Mei Wu Acoustics

Experts in acoustics, noise and vibration

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Date:	**October 24, 2016**	
Subject:	**Bloom Energy – Frontier Communications - Meriden, CT**	
	MWA Project – 16079	

Mei Wu Acoustics (MWA) has predicted the sound levels produced by the proposed fuel cell energy server system at 27 Butler St, Meriden, CT. In addition, MWA conducted 24-hour sound level measurements at the site to establish the existing ambient environmental sound levels in order to compare predicted noise levels with existing conditions and demonstrate compliance with the code requirements.

1. Project Overview

The proposed equipment will consist of two (2) ES-5 energy servers. The following figure provides a site plan showing the fuel cells' proposed location at the northwestern corner of the property.

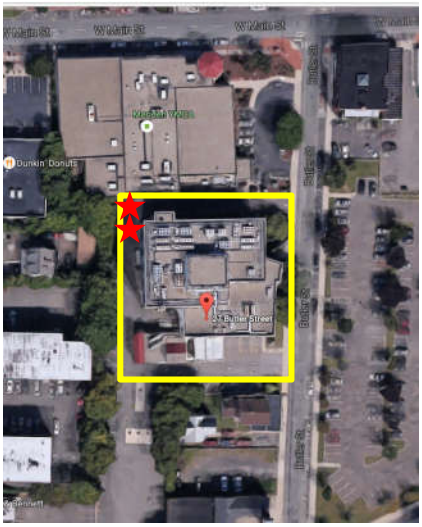


Figure 1: Site plan showing location of fuel-cells (red stars) and property outline (yellow outline).

2. Noise Criteria

This section documents the environmental noise criteria and code requirements applicable the project site.

2.1. Meriden Municipal Code

An excerpt of relevant portions of this code is provided here for reference:

Chapter 141 – Noise

Sec. 141-2- Definitions

When used in this chapter, the terms below shall have the following meanings:

AMBIENT NOISE or BACKGROUND NOISE - Noise of a measurable intensity which exists at a point as a result of a combination of many distant sources individually indistinguishable.

COMMERCIAL ZONE - Those areas designated as commercial districts in Chapter 213, Zoning, of the City Code.[1]

CONTINUOUS NOISE - Ongoing noise, the intensity of which remains at a measurable level (which may vary) without interruption over an indefinite period or a specified period of time.

DAYTIME HOURS - The hours between 7:00 a.m. and 9:00 p.m. Monday through Saturday and the hours between 9:00 a.m. and 9:00 p.m. on Sunday.

DECIBEL - A unit of measure of the sound level, the symbol for which is "dB."

EXCESSIVE NOISE - Any sound, the intensity of which exceeds the standards set forth in § 141-5.

IMPULSE NOISE - Sound of short duration, usually less than one second, with an abrupt onset and rapid decay, the level of which is measured with a sound-level meter, which shall conform to ANSI S127-1986 (R1993).

INDUSTRIAL ZONE - Those areas designated as industrial districts in Chapter 213, Zoning, of the City Code.[2]

NIGHTTIME HOURS - The hours between 9:00 p.m. and 7:00 a.m. Sunday evening through Saturday morning, between 9:00 p.m. and 9:00 a.m. Saturday evening through Sunday morning, and between 9:00 p.m. and 7:00 a.m. Monday through Friday.

NOISE - Any sound, the intensity of which exceeds the standards as set forth in this chapter.

NOISE LEVEL - The sound-pressure level as measured with a sound-level meter.

NOISE LEVEL, A-WEIGHTED - The sound-pressure level as measured with a sound-level meter using the A-weighting network. The sound level is designated "dBA."

PEAK SOUND-PRESSURE LEVEL (SPL) - The absolute maximum value of the instantaneous sound-pressure level occurring in a specified time period.

PROPERTY LINE - That real or imaginary line along the ground surface and its vertical extension which separates real property owned or controlled by any person from contiguous real property owned and controlled by another person and which separates real property from the public right-of-way.

PUBLIC RIGHT-OF-WAY - Any street, avenue, boulevard, highway, sidewalk, alley, park, waterway, railroad or similar place which is owned or controlled by a government entity, over which the public in general has a right of passage.

RESIDENTIAL ZONE - Those areas so designated in the Zoning Regulations of the City of Meriden.[3]

SOUND - A transmission of energy through solid, liquid or gaseous media in the form of vibrations which constitute alteration in pressure or position of particles in the medium and which, in air, evoke physiological sensations, including but not limited to an auditory response when impinging on the ear.

SOUND-LEVEL METER - An instrument used to measure sound levels. A sound-level meter shall conform, at a minimum, to the American National Standards Institute operation specifications for sound-level meters SI. 4-1983 (R 1994).

SOUND-PRESSURE LEVEL (SPL) - Equals 20 times the logarithm to the base 10 of the ratio of the sound pressure in question to the standard reference pressure of 20 micro pascals expressed in decibel (dB) units.

SOUND-PRESSURE LEVEL, A-WEIGHTED - The A-weighted sound-pressure level expressed in decibels (dBA), measured on a sound-level meter.

Sec. 141-3 Noise Measurement Procedures

For the purpose of determining noise levels as set forth in this chapter, the following guidelines shall be applicable:

A. A person conducting sound measurement shall be trained in the current techniques and principles of sound measuring equipment and instrumentation.

B. Instruments used to determine sound-level measurement shall be sound-level meters and analyzers as defined by this chapter.

C. The following steps should be taken when preparing to take sound-level measurements:

(1) The instrument manufacturer's specific instructions for the preparation and use of the instrument shall be followed.

(2) If using a sound-level meter, it shall be calibrated before and after each set of measurements.

(3) If using a sound-level meter, it shall be placed at an angle from the sound source as specified by the manufacturer's instructions and at least four feet above the ground. It shall be placed at that location so as not to be interfered with by individuals conducting measurements.

(4) Measurements to determine compliance with § 141-5 shall be taken at a point that is located more or less than one foot beyond the property line of the noise emitter's premises and within the noise receptor's premises.

(5) While measurements are being recorded, a continual visual and aural surveillance of extraneous sound sources shall be made to ensure that the measurements are due to the sound being investigated. The sound levels of extraneous sound sources shall be recorded.

(6) The intentional moving or rendering inaccurate or inoperative of any sound-monitoring device or instrument positioned or used by or for the City of Meriden, provided that such device or the immediate area is clearly labeled to warn of the potential illegality, shall be a violation of this chapter.

Sec. 141-4 Classification of Noise Zones

Noise zones within the City of Meriden shall be classified as to zoning applicable for the parcel or tract of land and the surrounding parcels or tracts. Noise zones specified herein shall correspond to the following zoning descriptions in the Zoning Regulations and Zoning Map of the City of Meriden:

Zone	***Actual or Intended Use***
Class A	***Residential***
Class B	***Commercial***
Class C	***Industrial***

Sec. 141-5 Noise Zone Standards

A. No person shall, except as provided in this chapter, allow or permit the creation, continuance or maintenance of any noise beyond the property line of his/her premises in excess of the noise levels established in these regulations.

B. It shall be unlawful for any person to emit or cause to be emitted any noise beyond the property lines or boundaries of his/her premises in excess of the following noise levels:

Emitter Noise Zone	*C (dBA)*	*B (dBA)*	*A-Day (dBA)*	*A-Night (dBA)*
Class C	*70*	*66*	*61*	*51*
Class B	*62*	*62*	*55*	*45*
Class A	*62*	*55*	*55*	*45*

C. Impulse noise standards.

(1) Class A receptor, nighttime. It shall be unlawful for any person to emit or cause to be emitted any impulse noise beyond the property lines of his/her premises to a Class A receptor noise zone during nighttime hours in excess of 80 dB peak sound-pressure level.

(2) Any receptor, at any time. It shall be unlawful for any person to emit or cause to be emitted any impulse noise beyond the property lines of his/her premises to any receptor noise zone at any time in excess of 100 dB peak sound-pressure level.

D. High background noise levels and impulse noise.

(1) In those individual cases where the background noise levels caused by sources not subject to these regulations exceed the standards contained herein, a source shall be considered to cause excessive noise if the noise emitted by such source exceeds the background noise levels by five dBA, provided that no source subject to the provisions of this chapter shall emit noise in excess of 80 dBA at any time and provided that this section does not decrease the permissible levels of other sections of this chapter.

(2) No person shall cause or allow the emission of impulse noise in excess of 80 dB peak sound-pressure level during the nighttime to any residential noise zone.

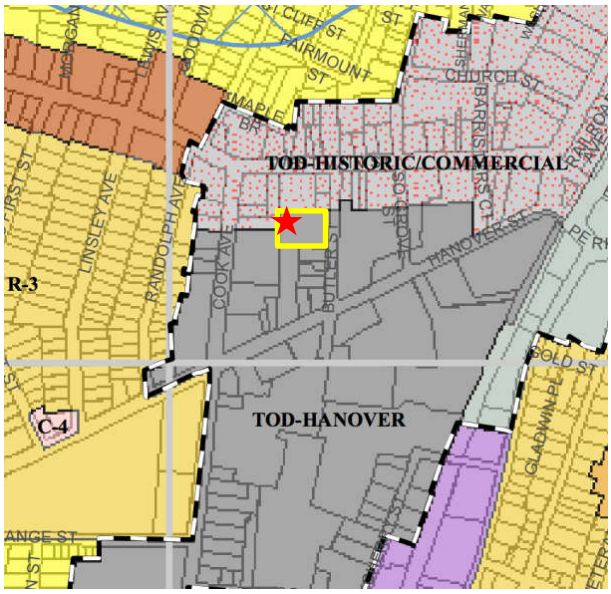
(3) No person shall cause or allow the emission of impulse noise in excess of 100 dB peak sound-pressure level at any time to any zone

2.2. Meriden City Plan

MWA has reviewed the Meriden City Plan and was not able to locate a "Noise Element" portion of this general plan. The Noise Element typically provides goals and policies to guide compatible land uses and the incorporation of noise attenuation measures for new uses to protect people living and working in the City from an excessive noise environment.

2.3. Meriden Zoning Map

The following figure provides a zoning map of the areas surrounding the project site. As shown, the project site is zoned TOD-Hanover, a Transit Oriented Development District, which is considered business/commercial. To the north and east is another transit oriented district, considered business/commercial in this analysis. However we note that the actual land uses to the east of the project site appear to be residential.



TOD-Historic/Commercial – Transit Oriented Development District
TOD-Hanover – Tranist Oriented Development District

Figure 2: Meriden Zoning Map – Approximate location of fuel cells indicated by red star.

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2.4. Connecticut Department of Energy and Environmental Protection (DEEP)

The Connecticut Siting Council (Council) is an autonomous agency residing within the merged Department of Energy and Environmental Protection (DEEP). The following is an exceprt of their noise requirements:

Sec.22a-69-1 Definitions

(h) daytime *means 7:00 a.m. to 10:00 p.m. local time.*
(n) nighttime *means 10:00 p.m. to 7:00 a.m. local time.*

Sec.22a-69-1.2 Acoustic Terminology and definitions

(c) ***background noise*** *means noise which exists at a point as a result of the combination of many distant sources, individually indistinguishable. In statistical terms, it is the level which is exceeded 90% of the time (L90) in which the measurement is taken.*

(f) ***excessive noise*** *means emitter Noise Zone levels from stationary noise sources exceeding the Standards set forth in Section 3 of these Regulations beyond the boundary of adjacent Noise Zones.*

Sec.22a-69-2 Classification of land according to use

Sec. 22a-69-2.1. Basis Noisy Zone classifications shall be based on the actual use of any parcel or tract under single ownership as detailed by the Standard Land Use Classification Manual of Connecticut

Sec. 22a-69-2.2. Multiple uses
Where multiple uses exist within a given Noise Zone, the least restrictive land use category for the Emitter and Receptor shall apply regarding the noise standards specified in Section 3 of these Regulations.

Sec. 22a-69-2.3. Class A noise zone
Lands designated Class A shall generally be residential areas where human beings sleep or areas where serenity and tranquility are essential to the intended use of the land. Class A Land Use Category. The land uses in this category shall include, but not be limited to, single and multiple family homes, hotels, prisons, hospitals, religious facilities, cultural activities, forest preserves, and land intended for residential or special uses requiring such protection

Sec. 22a-69-2.4. Class B noise zone
Lands designated Class B shall generally be commercial in nature, areas where human beings converse and such conversation is essential to the intended use of the land.

Sec. 22a-69-3. Allowable Noise Levels
Sec. 22a-69-3.1. General prohibition
No person shall cause or allow the emission of excessive noise beyond the boundaries of his/her Noise Zone so as to violate any provisions of these Regulation

Sec. 22a-69-3.5. Noise zone standards
(b) No person in a Class B Noise Zone shall emit noise exceeding the levels stated herein and applicable to adjacent

Noise Zones:

	Class C Receiver	Class B Receiver	Class A Receiver Day	Class A Receiver Night
Class B Emitter	62 dBA	62 dBA	55 dBA	45 dBA

Levels emitted in excess of the values listed above shall be considered excessive noise.

Sec. 22a-69-3.6. High background noise areas
In those individual cases where the background noise levels caused by sources not subject to these Regulations exceed the standards contained herein, a source shall be considered to cause excessive noise if the noise emitted by such source exceeds the background noise level by 5 dBA, provided that no source subject to the provisions of Section 3 shall emit noise in excess of 80 dBA at any time, and provided that this Section does not decrease the permissible levels of the other Sections of this Regulation

2.5. Summary of Noise Criteria

- The fuel cells produce steady, broadband noise. Therefore tonal, fluctuating, or impulsive penalties will not be applied.
- The project site is zoned business/commercial. The neighboring uses are also within the Transit Oriented Development Districts: Historic/Commercial or Hannover. However the actual land uses to the west appear to be residential.
- Section 22a-69-2.2 of the DEEP regulations specifies that when multiple uses exist within a given zone, that the least restrictive Land Use Category shall apply for the emitter and receiver. This would qualify residential uses within the business/commercial district as Class B receivers, subject to the criteria of 62 dBA maximum noise level at the property line.
- If this interpretation is not taken, the high background noise area exception will apply. This permits the project to emit a level which exceeds the local ambient by not more than 5 dBA.
- **DEEP Requirements**
    - According to the Noise Zone Standards, the neighboring receiving uses are Class B (to the north and south) and Class A (to the west). Therefore, the noise level at neighboring commercial properties should not exceed 62 dBA, and residential should not exceed 55 dBA during the daytime and 45 dBA during the nighttime.
    - The code allows for an exception to the above standard for “high background noise areas”. In which case, the noise level should not exceed 5 dBA above the background noise level (L90).
- **Meriden City Requirements**
    - The Meriden municipal code requirements are similar to the DEEP requirements – refer to summary above.
    - Meriden does not have a Noise Element in their General Plan.

3. Environmental Ambient Sound Level Measurements

3.1. Site visit details

MWA personnel: Joshua Marcley
Date and time: 9/27/2016 12:00 PM – 9/28/2016 10:30 AM
Equipment used: Cesva SC160, Type II sound level meter

3.2. Measurement procedure

A sound level meter was installed on a tree on the edge of the southern property line (the nearest adjacency to residential use). Ambient sounds were comprised primarily of traffic from in the downtown Meriden area.

The sound level meter recorded A-weighted L_{eq}, L_1, L_5, L_{10}, L_{50}, L_{90}, L_{95}, and L_{99} levels every one (1) minute for the time period described above. The meter was equipped with a windscreen. The measurement was aborted after 22 hours, 20 minutes due to weather concerns. The last 20 minutes of collected data is averaged and extrapolated to represent the entire final hour of the measurement.

3.3. Measurement Period Weather Conditions

The following table provides the weather conditions during the measurement period.

Date	9/27/2016	9/28/2016
Mean Temp.	66° F	59° F
Max Temp.	73° F	66° F
Min Temp.	57° F	54° F
Avg. Humidity	80%	84%
Avg. Wind Speed	5 mph [W]	7 mph [NE]
Precipitation	0.42 in	0.00 in

Table 1: Measurement weather conditions

3.4. Measurement Results

The following table provides the hourly average sound level measurements. All measurements indicated are given in dBA (A-weighted). LAeq is the average measured level for the entire 1-hour measurement period. L1/10/L90/L99 are statistical averages – for example, L10 indicates the level that was present for 10% of the time, whereas L90 indicates the level present for 90% of the measurement period. L99 & L90 are considered representative of the steady background sound levels, whereas L1 & L10 may suggest more infrequent and transient activities in the environment (door slams, car alarms, dog barking, etc.). The quietest 1-Hour L90 was **51.3 dBA**, measured from 12–1PM.

Hour	L1	L10	L90	L99	LAeq
12:00 PM	63.4	56.3	51.3	50.7	54.5
1:00 PM	59.8	55.3	51.4	50.8	53.4
2:00 PM	62.5	55.6	51.9	51.3	54.2
3:00 PM	68.5	61.2	52.2	51.5	58.0
4:00 PM	69.7	62.4	52.6	51.9	59.4
5:00 PM	65.6	58.8	52.0	51.5	56.0
6:00 PM	70.8	64.1	52.3	51.6	60.4
7:00 PM	56.4	54.4	52.2	51.7	53.2
8:00 PM	61.4	56.5	52.3	51.7	54.5
9:00 PM	54.4	53.1	51.9	51.5	52.5
10:00 PM	55.9	53.4	51.8	51.5	52.6
11:00 PM	56.7	53.5	52.0	51.6	52.8
12:00 AM	56.7	54.2	51.8	51.5	52.9
1:00 AM	54.5	53.1	51.9	51.5	52.5
2:00 AM	58.2	54.9	52.3	51.9	53.6
3:00 AM	64.7	57.5	53.2	52.7	55.7
4:00 AM	60.1	56.5	53.9	53.4	55.3
5:00 AM	62.5	57.2	54.3	53.9	55.9
6:00 AM	73.9	66.0	54.8	54.1	62.4
7:00 AM	63.9	58.8	54.4	53.8	56.9
8:00 AM	62.1	58.0	53.8	53.2	56.0
9:00 AM	62.8	59.9	54.4	53.7	57.4
10:00 AM	63.1	56.8	52.1	50.9	54.5
				CNEL	**63.1**

Table 2: Hourly environmental sound level measurements – 9/27 – 9/28/2016 (dBA)

The following figure plots the 1-minute average measurements for the duration of the measurement period, showing the difference between the L01/L99 percentiles and the LAeq average.

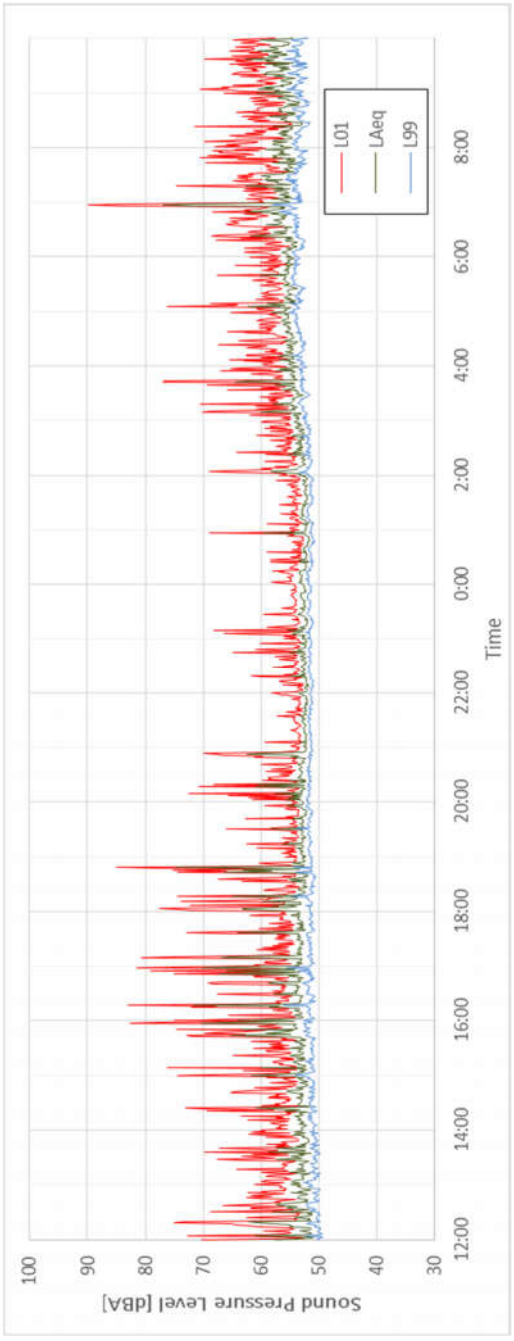

Figure 3: 1-minute average measurements plotted over the measurement period.

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4. Calculation and Prediction of Energy Server Noise Impacts to Adjacent Properties

Sound power levels for the energy server were used to calculate sound transmission to adjacent properties. As we understand it, the ES-5 (also referred to as ES-5 Linear) system will be installed. Sound power levels for the ES-5 Linear were provided in a MWA report dated June 21, 2016, and updated on August 30, 2016. The following table provides the total sound power for a single fuel cell. The following table provides the total sound power for a single fuel cell.

	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	LwA
ES-5 Linear	77.9 dB	80.9 dB	84.1 dB	82.3 dB	80.5 dB	76.9 dB	69.4 dB	84.9 dB

Table 3: Sound power levels (dB re 10^{-12} W) for a single ES-5 Linear.

Our calculations considered the sound power of the units (above x2), reflections from surrounding buildings and structures, and distance attenuation. There is a retaining wall running along the rear of the property. Though it was not measured during our measurement, the calculation assumes that the height of the retaining wall is 2 feet shorter than the top of the fuel cells. Additionally, the fuel cells do not radiate sound uniformly; the sides and rear of the fuel cells are significantly quieter than the top and front intakes. Therefore, the analysis assumes that the rear of the fuel cells is arranged to be facing the rear of the property, thereby minimizing the noise tranmission to the nearest property line. The following figure provides the predicted sound pressure level at the nearest adjacent properties.

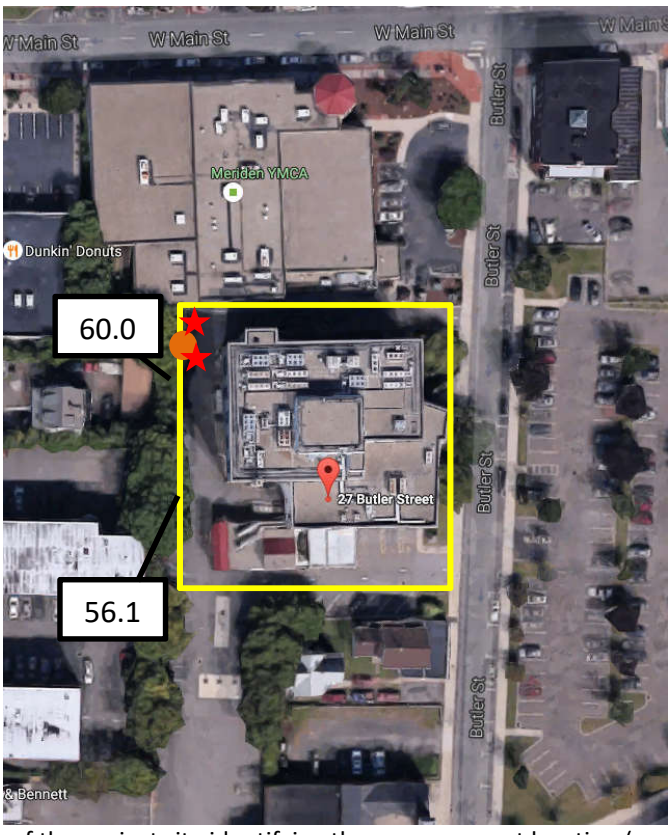

Figure 4: Satellite view of the project site identifying the measurement location (orange); the proposed location of the fuel cells (red stars). Numbers indicate the predicted sound pressure level due to the fuel cell (in dBA).

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5. Mitigation Strategy

The background noise level measurements show that this site is characterized as a "high background noise area" according to the DEEP regulations; the ambient level (52 dBA L90) exceeds the nighttime criteria for Class A receivers (45 dBA). Therefore the noise criteria for the project under this interpretation is the lowest ambient level plus 5 dBA, i.e. **56.3 dBA** (51.3 dBA + 5 dBA).

Figure 4 shows that the noise level at the receiver to the west does not satisfy the code requirements. We recommend the construction of a barrier which shall block the line-of-sight form the fuel cell system to the property line. The barrier should be 5 ft higher than the current retaining wall, constructed along the red line in Figure 5 will be sufficient to mitigate the noise emissions to the nearest receptor according to the levels shown in Figure 5. The barrier indicated by the red line should be the approximate length of the fuel cell system, 75 ft.

The barrier wall should be constructed with any solid material with a density no less than 2 lb. per square foot. Materials meeting this requirement include ½-inch thick wood, ½ inch outdoor plywood and 16 gauge steel sheet, masonry, or CMU blocks. All air gaps on the barrier should be properly sealed.

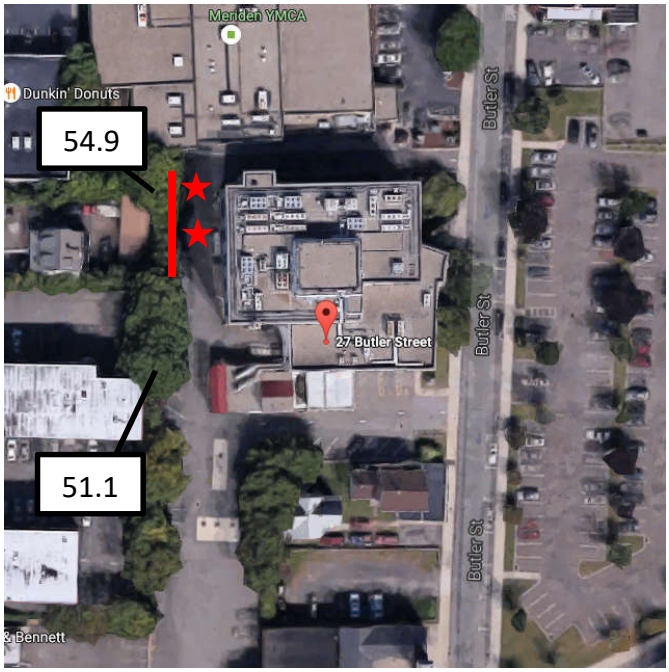

Figure 5: Satellite view of the project site identifying the location of recommended barrier wall (red line) and the location of the fuel cells. Numbers indicate the predicted sound level due to the fuel cells (in dBA).

6. Summary & Conclusion

The calculations show that the noise level at the location closest to the fuel cell along the property line is expected to be **60.0 dBA** and **56.1 dBA**, at the property lines of the two nearest receivers (see Figure 4). The calculation is valid assuming that the retaining wall at the rear of the property is 2 feet shorter than the top of the fuel cells, or taller, and that the fuel cells be aligned such that the rear of the fuel cells face the rear of the property.

The predicted noise levels exceeds those permitted at the property line of a Class A receiver. The ambient noise level measurement shows that this site shall be considered a “high background noise area” according to the DEEP regulations, therefore the noise limit is established to be 56.3 dBA.

We recommend a noise barrier be constructed above the existing barrier wall at the rear of the property to mitigate the noise levels from the proposed fuel cell system to levels which are compliant with the applicable codes. Figure 5 shows the expected noise levels at the nearest sensitive receptors to be complaint with the project noise criteria upon the implementation of this noise reduction strategy.

This concludes our report. Please contact Mei Wu Acoustics if there are any questions or comments regarding this document.

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