise limits.

This report demonstrates that construction and operation of the Raven Farm Substation will comply with all applicable MDEP noise standards, and that additional mitigation options could reduce sound impacts to well below applicable MDEP limits.

APPENDIX A – MITIGATION SOUND CONTOUR FIGURES

Path: Z:\Clients\ENS\CMP\99382_QMIPermitSOW\Studies\Permitting\Noise\Modeling\Noise\GIS\Figure A-1 Raven Farm Substation Option 1 Sound Level Contours.mxd gweger 5/7/2018



20 dBA
25 dBA
30 dBA
35 dBA
40 dBA
45 dBA
50 dBA
55 dBA
Property Line
Sound Wall

Note: 5-dBA tonal sound penalty is not depicted on this figure

NORTH

500 250 0 500
Scale in Feet

BURNS McDONNELL

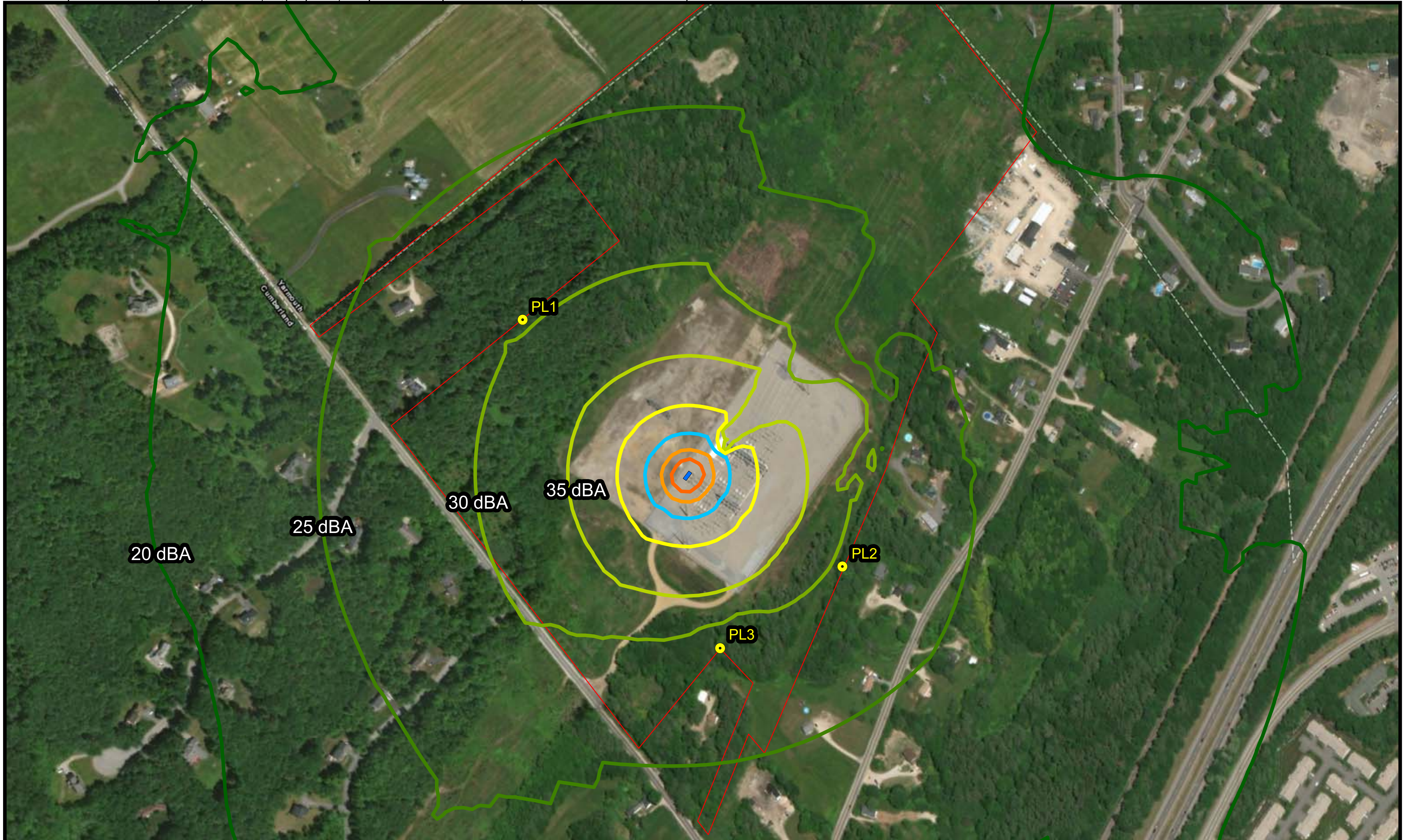
Figure A-1

CMP NECEC Raven Farm Substation Option 1 Sound Level Contours

Source: Burns & McDonnell Engineering Company, Inc.

Issued: 5/7/2018

Path: Z:\Clients\ENS\CMP\99382_QMIPermitSOW\Studies\Permitting\Noise\Modeling\Noise\GIS\Figure A-2 Raven Farm Substation Option 2 Sound Level Contours.mxd gweger 5/7/2018



20 dBA
25 dBA
30 dBA
35 dBA
40 dBA
45 dBA
50 dBA
55 dBA
Property Line

Note: 5-dBA tonal sound penalty is not depicted on this figure

NORTH

500 250 0 500
Scale in Feet

BURNS McDONNELL

Figure A-2

CMP NECEC
Raven Farm Substation
Option 2 Sound Level Contours

Source: Burns & McDonnell Engineering Company, Inc.

Issued: 5/7/2018

Path: Z:\Clients\ENS\CMP\99382_QMIPermitSOW\Studies\Permitting\Noise\Modeling\Noise\GIS\Figure A-3 Raven Farm Substation Option 3 Sound Level Contours.mxd gweger 5/7/2018

Service Layer Credits: Esri, HERE, DeLorme, MapmyIndia, ' OpenStreetMap contributors, and the GIS user community

20 dBA	40 dBA	Property Line
25 dBA	45 dBA	Sound Wall
30 dBA	50 dBA	
35 dBA	55 dBA	

Note: 5-dBA tonal sound penalty is not depicted on this figure

NORTH

500 250 0 500
Scale in Feet

BURNS McDONNELL

Figure A-3

CMP NECEC
Raven Farm Substation
Option 3 Sound Level Contours

Source: Burns & McDonnell Engineering Company, Inc.

Issued: 5/7/2018

BURNS & McDONNELL

CREATE AMAZING.

Burns & McDonnell World Headquarters
9400 Ward Parkway
Kansas City, MO 64114
O 816-333-9400
F 816-333-3690
www.burnsmcd.com