APPENDIX E

NOISE STUDY

CRANE ENERGY STORAGE
SANDHILL ENERGY STORAGE

SOUND STUDY

CRANE AND SANDHILL ENERGY STORAGE
PROJECT NO. 176103

REVISION 0
DECEMBER 2024

CONTENTS

TABLES

List of Abbreviations

Abbreviation	Term/Phrase/Name
BESS	battery energy storage system
CadnaA	Computer Aided Noise Abatement
dB	decibels
HVAC	heating ventilation and air conditioning
Hz	Hertz
ISO	International Organization of Standardization
L_{eq}	equivalent-continuous sound level
L_{10}	sound level not to be exceeded 10% of the time
L_{50}	sound level not to be exceeded 50% of the time
MPCA	Minnesota Pollution Control Agency
NAC	Noise Area Classification
Project or Projects	Crane Energy Storage and Sandhill Energy Storage
PWL	sound power level
SPL	sound pressure level

Executive Summary

Burns & McDonnell conducted a sound assessment study for two (2) adjacently located energy storage projects, the proposed Crane Energy Storage and Sandhill Energy Storage projects (“Project” or “Projects”). The Projects are comprised of two separate 200-megawatt, 800-megawatt-hour battery energy storage systems (“BESS”) with an associated substation located in Olmsted County, Minnesota. Cumulatively the Projects are a 400-megawatt, 1600-megawatt-hour BESS. The major sound sources included in the Projects are the BESS containers equipped with integrated inverters and heating, ventilation, and air conditioning (“HVAC”) equipment, and electrical transformers. The sound study has been completed assuming both Projects operate all of their equipment at full capacity at the same time.

The State of Minnesota has applicable sound level requirements for the Projects. The Projects were analyzed for cumulative sound level impacts at neighboring receptors. The sound level impacts were compared to the industrial nighttime limit of 75 dBA and the residential nighttime limit of 50 dBA, at the nearest respective locations. The battery containers with associated HVAC equipment and transformers were modeled with the provided sound level specifications. The Projects operational sound levels are predicted to be in compliance with the State of Minnesota sound level limits at the neighboring properties.

1.0 Acoustic 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 acoustic 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, expressed as C-weighted decibels or dBC, does not discriminate against low frequencies and measures more uniformly over the frequency range of 30 to 10,000 Hz.

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. Since the L_{eq} is the mean sound level of a given time period and the L_{50} is the median sound level for a given time period, it is common to assume that those two metrics are approximately equal for constant sound sources.

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

2.1 State of Minnesota

The State of Minnesota regulates noise under the Minnesota Administrative Rules Chapter 7030. Chapter 7030 is found within the Minnesota Pollution Control Agency ("MPCA") 2015 A Guide to Noise Control in Minnesota. Chapter 7030 identifies daytime and nighttime sound level limits based on the NAC of the receiving land use. NAC1 includes noise-sensitive areas such as residential areas, hotels, and medical facilities. NAC2 includes a variety of commercial uses and NAC3 includes manufacturing, industrial, and agricultural uses as further detailed in Section 7030.0050 Subpart 2 of the Minnesota Administrative Rules. Table 2-1 defines the daytime and nighttime sound level limits for all NAC.

Table 2-1: MPCA Sound Level Limitations

Noise Area Classification	Daytime L_{50} (dBA)	Daytime L_{10} (dBA)	Nighttime L_{50} (dBA)	Nighttime L_{10} (dBA)
1 (Residential)	60	65	50	55
2 (Commercial)	65	70	65	70
3 (Industrial)	75	80	75	80

2.2 Olmsted County, Minnesota

The Project is located within Olmsted County, Minnesota. There were no identified noise ordinances for Olmsted County applicable to the Project.

2.3 Kalmar Township, Minnesota

The Project is located within Kalmar Township, Minnesota. There were no identified noise ordinances for Kalmar Township applicable to the Project.

3.0 Predictive Modeling

3.1 Methodology

Sound modeling was performed using the industry-accepted sound modeling software Computer Aided Noise Abatement ("CadnaA"), version 2024. The software is a scaled, three-dimensional program, which takes into account air absorption, terrain, ground absorption, and reflections and shielding for each piece of noise-emitting equipment and predicts sound pressure levels. The model calculates sound propagation based on International Organization of Standardization ("ISO") 9613-2:2024, 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 software calculates sound propagation using omnidirectional, downwind sound propagation and worst-case directivity factors. In other words, the model assumes that each piece of equipment propagates its maximum sound level in all directions at all times. 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. Terrain elevations were included in the model to account for surface effects. Ground absorption values can range from 0.0 (fully reflective surface) to 1.0 (fully absorptive surface). Onsite ground absorption was set to 0.5, as a conservative measure. All sound modeling parameters used are provided in Table 3-1.

Table 3-1: Sound Modeling Parameters

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

3.2 Project Sound Sources

The main source of operational noise will be the battery containers with integrated inverters and HVAC equipment, and electrical transformers. Project sound sources were modeled according to the locations provided in the general arrangement drawing provided as Figure A-1 of Appendix A. The battery containers were located based on the provided layout. Sound levels for each piece of equipment were provided by the manufacturer or estimated based on similar equipment data, as provided below.

Sungrow provided a noise test report, dated November 2023, for the PowerTitan 2.0 battery system with a maximum measured sound level of 74 dBA at 1 meter on top of the unit where the cooling fans are located. Detailed sound level data was not provided for the substation transformers or MV transformers. The substation transformer was assumed to be 85 dBA at 3 feet and the MV transformers were assumed to be 65 dBA at 3 feet, based on similar equipment. Table 3-2 provides the modeled sound level assumptions for each piece of modeled equipment. For each piece of modeled equipment, a sound level spectrum was provided by the manufacturer or referenced from equipment of similar size and scope to accurately reflect the frequency characteristics for each source.

Table 3-2: Modeled Source Sound Level Assumptions

Equipment	Number of Sources Modeled	Modeled Sound Pressure Level	Modeled Sound Power Level
PowerTitan 2.0	472	68 dBA at 1 meter	90 dBA
MV Transformer	118	65 dBA at 3 feet	84 dBA
Substation Transformer	2	85 dBA at 3 feet	106 dBA

The battery container HVAC units would not be expected to run simultaneously at full load during nighttime hours due to the lower ambient temperatures at night, but they were modeled with all units at full load as a conservative measure.

3.3 Model Results

The model predicted Project sound levels at the nearest industrial property line (IND01) and at the nearest residential areas. IND01 will be compared to the applicable State of Minnesota nighttime industrial limit of 75 dBA L_{50}. The residential properties will be compared to the applicable State of Minnesota nighttime residential limit of 50 dBA L_{50}. Table 3-3 provides the modeled Project sound levels compared to the State of Minnesota sound limits for the highest model impacts at the industrial and residential properties. The model predicted sound levels assume all equipment is running at full load.

Table 3-3: Modeled Sound Level Results

Receiver	Receiver Type	Modeled Sound Level (dBA)	State of Minnesota Nighttime Limits (L_{50} dBA)
IND01	Industrial	55	75
REC121	Residential	47	50

The industrial receiver was modeled to be below 75 dBA, and all residential receivers were modeled to be at or below 50 dBA with the Project operating at full load, in accordance with the State of Minnesota regulations. Graphical representations of the Project sound levels are provided in Figure A-2 of Appendix A, as 5-dBA sound level contours.

The application guidance for solar farms in Minnesota requires projects to provide a table showing the number of receptors within 3,200 feet of the project and describe how these receptors were identified. This Project is not a solar project but includes similar electrical components. Therefore, receptors within 3,200 feet of the Project have been identified through aerial imagery and are shown on the map in Figure A-2 of Appendix A. The number of receptors within specific distances are provided in Table 3-4. The total number of receptors within 3,200 feet of either Project site is 453. Some receptors are within 3,200 feet of both sites. Tables showing the Project sound level impacts at all receivers within the 3,200-foot boundary are provided in Appendix B.

Table 3-4: Proximity of Residences within 3,200 feet

Distance From Site to Receptor (feet)	Crane Land Control Area	Sandhill Land Control Area
<400	2	2
400-800	1	1
800-1,600	14	102
1,600-3200	226	346

4.0 Conclusion

Burns & McDonnell conducted a sound study for the Projects. The State of Minnesota has applicable sound level requirements for the Projects. The Projects were compared to the industrial nighttime L_{50} sound level limit of 75 dBA at the nearest industrial property and the residential nighttime sound level limit of 50 dBA L_{50}, at the nearest residential locations.

The proposed equipment sound levels were modeled using industry-accepted sound modeling software to predict future sound levels at the property lines and in the surrounding community. Transformers and battery containers are expected to be the significant sound-emitting sources associated with the Projects and were modeled based on conceptual general arrangement drawings. A number of conservative assumptions were applied to the model to predict worst-case sound pressure levels at distance. The model results were then compared to the identified applicable regulations.

The Projects are cumulatively predicted to meet the 50-dBA-L_{50} residential limit at all adjacent residential properties and the 75-dBA-L_{50} industrial limit at all adjacent industrial properties. Although worst-case equipment sound levels were used in the model, daily operating levels may be less.

APPENDIX A – FIGURES

CRANE DESCRIPTION	
NAMEPLATE	200 MW / 800 MWh

CRANE MATERIAL LIST	
NUMBER OF PURPOSE BUILT ENCLOSURES (BOL)	212
NUMBER OF PURPOSE BUILT ENCLOSURES (EOL)	236
NUMBER OF MEDIUM VOLTAGE TRANSFORMERS (BOL)	53
NUMBER OF MEDIUM VOLTAGE TRANSFORMERS (EOL)	59

SANDHILL BESS DESCRIPTION	
NAMEPLATE	200 MW / 800 MWh

SANDHILL MATERIAL LIST	
NUMBER OF PURPOSE BUILT ENCLOSURES (BOL)	212
NUMBER OF PURPOSE BUILT ENCLOSURES (EOL)	236
NUMBER OF MEDIUM VOLTAGE TRANSFORMERS (BOL)	53
NUMBER OF MEDIUM VOLTAGE TRANSFORMERS (EOL)	59

LEGEND:

- PROPERTY LINE
- FENCE
- SETBACK
- GATE
- CRUSHED ROCK LIMITS

ABBREVIATION LIST:

BESS - BATTERY ENERGY STORAGE SYSTEM
BOL - BEGINNING OF LIFE
EOL - END OF LIFE
PCS - POWER CONVERSION SYSTEM
POI - POINT OF INTERCONNECTION
TYP - TYPICAL

NOTES:

1. FINAL LAYOUT SUBJECT TO CHANGE BASED ON FINAL ENVIRONMENTAL, CIVIL, GEOTECHNICAL, AND AUTHORITY HAVING JURISDICTION REQUIREMENTS.
2. EQUIPMENT QUANTITIES, CONFIGURATION, AND FOOTPRINT SUBJECT TO CHANGE BASED ON FINAL BESS TECHNOLOGY SELECTION AND ADDITIONAL PROJECT DUE DILIGENCE.
3. CIVIL GRADING AND STORMWATER NOT CONSIDERED IN LAYOUT DEVELOPMENT.
4. DESIGN MAINTAINS FACILITY NAMEPLATE RATING THROUGH YEAR 20. AUGMENTATION EVENTS OCCUR AT YEARS 6, 10, 13, AND 17.
5. LANDSCAPING NOT INCLUDED IN LAYOUT DEVELOPMENT.
6. WATER SUPPLY, SUCH AS TANKS, FIRE WATER LOOP, AND/OR HYDRANTS NOT INCLUDED OR CONSIDERED IN LAYOUT DEVELOPMENT.
7. WETLANDS, FLOODPLAINS, AND OTHER ENVIRONMENTAL CONSIDERATIONS SUBJECT TO CHANGE.

NORTH

PRELIMINARY - NOT FOR CONSTRUCTION

no.	date	by	ckd	description
C	10/21/2024	MRA	EDV	ISSUED FOR REVIEW
B	03/11/2024	MRA	EDV	ISSUED FOR REVIEW
A	01/18/2024	MRA	JLT	ISSUED FOR REVIEW

BURNS McDONNELL
9400 WARD PARKWAY
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Burns & McDonnell Engineering Co, Inc.

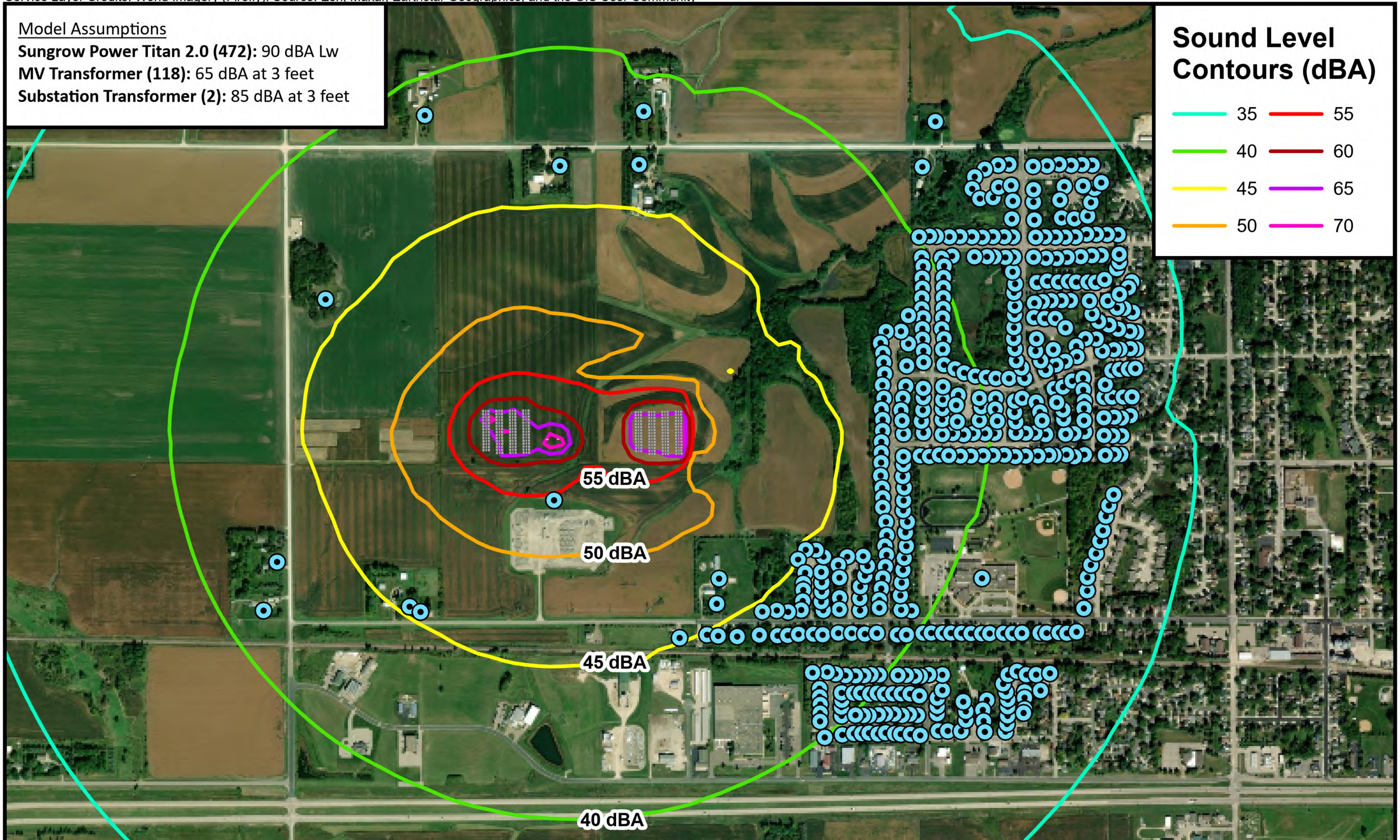
designed M. ANSTINE
detailed M. ANSTINE

OLMSTED COUNTY, MINNESOTA

TENASKA CRANE & SANDHILL BATTERY ENERGY STORAGE SYSTEM SITE PLAN

project
contract
drawing LAYOUT — rev. C
sheet 1 of 1 sheets
file TenaskaCraneSandhillLayout.dwg

Path: G:\Projects\Air-Noise Dept\Project Files\Tenaska\Crane Sandhill BESS\GIS\Tenaska Crane Sandhill BESS GIS Project\Tenaska Crane Sandhill BESS GIS Project.aprx gweger 12/6/2024
Service Layer Credits: World Imagery (Firefly): Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community



BESS Containers and Transformers

Receptors

NORTH

700 350 0 700

Scale in Feet

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Figure A-2

Crane and Sandhill BESS
Sound Level Contours

Source: ESRI, Burns & McDonnell

Issued: 12/6/2024

APPENDIX B – MODELED SOUND LEVELS

APPENDIX B - RECEIVER SOUND LEVELS

Receiver	Sound Level (dBA)
IND01	55
REC001	36
REC002	36
REC003	36
REC004	36
REC005	36
REC006	37
REC007	37
REC008	37
REC009	38
REC010	38
REC011	38
REC012	38
REC013	38
REC014	38
REC015	37
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REC080	44

Receiver	Sound Level (dBA)
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Receiver	Sound Level (dBA)
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REC451	37
REC452	39

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