ASSOCIATED ELECTRIC COOPERATIVE INC

SOUND STUDY REPORT

TURNEY

PROJECT NO. 141827

REVISION 0

OCTOBER 21, 2024

CONTENTS

TABLES

List of Abbreviations

Abbreviation	Term/Phrase/Name
AECI	Associated Electric Cooperative Inc
ANSI	American National Standards Institute
BOP	balance of plant
dB	decibel
dBA	A-weighted decibel
dBC	C-weighted decibel
Hz	hertz
L_{ANS}	A-weighted, noise compensated metric
L_{dn}	day-night average sound level
L_{eq}	equivalent-continuous sound level
L_{10}	10-percentile exceedance sound level
L_{50}	50-percentile exceedance sound level
L_{90}	90-percentile exceedance sound level
MW	megawatt
mph	miles per hour
NIST	U.S. National Institute of Standards and Technology
NSA	noise sensitive area
Project	Turney Energy Center Project
PWL	sound power level
SCR	selective catalytic reduction
SPL	sound pressure level

Executive Summary

Burns & McDonnell conducted a sound study for the proposed Associated Electric Cooperative Inc. (AECI) Turney Energy Center Project (Project), located in Clinton County, Missouri, outside the City of Turney. The Project is a new development of a 450-megawatt (MW) simple-cycle combustion turbine power generating facility built on a green-field site. The Project is expected to include one (1) Siemens 9000H-class simple-cycle unit equipped with a selective catalytic reduction (SCR) system and associated balance-of-plant (BOP) equipment.

The objectives of the sound study were to identify the applicable noise regulations, measure baseline sound levels near the Project property and surrounding area, and create an acoustical model to evaluate potential future noise impacts from the Project.

The State of Missouri does not have any applicable noise statutes and designates authority for noise to local jurisdictions. Clinton County also does not appear to have any applicable noise limits based on online available information. In absence of regulatory limits, sound levels were compared to existing ambient sound levels at the nearest residential receptors.

1.0 Acoustical Terminology

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

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

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

Sound in the environment is constantly fluctuating, as when a car drives by, a dog barks, or a plane passes overhead. Therefore, sound metrics have been developed to quantify fluctuating environmental sound levels. These metrics include the exceedance sound level. The exceedance sound level is the sound level exceeded during "x" percent of the sampling period and is also referred to as a statistical sound level. Common exceedance sound level values are the 10-, 50-,90-percentile exceedance sound levels, denoted by L_{10}, L_{50}, and L_{90}. The equivalent-continuous sound level (L_{eq}) is the arithmetic average of the varying sound over a given time period and is the most common metric used to describe sound. The USEPA uses a noise metric called the day-night average sound level (L_{dn}) which is a 24-hour average sound level, with a 10-dBA penalty applied to sound measured during nighttime hours (10:00 PM to 7:00 AM).

When audible noise observations and high-frequency octave band data (e.g., above 1,000 Hz) indicate that measured sound levels have a strong insect, bird, or leaf rustle noise component it may be appropriate to estimate what the sound levels would be without the influence of insect noise or other high-frequency sounds. The A-weighted, noise-compensated metric (ANS-weighted metric, "L_{ANS}") can be used to filter out sounds above 1,000 Hz and more accurately characterize the environment sound levels without the high-frequency noise.

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

Sound Pressure Level (dBA)	Subjective Evaluation	Environment
140	Deafening	Jet aircraft at 75 feet
130	Threshold of pain	Jet aircraft during takeoff at a distance of 300 feet
120	Threshold of feeling	Elevated train
110	Very loud	Jet flyover at 1,000 feet
100		Motorcycle at 25 feet
90	Moderately loud	Propeller plane flyover at 1,000 feet
80		Diesel truck (40 mph) at 50 feet
70	Loud	B-757 cabin during flight
60	Moderate	Air-conditioner condenser at 15 feet
50	Quiet	Private Office
40		Farm field with light breeze, birdcalls
30	Very quiet	Quiet residential neighborhood
20		Rustling leaves
10	Just audible	--
0	Threshold of hearing	--

Sources:
(1) Adapted from *Architectural Acoustics*, *M. David Egan, 1988*
(2) *Architectural Graphic Standards*, Ramsey and Sleeper, 1994

2.0 Applicable Regulations & Criteria

State and local noise regulations were reviewed to determine the applicable Project noise limits. The Project is located in Clinton County, Missouri. The State of Missouri does not appear to have any noise statutes, nor does Clinton County according to available online zoning information.

3.0 Sound Level Measurements

Burns & McDonnell personnel took sound level measurements to establish the existing ambient sound levels in the areas surrounding the Project. Sound level measurements were made using sound level meters that met the ANSI S1.4 requirements for a Type 1 Precision Sound Level Meter. One-half inch random-incidence microphones were used on the meters. Microphone windscreens were used for all measurements. Sound level meters were calibrated before and after each set of measurements using a sound level calibrator. Calibration level changes did not exceed ± 0.5 dB during the measurements. The meters and calibrator were checked within a year prior of the measurements to verify compliance with the U.S. National Institute of Standards and Technology (NIST) specifications. Calibration certificates for the equipment that was used for the survey are provided in Appendix C.

Continuous, long-term sound level measurements were collected at two measurement locations near the Project site and representative of the surrounding areas. The long-term measurement locations and nearby noise sensitive areas (NSAs) are shown in Figure A-1 of Appendix A. The microphones were placed at a height of approximately five feet above the ground and mounted on a tripod.

The long-term monitors measured sound levels continuously over a 24-hour period from approximately 11:00 AM on August 27, 2024, to 11:00 AM on August 28, 2024. Ambient sound levels near MP1 were mostly insect noise, local agricultural activity, and occasional plane flyovers. MP2 comprised of more local traffic noise and sound from the nearby substation. The measured sound level data is shown in graph and tabular form in Appendix B.

Due to the time of year, there was a significant increase in insect noise over the nighttime hours at MP1. To show the approximate sound levels that could be expected for other times of the year when insect noise is much lower, the ANS-weighted (L_{ANS}) values have been provided, which corrects for the insect noise by filtering out the high-frequencies typically associated with insect noise. A summary of the data is shown in Table 3-1 below and is broken down by time of day (e.g., daytime/nighttime).

Table 3-1: Long-Term Measurement Summary

Measurement Location	Time of Day[a]	L_{Aeq} (dBA)	L_{dn}[b] (dBA)	L_{A90} (dBA)	L_{ANS} (dBA)	L_{Ceq} (dBC)	L_{C90} (dBC)
MP1	Daytime	56	71	46	48	63	49
	Nighttime	64		54	41	64	54
MP2	Daytime	63	69	54	61	69	56
	Nighttime	62		55	54	64	57

a) Daytime is from 7 AM to 10PM, and nighttime is from 10 PM to 7 AM
b) Day-night average L_{eq} with a 10 dB penalty on nighttime sound levels

4.0 Modeled Sound Levels

Operational sound levels for the proposed Project were performed using the Computer Aided Noise Abatement (CadnaA) modeling software. Equipment sound levels used for modeling were based on a combination of in-house data and estimated values based on past experience with similar manufacturer equipment. This model was used for determining expected sound levels due to the Project and the associated impacts to the existing ambient sound levels at the nearest noise sensitive receptors.

4.1 Sound Modeling Methodology and Input Parameters

Predictive noise modeling was performed using the industry-accepted sound modeling software CadnaA, version 2024. The software is a scaled, three-dimensional program, which considers air absorption, terrain, ground absorption, and reflections and shielding for each piece of noise-emitting equipment, and then predicts sound pressure levels at discrete locations and over a gridded area based on input source sound levels. The model calculates sound propagation based on International Organization for Standardization (ISO) 9613-2:1996, General Method of Calculation. ISO 9613-2 assesses the sound level propagation based on the octave band center-frequency range from 31.5 to 8,000 Hz.

The ISO standard considers sound propagation and directivity. The sound-modeling software calculates omnidirectional, downwind sound propagation, in tandem with user-specified directivities and propagation properties. Empirical studies accepted within the industry have demonstrated that modeling may over-predict sound levels in certain directions, and as a result, modeling results generally are considered a conservative measure of the Project's actual sound level.

The modeled atmospheric conditions were assumed to be calm, and the temperature and relative humidity were left at the program's default values. Reflections and shielding were considered for sound waves encountering physical structures. Sound levels around the site can be influenced by the sound reflections from physical structures onsite. The area surrounding the Project has mild elevation changes, which scatter and absorb the sound waves. Thus, terrain was included to account for surface effects such as ground absorption. Average ground absorption for the Project site and surrounding area was set to a value of 0.5 to account for the mix of hard pavement soft vegetative ground. The modeling assumptions are outlined in Table 4-1. This model is exclusive of noise sources not associated with the Project (e.g., traffic noise and local fauna). Only Project sound levels have been evaluated.

Table 4-1: Sound Modeling Parameters

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

4.2 Project Acoustical Design

The Project general arrangement is included as Figure A-2 of Appendix A. The Project is expected to include one (1) Siemens 9000H-class simple-cycle combustion turbine and associated balance-of-plant (BOP) equipment. The combustion turbine is also expected to include a selective catalytic reduction (SCR) system. All equipment is expected to be typical base-package offerings and has been estimated based on in-house sound levels from projects with similar equipment. A basic silencer has also been included on the exhaust stack. No additional mitigation options beyond what is typically considered base package have been included in the noise model. All modeled sound levels are included in Appendix C.

4.3 Model Results

Project sound levels were modeled for normal operation, steady-state condition (i.e., no start-up, shutdown, or off-normal operating conditions). The acoustic model results are only for the new Project and do not include any contributions for existing ambient sound sources. The predicted A-weighted sound level contours for the existing Project design are shown in Figure A-3 of Appendix A. The Project sound levels predicted at nearby NSAs (i.e., residential areas) are provided in Table 4-2 below.

Table 4-2: Future Predicted Sound Level Results

Receptor Name	Ambient Sound Levels[1]		Model Results	
	dBA	dBC	dBA	dBC
NSA1	46	49	44	62
NSA2	46	49	41	60
NSA3	46	49	42	59
NSA4	46	49	35	55
NSA5	46	49	36	56

1) Existing Ambient sound levels based on lowest daytime/nighttime average L90 measurements at MP1

As shown in the table results, the Project is expected to contribute 44 dBA and 62 dBC at the nearest NSA.

5.0 Conclusion

Burns & McDonnell conducted a sound study for the AECI Turney Energy Center Project, located in Clinton County, Missouri. The study included a discussion of the applicable noise regulations for the Project, existing ambient sound level measurements, and acoustical modeling to estimate Project sound levels at the nearest noise sensitive areas (i.e., residential areas).

The Project does not have any applicable numerical noise limits. Project sound levels have been predicted based on acoustic modeling of expected base-package equipment as part of the Project's current design. Project sound levels have been compared to the existing ambient sound levels in the area surrounding the Project site. The Project is expected to contribute 44 dBA and 62 dBC at the nearest NSA.

APPENDIX A – FIGURES

LEGEND

- Project Area
- NSAs
- MPs

REFERENCE

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MILES

0 0.2 0.4
KILOMETERS

N

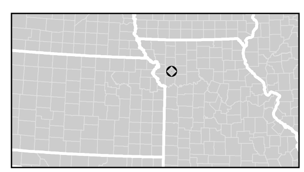

Figure A-1
Ambient Measurement Locations

LOCATION:	Clinton County, MO
CLIENT/PROJECT:	AECI Turney
PROJ. NO.:	141827
CREATED:	10/01/2024

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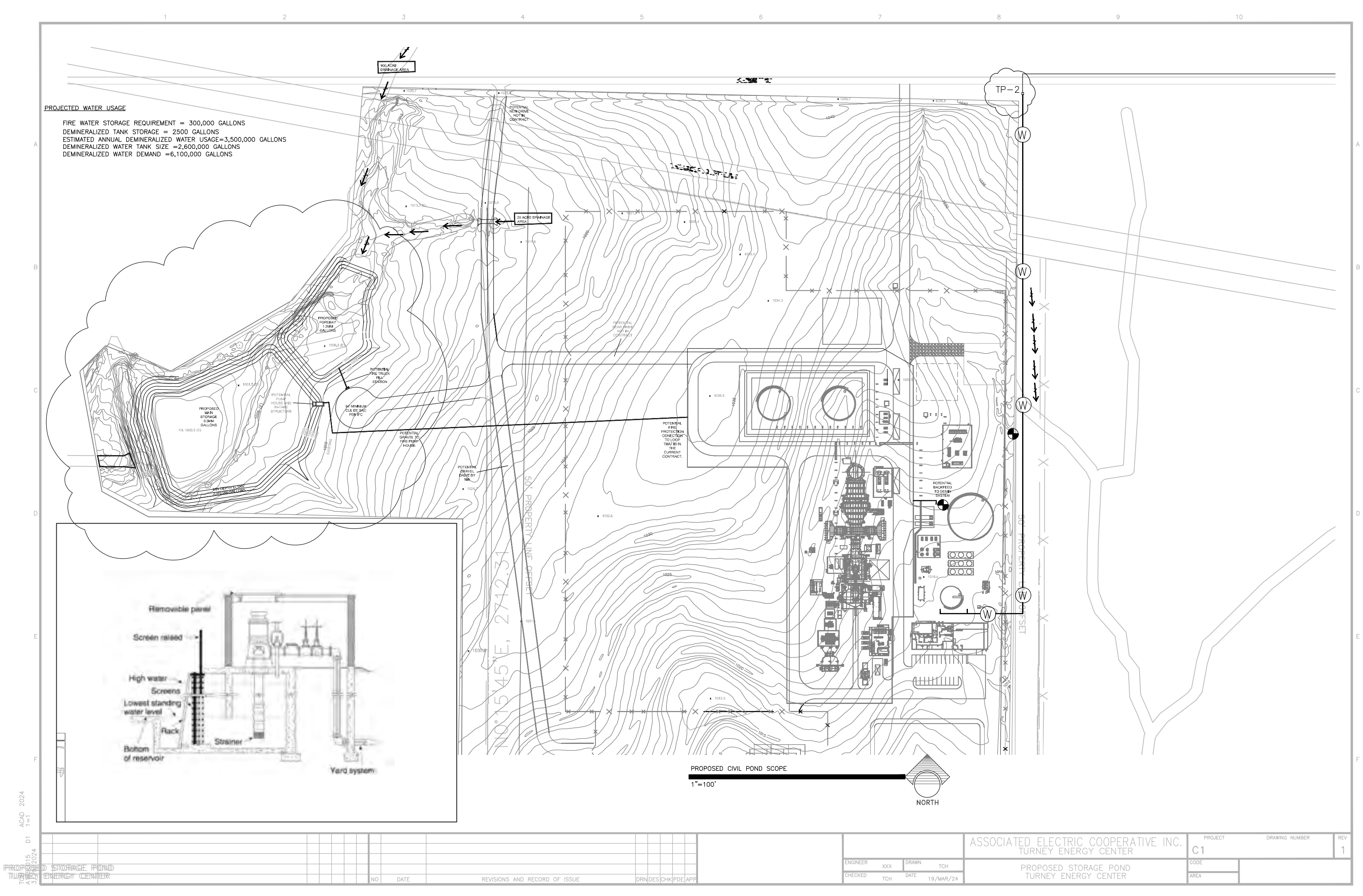
Path: G:\Projects\Air-Noise Dept\Project Files\AECI\Turney Noise\GIS\Turney\Turney Noise_Bit.aprx

Figure A-2 - General Arrangement



LEGEND

Project Area	MPs	40 dBA	55 dBA
Structures		45 dBA	60 dBA
NSAs		50 dBA	65 dBA

REFERENCE

0 0.2 0.4 MILES

0 0.2 0.4 KILOMETERS

N

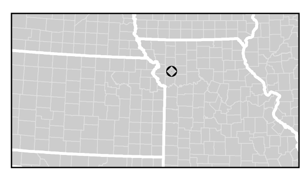


Figure A-3
Sound Level Contours

LOCATION: Clinton County, MO
CLIENT/PROJECT: AECI Turney
PROJ. NO.: 141827
CREATED: 10/01/2024

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Path: G:\Projects\Air-Noise Dept\Project Files\AECI\Turney Noise\GIS\Turney\Turney Noise_Bit.aprx

APPENDIX B – MEASUREMENT DATA

Turney Energy Center
Ambient Measurement Data

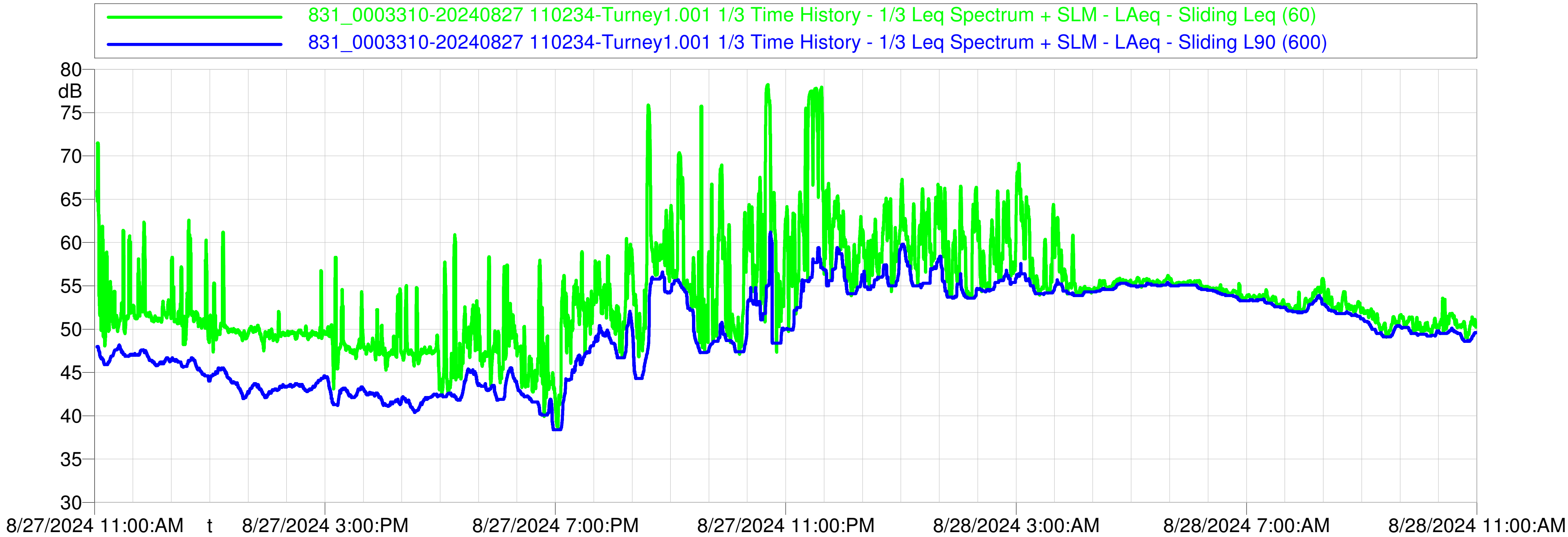
Time	MP1					MP2				
	L_{Aeq} (dBA)	L_{A90} (dBA)	L_{ANS} (dBA)	L_{Ceq} (dBC)	L_{C90} (dBC)	L_{Aeq} (dBA)	L_{A90} (dBA)	L_{ANS} (dBA)	L_{Ceq} (dBC)	L_{C90} (dBC)
8/27/24 11:15 AM	54	47	35	55	50	66	53	63	72	54
8/27/24 12:00 PM	53	46	35	53	47	63	53	61	68	53
8/27/24 1:00 PM	51	44	35	51	45	62	53	60	66	53
8/27/24 2:00 PM	50	43	35	56	44	62	52	60	67	53
8/27/24 3:00 PM	49	43	36	51	44	65	51	64	72	53
8/27/24 4:00 PM	49	42	35	52	43	63	52	61	68	52
8/27/24 5:00 PM	51	43	35	52	44	64	52	62	69	53
8/27/24 6:00 PM	49	42	34	50	44	64	52	62	69	54
8/27/24 7:00 PM	53	43	45	68	51	60	53	57	68	56
8/27/24 8:00 PM	63	47	51	68	59	60	50	58	69	60
8/27/24 9:00 PM	63	48	59	72	56	60	51	57	71	60
8/27/24 10:00 PM	67	49	49	69	53	62	53	53	69	58
8/27/24 11:00 PM	71	55	38	69	54	64	52	48	65	60
8/28/24 12:00 AM	60	55	37	62	57	63	59	53	64	58
8/28/24 1:00 AM	62	55	36	61	55	62	58	40	61	57
8/28/24 2:00 AM	61	54	34	60	54	59	56	43	59	56
8/28/24 3:00 AM	61	54	35	59	54	59	56	47	58	56
8/28/24 4:00 AM	55	54	36	55	54	60	55	54	62	56
8/28/24 5:00 AM	55	55	35	55	55	61	55	57	62	56
8/28/24 6:00 AM	55	54	36	55	54	61	56	59	65	57
8/28/24 7:00 AM	53	52	38	57	53	65	56	64	72	57
8/28/24 8:00 AM	53	52	36	55	53	62	57	59	65	58
8/28/24 9:00 AM	51	50	38	57	53	63	58	61	69	59
8/28/24 10:00 AM	51	49	38	56	53	63	58	60	68	59
8/28/24 11:00 AM	53	49	46	60	54	64	56	62	68	58
Daytime Average	**56**	**46**	**48**	**63**	**49**	**63**	**54**	**61**	**69**	**56**
Nighttime Average	**64**	**54**	**41**	**64**	**54**	**62**	**55**	**54**	**64**	**57**
Day-night Average (L_{dn})	**71**	**--**	**--**	**--**	**--**	**69**	**--**	**--**	**--**	**--**

**Daytime is from 7 AM to 10 PM, and nighttime is from 10 PM to 7 AM*

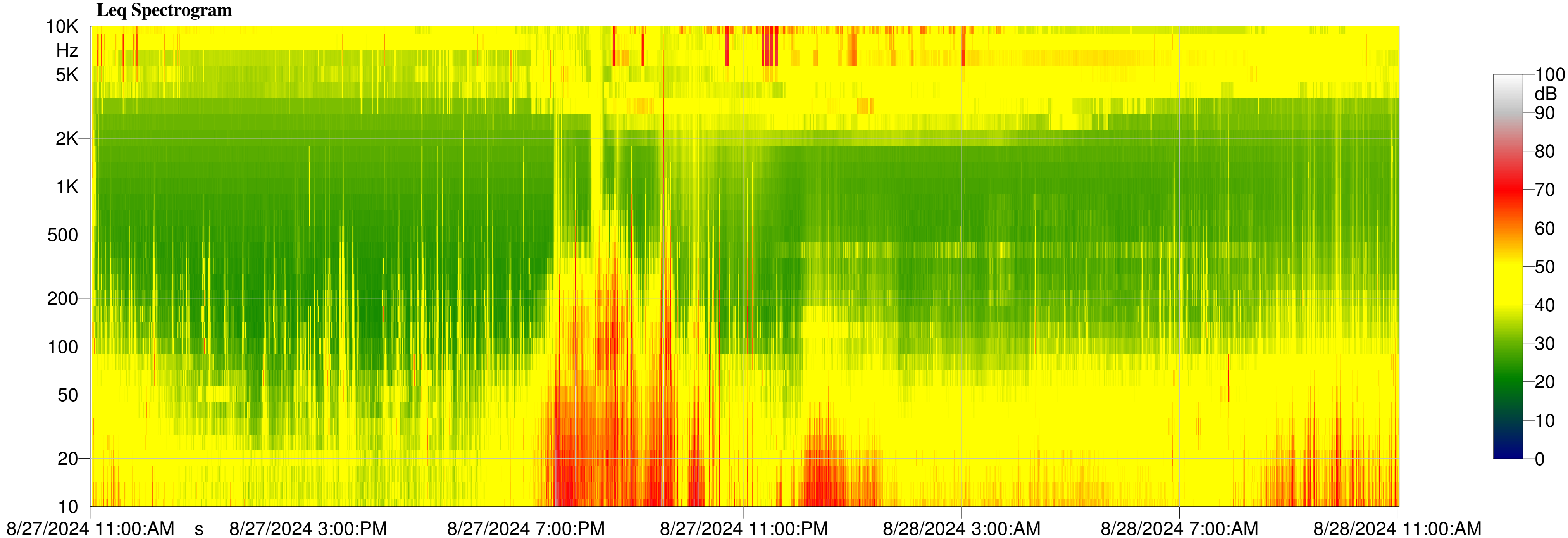
***Day-night average is average Leq with a 10 dB penalty on nighttime sound levels*

Measurement: AECI Turney Energy Center
Location: MP1

Leq is the 1-minute average sound level
L90 is the 10-minute 90th percentile exceedance sound level

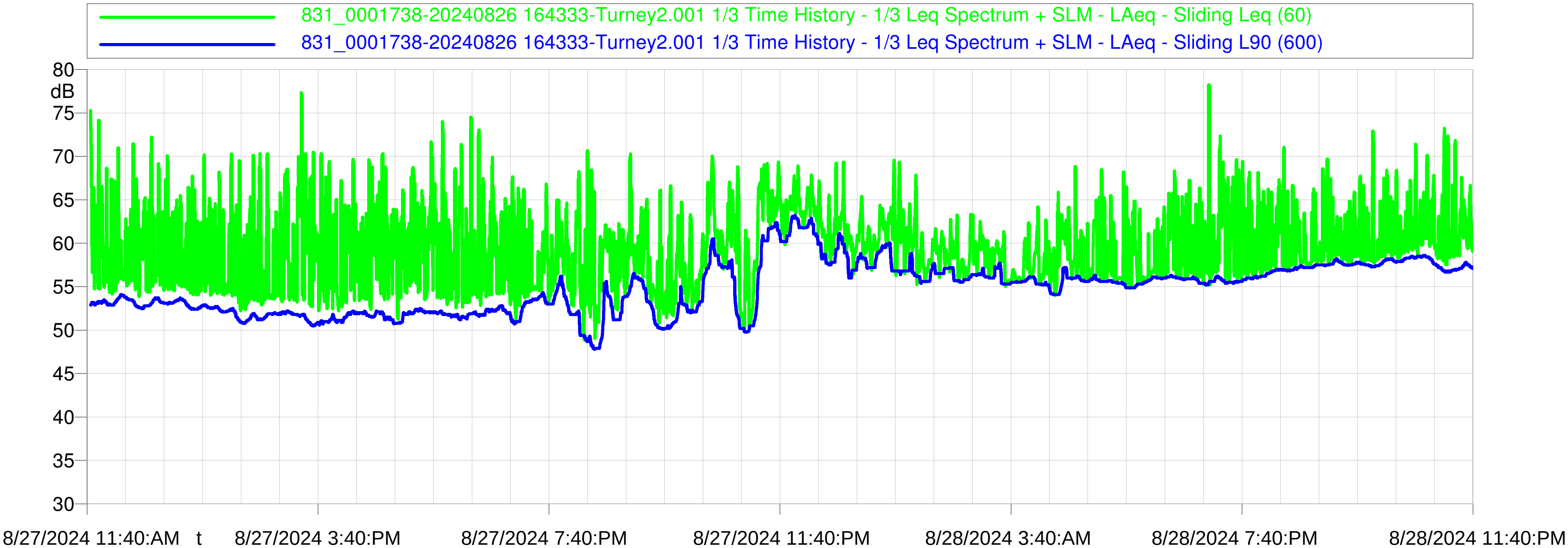


Leq Spectrogram

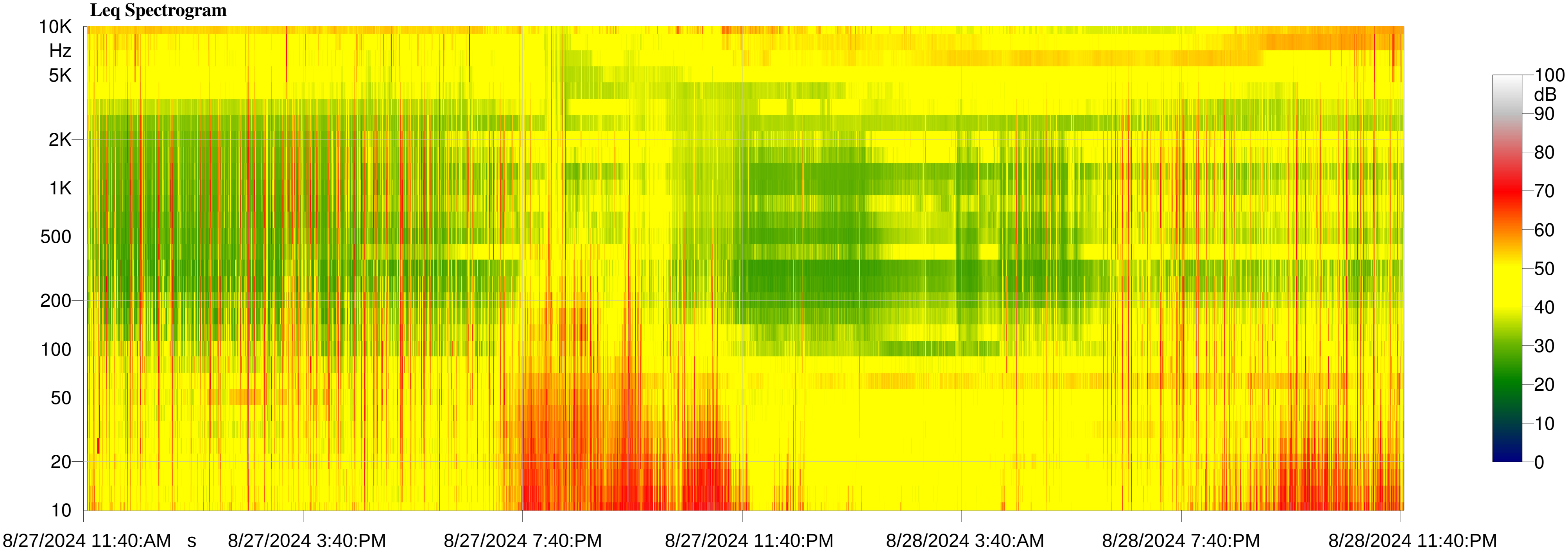


Measurement: AECI Turney Energy Center
Location: MP2

Leq is the 1-minute average sound level
L90 is the 10-minute 90th percentile exceedance sound level



Leq Spectrogram



APPENDIX C – MODELED SOUND LEVELS

Appendix C - Modeled Sound Power Levels

AECI

Turney Energy Center

Name	Number of Sources	Sound Power Level (dB)[1] Octave Band Frequency (Hz)									Overall (dBA)	Notes
		31.5	63.0	125	250	500	1000	2000	4000	8000		
Ammonia Pumps	4	96	102	100	99	98	97	96	95	91	**103**	Estimated 85 dBA @ 3ft
GT Enclosure Discharge Vent	4	89	96	84	82	79	86	88	89	89	**95**	In-house
GT Enclosure Air Inlet Vent	4	91	98	86	88	87	87	90	90	90	**96**	In-house
Dew Point Heater Stack	1	119	101	93	88	89	95	93	92	91	**100**	Estimated 85 dBA @ 3ft
Fuel Gas Heater	3	103	99	101	91	85	83	83	80	76	**91**	In-house
Fuel Gas Pumps	4	89	95	93	92	91	90	89	88	84	**96**	Estimated 85 dBA @ 3ft
Fuel Gas Valve	6	106	102	91	83	82	88	90	93	91	**98**	Estimated 85 dBA @ 3ft
Fuel Oil Pump Skid	1	98	114	101	104	107	107	109	105	98	**114**	In-house
GT Blower Skid	1	110	106	108	98	92	90	90	87	83	**98**	Estimated 85 dBA @ 3ft
Roto Air Cooler	1	107	105	100	96	94	89	85	83	79	**96**	In-house
Stack Exit	1	130	124	110	92	88	100	114	108	85	**116**	In-house
TA Inlet	4	132	125	108	84	79	77	73	68	80	**100**	In-house
TEC Blower	1	110	106	108	98	92	90	90	87	83	**98**	Estimated 85 dBA @ 3ft
ACHE	1	122	124	110	107	113	107	105	103	96	**114**	Estimated 85 dBA @ 3ft
Air Inlet Duct	1	111	106	105	94	88	102	87	88	93	**103**	In-house
Air Inlet House	1	118	112	108	99	87	90	79	96	105	**105**	In-house
Ammonia Flow Control Skid	1	93	99	97	96	95	94	93	92	88	**100**	Estimated 85 dBA @ 3ft
Aux Transformer	1	95	95	99	99	99	83	78	71	66	**97**	Estimated 80 dBA @ 3ft
GT Enclosure	1	113	117	101	96	96	99	92	93	99	**104**	In-house
CTG Cooling Air Package	1	103	105	91	88	94	88	86	84	77	**95**	Estimated 85 dBA @ 3ft
Dew Point Heater	1	116	108	107	100	96	97	95	92	87	**102**	Estimated 80 dBA @ 3ft
Exhaust Diffuser	1	133	130	115	113	110	108	106	100	77	**114**	In-house
FGC Cooler	2	112	114	100	97	103	97	95	93	86	**104**	Estimated 85 dBA @ 3ft
Fuel Gas Compressor	2	101	97	102	101	99	102	102	100	95	**108**	Estimated 90 dBA @ 3ft
GSUT	1	102	102	106	106	106	90	85	78	73	**104**	Estimated 85 dBA @ 3ft
GT Generator	1	116	122	119	111	118	108	112	110	107	**119**	On-site measurements
GT Oil Package	1	110	104	101	101	101	99	95	94	90	**104**	In-house
SCR Duct	1	106	105	89	78	77	94	86	69	41	**95**	In-house
SCR Transition Section 1	1	107	107	97	88	84	99	91	74	48	**100**	In-house
SCR Transition Section 2	1	107	106	90	80	79	96	88	71	44	**97**	In-house
SCR Transition Section 3	1	102	99	90	87	81	95	89	78	53	**96**	In-house
TA Duct and Casing	2	104	103	89	86	86	106	103	88	61	**108**	In-house
Water Injection Pump Skid	1	99	115	100	106	105	105	105	101	98	**111**	In-house
Stack Casing Upper	1	104	101	88	72	68	50	54	49	25	**77**	In-house
Stack Casing Lower	1	108	105	91	87	84	103	96	85	57	**104**	In-house

Notes:

1. All sound levels are inclusive of any base package designed mitigation

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