STATE OF CONNECTICUT
CONNECTICUT SITING COUNCIL

PETITION OF DOOSAN FUEL CELL, AMERICA, INC. FOR A DECLARATORY RULING FOR THE LOCATION AND CONSTRUCTION OF A 0.44 MEGAWATT FUEL CELL CUSTOMER-SIDE DISTRIBUTED ENERGY RESOURCE AT 2 BEACH STREET, WEST HAVEN, CONNECTICUT	:	PETITION NO. 1329
	:	Oct 2, 2017

PETITION OF DOOSAN FUEL CELL AMERICA, INC. FOR A DECLARATORY RULING

Pursuant to Conn. Gen. Stat. §§ 4-176 and 16-50k(a) and Conn. Agencies Regs. § 16-50j-38 et seq., Doosan Fuel Cell America, Inc. ("Doosan"), requests that the Connecticut Siting Council ("Council") approve by declaratory ruling the location and construction of a customer-side distributed resources project comprised of one (1) new PureCell® Model 400 phosphoric acid fuel cell ("PAFC") and associated equipment (the "Facility"), providing 0.44-megawatts ("MW") (net) of power to the West Haven WPCA complex located at 2 Beach Street, West Haven, Connecticut (the "Site") (*See* Attachment 1). The Facility will be installed, owned, maintained, and operated by Doosan.

Conn. Gen. Stat. § 16-50k(a) provides that:

> Notwithstanding the provisions of this chapter or title 16a, the council shall, in the exercise of its jurisdiction over the siting of generating facilities, approve by declaratory ruling . . . (B) the construction or location of any fuel cell, unless the council finds a substantial adverse environmental effect or of any customer-side distributed resources project or facility . . . with a capacity of not more than sixty-five megawatts, as long as such project meets air and water quality standards of the Department of Energy and Environmental Projection."

I. INTRODUCTION

The proposed Facility will be a customer-side distributed resource under 65 MW that complies with the air and water quality standards of the Department of Energy and Environmental Protection ("DEEP"). Doosan submits that no Certificate of Environmental Compatibility and Public Need is required because the proposed installation will not have a substantial adverse environmental effect.

II. DESCRIPTION AND PURPOSE OF THE PROJECT

The Facility is a customer-side installation distributed generation resource with grid interconnection to be located at West Haven WPCA, 2 Beach Street West Haven, CT 06516. The Facility will be located in the southwest corner of West Haven WPCA complex next to the parking lot. (*See* Attachments 1 and 2.1). The installation will consist of one (1) natural-gas fueled 440 kW PureCell® Model 400 phosphoric acid fuel cell system ("Fuel Cell") manufactured by Doosan in South Windsor, Connecticut (*See* Attachment 3 for Model 400 Data Sheets). The overall dimension of the Fuel Cell is eight feet four inches wide by twenty-seven feet four inches long by nine feet eleven inches tall. The unit is totally enclosed and factory-assembled and tested prior to shipment. See Attachment

The purpose of the proposed Facility is intended for distributed generation of electricity to be used to power West Haven WPCA's electrical loads. The Fuel Cell to be installed at West Haven WPCA will be capable of producing a total of 440 kW of continuous, reliable electric

power. The Facility will be net metered and will operate in parallel with the utility grid. Any electricity generated in surplus of the site's demand will be traded to the grid in accordance with the United Illuminating Interconnection Technical requirements. The Facility is capable of utilizing waste heat, but is currently not configured to do so. The Facility will provide 65% of the electrical requirements of the building under normal circumstances which would be enough power to cater for average electric baseload.

When a utility grid outage occurs, the Fuel Cell will automatically disconnect from the host facility electrical system using an internal breaker, while continuing to operate providing all the internal loads. Upon return of the utility supply, the Fuel Cell will automatically reconnect to the grid after a five minute delay. The Fuel Cell is designed to have a minimum 20-year product life. This requires overhaul or replacement of major components after 10 years of operation. Components requiring overhaul include the fuel stack assemblies and components in the fuel processing system.

III. SAFETY

The PureCell® Model 400 fuel cell system is certified by CSA international to meet strict ANSI/CSA FC-1 2014 safety standards to protect against risks from electrical, mechanical, chemical, and combustion safety hazards. The Fuel Cell will be installed in accordance with NFPA 853. In accordance with Public Act 11-101, the fuel line pipe cleaning procedure is uses inert nitrogen gas or atmospheric air. The following items are a few of the safety measures incorporated into the design. Please also refer to West Haven WPCA Emergency Response Plan in Attachment 4.

A. Fire Protection

The Fuel Cell design incorporates a combustible gas sensor and thermal fuses located throughout the Fuel Cell cabinet. The detection of a potential combustible gas mixture, a fire, or the failure of this detection circuit will result in a Fuel Cell shutdown, closing of the natural gas supply valves, and a subsequent inert gas (nitrogen) purge of the fuel cell stack and fuel processing system. This event will also result in an alarm callout notification to Doosan service personnel. The Fuel Cell is designed with an integral stop button on the outside of the enclosure to enable immediate shutdown in the event of an emergency. There is also a site-installed manual gas shut-off valve and electrical disconnect switch easily accessible to emergency personnel.

B. Gas Leak

The Fuel Cell is designed with a physical barrier that separates the equipment handling combustible gases (fuel compartment) from electrical or potential spark-creating equipment (motor compartment). The fuel compartment is maintained at a negative pressure relative to both ambient and the motor compartment in order to ensure that any gas leaks do not reach the electrical equipment in the motor compartment. The cabinet ventilation system (CVS) is designed to dilute a potential gas leak to non-combustible levels.

C. Cell Stacks and Hydrogen

The Fuel Cell operates by converting hydrogen to DC electricity. Hydrogen is lighter than air and thus does not pool like other fuels and will readily dissipate with proper ventilation, making it less likely to ignite. Also, the Fuel Cell does not store hydrogen; instead, it produces hydrogen-

rich gas at a rate equal to what it requires to produce power. The fuel cell stack is wrapped in a fire-retardant blanket. There are no materials inside the unit that would sustain a flame. There is no large volume of gas or any ignition that occurs within the cell stack.

D. Phosphoric Acid

Phosphoric acid is an integral part of the fuel cell system, acting as the electrolyte within the fuel cell stack. Phosphoric acid is a surprisingly common substance that is contained in common cola drinks. A leak of phosphoric acid is not possible because there is no reservoir of liquid: phosphoric acid is constrained within the porous structure of the fuel cell stack material by capillary action.

E. Fluid Leak

The only fluid source is water. All piping systems and pressurized water vessels are designed and fabricated to the appropriate ASME codes. Water produced through the electrochemical process is "pure" water and is reclaimed and reused by the process. Water mixed with propylene glycol and a rust inhibitor (to prevent rust and freezing in colder climates) is also used in the external cooling module.

IV. HAZARDOUS MATERIALS

The Model 400 is a PAFC power plant, capable of delivering 440 kW of electric power. As with other fuel cell technologies, hydrogen and oxygen combine in the presence of a catalyst, which causes an electrochemical reaction to produce an electric current. A PAFC uses an inorganic, concentrated phosphoric acid as the electrolyte, allowing the electrochemical reaction to take

place. The Model 400 also employs on-board natural gas reforming as part of the balance of plant to provide hydrogen to the fuel cell. Within this Fuel Cell, there are only two components that contain hazardous material: the CSA (Cell Stack Assembly) and the ILS (define here). Neither of these components present risk when servicing the Fuel Cell. The material in both the CSA and the ILS is classified as hazardous material for the purposes of shipping and therefore requires special attention. The CSA is classified as a "bulk bin", made from the repeating elements of the fuel cell stack. Some of these repeating elements are porous carbon graphite plates. The phosphoric acid used as the electrolyte is contained by capillary action within the pores of these plates. The ILS is a tank containing a self-heating solid catalyst composed of copper, zinc oxide, and alumina. Safety Data Sheets (SDS) are available in the West Haven Emergency Response Plan (See Attachment 4).

A. Shipping of Hazardous Material

The Model 400 is classified as "hazardous in transportation" under the U.S. Department of Transportation (DOT) 49CFR regulations, and likewise as dangerous goods under the International Maritime Dangerous Goods (IMDG) regulations. The description of hazardous materials contained within each Fuel Cell are listed in the following subsections.

B. Integrated Low Shift Converter

Tank (non-spec) SELF HEATING SOLID INORGANIC N.O.S. (contains metallic copper on zinc oxide and alumina), CLASS 4.2, UN3190, PGII, 900 lb. net wt of hazardous material.

C. Cell Stack Assembly

Bulk bin (non-spec) SOLIDS CONTAINING CORROSIVE LIQUID N.O.S. (contains phosphoric acid), Class 8, UN3244, PGII, 1200 lb. net of hazardous material.

D. Integration into Fuel Cell Power Plant

The above items are individual components that are assembled side by side in a full assembly, with other non-hazardous components, to form one complete Model 400. The containers holding the hazardous material are non DOT specification containers. U.S. DOT regulations allow for the transportation of the hazardous material noted above in non DOT specification portable tanks and closed bulk bins, as shipped in the Model 400. IMDG regulations require United Nations (UN) specified containers or an exemption for international ocean transport.

E. Servicing of Product with Hazardous Material Present

The hazardous material contained within the CSA and the ILS presents no danger to installation and service personnel since direct exposure to the material is not possible. Under normal operating conditions, each container, as defined above, will contain its hazardous material for the life of the component. When end of life requires replacement of either component, no special precautions need to be employed with respect to handling as hazardous material will not come in contact with service personnel.

F. Hazardous Waste

The fuel cell does not produce any hazardous waste.

V. **THE SITE**

The Facility is proposed to be located entirely on West Haven WPCA which is a gated and entirely fenced property located on 2 Beach Street, West Haven CT 06516. The proposed location is zoned Public Facility (PF) under the zoning regulations of the Town of West Haven (the "Town"). *See* Attachment 2.2. The surrounding parcels bordering the north of the host property are zoned One-Two-Three Family Residence (R3), to the west and south is zoned Open Space (OS), to the southwest is zoned Single Family Detached Residence (R2) (*See* Attachment 5).

The Facility would be located in the southwest corner of WHWPCA complex next to the parking lot (*See* Attachments 1). Refer to an Aerial map of West Haven WPCA which clearly shows the location of Fuel Cell Facility on the host property in Attachment 2.1. The nearest residential property is across Beach Street 300, feet from the Facility. The proposed Fuel Cell would be placed on an elevated concrete pad to be raised above the base elevation and will be protected from unauthorized intrusions or vehicle traffic by a fence as per detailed West Haven WPCA Site plan. New Haven Airport, the nearest airport, is 11,300 feet from the proposed Facility. The proposed Facility will be a maximum of 25 feet above ground level and does not fall under the FAA notification requirements of 14 CFR Part 77.9.

VI. **PROJECT BENEFITS**

Fuel cell technology represents an important step in advancing Connecticut's goal of diversifying its energy supply through the use of renewable energy, as expressed in Connecticut General Statutes Section 16-244 et seq. The Facility will serve as a cost-effective clean energy source while also reducing the demand for grid electricity from this location. Further, this Fuel

Cell installation will support the efforts of the State of Connecticut to be a leader in the utilization of fuel cell technology.

Because a fuel cell does not burn fuel, the system will significantly reduce air emissions associated with acid rain and smog. Emissions standards of Connecticut will further be discussed in the next section. The Facility is designed to operate in total water balance – no make-up water is normally required after start-up and no water discharges to the environment will occur under normal operating circumstances.

VII. ENVIRONMENTAL EFFECTS

1. Water, Heat and Air Emissions

The proposed installation will have no substantial adverse environmental effect. The installation and operation of the Fuel Cell will meet all air and water quality standards of the Connecticut Department of Environmental Protection ("DEEP").

Section 22a-174-42 of the Regulations of Connecticut State Agencies (RCSA) governing air emissions from new distributed generators exempts fuel cells from air permitting requirements. Notwithstanding this exemption, the Fuel Cell system meets the CT emissions standards for a new distributed generator as shown in Table 1 below, and no permits, registrations or applications are required under rules based on the actual emissions of the Fuel Cell. Furthermore, the Fuel Cell system is certified by the California Air Resources Board to meet the Distributed Generation Certification Regulation 2007 Fossil Fuel Emissions Standards (*See* Attachment 6).

Table 1: CT Emissions Standards for a New Distributed Generator

Air Pollutant	CT Emissions Standard (lbs/MWh)	PureCell Model 400 Fuel Cell System at Rated Power (lbs/MWh)
Oxides of Nitrogen	0.15	.01
Carbon Monoxide	1	.02
Carbon Dioxide	1650	1078

With respect to water discharges, the Model 400 Fuel Cell is designed to operate without water discharge under normal operating conditions. To the extent that minimal water overflow may occasionally occur, such discharges will consist of de-ionized water and will be directed to a site sanitary drain or dry well. This discharge will be incorporated into the overall site design, and will be covered by the site's water discharge permit, if necessary. The unit operates in water balance below 86°F. The initial fill requires 350 gallons of water. The amount of make-up water above 86°F increases linearly from 0gpm to 1gpm at 110°F. By offset power produced by the grid, it is expected the facility will save 1.65 million gallons per year of water.

2. Wildlife and Habitat

According to the relevant portion of the CT DEEP West Haven Natural Diverse Database areas Map (*See* attachments 7.1 and 7.2) portions of the West Haven WPCA complex ("Host Property") are situated within the West Haven Natural Diversity Data Base Area. The proposed Facility will be constructed just outside the boundary of the Natural Diversity Data Base Area. Furthermore, the Host Property is an already disturbed location developed with standing constructions like Waste Water Treatment Plant and other residential properties within the neighborhood. Therefore the Facility installation and operation will have no substantial adverse effect on listed endangered species. No trees over six inches in diameter are required to be

removed for the installation of the facility, and no parking spaces would need to be eliminated to create space for the Facility.

3. Noise Analysis

Based on the recommendation of acoustic site survey conducted by a professional acoustic engineer of the proposed site on September 15, 2017, Doosan plans to install a sound barrier 63 feet long and 8 feet high around the Facility to mitigate the effect of airborne noise on the nearest residences on 2nd Ave. With the installation of a sound barrier, the anticipated sound level at residential property boundary will be below all state and town noise threshold. Please review the attached Acoustic Survey Report and Recommendations in Attachment 8.

4. Visual Impact

The Host Complex is an enclosed/fenced Public Facility with a number of buildings within its proximity. External appearance of the new Facility should blend well with the existing structures and installed equipment in West Haven water pollution control complex site. Furthermore, an 8-feet tall sound barrier will enclose the Facility from the neighboring properties and will not alter the general look of the complex.

5. Public Notice

Notice was provided via certified mail to all property owners, abutters and state and local officials pursuant to Conn. Agencies Regs.§16-50j-40(a). Doosan's copy of the notice letter, Abutters list and Abutters' Map are included in Attachments 9, 10 and 11. Prior to filing Petition, Doosan sent notices to all applicable State and Municipal officials of West Haven as listed in Attachments 12, 13 & 14 showing the certified mail receipts for State and Municipal officials and Abutters.

6. Project Decommissioning Plan

Following the 20-year operational life of the Facility, the decommissioning plan is as follows:

A) Isolate, lock out and disconnect all piping for cooling module at the Power module. Remove gas piping to the unit. Disconnect nitrogen purge system at power module.

B) Disconnect all electrical conductors and conduit at the unit to include electrical power, cooling module power, and nitrogen pressure switch. Shore power to be maintained to the unit to maintain temperature as needed.

C) Contractor will work in concert with Doosan's Service Dept. personnel during decommissioning and shutdown.

D) Return facility to original condition with the exception of the concrete pads

E) The decommissioned Fuel Cell will be stripped, the parts are separated and either recycled, reclaimed or transported to landfill. There's no significant monetary recovery for the contents of the de-commissioned Fuel Cell.

7. Aquifer Protection Area, Coastal Boundaries and Flood Zones

From an analysis of the Federal Emergency Management Agency's ("FEMA) National Flood Insurance Program ("NFIP") flood mapping data for West Haven (*See* Attachment 15), the proposed Facility is situated within the 100- year or 500-year flood elevation. To prevent the Facility from inundation, the concrete pad will be raised above the 100- year flood elevation of 10 feet relative to 1988 NAVD. The Town of West Haven has no Aquifer Protection Areas near the host property.

According to National Wetlands Inventory, www.fws.gov/wetlands/data/mapper, the West Haven WPCA site is excluded and not considered as wetlands. Hence, the Facility that will be installed inside the limits of the WPCA site would not have negative impact on the watercourses and wetlands environment (*See* Attachment 16).

8. Cultural Resources.

The proposed facility will be located in an already developed vicinity, consequently construction and operation of the Fuel Cell Facility will have no unpleasant effect on any cultural (historical and archaeological) resources in the area.

9. Natural Gas Desulfurization Process

Sulfur is present in pipeline natural gas. It is primarily used as an odorant so leaks can be easily detected. Unfortunately sulfur is also a poison to fuel cell systems and must be removed by the Model 400 system. For further details of desulfurization please refer to the attached Desulfurization memo (See Attachment 17).

VIII. CONSTRUCTION AND MAINTENANCE

Doosan plans to start construction work by December 7, 2017. Construction will take approximately ten weeks, followed by approximately four weeks of testing and startup. Regular working hours for the proposed project are Monday through Friday from 8:00 am to 5:00 pm. Doosan and its contractors will cooperate in full with the City Inspector and will follow all West Haven town and Connecticut State construction policies and codes.

IX. LOCAL INPUT AND STATE FUNDING

Doosan Fuel cell America, Inc. met with the local and town officials and presented the plans for the installation of the Fuel Cell. A bid has been submitted for Class I renewable energy credits (RECs) through the CT Low and Zero Emission Renewable Energy Credit Program. Doosan will complete all necessary permitting before installing the unit at West Haven Water Pollution Control Authority.

X. CONCLUSION

As set forth above, Doosan requests that the Council issue a determination, in the form of a declaratory ruling, that the proposed installation above is not one that would have a substantial adverse effect, and, therefore, that a Certificate is not needed.

Respectfully submitted,

……

Patricia Walker, Esq.

Assistant General Counsel

Doosan Fuel Cell America, Inc.

LIST OF ATTACHMENTS

Attachment 13: West Haven Town and Connecticut State Officials Notification Letter

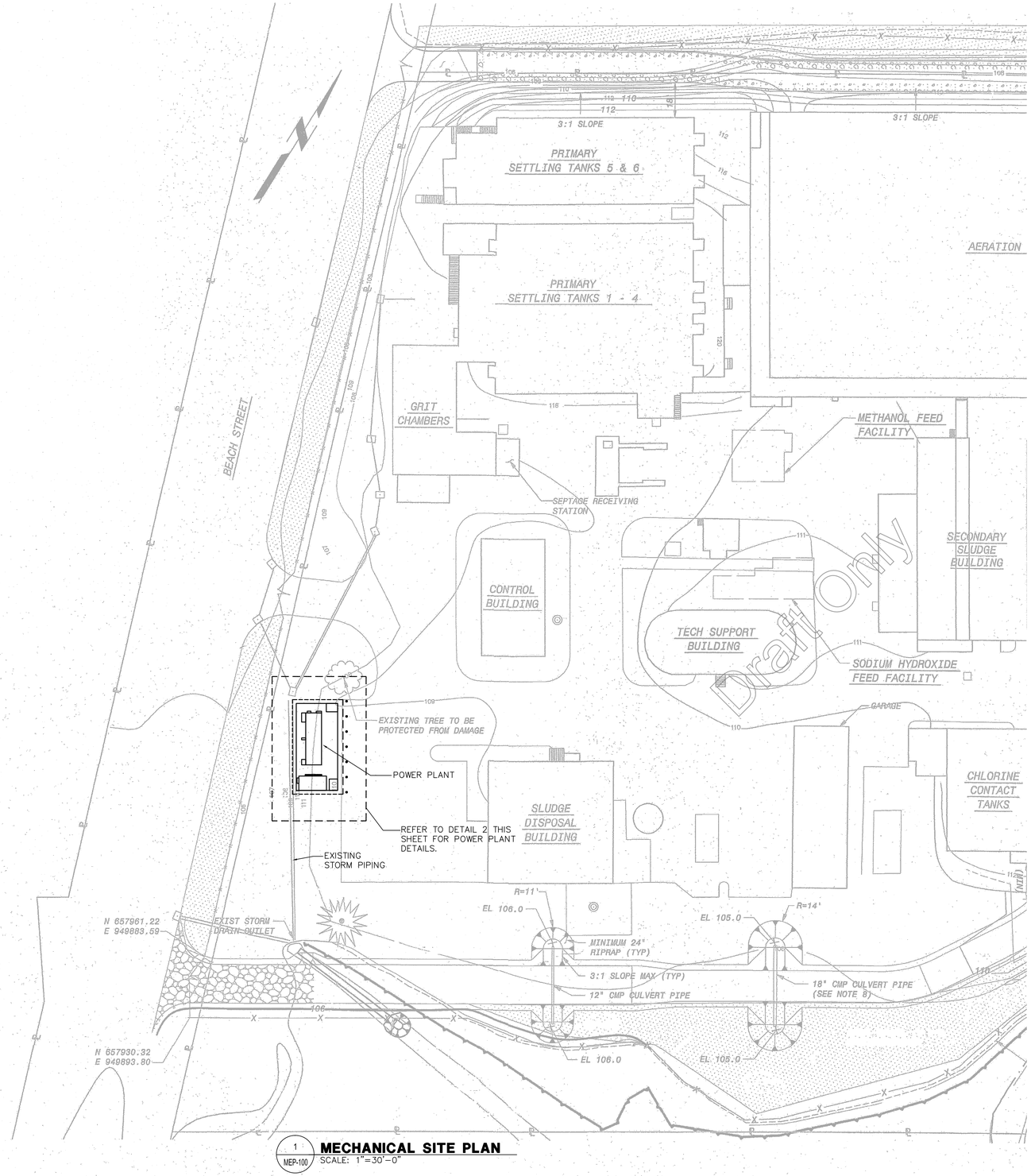
Attachment 14.1: Copy of Certified Mail receipts for letters to Abutters, State/Town officials

Attachment 14.2: Copy of Certified Mail receipts for letters to State/Town officials

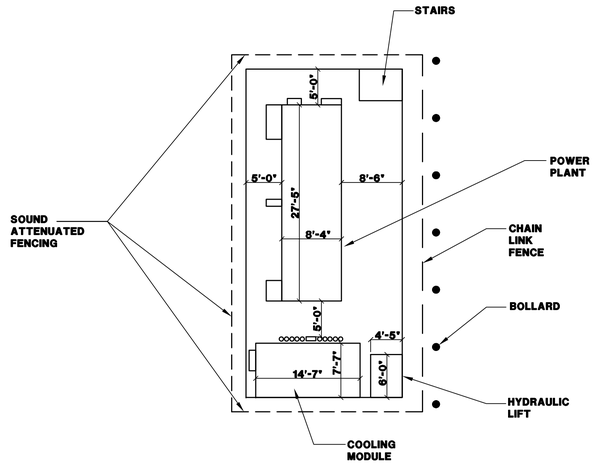
Attachment 15: FEMA Flood Map

Attachment 16: West Haven WPCA Wetlands Map

Attachment 17: Doosan Natural Gas Desulfurization Process Memorandum



1 MEP-100 **MECHANICAL SITE PLAN**
SCALE: 1"=30'-0"



2 MEP-100 **MECHANICAL PART PLAN**
SCALE: 1"=10'-0"

DOOSAN

SITE COUNCIL DRAWING
WEST HAVEN, CONNECTICUT

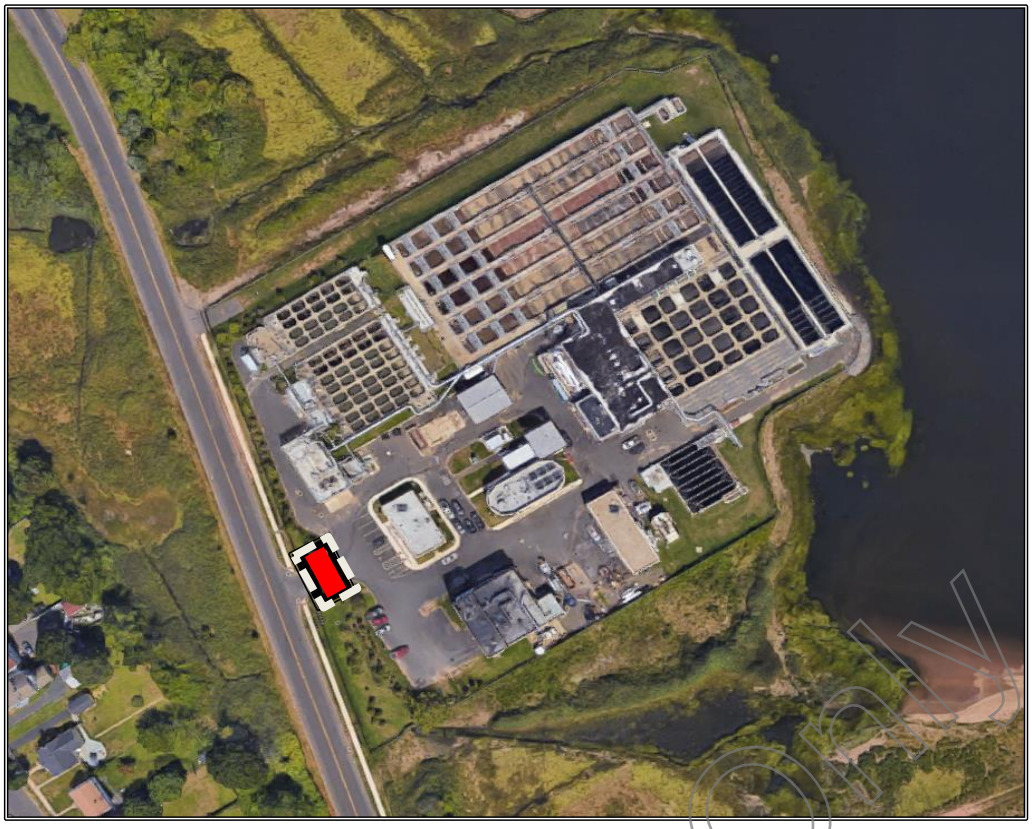
COLLECTIVE DESIGN ASSOCIATES INC.
46 Riverside Avenue
Westport, Connecticut 06880
Telephone (203) 299-0250 Fax (203) 299-0245

DRAWING TITLE: MECHANICAL SITE PLAN

REVISIONS:

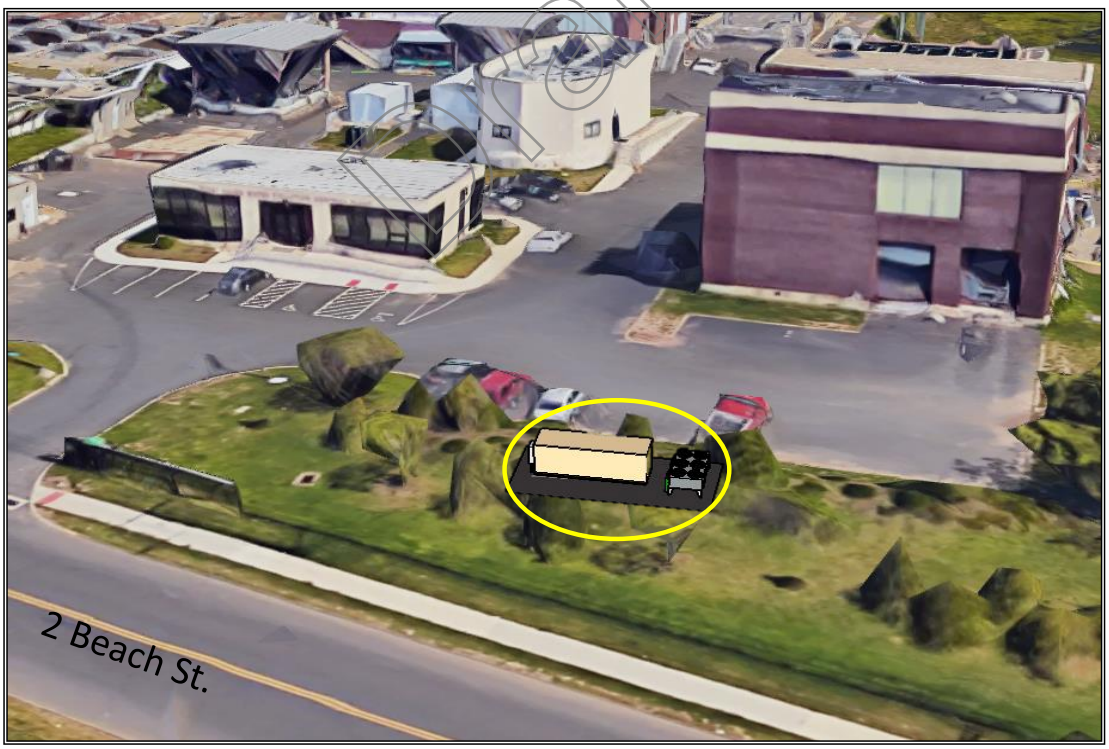
SCALE: AS NOTED
DATE: 09.21.17
DRAWN BY: B.D.T.
SHEET NO: **MEP-100**
JOB NO: 2017.132

WEST HAVEN WPCA AERIAL VIEW



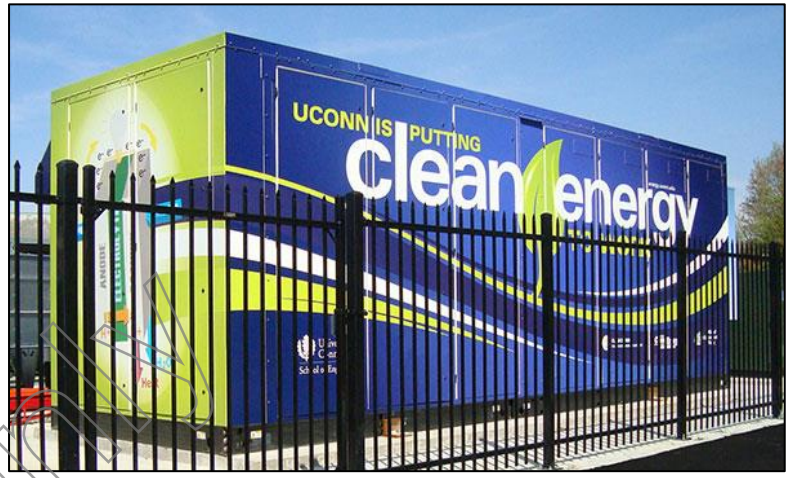
SCALE: 1" = 100'

WEST HAVEN WPCA LAYOUT CONCEPT



***Removed sound barrier for clarity**

Worldwide M400 PureCell Installations



Site Images

Proposed Pad Location: Facing South

Proposed Pad Location: Facing West

Proposed Pad Location: Facing North

Proposed Pad Location: Facing Northeast

PureCell® Model 400

PURECELL SYSTEM BENEFITS

Energy Security

Proven PAFC fuel cell technology that is setting durability records

Energy Productivity

Increased efficiency and continuous on-site generation reduces energy costs

Energy Responsibility

Ultra-low emissions equals sustainability

PURECELL SYSTEM COMPETITIVE ADVANTAGES

Long Life

Industry leading 10-year cell stack life assures high availability and low service cost

Modular & Scalable

Solutions for multi-megawatt applications to meet growing energy demand

Experience

Most knowledgeable and experienced team in the industry

High Efficiency

Up to 90% total CHP Efficiency

Grid-Independence

Proven performance delivering power when the utility grid fails

Load Following

Capable of dispatching power to match building needs

Small Footprint

Highest power density among clean generation technologies

Flexible Siting

Indoor, outdoor, rooftop, multi-unit

RATED POWER OUTPUT: 440KW, 480VAC, 50/60HZ

Characteristic	Units	Operating Mode	
		Power 460kW	Eco 440kW
Electric Power Output[1]	kW/kVA	460/541	440/518
Electrical Efficiency	%, LHV	43%	45%
Peak Overall Efficiency	%, LHV	90%	90%
Gas Consumption[1]	MMBtu/h, HHV (kW)	4.09 (1,200)	3.77 (1,104)
Gas Consumption[1,2]	SCFH (Nm^3/h)	3,995 (107)	3,674 (98.4)
High Grade Heat Output @ up to 250°F[1]	MMBtu/h (kW)	0.72 (212)	0.55 (162)
Low Grade Heat Output @ up to 140°F[1]	MMBtu/h (kW)	1.03 (301)	1.00 (292)

FUEL

Supply ..... Natural Gas
Inlet Pressure ..... 10 to 14 in. water (2.5 - 3.5 mbar)

EMISSIONS[3,4]

NOx ..... 0.01 lbs/MWh (0.006 kg/MWh)
CO ..... 0.02 lbs/MWh (0.009 kg/MWh)
VOC ..... 0.02 lbs/MWh (0.009 kg/MWh)
SO_2 ..... Negligible
Particulate Matter ..... Negligible
CO_2[1] (electric only) ..... 998 lbs/MWh (454 kg/MWh)
(with High-Grade heat recovery) ..... 815 lbs/MWh[5] (371 kg/MWh)
(with full heat recovery) ..... 485 lbs/MWh[5] (220 kg/MWh)

OTHER

Ambient Operating Temp ..... -20°F to 104°F (-29°C to 40°C)
Sound Level ..... <65 dBA @ 33 ft. (10m)
Water Consumption ..... None (up to 86°F (30°C) Ambient Temp.)
Water Discharge ..... None (Normal Operating Conditions)

CODES AND STANDARDS

ANSI/CSA FC1-2014: Stationary Fuel Cell Power Systems
UL1741-2010: Inverters for Use With Distributed Energy Resources

NOTES

1. Average performance during 1st year of operation.
2. Based on natural gas higher heating value of 1025 Btu/SCF (40.4 MJ/Nm3)
3. Emissions based on 440 kW operation.
4. Fuel cells are exempt from air permitting in many U.S. states.
5. Includes CO_2 emissions savings due to reduced on-site boiler gas consumption

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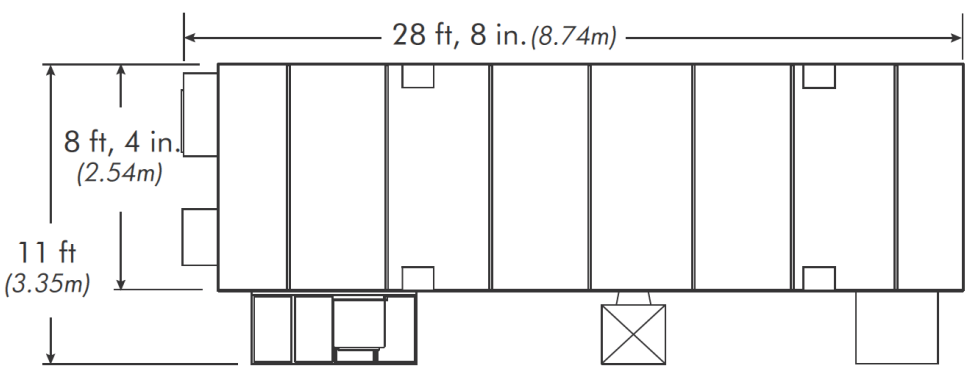
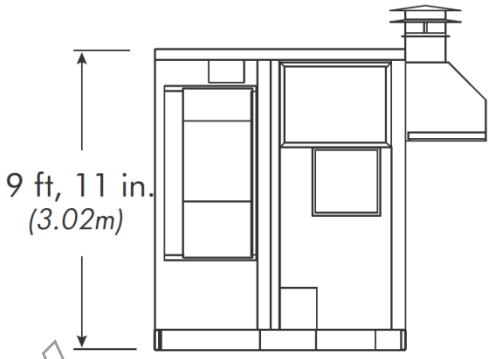
PureCell® Model 400

SYSTEM DIMENSIONS

Power Module

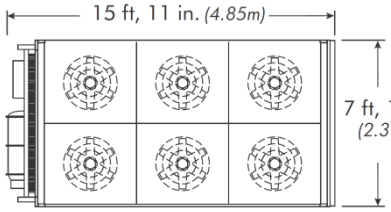


Top View

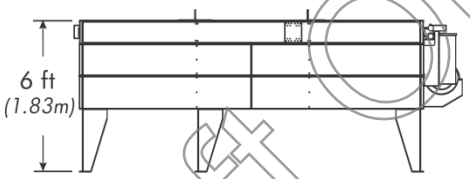


Side View

Cooling Module



Top View



Side View

PHYSICAL SPECIFICATIONS

	Power Module	Cooling Module
Length	28′ 11″ (8.74m)	15′ 11″ (4.85m)
Width	8′ 4″ (2.54m)	7′ 10″ (2.39m)
Height	9′ 11″ (3.02m)	6′ 0″ (1.83m)
Weight	57,000 lb (27,216 kg)	3,190lb (1,447 kg)

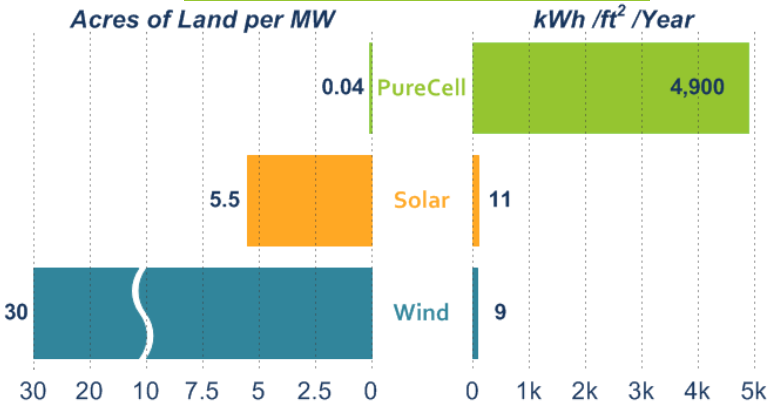
PURECELL ADVANTAGE

OFFSET 3x MORE CO_2

CAPACITY FACTOR

CO_2 OFFSET

USE LESS LAND



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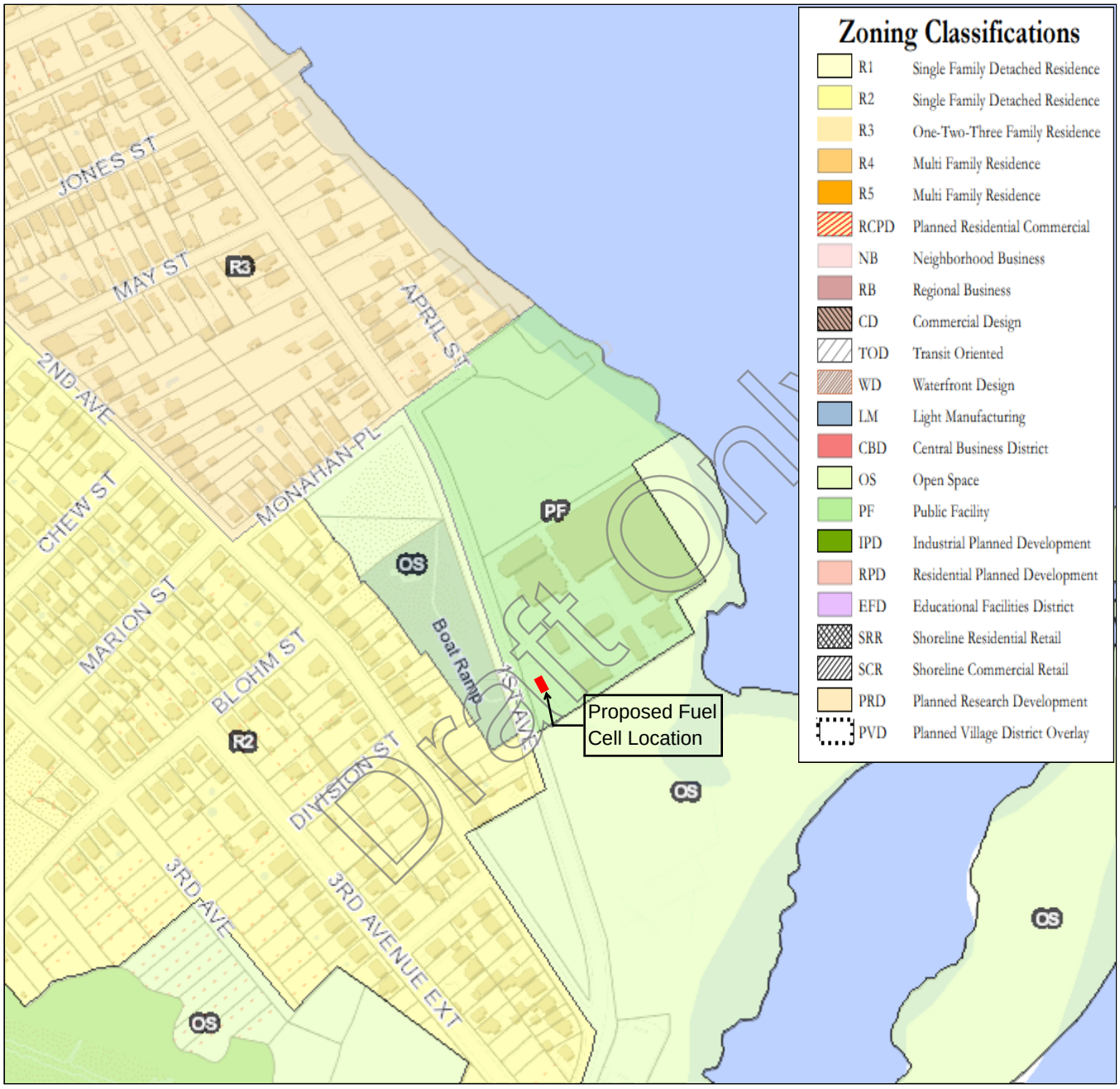
City of West Haven

Geographic Information System (GIS)

Date Printed: 9/21/2017



MAP DISCLAIMER - NOTICE OF LIABILITY

This map is for assessment purposes only. It is not for legal description or conveyances. All information is subject to verification by any user. The City of West Haven and its mapping contractors assume no legal responsibility for the information contained herein.

Approximate Scale: 1 inch = 400 feet

0 400 Feet

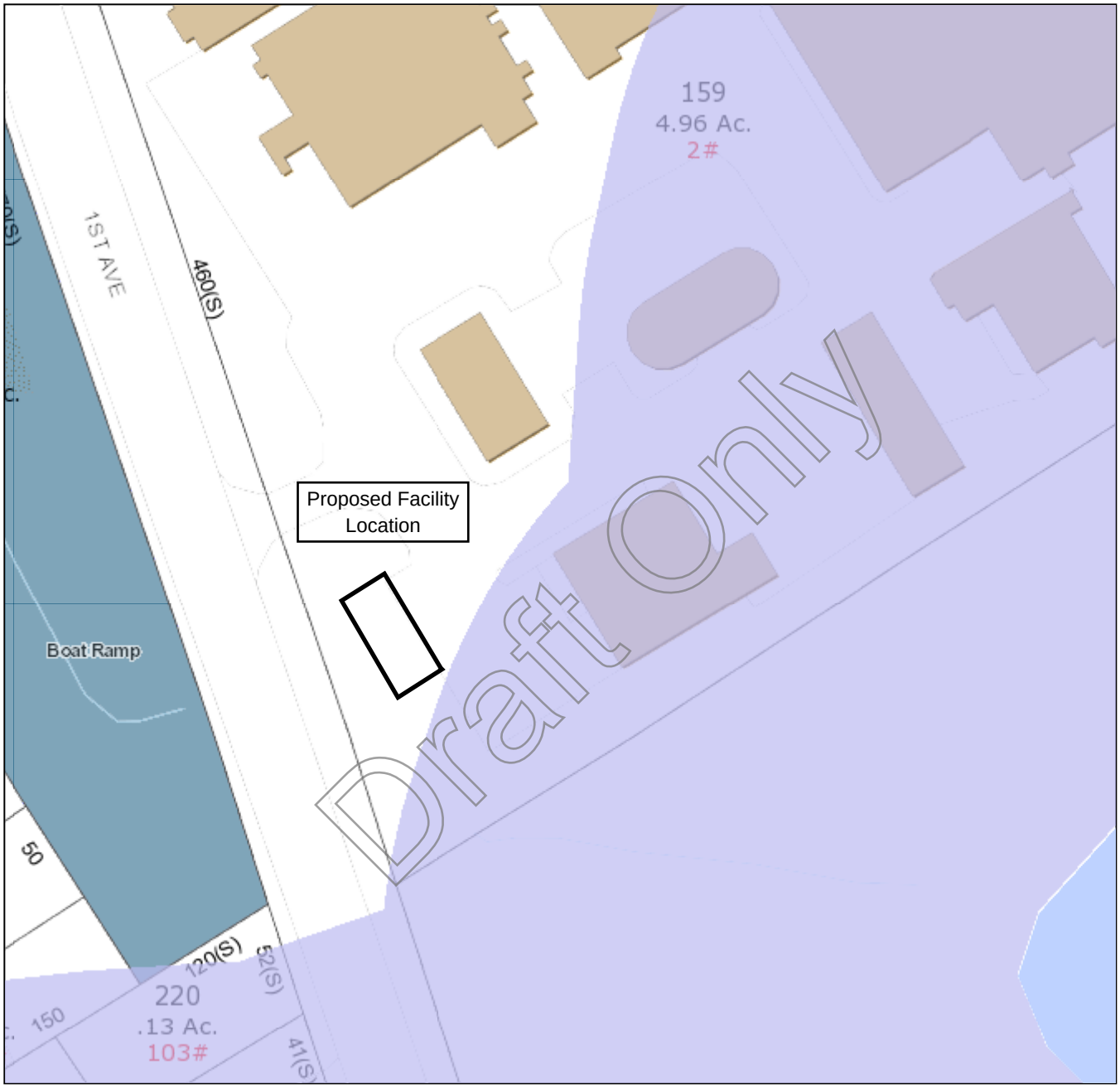
N W E S

City of West Haven

Geographic Information System (GIS)

West Haven DEEP Diverse Database Areas Map

Date Printed: 9/27/2017



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Approximate Scale: 1 inch = 75 feet

0 75 Feet

N W E S

Natural Diversity Data Base Areas

WEST HAVEN, CT

June 2017

State and Federal Listed Species & Significant Natural Communities

Town Boundary

NOTE: This map shows general locations of State and Federal Listed Species and Significant Natural Communities. Information on listed species is collected and compiled by the Natural Diversity Data Base (NDDB) from a number of data sources . Exact locations of species have been buffered to produce the general locations. Exact locations of species and communities occur somewhere in the shaded areas, not necessarily in the center. A new mapping format is being employed that more accurately models important riparian and aquatic areas and eliminates the need for the upstream/downstream searches required in previous versions.

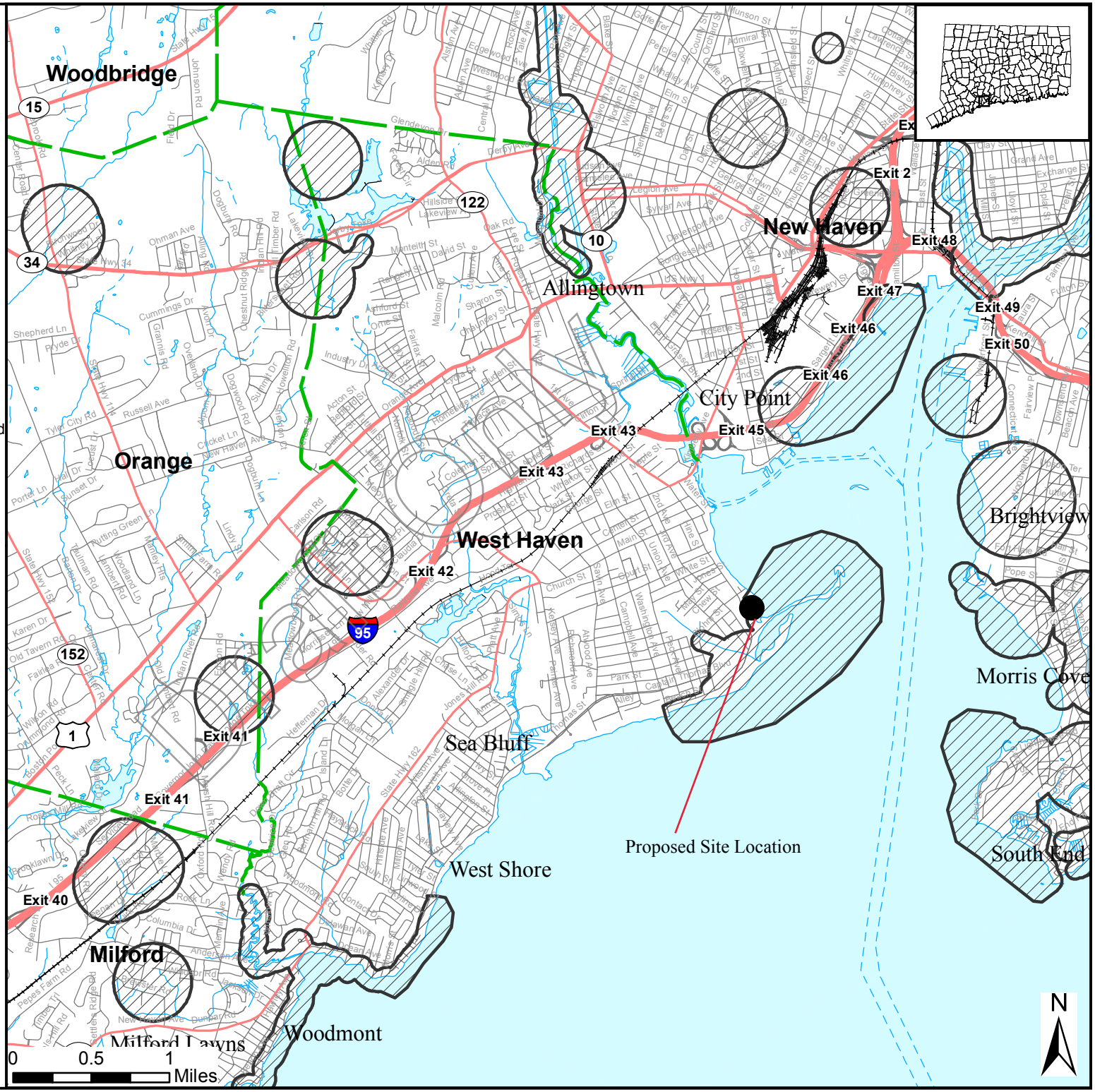
This map is intended for use as a preliminary screening tool for conducting a Natural Diversity Data Base Review Request. To use the map, locate the project boundaries and any additional affected areas. If the project is within a shaded area there may be a potential conflict with a listed species. For more information, complete a Request for Natural Diversity Data Base State Listed Species Review form (DEP-APP-007), and submit it to the NDDB along with the required maps and information. More detailed instructions are provided with the request form on our website.

www.ct.gov/deep/nddbrequest

Use the CTECO Interactive Map Viewers at www.cteco.uconn.edu to more precisely search for and locate a site and to view aerial imagery with NDDB Areas.

QUESTIONS: Department of Energy and Environmental Protection (DEEP)
79 Elm St., Hartford CT 06106
Phone (860) 424-3011

Connecticut Department of Energy & Environmental Protection
Bureau of Natural Resources
Wildlife Division



Prepared For: Doosan Fuel Cell America Inc.

Point of Contact: Ben Yoon

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Subject: West Haven WPCP
Airborne Noise Assessment

Author: Carl Cascio

Date: September 20, 2017

Revision: 0

Table of Contents

Summary

This document makes a positive acoustic assessment that should assist in meeting any acoustic noise concerns during the operation of a Doosan 440 KW fuel cell at the West Haven Water Pollution Control Plant (WPCP) in West Haven, 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 440 KW fuel cell. It is important to show that the airborne noise generated by the fuel cell will not significantly impact the facility's neighbors.

The airborne noise levels expected to be generated by the Doosan fuel cell operating at the West Haven WPCP were simulated by exciting a set of four co-located speakers at the fuel cell power and cooling module positions. The cooling modules are the dominant noise source. The four speakers produced an overall airborne noise level that was 12 to 13 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 or slightly exceed the fuel cell airborne noise levels at frequencies up to 250 Hertz where the airborne noise levels were low and to exceed the fuel cell signature by about 15 dB at higher frequencies where the fuel cell signature was higher in noise level. Airborne noise levels were measured at distances from 5 to 252 meters from the fuel cell location. The speakers produced average overall A-weighted sound pressure levels of approximately 88 dBA at 5 meters and 82 dBA at 10 meters (reference 20 microPascals) at the proposed fuel cell power module and cooling module locations. The airborne noise levels from the speakers at nearby property lines were measured at levels from 45 to 75 dBA. Measurement locations to the northeast and north were very quiet with levels below 52 dBA even with the speakers on. Measurement locations to the west were high because of the short distance to 1st and 2nd Avenue. Analysis of the speaker data indicated propagation losses from 7 to 37 dB from the fuel cell location to the nearby property lines. The source level at 10 meters from the operation of a Doosan fuel cell at Mount Sinai Hospital in Hartford, CT was then used as a basis for making the West Haven fuel cell airborne noise estimates.

Operation of the Doosan fuel cell should produce noise levels below the Industrial Zone noise limit of 66 dBA at all of the nearby commercial property lines (Open Space). The highest expected level of 62 dBA will be at the fence line due south 14 meters from the fuel cell cooling module. Two nearby neighbor property lines are expected to be above the night time residential noise limit with expected airborne noise levels of 55 and 56 dBA with the fuel cell on. Residences along the east side of 2nd Avenue from number 103 to 127 are also expected to be up to 5 dB above the night time noise limit. Other residences further away on 1st and 2nd Avenue are expected to be below the 51 dBA limit. All the nearby residences are expected to be below the 61 dBA daytime noise limit. An eight-foot high acoustic barrier lining the west, south and north sides of the fuel cell enclosure is recommended to eliminate this night time noise issue for the 12 residences on 2nd Avenue. With this noise barrier in place there should be no acoustic issues during operation of the Doosan 440 KW fuel cell.

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 fuel cell 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 West Haven WPCP on Beach Street and First Avenue in West Haven, CT. Responding to a request from Ben Yoon, a site visit was made on September 15, 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 a Doosan fuel cell in West Haven, CT.

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 a Doosan 440 KW fuel cell at the site in West Haven, CT. The West Haven WPCP at 2 Beach Street is located in a Public Facility Zone near Sandy Point in the New Haven Harbor. This Public Facility Zone (PF) is surrounded by Open Space (OS) on three sides and a Single Family Residential Zone (R2) to the west as well as a 1-3 Family Residential Zone (R3) to the north. (The West Haven zoning map is given below.) It is important to determine whether the airborne noise generated by the Doosan fuel cell will impact these neighbors.

The acoustic impact is assessed in the following way. The fuel cell is 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 both overall 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 have been programmed through a set of two octave band filters to generate a noise spectrum similar to that of the new fuel cell. (It is assumed that the cooling and fuel module noise in the existing measured units is similar to the new unit.) 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 potentially high background noise at the site the speaker output will be increased to a level higher than the overall dBA level measured on a fuel cell at a distance of 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 proposed fuel cell location 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 Town of West Haven has a Noise Ordinance with similar requirements to the State of Connecticut’s Noise Code and both have been consulted to assess the impact of the measured and estimated acoustic levels. Because of the closeness of the fuel cell site to the property lines noise mitigation may be recommended if the airborne noise estimated for the fuel cell exceeds the noise requirements at the neighbors’ property lines.

Acoustic Measurement Program

The acoustic data necessary to assess the impact of the 440 KW Doosan Fuel Cell are described below: Airborne sound pressure measurements and audio tape recordings were conducted at the West Haven WPCP on and near 2 Beach Street on September 15, 2017 during the morning hours. 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 407780A Digital Sound Level Meter (s/n 140401544) that had been calibrated just prior to and just 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 made with a Sony Digital Audio Tape Recorder (model TCD-D7 s/n 142000) with microphones on channels 1 and 2. The two PCB microphones (model 130C10 s/n 13286 and 130D10 s/n 16011) were powered by two Wilcoxon P702B power supply/amplifiers (s/n 1992 and 1995 respectively). The PCB microphones were also calibrated prior to and after the test with the Quest model QC-10 Calibrator (s/n Q19080194). All measurements were made with the microphones at a height above ground between five and six 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 were also used to verify the ExTech sound level meter overall dBA readings.

At the West Haven WPCP site "speaker on" and background airborne noise measurements were taken at the following thirteen nearby property lines in the Open Space and Residential Zones:

Location	Zone	Type
P1 - Fence East	OS	Open Space
P2 - Fence Corner	OS	Open Space
P3 - Fence North	OS	Open Space
P4 - Park South	OS	Open Space
P5 – 85 2nd Avenue	R2	Residential
P6 – 99 2nd Avenue	R2	Residential
P7 - Park Nearest Speakers	OS	Open Space
P8 - Park Across from WPCP Entrance	OS	Open Space
P9 - Park North near WPCP north west corner	OS	Open Space
P10 - Park at Corner 1st Avenue and Monahan Place	OS	Open Space
P11 – 1 1st Avenue, Moran Shipping	R3	Residential
P12 – 25 April Street	R3	Residential
P13 – Parking Lot nearest WPCP	PF	Public Facility

See the Google satellite maps in Figures 1 and 2 for the approximate measurement locations. Measurements near the proposed operating fuel cell cooling module site at position CM were simultaneously taken with the ExTech sound level meter and two microphones recording on the digital tape recorder. Figure 3 provides a photograph of this site location for the cooling module. The fuel cell power module location is shown in Figure 4 below and is indicated as FM in Figures 1 and 2. At locations CM and FM a one-minute record of the acoustic noise was stored

for the speakers in the "on" condition. One to two minutes of background airborne noise data were also recorded at the two speaker positions.

Figure 1. West Haven WPCP Site Map from Google Maps

Airborne noise measurements taken outside are corrupted by rain and wind so a day was selected when the winds were 10 miles per hour or less. Table 1 provides the weather data in West Haven for the acoustic measurements on September 15, 2017. Measurements were taken over the period from 9:30 am until 11:59 am. The table below shows the temperature and wind speeds in hourly intervals. Wind conditions were good and the wind did not affect the operating and background airborne noise measurements. Also, there was no rain during the morning of September 15. Motor traffic along 1st Avenue was heavy and the measurements on 1st Avenue were delayed until no traffic was present. (We waited for periods of time when no traffic was either seen or heard at these measurement locations.) A leaf blower on 1st Avenue also delayed the measurements for a few minutes. Background noise levels at the measurement positions were acceptable with levels from 43 to 52 dBA.

Figure 2. Doosan Fuel Cell Location for the West Haven WPCP Site from Google Maps

Data Analysis

This section analyzes the airborne noise levels measured at the West Haven site and then estimates the transmission loss to nearby property lines expected during fuel cell operation. These levels will be compared to the limits in the West Haven and Connecticut noise ordinances. Both background noise levels at the West Haven WPCP and estimated Doosan Fuel Cell equipment operating noise levels will be reported. Comparing these West Haven simulated fuel cell estimates with the town and state noise limits will identify which nearby locations do or do not meet the airborne noise requirements.

Table 1. West Haven Weather on September 15, 2017 from *www.wunderground.com/weather/us/ct/west-haven*

Time (EST)	Temp. (°F)	Humidity (%)	Dew Point (°F)	Barometer (in HG)	Wind Speed (mph)	Wind Direction	Condition
7:01 AM	64.9	97	64.0	30.01	Calm	Calm	Fog
7:53 AM	68.0	100	68.0	30.02	Calm	Calm	Partly Cloudy
8:53 AM	73.0	76	64.9	30.04	Calm	Calm	Partly Cloudy
9:53 AM	75.0	73	66.0	30.05	6.9	SSE	Partly Cloudy
10:53 AM	75.0	73	66.0	30.06	8.1	SSE	Partly Cloudy
11:53 AM	78.1	64	64.9	30.06	5.8	South	Partly Cloudy
12:53 PM	78.1	56	61.0	30.06	6.9	South	Partly Cloudy
1:53 PM	80.1	58	64.0	30.04	6.9	South	Scattered Clouds

Figure 3. Speakers Used as a Simulated Airborne Noise Source at the Cooling Module Location

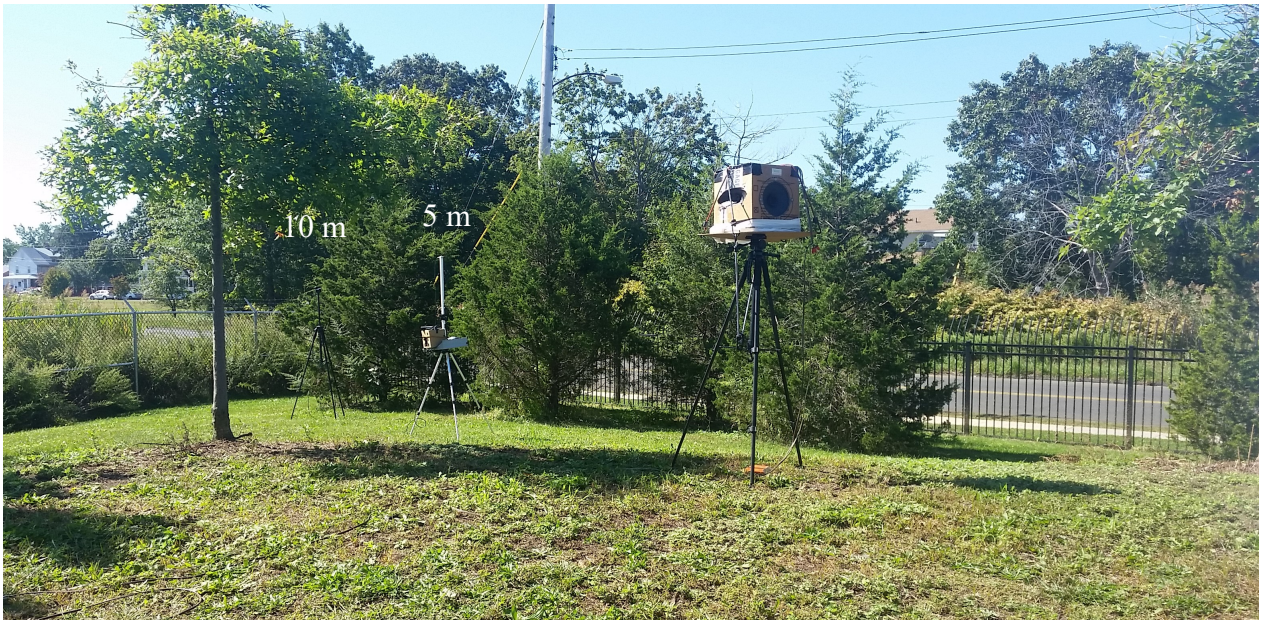


Figure 4. Speakers Used as a Simulated Airborne Noise Source at the Fuel Module Location

The complete set of overall A-weighted airborne noise levels that were measured in West Haven are provided in Table 2 for the conditions with the speakers on and off. Figure 5 is a map showing the West Haven zoning districts in the West Haven WPCP area. The position locations were calculated using the Pocket Ranger GPS App from the CT State Parks & Forests. The indicated GPS accuracy varied from 3 to 10 meters. The GPS range from the speakers to the microphone results in Table 2 were calculated with an application found at http://www.movable-type.co.uk/scripts/latlong.html and then checked with Google Maps. The estimate of the range in meters to each location are given in Table 2 and also in Table 3. The first value is the range to the center of the cooling module location and the second value is the range to the center of the fuel module location. The closest measurement location for the cooling module is P1, which is 14.4 meters due south to the fence line on the open space abutting the WPCP property. The closest measurement location for the fuel module is P3, which is 22 meters southwest to the fence line on 1st Avenue. This location is on WPCP property so the closest location on neighboring property is also P1, but now 22.6 meters from the source location at the center of the fuel module. Locations along Monahan Place and Boat Ramp Road, the first roads crossing 1st Avenue, are 232 to 252 meters away. Locations along 1st Avenue are at 32 to 84 meters.

Table 2. Overall Sound Pressure Levels in dBA ref. 20 microPascals measured at West Haven

Location	Range in Meters	Speakers On CM	Background	Bkgd Corrected	Speakers On FM	Background	Bkgd Corrected
Pos. at 5 m	5	88.5/88.7	46.9	88.6	88	48.4	88
Pos. at 10 m	10	83/82.3	<50	82.6	81.5	43.4	81.5
P1 – Fence S	14.4/22.6	75.2	<50	75.2	72.5	<50	72.5
P2 – Fence C	17.1/23.5	72.8	<50	72.8	72	<50	72
P3 – Fence N	17.3/22	78.7	<50	78.7	77	<50	77
P4 – Park S	77.2/84.3	64.5	51.3	64.3	64	51	63.8
P5 – 85 2nd A	59.3/66	66	51.5	65.8	67	49	67
P6 – 99 2nd A	57/63.7	67.5	49	67.4	68	51	68
P7 – Park Spk	32/36.2	74	49	74	73	<50	73
P8 – Park Ent	32.6/29.8	63.5	51	63.3	68.7	<50	68.7
P9 –Park NW	118/110	56	48	55.2	61	<50	60.6
P10 –1st&M P	239/232	51.3	45.7	50	51	<50	50
P11 – 1 1st A	249/242	50.4	49	45.5	49	<50	48
P12 – 23 Apr	252/246	48.6	50	<49	47.4	<50	46
P13 – P Lot	209/202	51.4	52	<51	51.5	<50	50

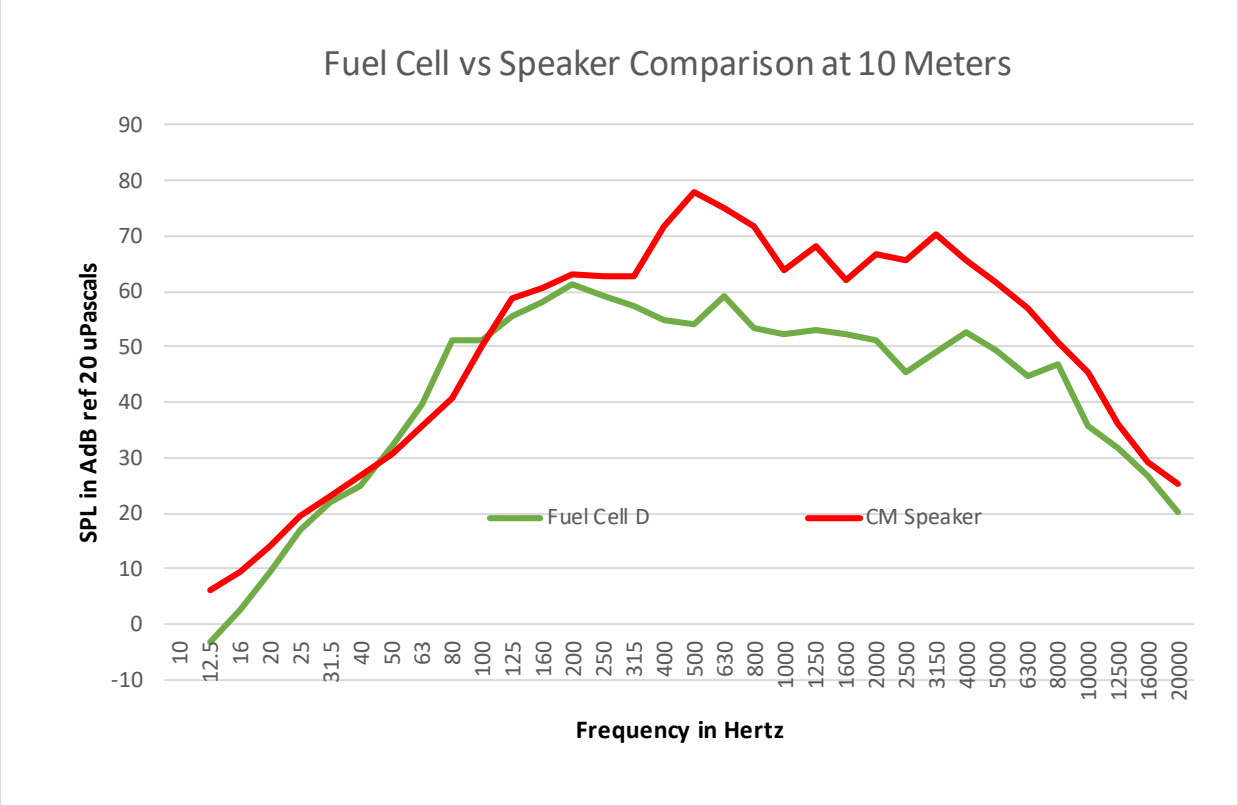
Red indicates locations where we have concern about meeting the noise regulations

Figure 5. West Haven Zoning Map Showing Speaker Location at Position CM

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 West Haven WPCP site is shown in Figure 6. The speakers roughly match the fuel cell airborne noise for frequencies below 250 Hertz and greatly exceed the fuel cell airborne noise at higher frequencies where the airborne noise levels are the highest. The overall airborne noise levels are 13 dB and 12 dB higher for the speakers at the cooling module and fuel module locations, respectively, as compared to what is expected from the Doosan 400 KW fuel cell that was measured at Mount Sinai Hospital in Hartford, CT. These 13 and 12 dB differences will be subtracted from the West Haven measured levels to estimate the actual fuel cell's acoustic signature at each location. These calculations are displayed in Table 3 below.

The West Haven WPCP speaker data were compared with the Mount Sinai Hospital fuel cell measurements. Averages were 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 of about 5 dB at Mount Sinai and 6 dB at West Haven, close to the 6 dB expected. At 5 meters, the speakers generate airborne noise levels 14.7-15.3 dB higher than the operation of the fuel cell. At 10 meters, the speakers generate airborne noise levels about 12 to 13 dB higher than the operation of one fuel cell. The 10 meter Mount Sinai airborne noise levels were used with the West Haven WPCP transmission loss data to estimate the expected fuel cell airborne noise at the West Haven WPCP property lines.

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



The estimated airborne noise levels to be produced by the Doosan fuel cell are shown in Table 3. For each of the thirteen locations the West Haven measurements are corrected to account for the higher speaker levels. The speakers at the cooling module location were 13 dB higher than the Mount Sinai fuel cell while the speakers at the fuel module were 12 dB higher. These measurements were taken at various distances from the speakers and then background corrected. Close to the speakers the fence line values in the Open Space next to the WPCP property are expected to be approximately 60 to 62 dBA. The properties across 1st Avenue are expected to be 51 to 61 dBA depending on how close the locations are to the speakers. Further along 1st Avenue and on the Monahan and Boat Ramp cross streets the noise levels drop below 51 dBA.

The transmission loss from the speakers to the measurements locations along 1st Avenue were averaged and it was found that the data followed the following expression:

Transmission Loss (TL) = 19 times the log of the distance ratio

For example, at 85 2nd Avenue TL = 19 x Log(59.3/10) or 15.6 dB below the 10 m speaker level. The FM speaker level at 10 m was 81.5 dBA so the level at 85 2nd Avenue should be 66 dBA. The background corrected level at 85 2nd Avenue shown in Table 2 was 67 dBA, 1 dB higher. Looking at 105 2nd Avenue, the nearest property not measured, the distance to the closest point is approximately 55 meters. The TL would be 14 dB with an expected noise level of 55.5 dBA. This is just below the level of 56 dBA next door at 99 2nd Avenue.

Table 3. Estimated West Haven Overall Sound Pressure Levels in dBA ref. 20 microPascals

Location	Range in Meters	Speakers On C M	Correction	Estimated SPL in dBA	Speakers On F M	Correction	Estimated SPL in dBA
P1 – Fence S	14.4/22.6	75.2	13.1	62.1	72.5	12	60.5
P2 – Fence C	17.1/23.5	72.8	13.1	59.7	72	12	60
P3 – Fence N	17.3/22	78.7	13.1	65.6	77	12	65
P4 – Park S	77.2/84.3	64.3	13.1	51.2	63.8	12	51.8
P5 – 85 2nd A	59.3/66	65.8	13.1	52.7	67	12	55
P6 – 99 2nd A	57/63.7	67.4	13.1	54.3	68	12	56
P7 – Park Spk	32/36.2	74	13.1	60.9	73	12	61
P8 – Park Ent	32.6/29.8	63.3	13.1	50.2	68.7	12	56.7
P9 –Park NW	118/110	55.2	13.1	42.1	60.6	12	48.6
P10 –1st&M P	239/232	50	13.1	36.9	50	12	38
P11 – 1 1st A	249/242	45.5	13.1	32.4	48	12	36
P12 – 23 Apr	252/246	<49	13.1	<36	46	12	34
P13 – P Lot	209/202	<51	13.1	<38	50	12	38

Red indicates residential locations above the night time airborne noise limit of 51 dBA

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 Town of West Haven has a noise ordinance (Ref. 2) with the same noise limits as the CT Code. These two ordinances will be used to evaluate the noise generated by the Doosan Fuel Cell. Following sections discuss each type of noise using the results obtained from the Mount Sinai fuel cell measurements and the recent airborne noise measurements at the West Haven WPCP.

The southern part of the West Haven zoning map is given in Figure 5. As stated above, the West Haven WPCP at 2 Beach Street is located in a Public Facility Zone. This is taken to be an Industrial Zone and is adjacent to Single Family (R2) and 1 to 3 Family (R3) Residential Zones to the west and north, respectively. To the west and south are Open Space Zones. The closest measured home to the west is 57 meters away at 99 2nd Avenue in the R2 residential zone. 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 residential noise limit at about 75 meters from the fuel cell. The shorter 57 meter distance to the cooling module will probably put the 99 2nd Avenue property line above the night time noise limit. Using the West Haven speaker measurements, the airborne noise level expected at a distance of 57 meters at the 99 2nd Avenue property line should be about 56 dBA. Other nearby properties are also expected to be above the night time residential noise limit of 51 dBA for an emitter in an industrial zone.

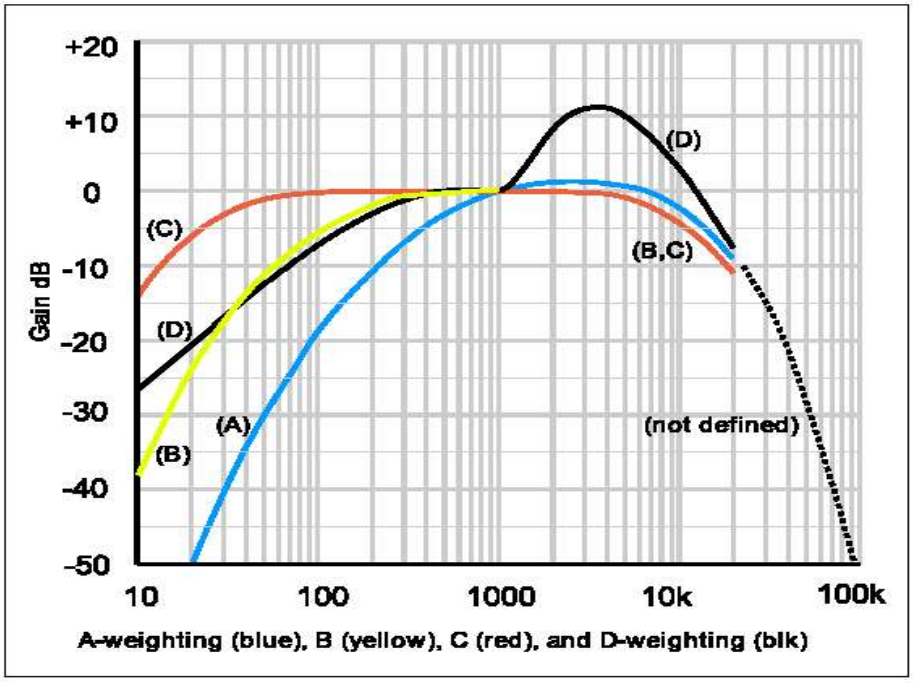
Impulse Noise

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 night time to any class A Noise Zone. West Haven has a similar subsection. Class A Noise Zones are residential. Night time hours are defined as 10 pm to 7 am in both the CT and West Haven ordinances. *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. West Haven has a similar subsection.

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 unit that will be installed in West Haven. Given the steady state nature of the fuel cell's noise signature there should be no acoustic issues with the State of Connecticut's and West Haven's impulse noise requirements.

Figure 7. Acoustic Weighting Curves

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



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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.

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. West Haven's ordinance does not discuss *Prominent discrete tones*. The CT 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 West Haven WPCP 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:

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)

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. 2) 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. The minimum transmission loss to the residential property lines on 1st Avenue is at least 13 dB so the maximum possible discrete tone would be 41 dBA at the nearest property line. This level is below the 46 dBA night time requirement in a Residential Zone. The minimum transmission loss to the Open Space property lines next to the WPCP is at least 3 dB so the maximum possible discrete tone would be 51 dBA at the nearest Open Space property line. This level is below the 61 dBA requirement in a Commercial Zone. Operating the Doosan fuel cell should produce airborne noise levels well below the CT discrete tone requirement at all the property lines. There should be no acoustic issue with the CT discrete tone noise requirements.

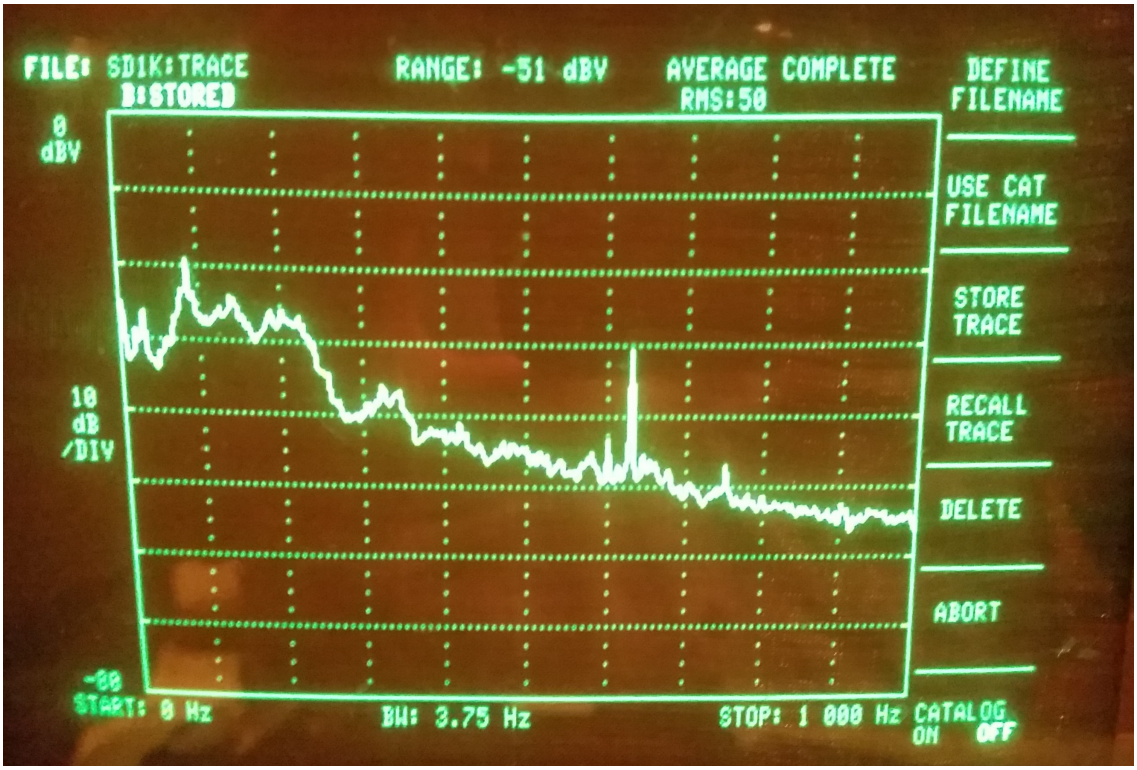
Infrasonic and Ultrasonic Noise

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 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. West Haven's ordinance does not discuss Infrasonic or Ultrasonic Noise.

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 were 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 at 10 meters. 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 ref. 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 all the Open Space property lines will be at least 3 dB lower. The noise levels at the residential neighbors will be even 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.

Figure 8. Discrete Tones Produced by the Fuel Cell Cooling Module (0 dBV = 88.6 dB re20µPa)



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.

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 below:*

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

West Haven's noise ordinance uses the same dBA values as the CT ordinance. The WPCP is in a Public Facility Zone (PF) that is surrounded by Open Space (OS) on three sides and a Single Family Residential Zone (R2) to the west as well as a 1-3 Family Residential Zone (R3) to the north. The nearby neighbors are classified as either residential or commercial (Open Space) with the residential noise limit at 61 dBA during the day and 51 dBA at night. The commercial noise limit at the Open Space locations is 66 dBA

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

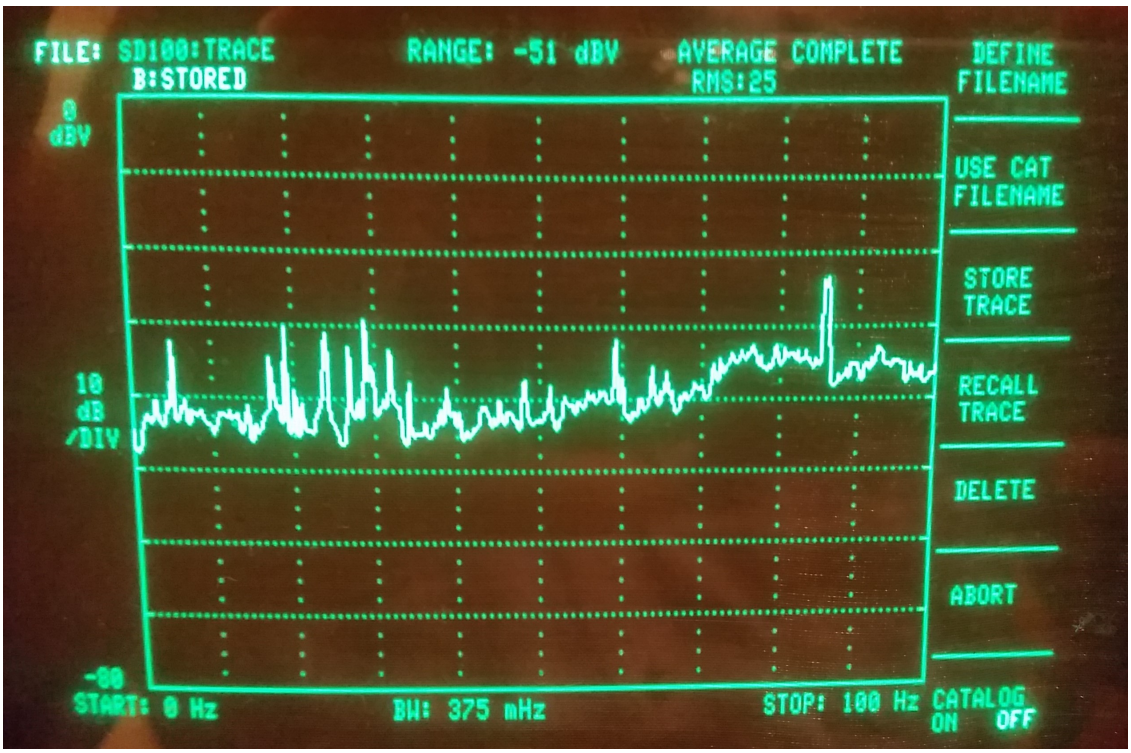
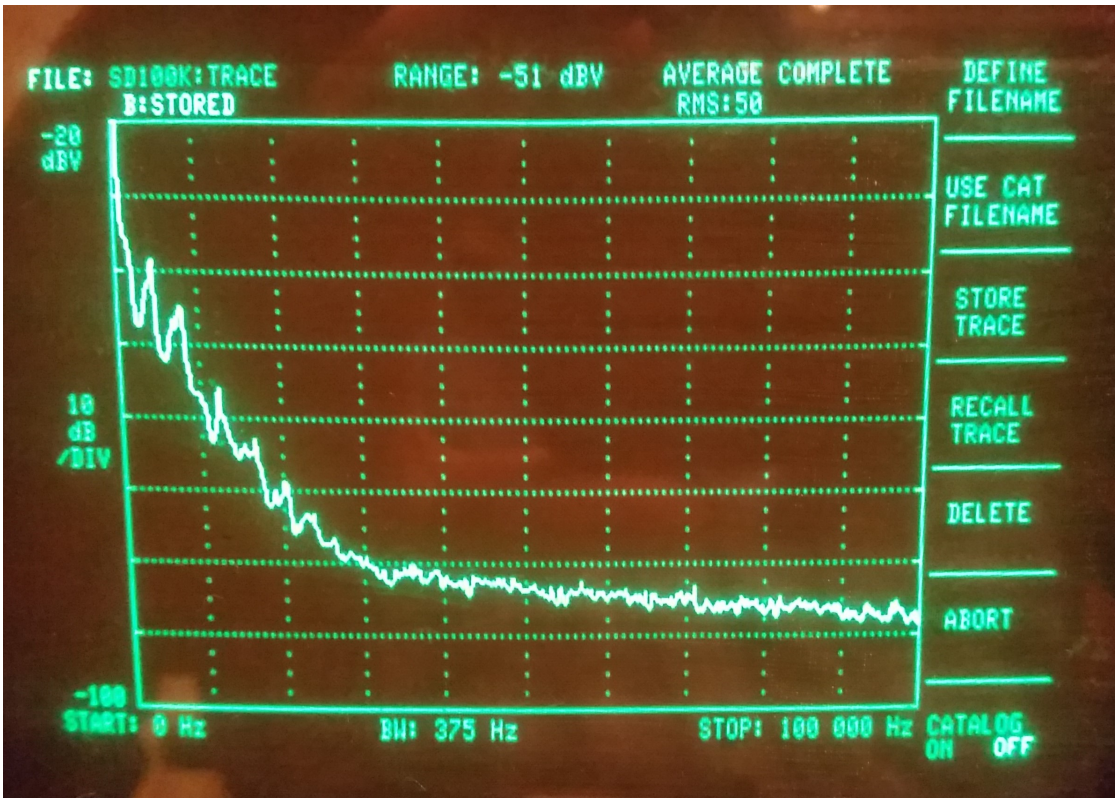


Figure 10. Ultrasonic Noise from the Fuel Cell Cooling Module (0 dBV = 88.6 dB re 20µPa)



The estimated overall A-weighted sound pressure level measurements in dBA reference 20 microPascals are given in Table 3 above for the measurements made on September 15. The second column gives the approximate distance from the speakers to the measurement location, identified by a P number in Figures 1 and 2. The first number is the approximate distance to the speaker at the cooling module position while the second number is the approximate distance to the fuel module position. Column 3 gives the noise levels measured with the speakers "on" at the cooling module while column 6 gives the noise levels measured with the speakers "on" at the fuel module. Background levels before the speakers were turned on can be found in Table 2. Background corrections were applied in creating the values in Table 3. The background corrected speaker noise at 5 and 10 meters is also given in Table 2. The airborne noise values in Table 3 with the background noise removed are then corrected to estimate the contribution provided by the new fuel cell at each location. Column 5 has the cooling module estimates while column 8 has the fuel module estimates. Values shown in red are above the residential night time noise requirements.

Reviewing Table 2 it is clear that the airborne noise levels drop significantly in propagating to the nearby properties as the range increases. The highest property line background corrected speaker level was measured at 74 dBA directly across 1st Avenue from the speakers. This property line should see airborne noise levels no higher than 61 dBA with the fuel cell operating. Two residential properties on 1st Avenue showed levels above 51 dBA for homes numbers 85 and 99 2nd Avenue. Because of the increasing loss with distance to the remaining property lines the expected fuel cell noise levels fell below 66 dBA for the Open Space property. All the expected maximum values (worse case between speaker locations) are shown in Table 4 below. All of the property line estimates will meet the 66 dBA commercial and 61 dBA daytime residential noise limits.

Table 4. Expected Airborne Noise Levels from Operating the Doosan Fuel Cell (ref. 20 µPA)

P1	P2	P4	P5	P6	P7	P8	P9	P10
62 dBA	60 dBA	52 dBA	55 dBA	56 dBA	61 dBA	57 dBA	49 dBA	38 dBA

Operation of the Doosan fuel cell will have a minor acoustic impact at the homes adjacent to the cooling module on 1st Avenue. Residential property lines on 1st and 2nd Avenue close to the fuel cell will see airborne noise levels up to 5 dB above the night time noise limit. Properties up to 100 meters away from the cooling module along 2nd Avenue would be affected (the twelve homes from 85 to 127 2nd Avenue). Property lines further away on 1st and 2nd Avenue and all the other surrounding property lines will not be affected by the operation of the fuel cell.

Conclusions

The purpose of this effort is to evaluate the acoustical environment at the proposed West Haven WPCP fuel cell site in West Haven, CT. This has been accomplished and the results show that the operation of a Doosan 440 KW fuel cell will meet all of the State of Connecticut airborne noise requirements on property lines to the north, east and south quadrants. Residences to the west along 1st and 2nd Avenue are expected to meet the commercial and daytime noise limits but be as much as 5 dB above the night time noise limit. An acoustic barrier lining the north, south and west sides of the fuel cell enclosure is recommended to eliminate this minor night time noise issue along 1st and 2nd Avenue.

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) west_haven_amended_noise_ordinance.pdf *www.ct.gov/deep/lib/deep/air/noise/.../west_haven_amended_noise_ordinance.pdf*

3) Mount Sinai Rehabilitation Hospital Airborne Noise Assessment, Carl A. Cascio, Acoustical Technologies Inc., January 26, 2017

Prepared For: Doosan Fuel Cell America Inc.

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Prepared by: Acoustical Technologies Inc.
50 Myrock Avenue
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Subject: West Haven WPCP
Noise Treatment Recommendations

Author: Carl Cascio

Date: September 22, 2017

Revision: 0

Table of Contents

Summary

This document makes acoustic noise control recommendations that should assist in meeting the acoustic noise concerns during the operation of a Doosan 440 KW fuel cell at the West Haven Water Pollution Control Plant (WPCP) on Beach Street. 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 the Doosan 440 KW fuel cell at the West Haven WPCP. This has been accomplished and the results show that the acoustic impact on the closest nearby homes on 2nd Avenue needs to be addressed.

The airborne sound pressure levels produced by four speakers simulating the airborne noise expected from operation of the Doosan fuel cell have been measured at distances from five to 252 meters from the proposed fuel cell location. With this speaker excitation, the airborne noise levels at nearby property lines varied from 45 to 75 dBA reference 20 microPascals as well as being undetectable on the north side of the WPCP site. Only the nearby west side airborne noise levels on 1st Avenue are expected to be above the state and town night time noise requirement. Airborne noise levels measured at the property lines of homes at 85 and 99 2nd Avenue (nearest to the speakers) are expected to be about 4 to 5 dB above the 51 dBA night time airborne noise limit. Ten other homes on 2nd Avenue from numbers 103 to 127 were also estimated to be slightly above the night time noise limit, all at the property line nearest 1st Avenue. The overall airborne noise estimates are all expected to meet the state and town day time 61 dBA requirement at all the residential locations, as well as meeting the state and town 66 dBA requirement at all the commercial locations (Open Space) without additional noise treatment. Operation of the fuel cell is expected to meet all requirements associated with impulse noise, prominent discrete tones, infrasonic and ultrasonic noise at all of the nearby property lines without additional noise treatment.

Operation of the fuel cell produces airborne noise predominately from the cooling module. Efforts to reduce the fuel cell's airborne noise should be directed at adding a sound barrier treatment to block the cooling module's noise from reaching the nearby residential property. The performance of a commercially available noise barrier, from Acoustical Solutions, called ABBC-EXT-R Sound Curtains was found to provide the necessary mitigation. While the recommended treatment is expected to be successful when deployed in an eight foot height, a lesser height of seven feet may also provide acceptable performance with a very small amount of margin (0.7 dB).

Installation of at least 63 linear feet of 8 foot high barrier material is recommended on the north, south and west sides of the cooling module. This amount of barrier material should meet the night time noise limits at all the neighboring property lines with about 2 dB of margin. Given this noise treatment the airborne noise generated by the fuel cell will not significantly impact the West Haven WPCP 's neighbors and will be below all state and town noise requirements at all the neighbor's property lines. An eight foot high acoustic barrier as described in this report should mitigate this noise issue and remove any acoustic concerns about siting and operating the Doosan fuel cell at the West Haven WPCP.

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 West Haven Water Pollution Control Plant on Beach Street in West Haven, CT. Responding to a request from Ben Yoon, a site visit was made on September 15, 2017. During the visit, a measurement of the simulated airborne noise levels expected to be produced by the Doosan 440 KW Fuel Cell was made in order to identify potential noise issues. Estimated airborne noise levels along the closest nearby street (1st Avenue) were higher than the state and town night time noise requirement at two locations. This document provides recommendations for the installation of a noise control treatment that will eliminate these acoustic noise concerns during the operation of the 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 Doosan Fuel Cell at the West Haven WPCP on Beach Street. The State of Connecticut and the Town of West Haven Noise Ordinances have been consulted to assess the impact of the estimated acoustic levels. Noise mitigation is needed to reduce the airborne noise propagated by the fuel cell to the closest nearby neighbors' property on 1st and 2nd Avenue directly to the west of the fuel cell location.

Acoustic Measurement Program

Airborne sound pressure measurements and audio tape recordings were conducted at and near the West Haven WPCP at 2 Beach Street on the morning of September 15, 2017. The purpose was to measure both background and airborne noise levels with the four speakers simulating the operation of the Doosan 440 KW fuel cell. Speaker and background airborne noise measurements were taken at the site at each neighbor's property line at twelve locations surrounding the West Haven WPCP. Seven measurements were made along 1st Avenue, the closest location to the fuel cell site. Two measurements were made along the fence line to the south on Open Space property. Three measurements were made along Monahan Place and Boat Ramp Road to the north on residential property. One measurement was made along the fence line to the west on West Haven WPCP property. Measurements at 5 and 10 meters from the four speakers' cooling module location were simultaneously taken with a sound level meter and two microphones recording on a digital tape recorder. These tape recorder measurements were repeated for the power module location. One-third octave and overall levels were calculated.

See Figures 1 and 2 below for photographs of similar Fuel Cell Power and Cooling Modules that have been installed at the Mount Sinai Hospital site. Figures 3 and 4 have a Google Map of the West Haven WPCP site with the property line measurement locations identified as P1 through P13. The expected site of the Power Module is identified in white as Location FM and the Cooling Module as Location CM. Figure 5 provides a photograph of the intended cooling module location where the fuel cell cooling system hardware will be placed. The photograph shows the speakers at the center of the cooling system location and the two microphones at 5 and 10 meters from the speakers. Table 1 provides estimates of the Doosan fuel cell airborne noise at each of the thirteen measurement locations. Column 5 provides the airborne noise estimates for the cooling system location and column 8 provides the estimates for the power module location. Positions 5 and 6 on 2nd Avenue exceed the night time residential noise limit by up to 5 dB.

Figure 1. Doosan Fuel Cell Power Module at the Mount Sinai Hospital Site in Hartford CT

Figure 2. Doosan Fuel Cell Cooling Module at the Mount Sinai Hospital Site in Hartford CT

Figure 3. West Haven WPCP Site Measurement Locations from Google Maps

Allowable Noise Levels

CT section 22a-69-3.1 (Ref. 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 Town of West Haven and the CT noise ordinances have been used to evaluate the noise generated by the Doosan Fuel Cell Power and Cooling Modules. The following subsection discusses the overall noise requirement and discusses the results obtained from the measurements at the West Haven WPCP site in order to determine what noise controls need to be applied. The Impulse, Prominent Discrete Tones, Infrasonic and Ultrasonic measurements of fuel cell airborne noise showed no acoustic concerns and will not be discussed further as no acoustic treatment is needed.

Figure 4. West Haven WPCP Site Measurement Locations from Google Maps-Expanded

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 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

The nearby neighbors are classified as either residential or commercial with the commercial noise limit at 66 dBA and the residential noise limit at 61 dBA during the day and 51 dBA at night. The east side of 2nd Avenue is residential and the Open Space is commercial. All locations are expected to meet the commercial and day time residential airborne noise limits.

Figure 5. Proposed Doosan Cooling Module Location for the West Haven WPCP Site

Fuel Cell Site

Table 1. Estimated West Haven Overall Sound Pressure Levels in dBA ref. 20 microPascals

Location	Range in Meters	Speakers On C M	Correction	Estimated SPL in dBA	Speakers On F M	Correction	Estimated SPL in dBA
P1 – Fence S	14.4/22.6	75.2	13.1	62.1	72.5	12	60.5
P2 – Fence C	17.1/23.5	72.8	13.1	59.7	72	12	60
P3 – Fence N	17.3/22	78.7	13.1	65.6	77	12	65
P4 – Park S	77.2/84.3	64.3	13.1	51.2	63.8	12	51.8
P5 – 85 2nd A	59.3/66	65.8	13.1	52.7	67	12	55
P6 – 99 2nd A	57/63.7	67.4	13.1	54.3	68	12	56
P7 – Park Spk	32/36.2	74	13.1	60.9	73	12	61
P8 – Park Ent	32.6/29.8	63.3	13.1	50.2	68.7	12	56.7
P9 –Park NW	118/110	55.2	13.1	42.1	60.6	12	48.6
P10 –1st&M P	239/232	50	13.1	36.9	50	12	38
P11 – 1 1st A	249/242	45.5	13.1	32.4	48	12	36
P12 – 23 Apr	252/246	<49	13.1	<36	46	12	34
P13 – P Lot	209/202	<51	13.1	<38	50	12	38

Red indicates residential locations above the night time airborne noise limit of 51 dBA

Reviewing Table 1 it is clear that the airborne noise levels drop significantly in propagating to the nearby properties as the range increases. This relationship was estimated as 19 times the log of the distance. The highest property line background corrected **speaker** level was measured at 74 dBA directly across 1st Avenue from the speakers (in the Open Space area). This property line should see airborne noise levels no higher than 61 dBA with the **fuel cell** operating. Two residential properties on 1st Avenue showed estimated levels above 51 dBA for homes numbers 85 and 99 2nd Avenue. Because of the increasing loss with distance to the remaining property lines the expected fuel cell noise levels fall below 66 dBA for the Open Space property. All the expected maximum values (worse case between speaker locations) are shown in Table 2 below.

Table 2. Expected Airborne Noise Levels from Operating the Doosan Fuel Cell (ref. 20 µPA)

P1	P2	P4	P5	P6	P7	P8	P9	P10
62 dBA	60 dBA	52 dBA	55 dBA	56 dBA	61 dBA	57 dBA	49 dBA	38 dBA

Operation of the Doosan fuel cell will have a minor acoustic impact by exceeding 51 dBA at the homes adjacent to the cooling module on 1st Avenue. Residential property lines on 1st and 2nd Avenue close to the fuel cell will see airborne noise levels up to 5 dB above the night time noise limit. This includes properties up to 100 meters away from the cooling module along 2nd Avenue that would be affected (the twelve homes from 85 to 127 2nd Avenue). Property lines further away on 1st and 2nd Avenue and all the other surrounding property lines will not be affected by the operation of the fuel cell.

Noise Treatment Recommendations

The two separate pieces of the Doosan hardware are shown in Figures 1 and 2 above. Estimates from the West Haven WPCP testing indicate that we need to reduce the fuel cell noise by about 6 dB to bring the 1st and 2nd Avenue airborne noise levels below the night time noise requirement of 51 dBA. Mount Sinai airborne noise measurements have indicated that the cooling module is the dominant noise source (Ref. 2). Since the power module noise levels are about 17 dB below the cooling module, a reduction of the noise level of the cooling module of about 6 dB to meet the night time noise requirement will still leave the cooling module dominant. The nearby property lines would then see airborne noise from the cooling module at levels about 11 dB higher than from the power module. As a result, we don't have to be concerned with treating the power module. Treatment of the cooling module (i.e. reducing its noise by 6 dB) should result in about 5.7 dB less noise at the nearby property lines. If these dBA numbers were exact the summation of a 39 dBA source from the power module and a 50 dBA source from the cooling module would result in airborne noise of 50.3 dBA at the property line, just below the limit.

The cooling module will probably be surrounded by an 8 foot high chain link fence and the first option for noise control would be to attach 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. The diffraction over the top of the acoustic barrier has been calculated and the results are shown

in the following figures as a function of frequency. Figure 6 looks at the sound diffraction over the top of an 8 foot wall with the desired performance applied to the homes on 2nd Avenue that have distances from the source of 55 to 100 meters. The curve labeled 55 is for the closest home at 99 2nd Avenue. The curve labeled 101 is for the home expected to be just outside the range where treatment is needed. This location is expected to be below the 51 dBA limit without treatment. The home at 99 2nd Avenue achieves 6 dB of performance for frequencies above 100 Hertz. The spread in performance is small (less than 1 dB) for all the other homes along 2nd Avenue and indicates that the noise treatment should be equally effective.

Figure 7 shows the importance of having the acoustic barrier higher than the cooling module. The top of the cooling module is about 6 feet above ground. The acoustic peformance of barriers of height 6, 7 and 8 feet have been calculated and show an ever increasing noise reduction as the height of the barrier increases. When the barrier height is the same as the cooling module height the performance is limited to about 4.8 to 5.2 dB. For another foot of barrier height the maximum performance at 8 KiloHertz increases to about 14 dB. Adding another foot causes the 8 foot barrier to increase this number to about 17 dB. We shall see that increases in performance at low frequency are very important as well, especially in the 160 to 250 Hertz region. An 8 foot high barrier is needed to produce the 6 dB reduction that we are looking for.

Figure 6. Acoustic Wall Performance for Different Receiver Locations

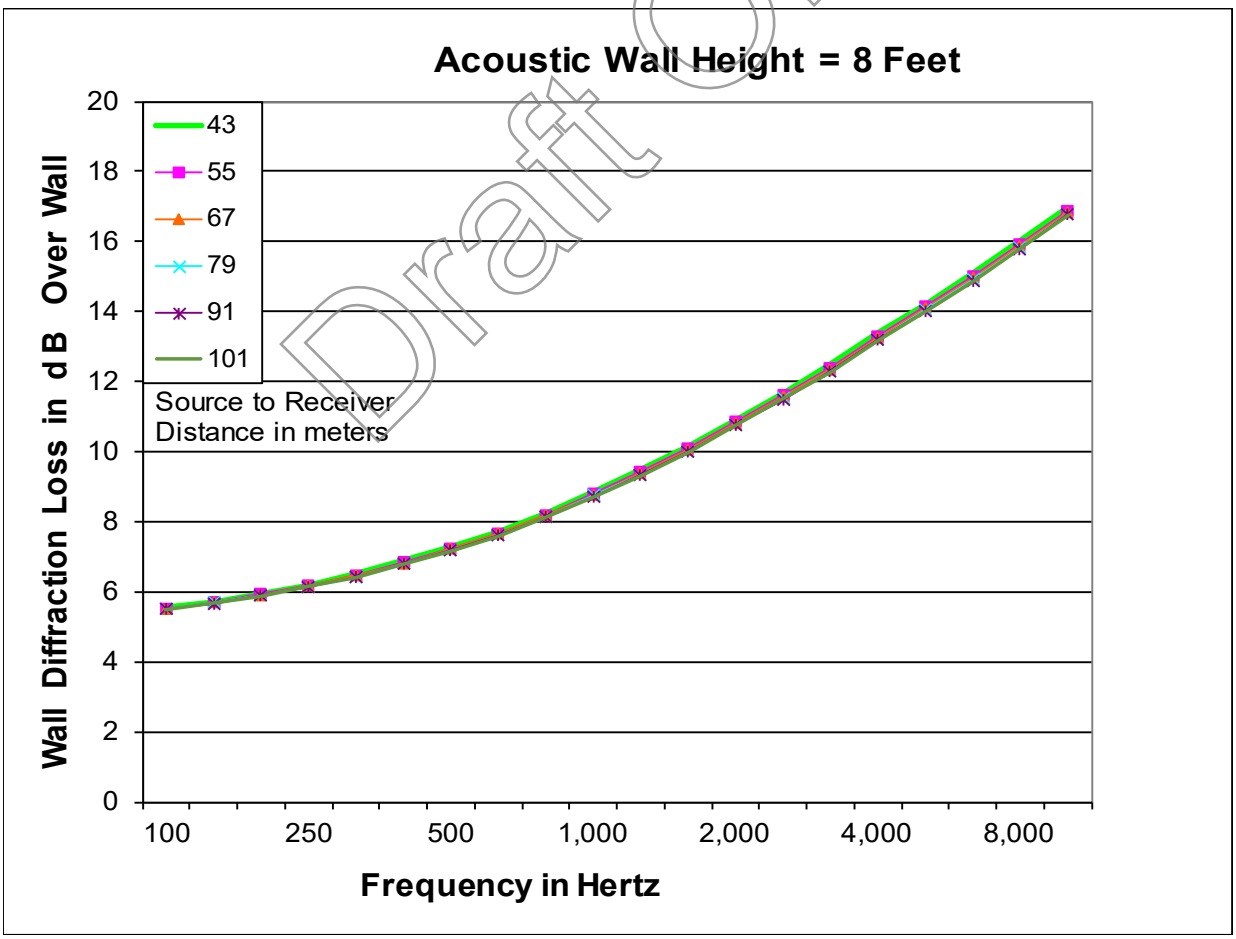
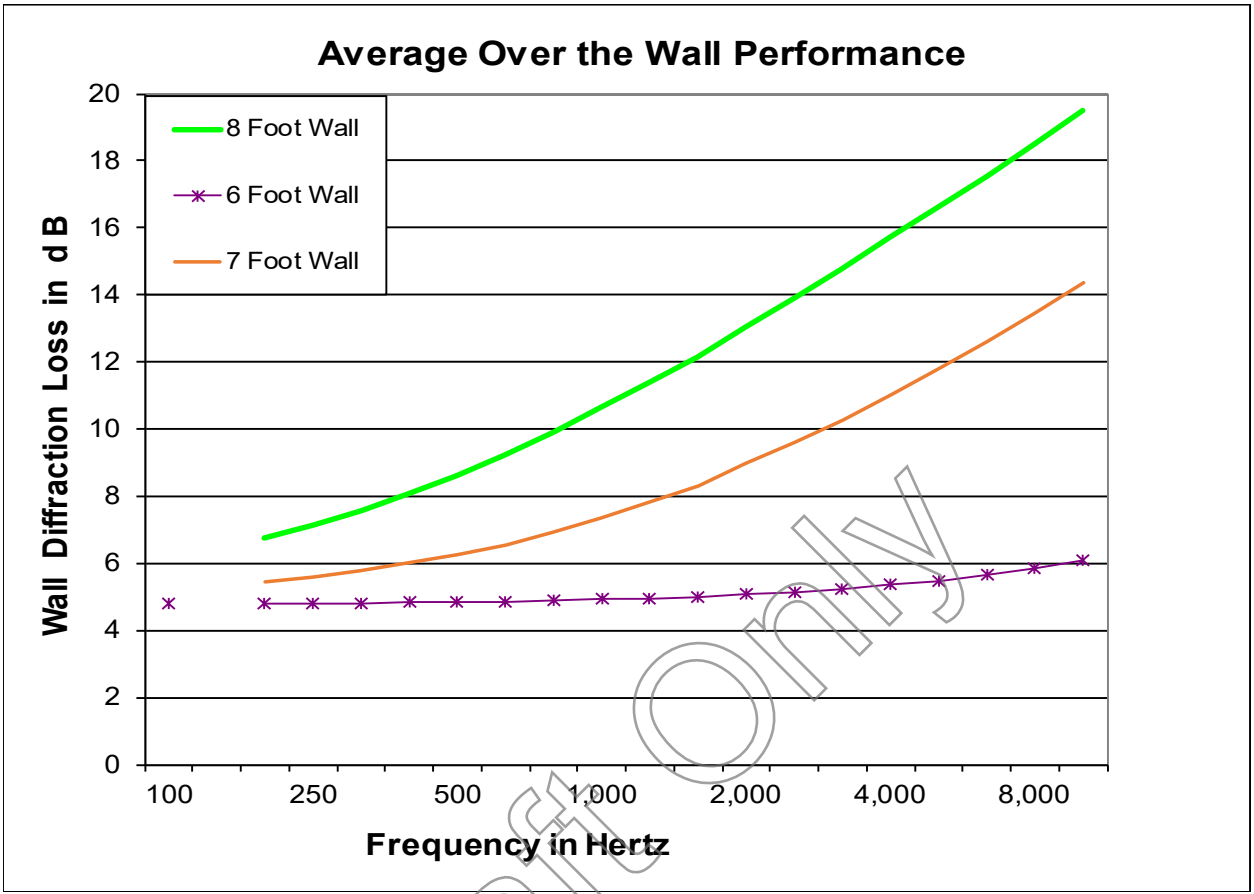


Figure 7. Acoustic Wall Performance for Different Treatment Heights



Another 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 is shown in Figure 8 as the Direct Path. 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. (Increasing the thickness to 2 inches would help the low frequencies.)

To evaluate the ability of this material to provide the 6 dB of performance we need requires the combination of both paths leading to an estimate of the airborne noise level at the property lines on 2nd Avenue. This has been done and the results are shown in Figure 9. The calculation starts with the one-third octave airborne noise levels actually measured 10 meters from the Mount Sinai cooling module. These levels are then attenuated by the barrier losses shown in Figure 8 to produce a direct and a diffraction component all at 10 meters. These two levels are then attenuated by 14 dB to account for the propagation loss measured at 99 2nd Avenue. The two results are then power summed to provide the estimate of airborne noise at the property line of 99 2nd Avenue as shown in Figure 9. The one-third octave bands are power summed to calculate the overall dBA for each material wall height (the calculated dBA values are shown in the figure caption). The estimates indicate that two of the three material heights meet the night time noise limit. The 8 foot height provides the most margin (2.1 dB) while the 7 foot wall has 0.7 dB margin and the 6 foot wall is over by 0.2 dB. Note that the peak airborne noise level falls in the

200 Hertz one-third octave band while a smaller peak shows up in the 630 Hertz band where the highest discrete tone was found. Similar calculations for 85 2nd Avenue found estimates to be about 1.3 dB lower or 47.6 dBA with an 8 foot wall. The other locations on 2nd Avenue would meet the 51 dBA limit with additional margin.

Installation of an eight foot high acoustic barrier is recommended to mitigate the airborne noise reaching the property lines on 2nd Avenue. Materials such as the ABBC-EXT-R Sound Curtains from Acoustical Solutions (Reference 3) or equivalent should be sufficient to produce the 6 dB of sound reduction needed. An example of a noise treatment installation is shown in Figure 10. The ABBC-EXT-R Sound Curtains were hung from two sides of a security fence around the cooling module at the fuel cell installation at Mount Sinai Hospital in Hartford, CT.

Coverage should extend around the west, south and north sides of the cooling module. Looking at Figure 2 and assumming the West Haven site will have a 2 meter stand-off of the fence from the cooling system, the 4.4 by 2.5 meter cooling system foot print should have a noise treatment about 20 meters in length. Locating the entrance gate on the east side will allow the gate and the rest of the east side to remain untreated. The west side will have six of the 54-inch-wide noise blanket panels hung from the fence. The north and south sides will have four panels each to complete the three sided enclosure of the cooling module. These side extensions are needed to make the diffraction performance around the side of the treatment a little better than that over the top of the treatment. The length of the necessary treatment would be about 63 feet with a height of 8 feet for a surface area of 504 square feet. (Doosan has purchased this material in the past for the Mount Sinai Hospital site in Hartford, CT.)

Figure 8. The Effect of an Acoustic Barrier on Transmission to Nearby Properties

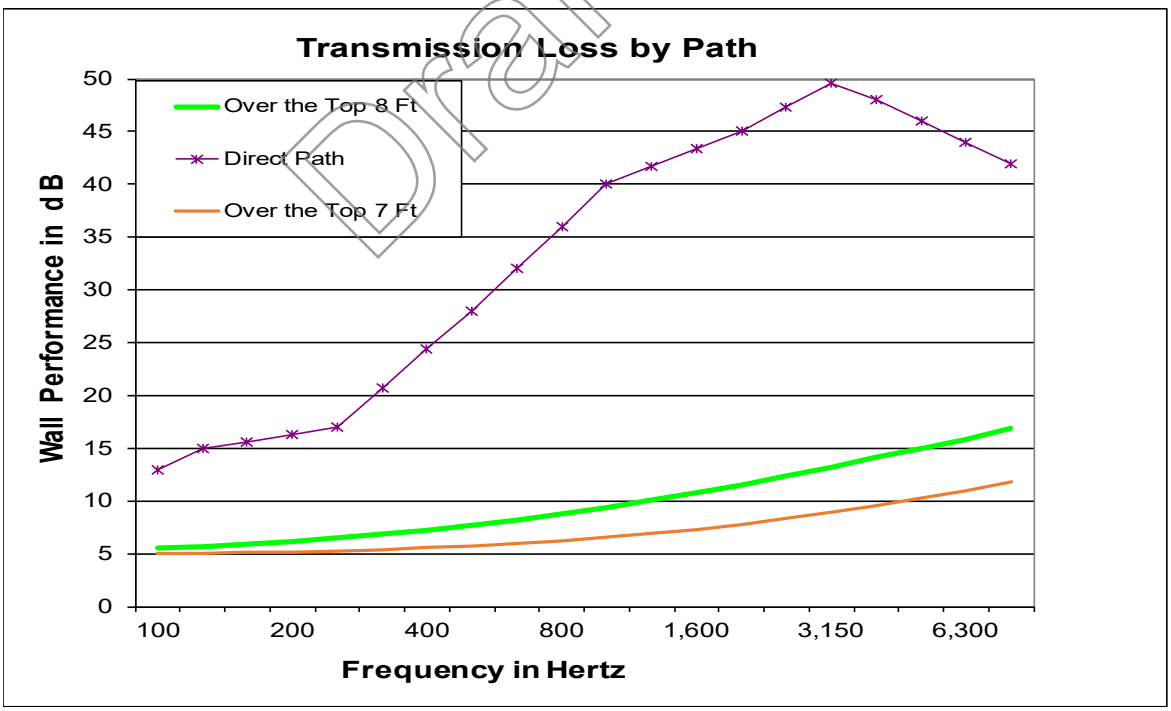
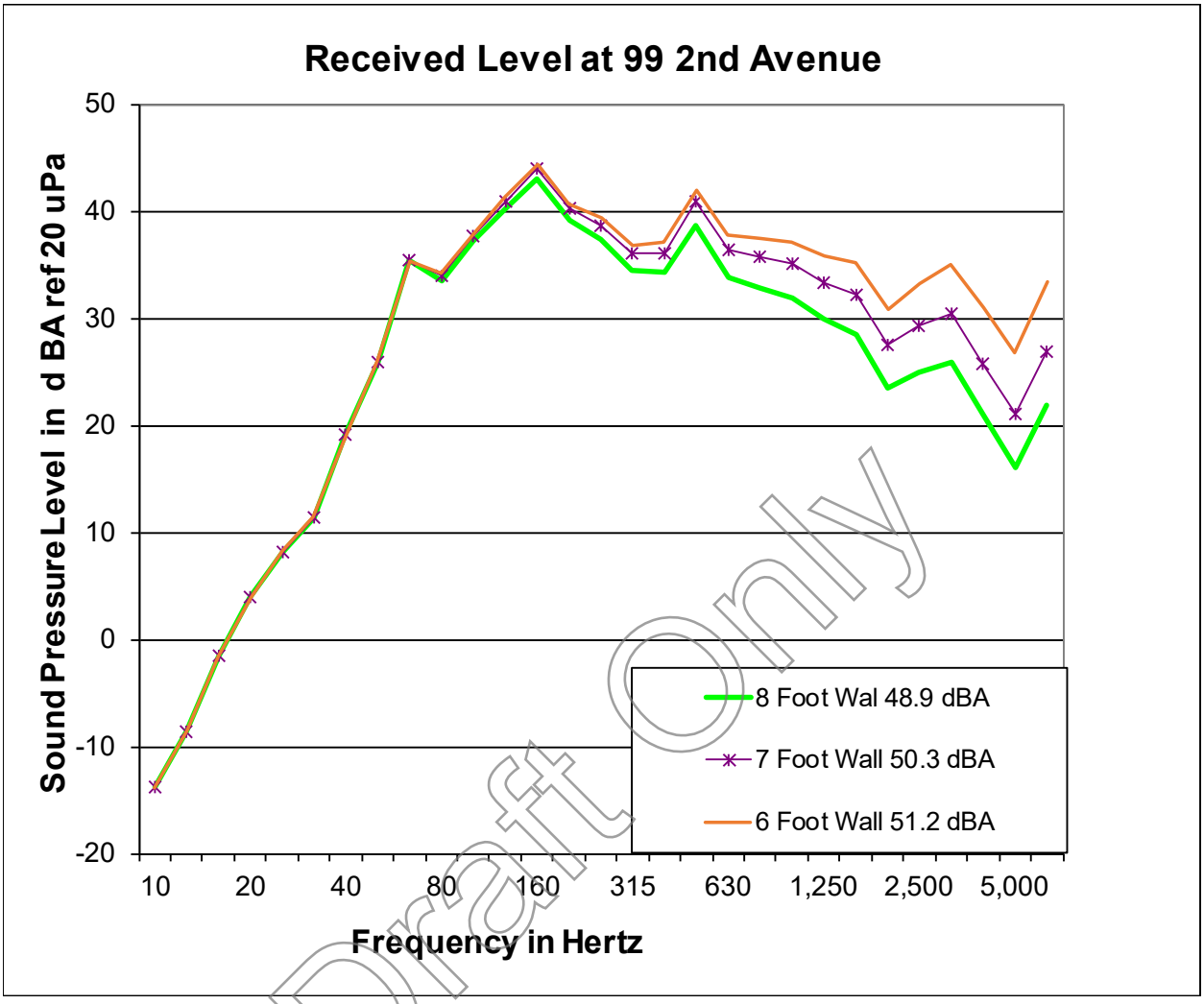


Figure 9 Estimated 2nd Avenue Airborne Noise Levels versus Wall Height



Discussions with Doosan indicated that the cooling module and power module would be placed end to end along 1st Avenue on the WPCP property. This arrangement leads to recommending a barrier acoustic treatment on the fence just around the cooling module. If the cooling module location was placed side to side with the power module (located on the street side of the property), the amount of noise barrier treatment could be reduced. The power module would act as the noise barrier in the westerly direction removing the need for a noise treatment on the street side. Four of the sound curtain panels (length 5.5 meters) could then be placed at each of the north and south ends of the power module to block noise traveling to the north and south and diffracting around to the residential area to the west. This arrangement would be equivalent acoustically to the placement of a sound barrier around the three sides of the cooling module.

Figure 10. Eight Foot Fence Surrounding Doosan Cooling Module with Noise Treatment

Conclusions

The purpose of this effort has been to evaluate the acoustical environment at the West Haven WPCP fuel cell site in west Haven, CT. This has been accomplished and the results show that the acoustic impact on the closest nearby homes on 2nd Avenue needs to be addressed. Operation of the fuel cell meets all of the other state noise requirements except for the overall night time limit. The two closest homes on 2nd Avenue are up to 5 dB above the night time 51 dBA limit. An eight foot high acoustic barrier as described in this report should mitigate this noise issue and remove any acoustic concerns about siting and operating the Doosan 440 KW fuel cell at the West Haven WPCP.

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

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

Parcel ID	Site Address	Owner Name	Mailing Address	Mailing City	Mailing	Mailing Zip
028-0212-0-0000	115 SECOND AVE	MARRANZINO ANTHONY J & JOANN	115 SECOND AVE	WEST HAVEN	CT	06516- 0000
028-0213-0-0000	111 SECOND AVE	HUNT GARY	50 MILTON AVE	WEST HAVEN	CT	06516- 0000
028-0216-0-0000	99 SECOND AVE	GARCIA ANA L	99 SECOND AVE	WEST HAVEN	CT	06516- 0000
028-0217-0-0000	85 SECOND AVE	MANCINI SHARON R & FRANCO	85 SECOND AVE	WEST HAVEN	CT	06516- 0000
028-0220-0-0000	103 SECOND AVE	GARCIA ANA L	160 PARK ST	WEST HAVEN	CT	06516- 0000
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036-0315-0-0000	121 SECOND AVE	COSMUS RICHARD N EST OF & RIGHT JESSICA	260 WEST 26TH ST APT 2A	NEW YORK	NY	10001- 0000

City of West Haven

Geographic Information System (GIS)

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N W E S

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

September 22, 2017

RE: Petition For a Declaratory Ruling That No Certificate of Environmental Compatibility And Public Need is Required ("Petition") for the Installation of One (1) on-site, 440 kW Fuel Cell at West Haven WPCA, 2 Beach Street, West Haven, CT 06516.

Dear Recipient,

Pursuant to Section 16-50j-40 of the Connecticut Siting Council's (the "Council") Rules of Practice, we are notifying you that Doosan Fuel Cell America, Inc. intends to file a petition for declaratory ruling with the Connecticut Siting Council ("Council") on or about September 24, 2017. The petition will request the Council's approval of the installation of one (1) 440kW fuel cell and ancillary equipment in support of a customer-side, distributed generation project at 2 Beach Street West Haven, CT 06506. The fuel cell will be powered by natural gas and generated electricity will be consumed on-site.

The proposed placement of the fuel cell is located within the parking lot near the southwest corner of the water pollution control facility. The proposed new construction will be approximately 29 feet long, 8 feet wide and 10 feet high.

If you have any questions regarding the proposed work, please contact any of the following:

Doosan Fuel Cell America, Inc.
Ben Yoon
195 Governor's Highway
Tel: 860-727-2200
ben.yoon@doosan.com

Connecticut Siting Council
10 Franklin Square
New Britain, CT 06051
Tel: 860-827-2935

Sincerely,
Doosan Fuel Cell America, Inc.

Patricia Walker, Esq.
Associate General Counsel
Doosan Fuel Cell America, Inc.
195 Governor's Highway
Tel: 860-727-2089
Patricia.walker@doosan.com

This is to certify that on the **30th day** of Sep 2017, the foregoing notice was sent via certified mail with e-return receipt to the following:

AGENCY	**NAME/ADDRESS**
Office of the Mayor	Edward M. O'Brien City Hall 355 Main Street West Haven CT 06516
Department of Planning and Development	**Joseph A. Riccio Jr.- Commissioner** City Hall 355 Main Street West Haven CT 06516
Building Official	**Flank Gladwin** City Hall 355 Main Street West Haven CT 06516
Zoning Enforcement Official	Catherine Conniff City Hall 355 Main Street West Haven CT 06516
State House	**Dorinda Borer - Representative** House District 115 821 W Main west Haven CT 06516- 4867
State House	**Michael DiMassa - Representative** House District 116 405 sycamore Ln Cheshire 06410-2023
State House	**Charles Ferraro - Representative** House District 117 13 Twin Circle Rd West Haven 06516 -6231
State Senate	**Gayle Slossberg** Senate District 14 14 Honeysuckle Ln Milford CT 06461-1671
State Senate	**Gary Winfield** Senate District 10 480 Winchester Ave New Haven CT 06511-1920
United State Congressman	**Rosa L. DeLauro - Congress Woman** 59 Elm Street New Haven, CT 06510
United State Senator	**Christopher S. Murphy** One Constitution Plaza, 7th Floor Hartford, CT 06103
United State Senator	**Richard Blumenthal** 90 State House Square Hartford, CT 06103
State Department of Energy and Environmental Protection	**Robert Klee, Commissioner** 79 Elm Street

	Hartford, CT 06106
State Department of Public Health	**Dr. Jewel Mullen Commissioner** 410 Capitol Avenue Hartford, CT 06134
State Council on Environmental Quality	**Susan Merrow, Chair** 79 Elm Street Hartford, CT 06106
State Department of Agriculture	**Steven K. Reviczky Commissioner** 165 Capitol Avenue Hartford, CT 06106
Office of Policy and Management	**Benjamin Barnes, Secretary** 450 Capitol Avenue Hartford, CT 06106-1379
State Department of Economic and Community Development	**Catherine Smith, Commissioner** 505 Hudson Street Hartford, CT 06106-7106
South Central Regional Council of Governments	**Benjamin Blake** chairman 127 Washington Avenue, 4th Floor West, North Haven, CT 06473-1715
Attorney General	**George Jepsen, Attorney General** Office of the Attorney General 55 Elm Street Hartford, CT 06106
Public Utilities Regularity Authority	**Arthur House, Chairman** Public Utilities Regularity Authority Ten Franklin Square, New Britain, CT 06051
Department of Transportation	**James P. Redeker, Commissioner** Department of Transportation 2800 Berlin Turnpike, Newington, CT 06111
Department of Emergency Services and Public Protection	**Dora B. Schriro Commissioner** 1111 Country Club Road Middletown, CT 06457
Department of Consumer Protection	**Jonathan A Harris Commissioner** 165 Capitol Avenue Hartford, CT 06106-6300
Department of Administrative Services	**Melody A. Currey Commssioner** 165 Capitol Avenue Hartford, CT 06106
Department of Labor	**Scott D. Jackson Commissioner** 200 Folly Brook Boulevard Wethersfield, CT 06109

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September 22, 2017

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To whom it may concern,

Pursuant to Section 16-50j-40 of the Connecticut Siting Council's (the "Council") Rules of Practice, we are notifying you that Doosan Fuel Cell America, Inc. intends to file a petition for declaratory ruling with the Connecticut Siting Council ("Council") on or about September 24, 2017. The petition will request the Council's approval of the installation of one (1) 440kW fuel cell and ancillary equipment ("the Facility") in support of a customer-side, distributed generation project at 2 Beach Street West Haven, CT 06506. The Facility will be powered by natural gas and generated electricity will be consumed on-site.

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ANGELO MICHAEL R
27 MONAHAN PL
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Cosmus Richard N Est of & Right Jessica
260 W. 26TH STREET APT 2A
NEW YORK, NY 10001

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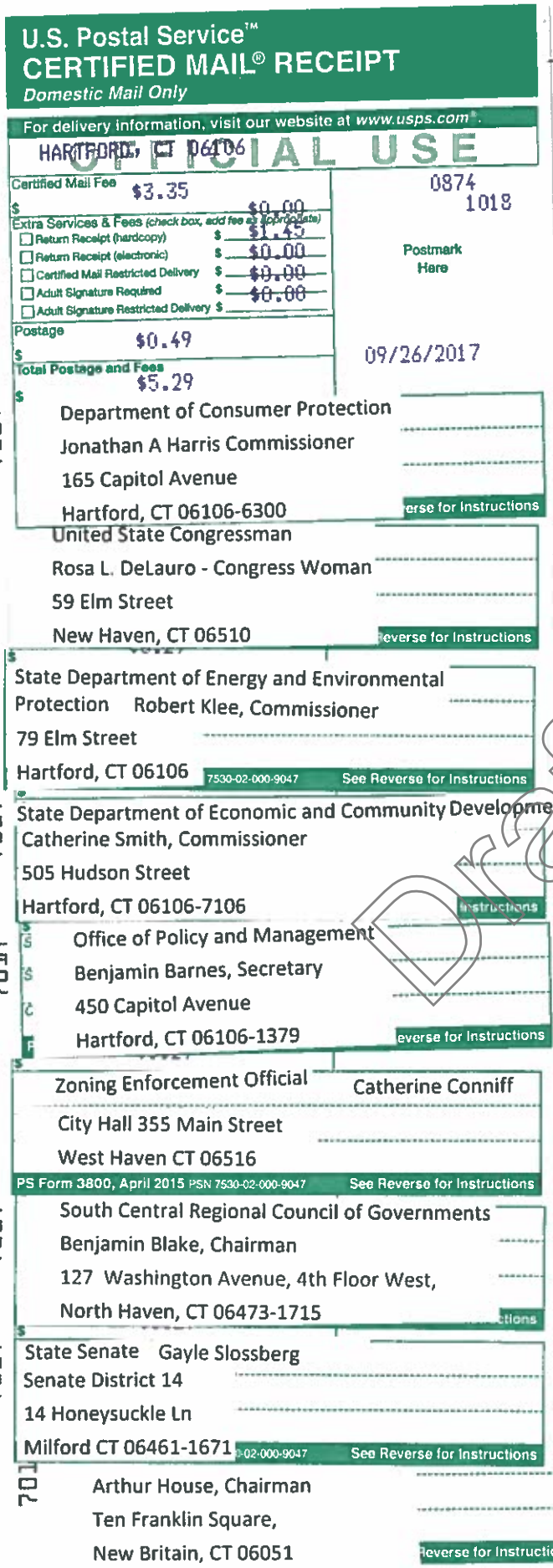

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New Haven, CT 06510

State Department of Energy and Environmental Protection Robert Klee, Commissioner
79 Elm Street
Hartford, CT 06106

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Office of Policy and Management
Benjamin Barnes, Secretary
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Hartford, CT 06106-1379

Zoning Enforcement Official Catherine Conniff
City Hall 355 Main Street
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State Senate Gayle Slossberg
Senate District 14
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Milford CT 06461-1671

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Ten Franklin Square,
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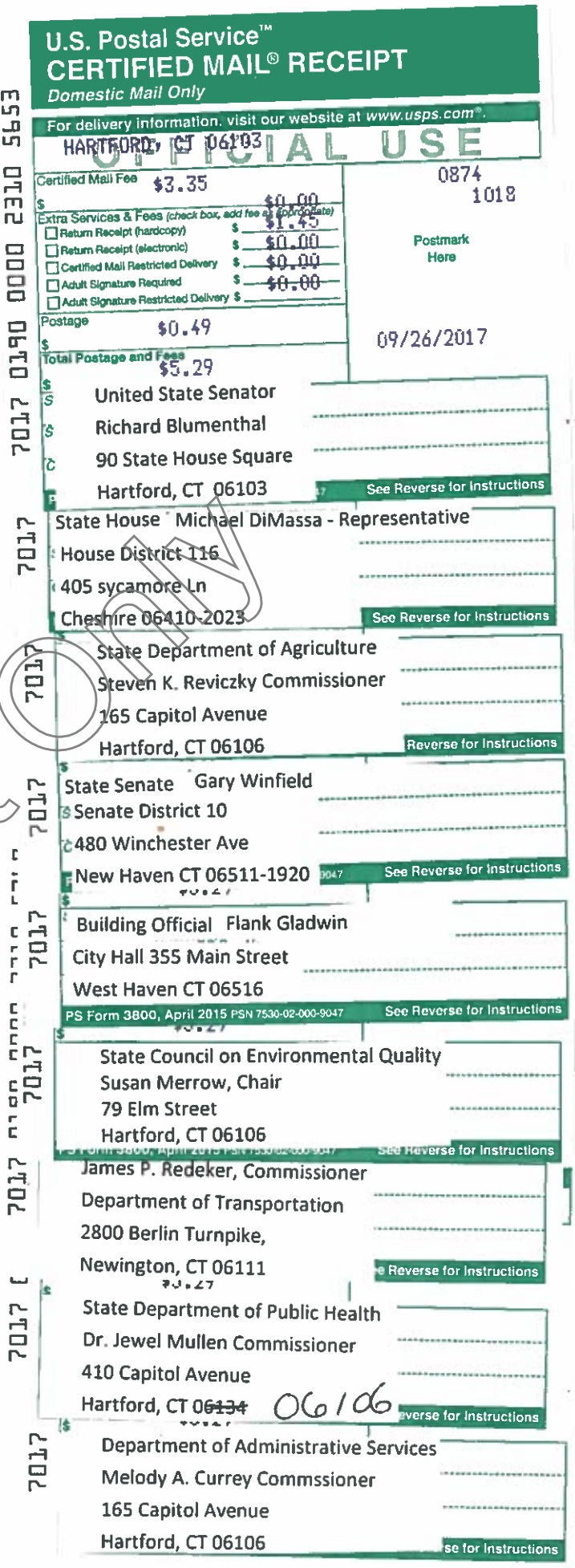

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Steven K. Reviczky Commissioner
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Senate District 10
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Building Official Flank Gladwin
City Hall 355 Main Street
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2800 Berlin Turnpike,
Newington, CT 06111

State Department of Public Health
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Scott D. Jackson Commissioner
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City Hall
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West Haven CT 06516

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George Jepsen, Attorney General
Office of the Attorney General
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Department of Planning and Development
Joseph A. Riccio Jr.- Commissioner
City Hall 355 Main Street
West Haven CT 06516

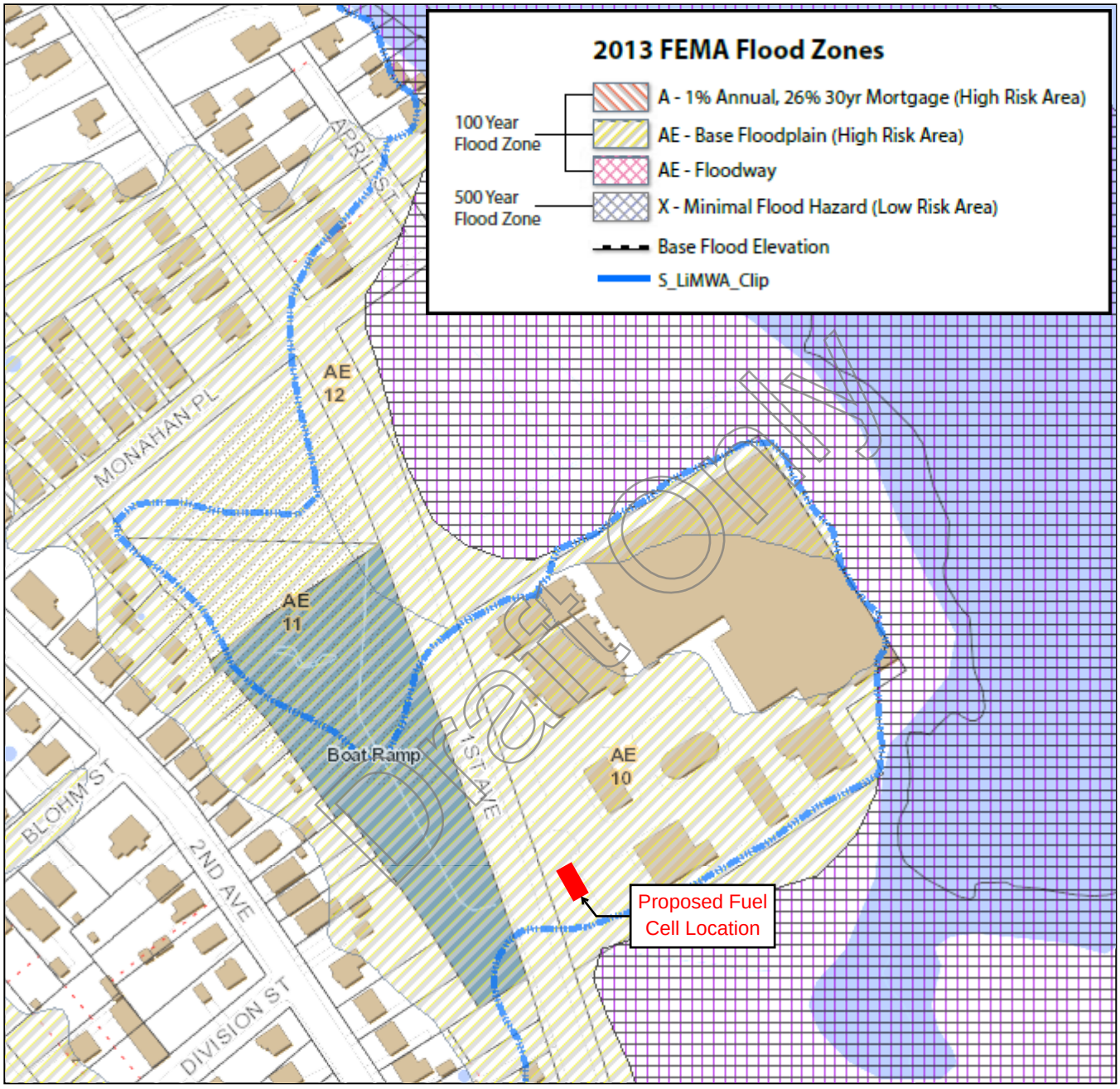
Instructions

City of West Haven

Geographic Information System (GIS)

FEMA FIRM: Flood Zone Map

Date Printed: 9/25/2017



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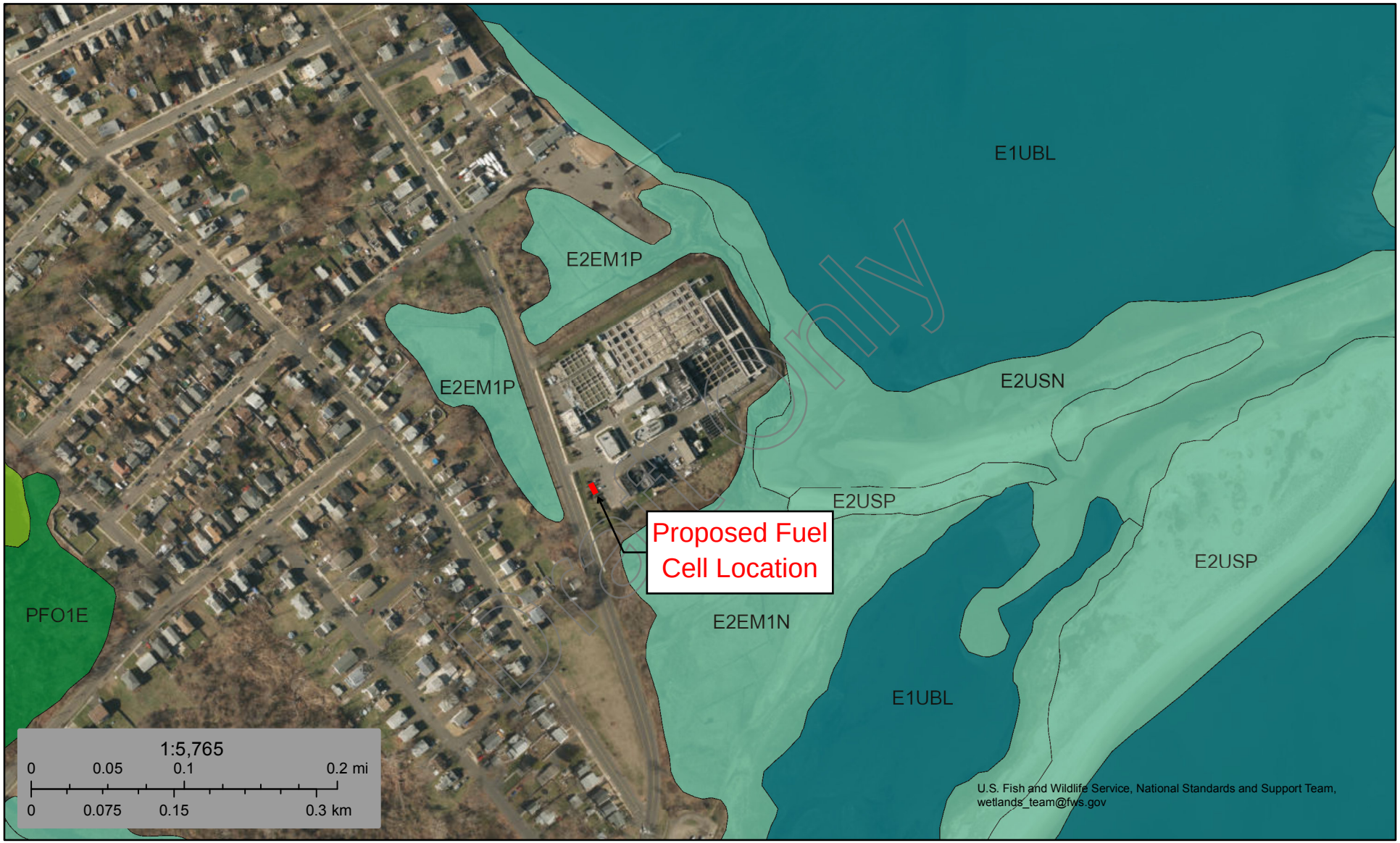
N W E S

U.S. Fish and Wildlife Service
National Wetlands Inventory

West Haven WPCA Wetlands Map



September 27, 2017

Wetlands

- Estuarine and Marine Deepwater
- Estuarine and Marine Wetland
- Freshwater Emergent Wetland
- Freshwater Forested/Shrub Wetland
- Freshwater Pond
- Lake
- Other
- Riverine

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National Wetlands Inventory (NWI)
This page was produced by the NWI mapper

PureCell Model 400 Fuel Processing System (FPS)

The FPS converts pipeline-quality natural gas into hydrogen reformate – a hydrogen-rich gas that is delivered to the anode side of the fuel cell stacks. This module includes a condenser to recover water generated in the fuel cell reaction by condensing water vapor from the process exhaust. This eliminates the need for makeup water under most operating conditions. The recovered water is used in the steam reformation process. The main components of the FPS include the following:

Hydro-Desulfurizer

The desulfurizer system removes sulfur used as an odorant in natural gas, which is a poison to the catalysts used in the fuel cell systems. Sulfur is converted to zinc-sulfide, a non-hazardous waste, within the desulfurizer and remains there until an overhaul is required, nominally after 10 years. This system will also remove small amounts of oxygen in the gas.

Steam Reformer

Steam (H_2O) generated in the cell stack cooling loop of the TMS is combined in the reformer with methane (CH_4) in the natural gas to generate a gas composed of hydrogen (H_2), carbon monoxide (CO), and carbon dioxide (CO_2).

$2CH_4 + 3H_2O = 7H_2 + CO + CO_2$ *Equation 1*

Integrated Low-Temperature Shift Converter

The integrated low-temperature shift converter (ILS) generates additional hydrogen through a water-gas reaction in which CO and water is converted to hydrogen and CO_2. The reduced CO content minimizes its adverse effect on fuel cell stack performance.

CO + H2O = H2 + CO2 *Equation 2*

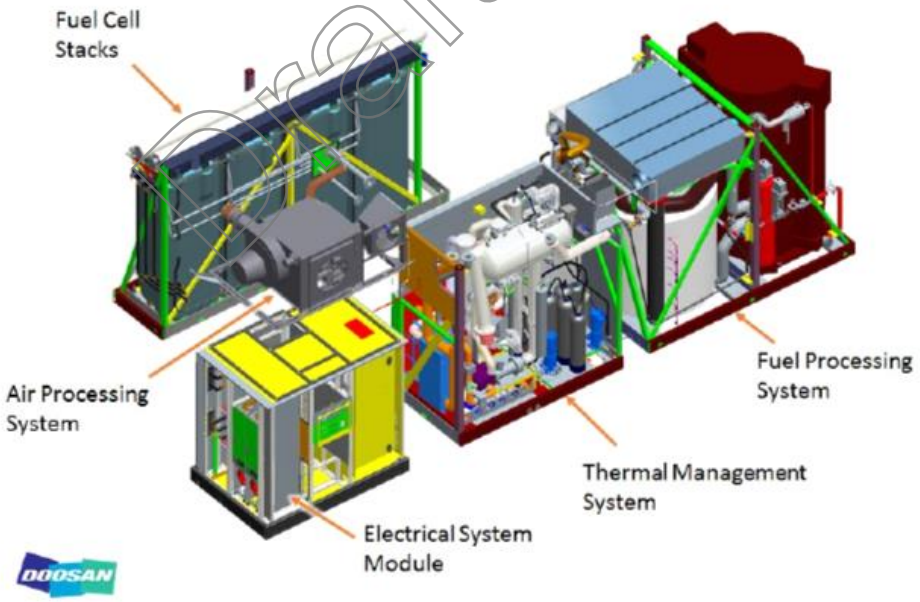

Figure 1. PureCell Model 400 Subsystems

Desulfurization Memorandum
PureCell® Model 400 Stationary Fuel Cell System

Date: 2017-01-05

Sulfur Background

Sulfur is present in pipeline natural gas. It is primarily used as an odorant so leaks can be detected. Unfortunately, sulfur is also a poison to fuel cell systems and exposure to sulfur will drastically reduce the life and efficiency of the fuel cell.

Types of sulfur found in natural gas vary from region to region. Some common examples are:

- Hydrogen Sulfide (H_2S)
- Tetrahydrothiophene (THT)
- Mercaptain – (MCP) - Broad family of sulfur molecules characterized by a sulfur atom attached to a hydrocarbon molecule or chain

The majority of it the odorants are organic with the exception of hydrogen sulfide. Standard pipeline natural gas contains up to 6 parts per million by volume (ppmv) sulfur on average with spikes as high as 30 ppmv possible. In order to successfully maintain operation of the fuel cell for a period of 10 years, the sulfur levels must be reduced to less than 0.02 ppmv, or a 99.7% removal rate. An additional benefit of this is that it removes sulfur dioxide from the emissions of the fuel cell power plant.

Sulfur Removal Techniques

Sulfur removal can be broken down into two main techniques, physical capture and reactive capture.

Physical capture involves using porous media such as activated carbon or molecular sieves to capture and concentrate the odorant before it enters the fuel cell. Doosan elected not to pursue this path due to several factors, including:

- The process concentrates the odorant and turned it into hazardous waste
- The concentrated odorant is highly toxic and requires specially trained personnel to handle the waste
- Would result in more service being required at customer sites to maintain the system

Reactive capture is the method used by Doosan to remove sulfur. It involves chemically reacting the odorant over a catalyst bed in order to separate the sulfur molecule. Once the sulfur molecule is separated from the odorant, the remaining odorant is destroyed in another catalyst bed. The sulfur molecule is then captured and converted to a compound called Zinc Sulfide.

$$* S + H_2 \leftrightarrow H_2S + * \qquad \textit{Equation 4}$$

$$H_2S + ZnO_{(s)} \leftrightarrow ZnS_{(s)} + H_2O \qquad \textit{Equation 5}$$

Note: * represents the non-sulfur odorant components

Doosan's system has been sized such that it will run for the 10 year service life of the unit and not need to be changed out. When the unit is removed from service, the decommissioning or refurbishment of the unit will be carried out by trained personnel and a company specializing in removal of the waste Zinc Sulfide will recover the spent material. Zinc sulfide has some commercial value, so that company will either process it and sell it or split it into Zinc and Sulfur and sell them separately.

Respectfully,
Jesse Hayes, Director, Product Management, Doosan Fuel Cell
195 Governors Highway
South Windsor, CT 06074
Jesse.hayes@doosan.com
(860) 560-3309