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Subject: The Taft School
Noise Treatment Recommendations
110 Woodbury Road
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Summary

This document makes acoustic noise control recommendations that should assist in meeting the acoustic noise concerns during the operation of a Bloom 195 KW fuel cell on the Taft School site near 110 Woodbury Road in Watertown, CT. An acoustic assessment plan was developed and executed to acquire acoustic information useful in explaining and mitigating the potential airborne noise issues associated with the future operation of a Bloom 195 KW fuel cell at the site in Watertown. This has been accomplished and the results show that the acoustic impact of operating the Bloom 195 KW fuel cell will be minimal with the recommended mitigation.

The airborne noise levels expected to be generated by the Bloom fuel cell operating at the Taft School site were simulated by exciting a Soundboks speaker at the nominal fuel cell's east and west positions[1]. The speakers produced average overall A-weighted sound pressure levels of 98 to 99 dBA at 5 meters and 93 dBA at 10 meters (reference 20 microPascals) at the proposed fuel cell's location. The airborne noise levels from the speakers were measured at nearby property lines at noise levels from 59 to 91.5 dBA. Measurement locations at the adjacent properties to the north, east and south were too far away to be able to measure the airborne noise with the speaker on. Analysis of the speaker data indicated propagation losses of 1.7 to 34 dB from the fuel cell's location to the nearby properties to the west. Based on the operation of a VFS, LLC fuel cell at Bristol, the 195 KW fuel cell was modeled at a 10-meter source level of 60 dBA.[2,]

The Watertown site is located in a Residential Zone next to North Street and is surrounded by other Residential Zones. Based on the analysis displayed in Table 1 the airborne noise from the new fuel cell should be below the 45 dBA noise limit at distances greater than 100 meters. All other nearby residential properties at greater distances are expected to be well below the day time and night time Residential Zone noise limits for an emitter in a Residential Zone. The closest property line to the west is only about 16 meters from the fuel cell so noise mitigation will be required to bring the property line noise level below the night time noise limit of 45 dBA for the six closest homes on North Street.

Efforts to reduce the fuel cell airborne noise at the Woodbury Road location should be directed at adding a sound barrier treatment to block the fuel cell's noise from reaching these six residential properties. This approach places a transmission loss treatment on the chain link fence surrounding the Bloom fuel cell. The performance of a commercially available noise barrier, from Acoustical Solutions, called ABBC-EXT-R Sound Curtains can be used to provide the necessary mitigation. The fuel cell should be partially enclosed as shown in Figure 4 with the noise barrier on three sides to prevent airborne noise from escaping to the west. A ten-foot-high acoustic barrier as described in this report should mitigate the noise issue at the two closest residences (87 and 93 North Street) on the west side of the fuel cell. An 8-foot-high wall on the north and south sides would be effective for the four other North Street residences (59, 71, 99 and 101 North Street) in blocking the Bloom fuel cell sound propagating to these properties. Predicted airborne noise levels as shown in Table 3 are expected to be below 45 dBA at all these residential property lines. This noise control approach should remove any acoustic concerns about siting and operating the Bloom 195 KW fuel cell at the Taft School.

Introduction

Acoustical Technologies Inc. was tasked with an assessment of potential acoustic issues associated with fuel cell airborne noise reaching the properties adjacent to the Taft School site near 110 Woodbury Road in Watertown, CT[1] Responding to a request from Walter Bonola, a site visit was made on June 12, 2024. During the visit, measurement of the simulated airborne noise expected to be produced by a Bloom 195 KW fuel cell was made in order to identify potential noise issues. This document provides recommendations for a noise control approach that will mitigate the acoustic noise concerns during the operation of the new fuel cell.

The purpose of this effort is to utilize the available acoustic information to mitigate the potential airborne noise issues associated with the operation of a 195 KW Bloom fuel cell at 110 Woodbury Road in Watertown, CT. The State of Connecticut and the Town of Watertown Noise Ordinances have been consulted to assess the impact of the estimated acoustic levels. (The night time airborne noise levels should be kept below 45 dBA reference 20 µPa). Noise mitigation is required and would be appropriate in order to reduce the airborne noise propagated by the fuel cell to the closest neighbor's properties on North Street directly west of the fuel cell's location.

Acoustic Measurement Program

Airborne sound pressure measurements and audio tape recordings were conducted at the Taft School site near North Street on June 12, 2024 during the morning hours. The purpose was to measure both background and airborne noise levels with the Soundboks speaker simulating the operation of a Bloom 195 KW fuel cell. Speaker and background airborne noise measurements were taken at each neighbor's property line at ten locations along the west side of the Taft School site (see Table 1 below). Measurements at 5 and 10 meters from the east and west fuel cell module locations were simultaneously taken with a sound level meter and two microphones recording on a digital tape recorder. Overall airborne noise levels were calculated and reported.

Table 1 provides estimates of the expected Bloom fuel cell airborne noise at each of the ten measurement locations. Column 6 provides the airborne noise estimates for the fuel cell using each of the two speaker positions. Table 2 provides the total Bloom fuel cell estimated airborne noise level at each of the closest locations at the ten property lines. See Figures 1 and 2 below for photographs of the Watertown measurement locations. Figure 3 provides a Google Map of the Taft School site with the property line measurement locations identified as P1 through P10.

It should be noted that the calculations in Table 2 combined the noise estimates from the East and West speaker module locations using 63 dBA as the estimate of the fuel cell source level for each speaker location. A correction of 3 dB was subtracted to account for using two sources of noise to model one fuel cell at different distances of the fuel cell modules from the property line. If the fuel cell source was assumed to be at the center fuel cell module, the result would be 1 dB lower (55.7 dBA) for the closest residence. At other residences the difference in results is 1 dB for 93 North Street, 0.3 dB for 99 North Street and 0 dB for all the other residences. The noise mitigation calculations will use the same two module approach knowing there may be a dB of uncertainty at the two closest residences. (This approach gives the higher property line airborne noise estimate.)

Table 1. Background Corrected L90 Sound Pressure Levels in dBA ref. 20 microPascals

Location	Range in Meters	Direction	L90 Estimate	Transfer Function	Property Line	Night Spec	Over Spec
West Speaker			In dBA	In dB	dBA	dBA	dBA
Watertown Green	335	Southwest	47.2	46	33	45	-12
Guernseytown	230	Southwest	59.1	34.1	37	45	-8
37 North Street	170	Southwest	62.3	30.9	40	45	-5
17 North Street	115	Southwest	69.1	24.1	42.8	45	-2.2
59 North Street	87	West	75.5	17.7	46.1	45	**1.1**
71 North Street	64	West	80.5	12.7	51.4	45	**6.4**
87 North Street	16	West	91.5	1.7	58.9	45	**13.9**
93 North Street	50	West	81.4	11.8	57.9	45	**12.9**
99 North Street	55	Northwest	74.4	18.8	53.5	45	**8.5**
107 North St	74	Northwest	68.8	24.4	46.1	45	**1.1**
East Speaker							
Watertown Green	335				33	45	-12
Guernseytown	230	Southwest	58.8	33.9	36.9	45	-8.1
37 North Street	170	Southwest	61.2	31.5	39.8	45	-5.2
17 North Street	115	Southwest	70.6	22.1	42.6	45	-2.4
59 North Street	87	Southwest	76.7	16	45.5	45	**0.5**
71 North Street	64	West	82	10.7	49.7	45	**4.7**
87 North Street	16	West	87.1	5.6	53.3	45	**8.3**
93 North Street	50	West	81.3	11.4	53	45	**8**
99 North Street	55	West	73.4	19.3	51	45	**6**
107 North St	74	Northwest	67.8	24.9	45.5	45	0.5

Note: Column 4 above has the background corrected speaker generated noise levels

Table 2. Expected Airborne Noise at the Closest Property Lines in dB re 20 microPascals

Home	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
Address	107 N	99 N	93 N	87 N	71 N	59 N	17 N	37 N	66 G	Green
Level	**45.8**	**52.4**	**56.1**	**57**	**50.7**	**45.8**	42.7	39.9	37	33

Figure 1. West Fuel cell Location Looking West Towards 87 North Street

Figure 2. East Fuel Cell Location Looking East Towards the Taft School

Figure 3. Google Map Showing Measurement Positions P1 through P10

The west speaker position will produce the highest **residential** property line noise levels since the property lines are closer (about 16 to 200 meters). The Evergreen Cemetery to the North is at least 180 meters away and the residential properties to the east and south are more than 300 meters away. At 16 meters from the west position, the closest property line at 87 North Street can expect to see about 57 dBA, including 3 dB of source level margin. Noise mitigation is recommended to bring this level down to 45 dBA. The margin of 3 dB is removed for the noise mitigation calculations and the fuel cell will be modeled at a 10-meter source level of 60 dBA at a height of 1.5 meters at the west and east ends of the seven fuel cell modules.

Allowable Noise Levels

CT section 22a-69-3.1 (Ref. 2) states that 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 Regulations. The Town of Watertown and the CT noise ordinances have been used to evaluate the noise generated by the Bloom fuel cell. Six homes along North Street could see airborne noise levels as much as 12 dB above 45 dBA. All the other residential properties at greater distances are expected to be below the day time and night time Residential Zone noise limits for an emitter in a Residential Zone. Noise mitigation is recommended for these six properties. The closest commercial zone near Town Hall is about 600 meters away. The airborne noise from the new fuel cell should be well below the 55 dBA noise limit at any of the nearby commercial properties.

The Impulse, Prominent Discrete Tones, Infrasonic and Ultrasonic measurements of the fuel cell's airborne noise showed no acoustic concerns and will not be discussed further as no acoustic treatment is needed. The Town's noise limits are the same as the CT noise limits.

Overall Sound Pressure Levels

The Connecticut regulation for the control of noise states in *CT section 22a-69-3.5 Noise zone standards (c) No person in a Class A Noise Zone shall emit noise exceeding the levels stated herein and applicable to adjacent Noise Zones:*

Class C emitter to C 62 dBA B 55 dBA A/day 55 dBA A/night 45 dBA

The neighbors are classified as residential and have a Residential Zone noise limit of 55 dBA during the day and 45 dBA at night. All of the nearby residential homes are expected to meet the nighttime and day time residential airborne noise limits with the exception of the six closest homes on North Street. Operation of the Bloom fuel cell may have an acoustic impact by exceeding 45 dBA at the property line adjacent to the fuel cell at the six closest North Street locations. The west property line is expected to be as high as 57 dBA without noise mitigation.

Noise Treatment Recommendations

The layout of the Bloom fuel cell is shown in Figure 4. Estimates from the Taft School testing indicate that the fuel cell's noise contribution may be about 12 dB above the night time noise limit at the adjoining property line. Noise treatment of the fuel cell (i.e. reducing its noise by at least 12 dB or more) should mitigate the noise at the nearby property lines on North Street.

The mitigation can be obtained by building an acoustic barrier around the fuel cell. This approach places a transmission loss treatment on the chain link fence surrounding the fuel cell as shown in Figure 4. The following paragraphs describe the analysis used in designing this barrier noise treatment.

The fuel cell is initially designed to be surrounded by a 10-foot-high chain link fence adjacent to the west property boundary and the noise control is provided by attaching an acoustic barrier

material to the fence. Calculating the acoustic performance of the barrier requires an estimate of the transmission loss through the barrier as well as an estimate of the acoustic leakage over and around the barrier. Typical noise treatments will have at least 20 dB of performance for sound traveling through the treatment. This means diffraction over the top of the barrier will be the dominant noise path. Figure 5 below shows the results for the source model for the fuel cell – a 60 dBA level at a distance of 10 meters. Figure 6 shows the diffraction results for a 10-foot-high barrier for the closest residence at 87 North Street – a 45.1 dBA level at a distance of 16 meters. The value of 45.1 dBA should actually be reduced to 44.9 dBA because 10 feet is actually 3.048 meters, not the 3 meters in the graph (the software app does not accept two-digit decimal input).

The diffraction over the top of the acoustic barrier has been calculated and the results are shown in Table 3 as a function of barrier height. A 10-foot-high barrier provides about 12 dB of mitigation to the closest west property line at 87 North Street.

My recommendation is to install a 10-foot acoustic barrier on the west side of the fuel cell and 8-foot-high acoustic barriers on the north and south sides of the fuel cell as shown in Figure 4. These barriers are expected to bring the North Street airborne noise levels below 45 dBA.

Figure 4. ICDS Drawing of the Fuel Cell with Noise Mitigation in Red on the Chain Link Fence

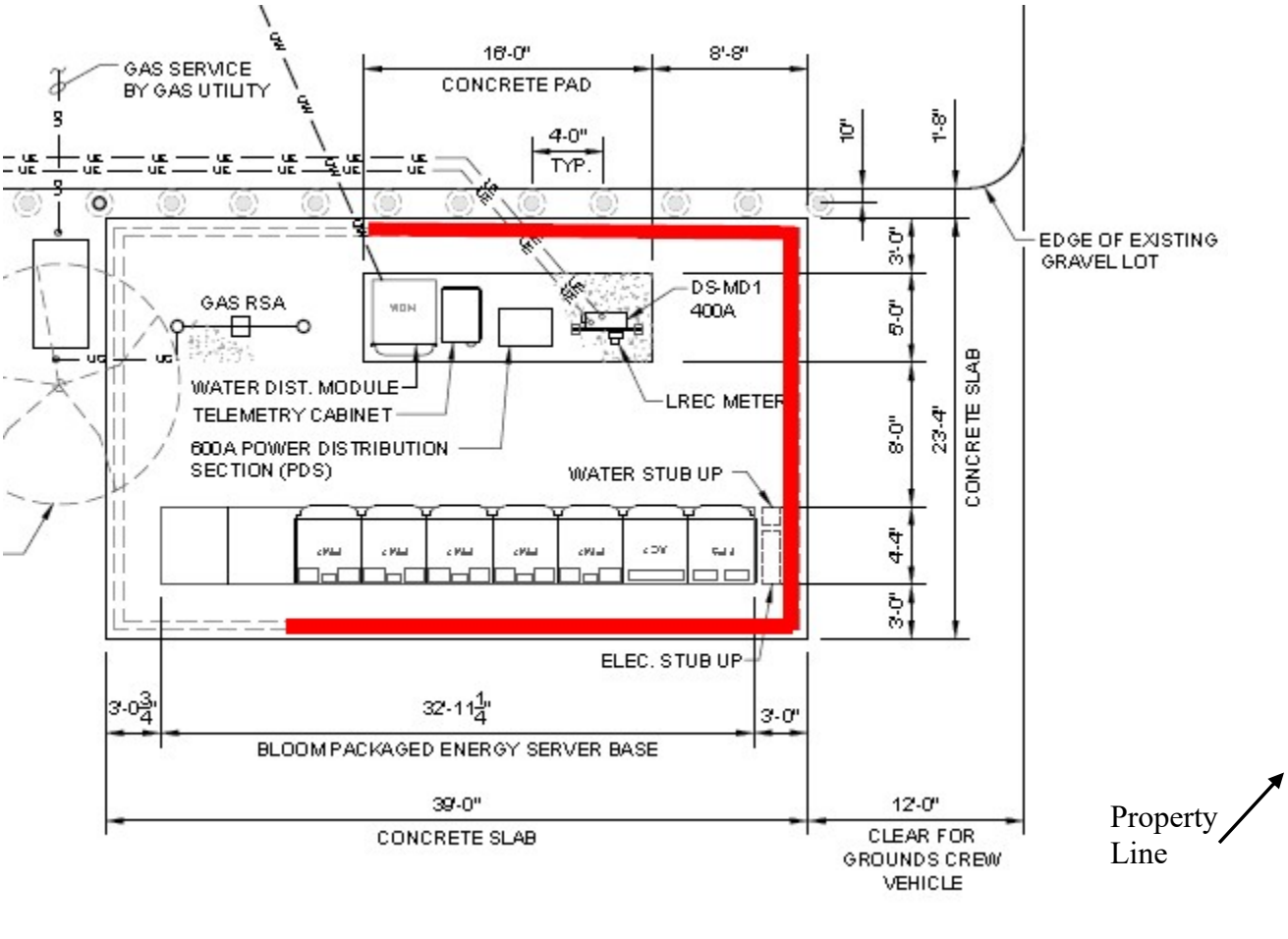

Figure 5. Noise Model for the Bloom 195 KW Fuel Cell at 10 Meters in dBA re 20 µPa

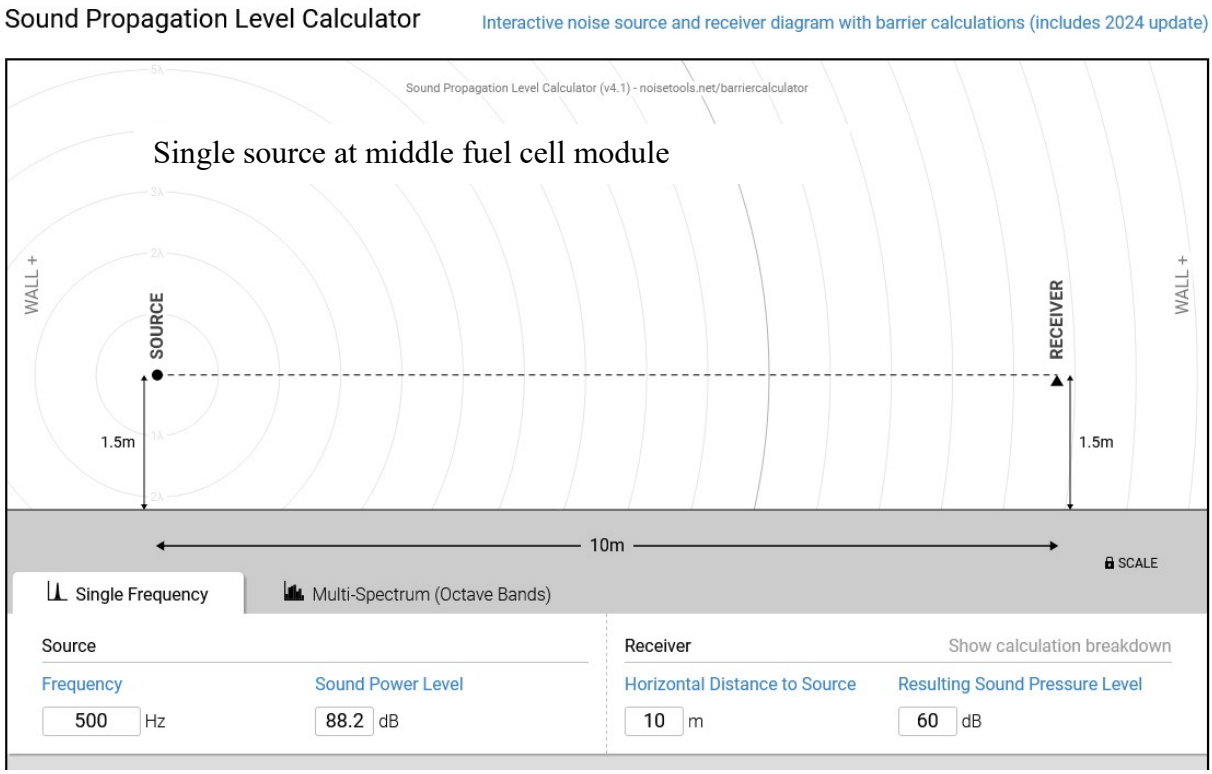

Figure 6. Noise Model for the Bloom 195 KW Fuel Cell with 10 Foot Noise Barrier

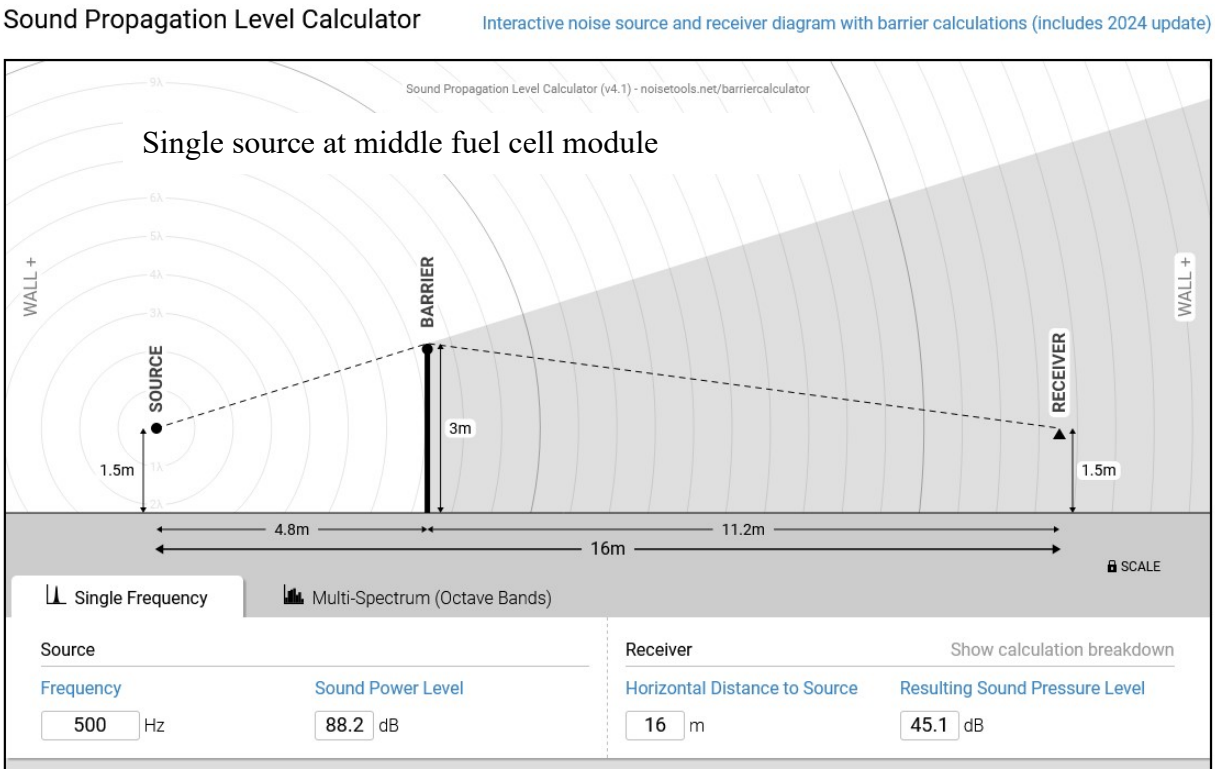

Table 3. Estimates of Fuel Cell Property Line Noise Versus Barrier Fence Height

Barrier Height	101 North	99 North	93 North	87 North	71 North	59 North
8 ft, 2.4 m	36.7	42.6	**45.9**	**47.2**	38.5	32.1
10 ft, 3.0 m	33.9	39.9	43.3	44.3	35.2	28.9
12 ft, 3.7 m	31.2	37.4	40.7	41.6	32.7	26.6
Height Needed						
North	8	8				
West	In Feet	8	10	10	8	
South					8	8

Materials such as the ABBC-EXT-R Sound Curtains from Acoustical Solutions (Reference 5) or equivalent should be sufficient to produce about 12 dB of sound reduction. One path of noise transmission to consider is the path directly through the barrier. The transmission loss for a one-inch-thick material from Acoustical Solutions called ABBC-EXT-R Sound Curtains[5] is shown in Figure 7. The material has great high frequency performance and the lower frequencies still have 10 dB better performance than the diffraction of sound over the barrier.
An example of the noise treatment installation at Mt Sinai Hospital in Hartford, CT is shown in Figure 8. The ABBC-EXT-R Sound Curtains were hung from two sides of a security fence around the fuel cell cooling module to mitigate the airborne noise at the site.

Coverage should extend around three sides of the Bloom fuel cell. See Figure 4 above for a sketch of the recommended approach. The length of the necessary treatment should be about 84 feet and with a height of 8 feet on the north and south sides and 10 feet on the west side giving a surface area of 718 square feet. (This material has been purchased in the past for the Mount Sinai Hospital site in Hartford, CT.)

Figure 7. The Effect of an Acoustic Barrier on Transmission to Nearby Properties

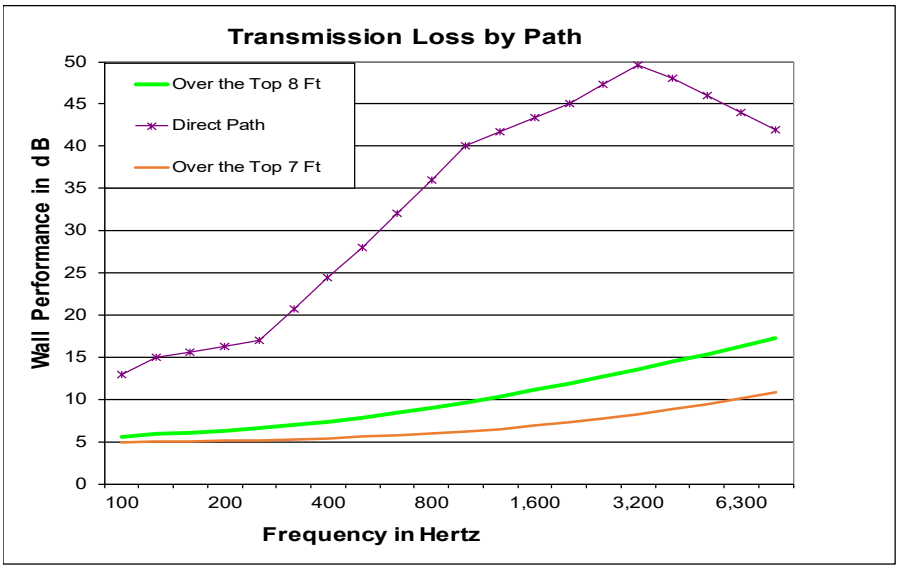

Figure 8. Eight Foot Fence Surrounding Fuel Cell Cooling Module with Noise Treatment

Conclusions

The purpose of this effort has been to evaluate the acoustical environment at the Taft School site near 110 Woodbury Road in Watertown, CT. This has been accomplished and the results show that the acoustic impact on the closest properties on North Street needs to be addressed. Operation of the fuel cell is estimated to meet all of the state and town noise requirements with 8 and 10-foot noise barriers. A ten-foot-high acoustic barrier as described in this report should mitigate the noise issue at the two closest residences (87 and 93 North Street) on the west side of the fuel cell. An 8-foot-high wall on the north and south sides would be effective for the other North Street residences (59, 71, 99 and 101 North Street) in blocking the Bloom fuel cell sound propagating to the northwest and southwest. This noise control approach should remove any acoustic concerns about siting and operating the Bloom 195 KW fuel cell at the Taft School.

References

1) The Taft School Airborne Noise Assessment, Carl A. Cascio, Acoustical Technologies Inc., June 18, 2024
2) Bristol Hospital Test Report.pdf, Carl A. Cascio Acoustical Technologies Inc., December 27, 2023

3) CT DE&EP *Noise Control Regulation RCSA Section 22a-69*-1 to 22a-69-7.4

Acoustical Technologies Inc.

http://www.ct.gov/dep/lib/dep/regulations/22a/22a-69-1through7.pdf

4) Mount Sinai Rehabilitation Hospital Airborne Noise Assessment, Carl A. Cascio, Acoustical Technologies Inc., January 24, 2017

5) https://acousticalsolutions.com/product/abbc-13-ext-audioseal-exterior-sound-blanket/

The sound curtain material comes in 4.5 foot by 8-foot blankets.
The north side would require 6 curtains, while the south side would require 8 curtains.
The west side would require 6 special orders 10-foot-long curtains.