



Doosan Fuel Cell America, Inc.
195 Governor's Highway
South Windsor, CT 06074
T - 860 727 2200

February 10, 2017

**RE: PETITION NO. 1266- Response to Interrogatories - Set Two;
Doosan Fuel Cell America, Inc. petition for a declaratory ruling that no Certificate of Environmental Compatibility and Public Need is required for the construction, maintenance, and operation of a 1840-kilowatt customer-side fuel cell facility to be located at the Waterbury Water Pollution Control Plant, 210 Municipal Road, Waterbury, Connecticut.**

Dear Siting Council,

Please find attached the response to Council Interrogatory 30 - Set Two (along with corresponding exhibit), requisitioned on 12/28/2016 for PE 1266 by the Connecticut Siting Council. Doosan filed a Motion for Extension of Time to Respond to Interrogatory 30 on January 17, 2017, in which Doosan requested an extension until February 10th.

Additional questions may be addressed to:

Walter Bonola

195 Governor's Highway

South Windsor, CT 06074

(860) 727-2010

Walter.Bonola@doosan.com

Sincerely,

Doosan Fuel Cell America, Inc.

A handwritten signature in dark ink that reads "Dawn Mahoney". The signature is fluid and cursive, with the first name "Dawn" being more prominent.

Dawn Mahoney, Esq.

General Counsel

Doosan Fuel Cell America, Inc.

VIA ELECTRONIC MAIL

December 28, 2016

Dawn Mahoney, Esq.
General Counsel
Doosan Fuel Cell America Inc.
195 Governor's Highway
South Windsor, CT 06074

RE: **PETITION NO. 1266** - Doosan Fuel Cell America, Inc. petition for a declaratory ruling that no Certificate of Environmental Compatibility and Public Need is required for the construction, maintenance, and operation of a 1840-kilowatt customer-side fuel cell facility to be located at the Waterbury Water Pollution Control Plant, 210 Municipal Road, Waterbury, Connecticut.

Dear Attorney Mahoney:

The Connecticut Siting Council (Council) requests your responses to the enclosed questions no later than January 18, 2017. To help expedite the Council's review, please file individual responses as soon as they are available.

Please forward an original and 15 copies to this office, as well as send a copy via electronic mail. In accordance with the State Solid Waste Management Plan and in accordance with Section 16-50j-12 of the Regulations of Connecticut State Agencies the Council is requesting that all filings be submitted on recyclable paper, primarily regular weight white office paper. Please avoid using heavy stock paper, colored paper, and metal or plastic binders and separators. Fewer copies of bulk material may be provided as appropriate.

Any request for an extension of time to submit responses to interrogatories shall be submitted to the Council in writing pursuant to §16-50j-22a of the Regulations of Connecticut State Agencies.

Yours very truly,

Melanie Bachman
Acting Executive Director

MB/CW

c: Council Members

**Petition No. 1266
Doosan Fuel Cell America, Inc.
Waterbury Water Pollution Control Plant
210 Municipal Road
Waterbury, CT
Interrogatories – Set Two**

30. In response to Council interrogatory number 9, Doosan did not provide a noise analysis report for the proposed fuel cell facility; however, Doosan states it will perform site specific noise studies at host property boundaries to confirm compliance. Please provide such noise analysis report including the cumulative effects of all four fuel cell units proposed at the host property boundaries.

R30. Please see attachment Waterbury -1 Site Specific Detailed Noise Report

WATERBURY -1

DETAILED SITE SPECIFIC NOISE REPORT

Prepared For: Doosan Fuel Cell America Inc.

Point of Contact: Walter Bonola

**Prepared by: Acoustical Technologies Inc.
50 Myrock Avenue
Waterford, CT 06385-3008**

**Subject: Waterbury WWTP
Airborne Noise Assessment**

Author: Carl Cascio

Date: January 30, 2017

Revision: 1

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Summary

This document makes a positive acoustic assessment that should assist in meeting any acoustic noise concerns during the operation of four Doosan 460 KW fuel cells at the Waterbury Waste Water Treatment Plant in Waterbury, CT. An acoustic assessment plan was developed and executed to acquire airborne acoustic information useful in explaining and mitigating the potential airborne noise issues associated with operation of the Doosan 460 KW fuel cells. It is important to show that the airborne noise generated by the four fuel cells will not significantly impact the Waterbury WWTP's neighbors.

The airborne noise levels expected to be generated by four Doosan fuel cells operating at the Waste Water Treatment Plant in Waterbury were simulated by exciting a set of four co-located speakers at two of the fuel cell cooling module positions. The cooling modules are the dominant noise source. The four speakers produced an overall airborne noise level that was 10 to 12 dB higher than the levels measured for a similar Doosan fuel cell installed at Mount Sinai Hospital in Hartford, CT. One-third octave band analysis showed the speakers to match the fuel cell noise levels at frequencies below 400 Hertz where the A-weighted levels were low and to exceed the fuel cell signature by 10 to 12 dB at higher frequencies where the fuel cell signature was higher.

Airborne noise levels were measured at distances from 5 to 150 meters from the fuel cell locations. The speakers produced overall A-weighted sound pressure levels of 86 and 79 dBA reference 20 microPascals at distances of 5 and 10 meters from the proposed cooling module locations. The airborne noise levels at nearby property lines varied from a low of 62 to a high of 72 dBA reference 20 microPascals with the speakers on. Operation of the four fuel cells should produce levels below the Industrial Zone limit of 70 dBA. The highest expected level of 68 dBA will be at the river gate 24 meters from the fuel cells. Other Industrial Zone property lines are much further away with levels of 60 to 65 dBA with the speakers on. These levels should drop below 61 dBA with the four operating fuel cells. The property line in the commercial zone showed levels of 62 to 63 dBA with the speakers on. These levels should drop below 60 dBA with four fuel cells operating meeting the commercial noise limit of 66 dBA. The nearest residential zone is more than 200 meters from the fuel cell location and the airborne noise levels are expected to be below the residential noise limits. There are no acoustic issues expected with operation of the four fuel cells at the Waterbury WWTP site.

Four fuel cells are expected to produce 6 dB more airborne noise than one fuel cell. Since the speakers generated an airborne noise level 4 to 6 dB higher than the levels expected to be produced by four operating fuel cells, the speaker results at the property lines discussed above exceed the expected noise levels from four fuel cells by at least 4 dB. This allows 4 dB more margin to be added to the results in Table 2 reducing the airborne noise levels expected at the nearby property lines. The end result is that airborne noise at all the property line locations are expected to meet the state and city overall sound pressure level requirements at all the locations.

The Connecticut's Noise Code (Reference 1) also calls for review of acoustic issues associated with impulse noise, prominent discrete tones, infrasonic and ultrasonic noise. Operation of the four fuel cells is expected to meet all of these requirements at all of the nearby property lines.

Introduction

Acoustical Technologies Inc. was tasked as part of a Doosan site permitting process with an assessment of potential acoustic issues associated with fuel cell airborne noise reaching the properties adjacent to the Waterbury Waste Water Treatment Plant (WWTP) in Waterbury, CT. Responding to a request from Walter Bonola, a site visit was made on January 20, 2017. During the visit a survey of the airborne noise levels produced by a set of speakers simulating the airborne noise produced by a Doosan Fuel Cell was made in order to identify potential airborne noise issues. Airborne noise measurements were taken to quantify the propagation of the simulated fuel cell airborne noise to the adjacent properties. Background airborne noise levels were also made with the speakers off. This document provides an acoustic assessment to assist in meeting acoustic noise concerns during the permitting process for the siting of four Doosan fuel cells at 210 Municipal Road on the Waterbury WWTP property.

Development of the Acoustic Assessment Plan

The purpose of this effort is to acquire acoustic information useful in explaining the potential airborne noise issues associated with the operation of four Doosan 460 KW fuel cells at the Waterbury WWTP in Waterbury, CT. The WWTP site at 210 Municipal Road is located in an Industrial Zone adjacent to the Naugatuck River. The closest residential area is more than 200 meters across the Naugatuck river to the northeast on Baldwin Street. Industrial Zones lie to the west, north and south. A Commercial Zone lies to the southeast across the Naugatuck river. It is important to determine whether the airborne noise generated by the four Doosan fuel cells will impact these neighbors.

The acoustic impact is assessed in the following way. The fuel cells are yet to be installed so there is no way to measure fuel cell operating airborne noise levels at the new site. The fuel cell airborne noise has been measured at other sites and one-third octave band airborne noise data of a typical Doosan 400 KW fuel cell are available for reference. Using this data, a set of four speakers will be programmed through a set of two octave band filters to generate a noise spectrum similar to that of the fuel cell. This spectrum will then be played through an audio amplifier to create the electrical voltage necessary to drive the four symmetrical speakers. In order to overcome the high background noise at the site the speaker output will be increased to a level about 10 dB higher than the overall dBA level measured on a fuel cell at 10 meters. With the speakers on, this approach then follows the traditional "What is the airborne noise level at the neighbor's property line?,,. The four speakers were run and airborne measurements made near the fuel cell and at several of the neighbor's property lines. This measured site data can also be used to estimate noise levels at other neighbor's property lines. The City of Waterbury Noise Ordinance and the State of Connecticut Noise Code have been consulted to assess the impact of the measured and estimated acoustic levels. Noise mitigation may be recommended if the airborne noise estimated for the fuel cells exceed the city and state noise requirements at the neighbor's property lines.

Acoustic Measurement Program

The acoustic data necessary to assess the impact of the Doosan Fuel Cells are described below: Airborne sound pressure measurements and audio tape recordings were conducted at the Waterbury WWTP property on and near 210 Municipal Road during the morning hours of January 20, 2017. This testing established both background airborne noise levels and simulated airborne noise levels with the speakers operating. The overall A-weighted airborne noise measurements were made with an ExTech model 407750 Digital Sound Level Meter (s/n 3072577) that had been calibrated just prior to and after the test with a Quest model QC-10 Calibrator (s/n Q19080194). Measurements were taken with A-weighting (frequency filtering that corresponds to human hearing) and with the sound level meter in a Slow response mode. For reference, a noise level increase of 1 dB is equal to an airborne sound pressure increase of 12.2 per cent. The audio tape recordings were conducted with two Sony Digital Audio Tape Recorders (model TCD-D8 s/n 579588 on channels 1 and 2 and model TCD-D7 s/n 142000 on channels 3 and 4). Four PCB microphones (model 130C10 s/n 11283, 130C10 s/n 10641, 130C10 s/n 13286, and model 130D10 s/n 16011) were powered by four Wilcoxon P702B power supply/amplifiers (s/n 1992, 1995, 2063 and 2066 respectively). The PCB microphones were also calibrated just prior to and after the test with a Quest model QC-10 Calibrator (s/n Q19080194). All measurements were made with the microphones at a height between four and five feet. A Hewlett Packard model HP3561A Dynamic Signal Analyzer, s/n 2338A00659, was used to perform A-weighted spectral analysis on the tape-recorded data. The tape-recorded data was used to verify the ExTech sound level meter overall dBA readings,

At the WWTP site “source on,, and background airborne noise measurements were taken at the east property line nearest the gate next to the river on adjacent property (P1) and at three neighbor’s property lines (P2 – P4). See the Google satellite map in Figure 1 for the locations. Measurements near the operating fuel cell and at positions 2, 3 and 4 were simultaneously taken with a sound level meter and two microphones recording on the digital tape recorder. Figure 2 provides a drawing of the site locations for the four fuel cells. Figure 3 below shows a photograph of the speakers at one of the two source locations (W). The two locations were chosen because they are closest to the nearby property lines. At locations W and Z fifty-three minute records of the acoustic noise were stored for the speakers in the “on,, condition. Two minutes of background data were also recorded. Position Z is at the center of the first cooling module next to the electrical building while position W is at the center of the fourth cooling module from the electrical building.

Airborne noise measurements taken outside are corrupted by rain and wind so a day was selected when the weather was dry and the winds were 10 miles per hour or less. Table 1 provides the weather data in Waterbury for the measurements on January 20, 2017. Measurements were taken over the period from 10:25 am until 1:15 pm. The table below shows the temperature and wind speeds in hourly intervals. Wind conditions were excellent and the wind did not affect the operating and background airborne noise measurements. There was no rain. Motor traffic was moderate and it was possible to wait for periods of time when no traffic was seen or heard at the measurement locations. Continuous operation of the waste water treatment plant did cause high background noise levels in the vicinity of the plant. (Airborne noise levels were around 56 dBA.)

Data Analysis

This section analyzes the airborne noise levels measured at the Waterbury site and then estimates the property line airborne noise expected during operation of four Doosan fuel cells. These levels are compared to the regulations in the Connecticut and City of Waterbury noise ordinances. Both background noise levels at the Waterbury WWTP site and estimated Doosan Fuel Cell equipment operating noise levels will be reported. Comparing these Waterbury WWTP measurements with the state and city noise requirements will identify which nearby locations are quiet and meet the requirements and which locations are not quiet enough. The complete set of measured overall A-weighted airborne noise levels are given in Table 2 below for the conditions with the speakers on and off. The CT and City of Waterbury daytime noise requirement is 61 dBA and the nighttime requirement is 51 dBA for residential areas. The requirement in the Commercial Zone is 66 dBA and the Industrial Zone is 70 dBA. Figure 4 is a map showing the Waterbury zoning in the WWTP area. Figure 5 provides a photograph showing the proposed location for the fuel cells and a neighboring property on South Main Street. The range data was calculated using the Pocket Ranger GPS App from the CT State Parks & Forests. The indicated GPS accuracy was about 10 meters. The GPS results were compared with Google Maps data for a check on the validity of the calculated ranges between source and receiver.

Figure 1. Waterbury WWTP Site Map from Google



A comparison of the airborne noise produced at 10 meters by the Doosan fuel cell on the Mount Sinai Hospital site with the airborne noise produced by the speakers at the Waterbury WWTP site is shown in Figure 6. The speakers match the fuel cell airborne noise for frequencies below 400 Hertz and greatly exceed the fuel cell airborne noise at higher frequencies. The overall airborne noise levels are 10 to 12 dB higher for the speakers at positions W and Z.

Table 1. Waterbury Weather on January 19, 2017

Date	Time	Temp. (°F)	Humidity (%)	Visibility	Barometer	Wind Speed	Wind Direct
Friday	2:55 PM	39 °F	65%	10 mi	29.92 "Hg	5 mph	SW
Jan 20	1:55 PM	39 °F	65%	10 mi	29.94 "Hg	5 mph	SSW
	12:55 PM	39 °F	65%	10 mi	29.97 "Hg	5 mph	SW
	11:55 AM	39 °F	65%	10 mi	29.99 "Hg	5 mph	SSW
	10:45 AM	37 °F	70%	10 mi	30.01 "Hg	6 mph	S
	9:50 AM	37 °F	70%	10 mi	30.02 "Hg	6 mph	S
	8:55 AM	37 °F	70%	10 mi	30.01 "Hg	No wind	N
Jan 20	7:45 AM	36 °F	75%	10 mi	30.00 "Hg	No wind	N

Figure 2. Doosan Fuel Cell Installation Drawing

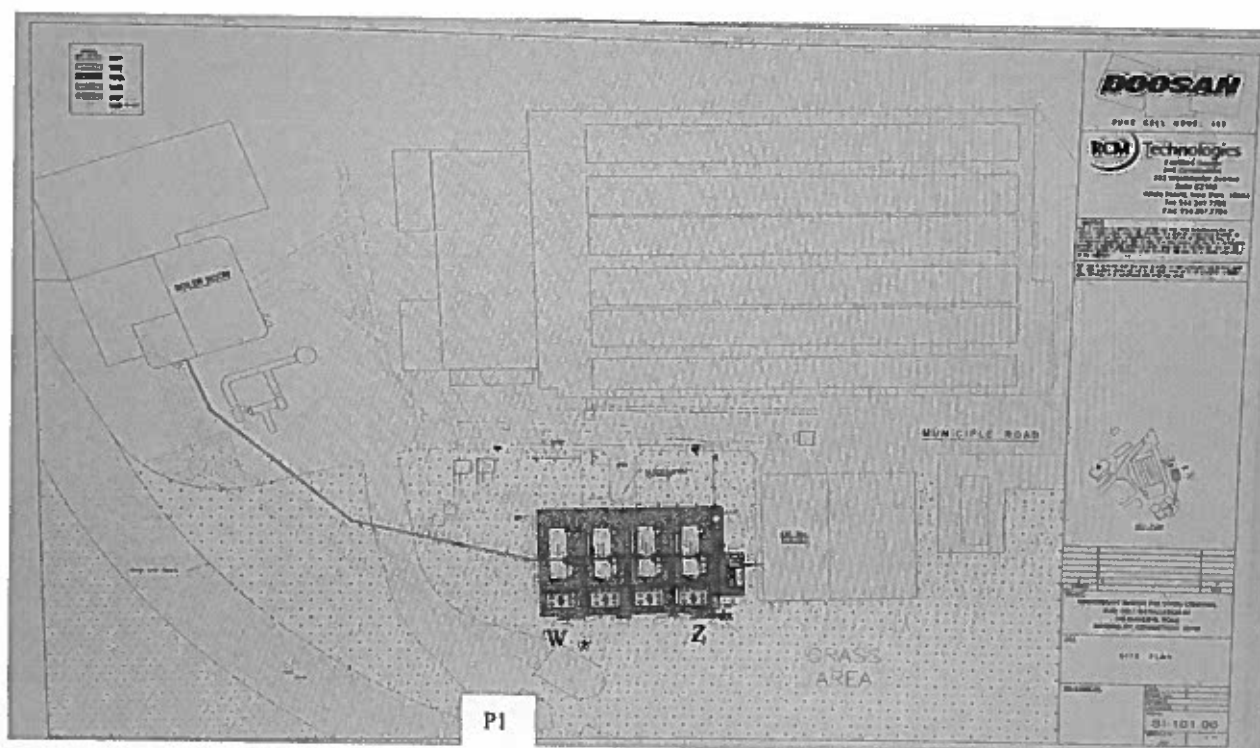


Figure 3. Speaker Source at Position W where the Fourth Fuel Cell Will Be Located

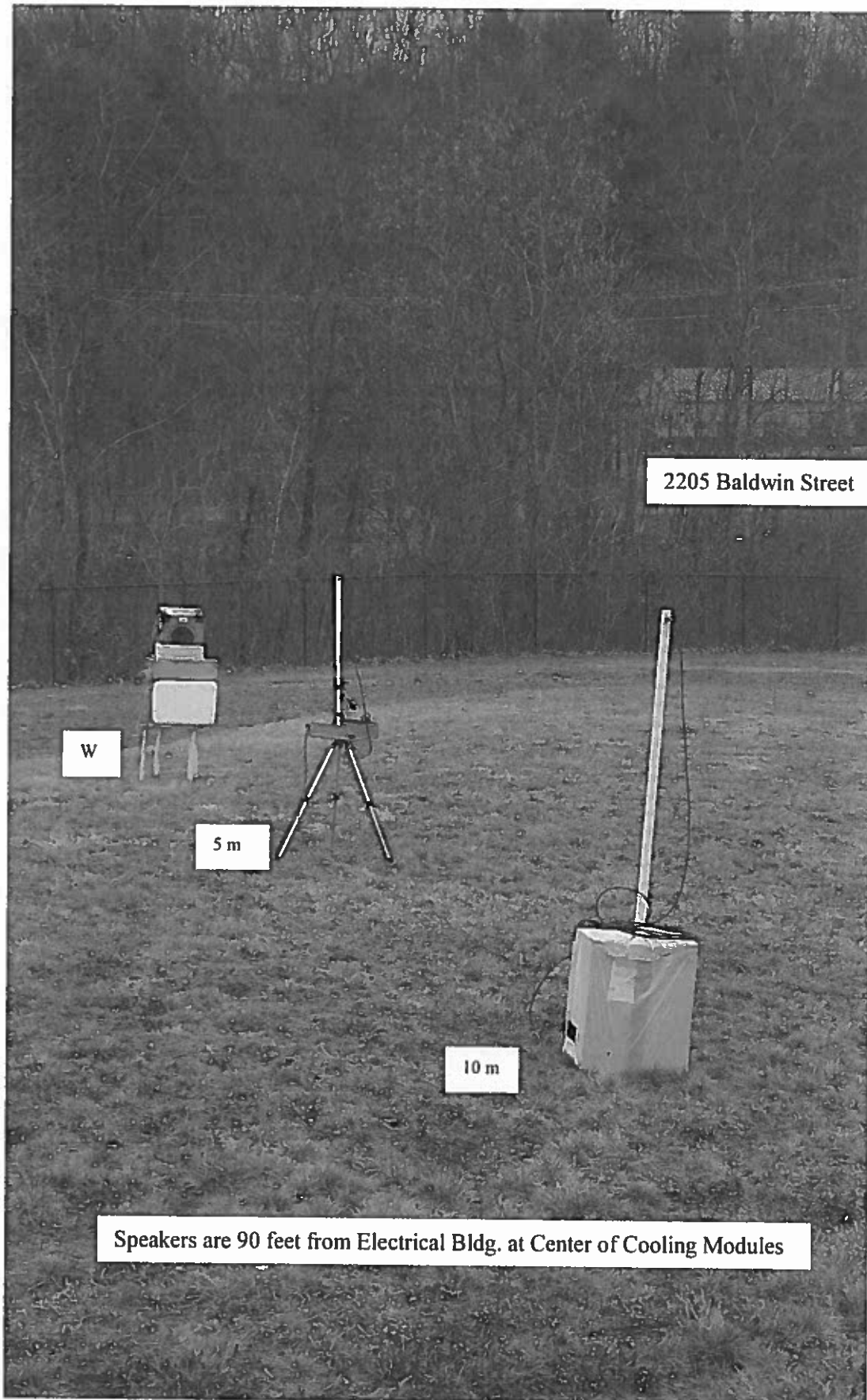


Figure 4. Waterbury Zoning Map Showing Speaker Locations W and Z

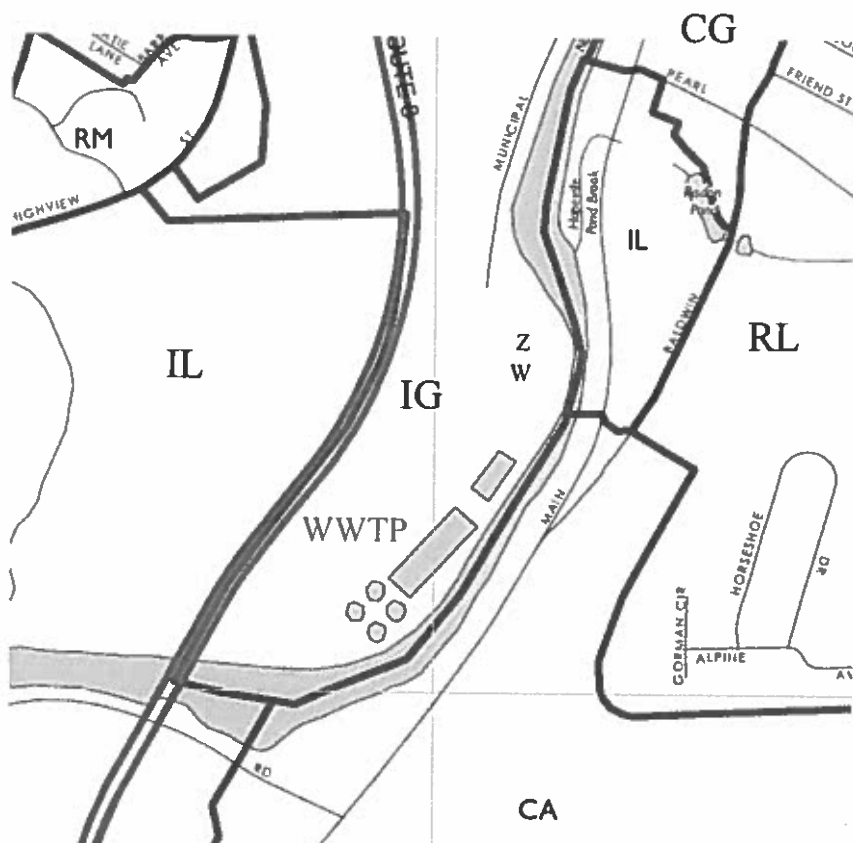


Figure 5. Proposed Location for Waterbury Fuel Cell Cooling Modules

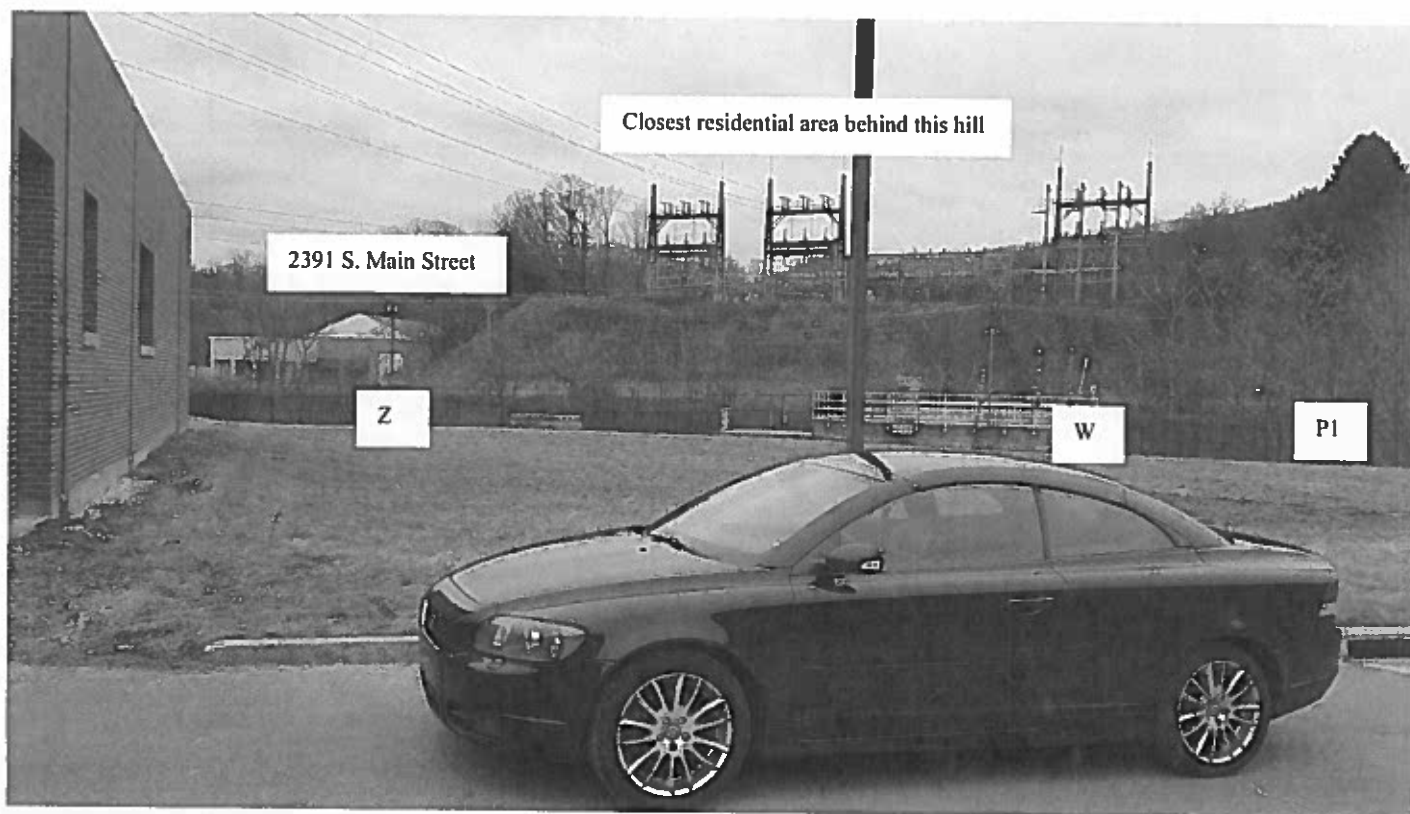


Figure 6 The Four Speakers Generate Airborne Noise Well Above That of a Single Fuel Cell

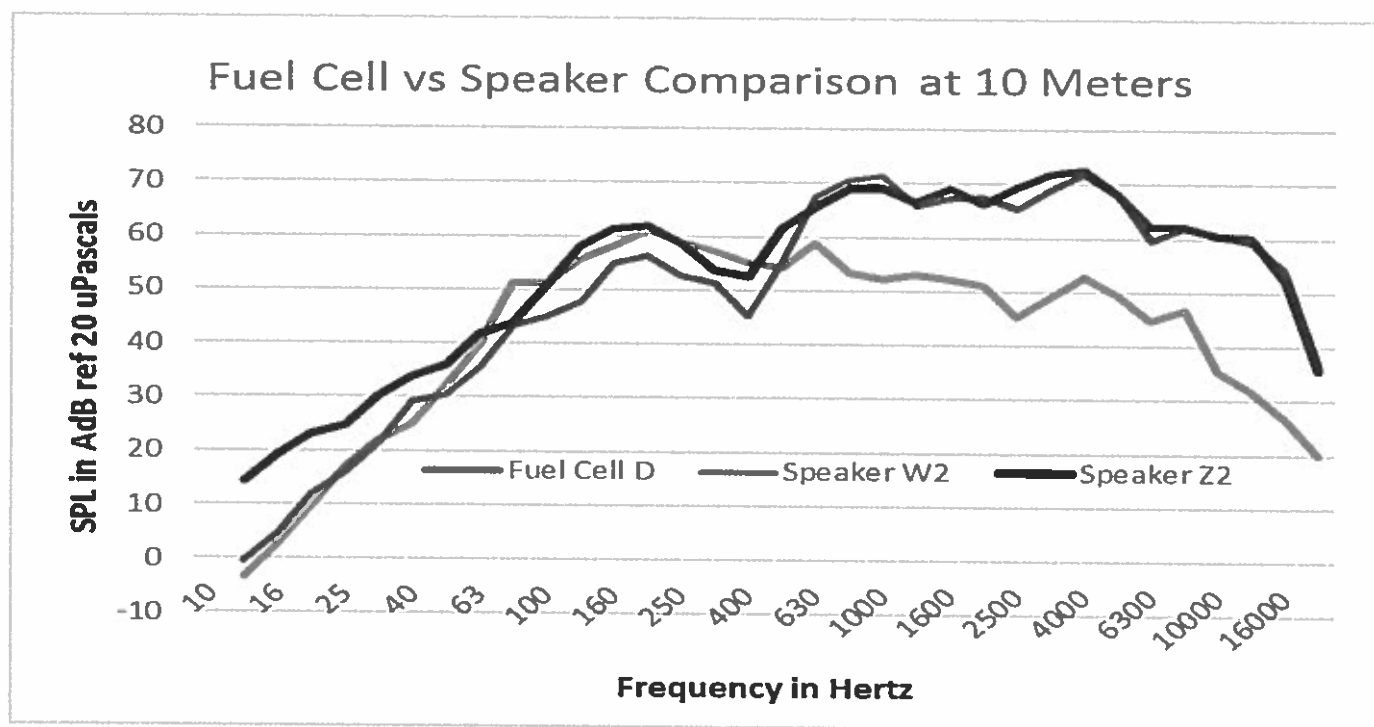


Table 2. Overall Sound Pressure Levels in dBA ref. 20 microPascals at Waterbury WWTP Site

Location	Range in Meters	Speakers On - W	Back-ground	Background Corrected	Speakers On - Z	Back-ground	Background Corrected
Pos. W Ch 1	5	86.2	56	86.2			
Pos. W Ch 2	10	79.4	56	79.4			
Pos.Z Ch 1	5				84.2	58	84.2
Pos. Z Ch 2	10				79.9	57	79.9
P 1 – River Gate	24/38 m	72	57	71.9	67	55	66.7
P 2 – 184 Municipal	130/140 m	57	57	Not Heard	59	59	Not Heard
P 3 – 2391 S. Main	140/150 m	57.5	58	Not Heard	66	60	64.8
P 4 – 2205 Baldwin	140/140 m	64	58	62.8	63	56	62

Allowable Noise Levels

The Connecticut regulation for the control of noise provides in *CT section 22a-69-3* (Ref. 1) the requirements for noise emission in Connecticut. *CT section 22a-69-3.1* 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 Waterbury Noise Ordinance (Ref. 2) uses the same noise levels in the pertinent sections of the CT Noise Code changing only the nighttime hours on Sunday. The CT Code and Waterbury Noise Ordinance will be used to evaluate the noise generated by the Doosan Fuel Cells. Following subsections discuss each type of noise and describe the results obtained from the measurements at the Waterbury WWTP site.

The southern part of the Waterbury zoning map is given in Figure 4. Waterbury WWTP is in Industrial Zone IG. The Waterbury dog pound and recycling office at 184 Municipal Road is also in Industrial Zone IG. The business at 2391 S. Main Street is in Industrial Zone IL to the east. The VFW at 2205 Baldwin Street is in the Commercial Zone CA to the southeast. The closest point of the residential RL zone to the northeast is about 204 meters from the fuel cell location. The closest point of the RM zone to the west is about 540 meters from the fuel cell location. The homes in the residential zones RL and RM are too far away (more than 200 meters) to hear the speakers and by comparison the operation of the four fuel cells. The Mount Sinai Hospital report (Ref. 3) showed that its single fuel cell's airborne noise was estimated to be below the 45 dBA Hartford noise limit at about 75 meters. Operating 4 fuel cells would add about 6 dB bringing the 75 meter noise level to about 51 dBA which is equal to the 51 dBA residential limit at the Waterbury site. An additional 125 meters of distance to the residential zone would reduce the noise bringing it well below the required residential level of 51 dBA.

Impulse Noise

The Connecticut noise code states in *CT section 22a-69-3.2* (part a) *Impulse Noise* that 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 class A Noise Zone. Class A Noise Zones are residential. Nighttime hours are defined as 10 pm to 7 am. *CT section 22a-69-3.2* (part b) *Impulse Noise* states that 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 Noise Zone. Waterbury follows the state requirements on levels while moving the hours from 7 am to 9 am on Sunday to the nighttime requirement.

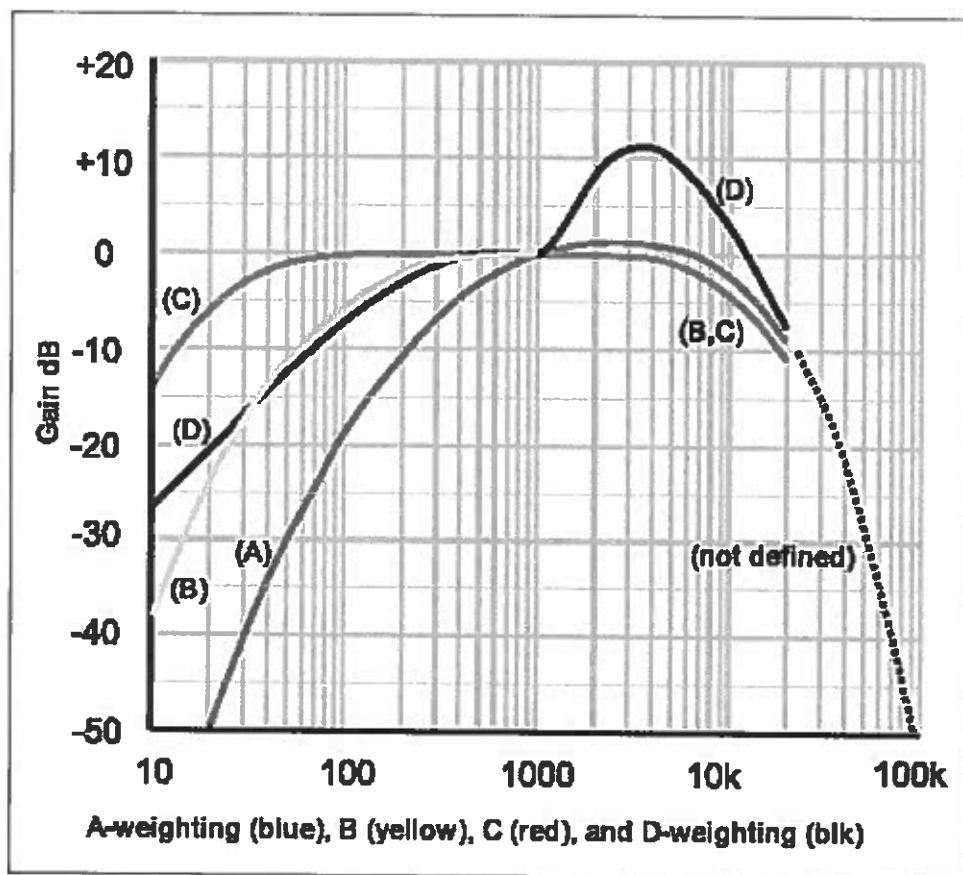
A few words are in order to discuss the difference between A-weighted and un-weighted impulse noise. A-weighting emphasizes the middle and higher frequencies while reducing the influence of the low frequencies. Figure 7 plots the A-weighting curve versus frequency in blue. Below a frequency of 1 kiloHertz the acoustic level is attenuated by increasing amounts. The reduction is about 10 dB at 200 Hertz, 20 dB at 90 Hertz and 30 dB at 50 Hertz. It also reduces the level at very high frequency being down in level by 10 dB at 20 kiloHertz.

Impulse noise in excess of 80 dB was not observed on the tape-recorded data during any of the measurements of the Doosan 400 KW fuel cell made at the Mount Sinai Rehabilitation Hospital on 18 January, 2017. This fuel cell design is similar to the units that will be installed in

Waterbury. Given the steady state nature of the fuel cell's noise signature there should be no acoustic issues with either the State of Connecticut's or the City of Waterbury's requirements.

Figure 7. Acoustic Weighting Curves

[http://upload.wikimedia.org/wikipedia/commons/3/39/Acoustic_weighting_curves_\(1\).svg](http://upload.wikimedia.org/wikipedia/commons/3/39/Acoustic_weighting_curves_(1).svg)



1 of 1

1/25/2013 9:35 PM

Prominent Discrete Tones

The Connecticut regulation for the control of noise states in *CT section 22a-69-3.3 Prominent discrete tones*: Continuous noise measured beyond the boundary of the Noise Zone of the noise emitter in any other Noise Zone which possesses one or more audible discrete tones shall be considered excessive noise when a level of 5 dBA below the levels specified in section 3 of these Regulations is exceeded. The Regulations establish different noise limits for different land use zones. Residential (homes and condominiums) and hotel uses are in Class A. Schools, parks, recreational activities and services are in Class B. Forestry and related services are in Class C. By my reading of the regulations Waterbury WWTP is a Class C emitter in an Industrial Zone. The noise zone standards in *CT section 22a-69-3.5* state that a Class C emitter cannot exceed the following overall sound pressure levels:

Acoustical Technologies Inc.

To Class C 70 dBA To Class B 66 dBA To Class A 61 dBA (day) 51 dBA (night)

The discrete tones limits are 5 dBA lower so that no tone may be higher than the following:

To Class C 65 dBA To Class B 61 dBA To Class A 56 dBA (day) 46 dBA (night)

Waterbury's noise ordinance does not mention discrete tones so the state ordinance shall be used. The requirements for operating at the Waterbury WWTP site for discrete tones would be 56 dBA for the surrounding residential properties during the day and 46 dBA at night. For adjacent properties in the Commercial Zone the discrete tone requirement would be 60 dBA. For adjacent properties in the Industrial Zone the discrete tone requirement would be 65 dBA.

To address the discrete tone issue we use measured data from the January 18 testing of a similar Doosan fuel cell. This data does not have A-weighting. The photo in figure 8 plots the airborne noise measured 10 meters from the Mount Sinai Cooling Module (Ref. 3) for frequencies from 0 to 1000 Hertz. This curve shows the two largest discrete tones produced by the Doosan Fuel Cell Cooling Module. The first tone is at 86 Hertz at a level of 65 dB reference 20 microPascals. The second tone is at 630 Hertz at a level of 56 dB reference 20 microPascals. The A-weighting corrections are -21.5 dB at 86 Hertz and -1.9 dB at 630 Hertz. Incorporating these corrections gives A-weighted levels of 44 dBA at 86 Hertz and 54 dBA at 630 Hertz both at a distance 10 meters from the Cooling Module. With four units operating these airborne noise levels would be about 50 dBA at 86 Hertz and about 60 dBA at 630 Hertz at a distance 10 meters from the fuel cells. These two levels are below the 65 dBA requirement in the Industrial Zone right at the fuel cells and certainly would be much lower at any of the property lines within the Industrial Zone. For example, at the river gate, position P1 shows a drop of 7 dB from the overall level at speaker position W. This implies that the discrete tone would also drop 7 dB and the 630 Hertz tone would fall to 53 dBA at the property line. The transmission losses to the other property lines in nearby zones are at least 15 dB so the maximum possible discrete tone would be about 45 dBA in the nearby zones which is substantially below the 60 dBA requirement in the Commercial Zone and the 65 dBA requirement in the Industrial Zone. The 45 dBA level is also below the 46 dBA residential limit with its even greater distances from the fuel cells. Operating the four fuel cells should produce airborne noise levels well below the discrete tone requirements at all the property lines. There should be no acoustic issue with the State of Connecticut's discrete tone airborne noise requirements.

Infrasonic and Ultrasonic Noise

The Connecticut regulation for the control of noise states in *CT section 22a-69-3.4 Infrasonic and Ultrasonic* that no person shall emit beyond his/her property infrasonic or ultrasonic sound in excess of 100 dB at any time. 100 dB with respect to the common reference of 20 microPascals is a sound pressure of 2 Pascals or 0.00029 psi. Infrasonic sounds are sound pressure fluctuations below a frequency of 20 Hertz. Ultrasonic sounds are sound pressure fluctuations at frequencies above 20,000 Hertz. Waterbury's noise ordinance does not mention either infrasonic or ultrasonic noise so the state ordinance shall be used.

Narrow bandwidth sound pressure spectrums in dB reference 20 microPascals at the 10 meter Cooling Module location given in Reference 3 can be used to compare with these Infrasonic and Ultrasonic noise requirements. Mount Sinai Hospital airborne noise data was processed in the 0 to 100 Hertz and 0 to 100,000 Hertz frequency ranges. The bandwidth of each data point is 0.375 Hertz for the 100 Hertz range and 375 Hertz for the 100,000 Hertz frequency range. The infrasonic noise for frequencies up to 20 Hertz is shown in Figure 9. The maximum level at 10 meters is 57 dB reference 20 microPascals. The entire 20 Hertz band can be power summed and equals a value of 66 dB reference 20 microPascals, well below the requirement. The ultrasonic noise for frequencies up to 100 KiloHertz is given in Figure 10. The maximum level at 10 meters is 20dB reference 20 microPascals. The entire 80 KiloHertz band from 20 to 100 kiloHertz has been power summed and equals a value of 31 dB reference 20 microPascals. Both levels fall well below the 100 dB limit at a distance 10 meters from the Cooling Module. The airborne noise level at the river gate will be at least 7 dB lower. The noise levels at the other neighbors will be at least 15dB lower based on the analysis in the previous section and there should be no issue with either infrasonic or ultrasonic noise at any of the neighboring properties. It should be noted that while the spectrum analysis covers frequencies up to 100 kiloHertz, the microphone sensors lose some sensitivity above 25 kiloHertz. The flat response below a frequency of 25 kiloHertz changes to a gradual roll off that reduces the amplitudes at higher frequencies. Fortunately, the measured noise levels are very low at 20 kiloHertz and decrease with higher frequencies and thus, no ultrasonic acoustic issues are expected above 25 kiloHertz.

Figure 8. Discrete Tones Produced by the Fuel Cell Cooling Module (0 dBV = 88.6 dB re 20uPa)

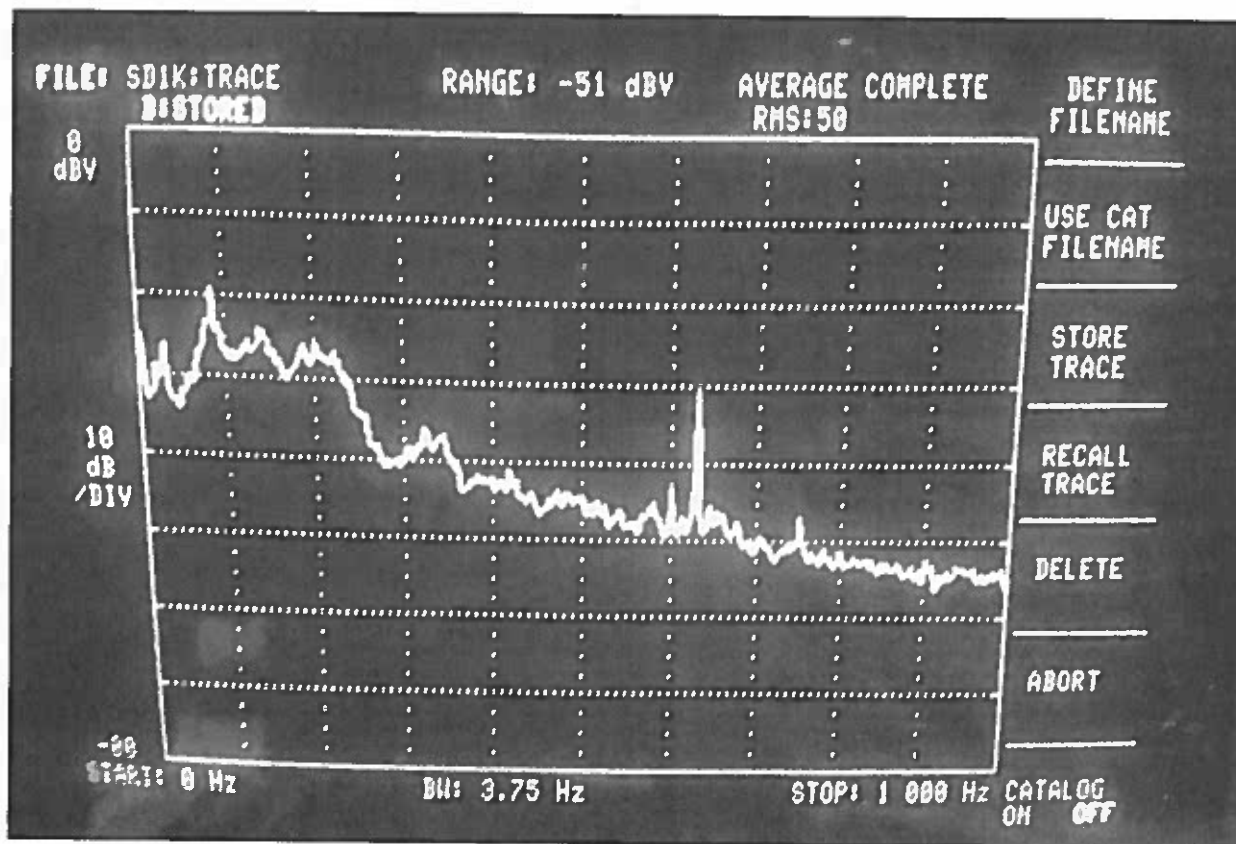


Figure 9. Infrasonic Noise from the Fuel Cell Cooling Module (0 dBV = 88.6 dB re 20uPa)

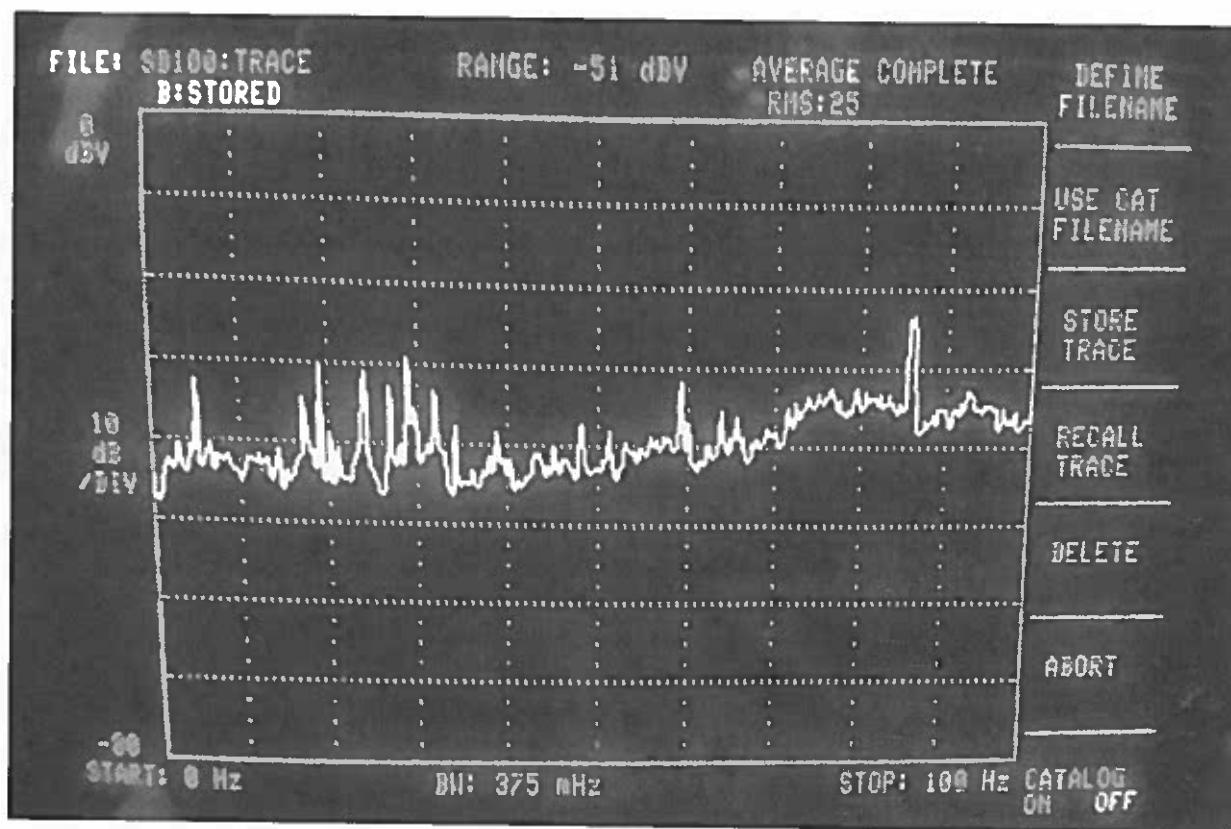
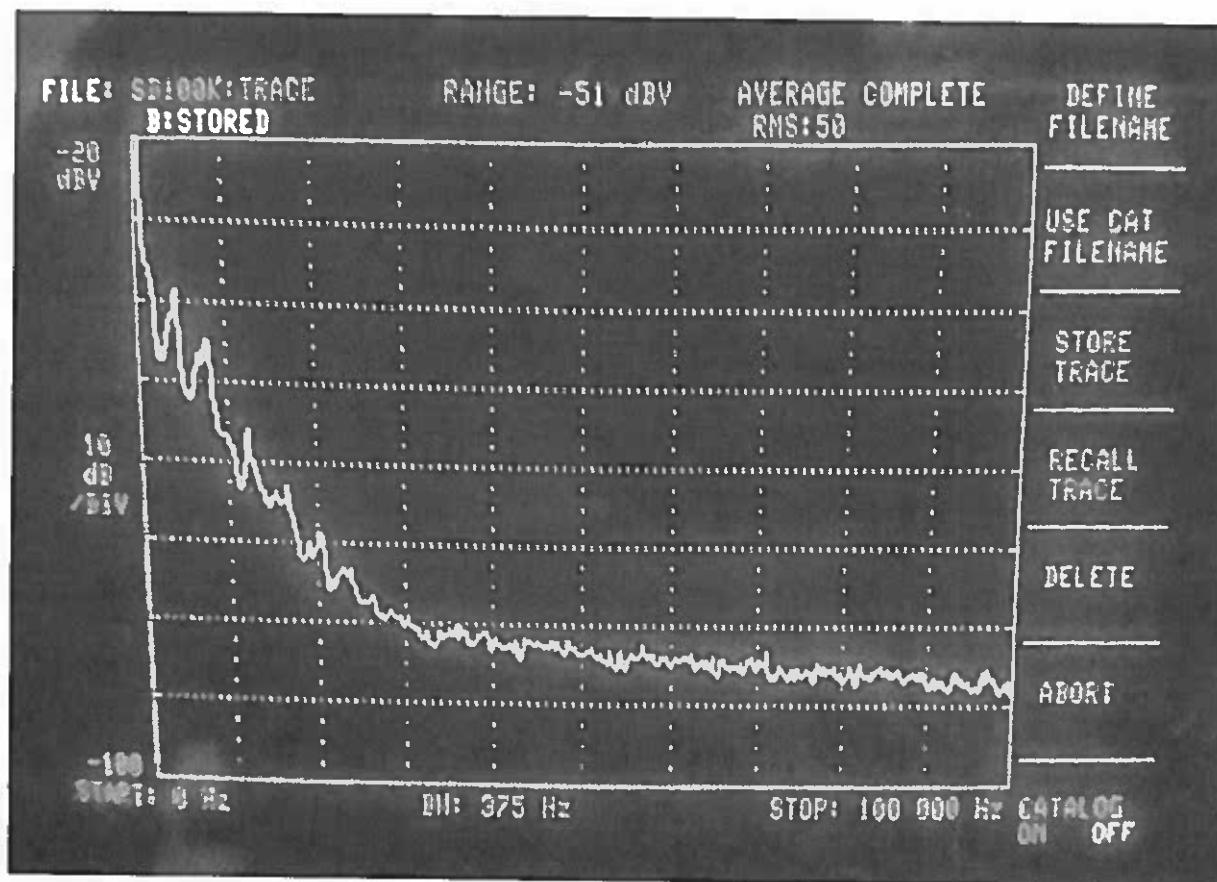


Figure 10. Ultrasonic Noise from the Fuel Cell Cooling Module (0 dBV = 88.6 dB re 20uPa)



Overall Sound Pressure Levels

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

Class C emitter to C 70 dBA B 66 dBA A/day 61 dBA A/night 51 dBA

This subsection is the most important noise requirement in the Connecticut noise ordinance. The Waterbury noise ordinance uses the same airborne noise levels. The Waterbury WWTP falls into Class C. Please see *CT section 22a-69.2 Classification of land according to use* of the Connecticut noise ordinance for details.

It is important to establish the adjacent noise zones. As stated above, the Waterbury WWTP and the Waterbury dog pound at 184 Municipal Road are in Industrial Zone IG. The business at 2391 S. Main Street is in the Industrial Zone IL to the east. The VFW at 2205 Baldwin Street is in the Commercial Zone CA to the southeast. The closest part of the residential RL zone to the northeast is about 204 meters from the fuel cell location. The closest point of the RM zone to the west is about 540 meters from the fuel cell location. The homes in the residential zones RL and RM are too far away (more than 200 meters) to hear the speakers and by comparison, the operation of the four fuel cells. The 51 dBA maximum residential level is expected to occur at about 75 meters from the four operating fuel cells.

The overall A-weighted sound pressure level measurements in dBA reference 20 microPascals are given in Table 2 above for the measurements made on January 20. The second column gives the approximate distance from the speakers to the measurement location, identified by a P number in Figure 1. The first number is the distance to the speaker at the "W,, position while the second number is the distance to the "Z,, position. Column 3 gives the noise levels measured with the speakers "on,, at position "W,, while column 4 gives the background levels before the speakers were turned on. Background corrections are applied to column 3 and the background corrected speaker noise is given in column 5. The column 5 levels with the background noise removed are estimates of the contribution provided only by the speakers at each location. Columns 6, 7 and 8 repeat this same information for the case with the speakers at position "Z,,. In this case the background was taken after the speakers at position "Z,, were turned off

The following table compares the Waterbury WWTP speaker data with the Mount Sinai Hospital fuel cell measurements. Averages are calculated for the two speaker positions and the three 5 and 10 meter locations measured at the Mount Sinai Hospital. Doubling the measurement distance from 5 to 10 meters shows a drop in level from 4.3 to 6.8 dB, fairly close to the 6 dB expected. At 5 meters the speakers generate airborne noise levels 12 dB higher than the operation of one fuel cell. At 10 meters the speakers generate airborne noise levels about 10 dB higher than the operation of one fuel cell. If we assume that four fuel cells create noise levels about 6 dB or $10 \cdot \log(4)$ higher than one fuel cell, the speakers are at least 4 dB louder than the four fuel cells using the 10 meter data. This is a conservative assumption since the middle two fuel cells may block some of the airborne noise coming from the adjacent units before the total airborne noise can propagate towards the nearby property lines.

Table 3 Measured Airborne Noise Levels in dBA (20 microPascals) Corrected for Background

Source	5 meters dBA	10 meters dBA	Range Difference In dB	Level Difference In dB	Expected dBA Level For 4 Fuel Cells
"W,"	86.2	79.4	← 6.8		
"Z,"	84.2	79.9	← 4.3	5 meters →	79.3
Speaker Avg	85.2	79.6		11.9	
Fuel Cell Avg	73.3	69.5	← 4.5	10 meters →	75.5
Mt Sinai "A,"	74	69.9		10.1	
Mt Sinai "B,"	74.3	70.3			
Mt Sinai "C,"	71.5	68.3			

Reviewing Table 2 it is clear that the airborne noise levels drop significantly in propagating to the nearby properties. The highest background corrected level was measured at 71.9 dBA at the river gate. This level is just above the Class C requirement of 70 dBA for an industrial zone. This level was created by four speakers operating at least 4 dB above the level expected during operation of four fuel cells. The river gate property line should see airborne noise levels no higher than 68 dBA with four fuel cells operating. The location at 184 Municipal Road was background limited at 57 to 59 dBA and thus will be well below the 70 dBA industrial zone limit. The business at 2392 S. Main Street showed a maximum of 64.8 dBA with the speakers on. With four fuel cells operating this level should drop to about 61 dBA, below the 70 dBA industrial zone limit. The remaining location at 2205 Baldwin Street saw airborne noise levels of 62 and 62.8 dBA with the speakers on. These should fall to about 59 dBA with four fuel cells operating, well below the commercial zone limit of 66 dBA. Operation of the four fuel cells will have no significant acoustic impact at the Waterbury WWTP site and to the nearby neighbors.

Conclusions

The purpose of this effort is to evaluate the acoustical environment at the proposed Waterbury WWTP fuel cell site in Waterbury, CT. This has been accomplished and the results show that the operation of four Doosan fuel cells will meet all of the State of Connecticut and City of Waterbury airborne noise requirements.

References

- 1) CT DE&EP *Noise Control Regulation RCSA Section 22a-69-1 to 22a-69-7.4*
<http://www.ct.gov/dep/lib/dep/regulations/22a/22a-69-1through7.pdf>
- 2) City of Waterbury Noise Ordinance
www.ct.gov/deep/lib/deep/air/noise/ordinances/waterbury_noise_ordinance.pdf
- 3) Mount Sinai Rehabilitation Hospital Airborne Noise Assessment, Carl A. Cascio, Acoustical Technologies Inc., January 26, 2017