APPENDIX E – NOISE STUDY

EAST KENTUCKY POWER COOPERATIVE

SOUND STUDY REPORT

LIBERTY RICE POWER PLANT

PROJECT NO. 168547

REVISION 1

NOVEMBER 2024

CONTENTS

TABLES

List of Abbreviations

Abbreviation	Term/Phrase/Name
BOP	Balance of Plant
CadnaA	Computer Aided Noise Abatement
dB	decibel
dBA	A-weighted decibel
EKPC	East Kentucky Power Cooperative
Hz	Hertz
ISO	International Organization for Standardization
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
MP	measurement point
mph	miles per hour
Project	Liberty RICE Power Plant
PWL	sound power level
RICE	Reciprocating Internal Combustion Engine
SPL	sound pressure level

Executive Summary

Burns & McDonnell conducted a sound study for the East Kentucky Power Cooperative (EKPC) Liberty Power Plant (Project), located in Casey County, Kentucky. The Project is a reciprocating internal combustion engine (RICE) power generation facility which is expected to include 12 Wartsila W18V50DF RICE units housed inside a building and associated balance-of-plant (BOP) equipment.

The objectives of this study were to identify the applicable noise regulations, model operational sound levels of the Project, and compare Project-generated sound levels to the applicable noise regulations. As of this version of the report, the existing ambient sound level measurements have not been completed. However, measurements were conducted at a nearby location which were used to estimate the ambient sound levels for this area.

The State of Kentucky does not have applicable noise statutes which limit noise from the Project nor does Casey County. Project operational sound levels, inclusive of all designed noise mitigation, have been predicted and compared to the expected existing ambient sound levels in the surrounding area.

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.

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).

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 Project noise limits. The State of Kentucky, nor Casey County, have applicable noise statutes which limit noise from the Project.

3.0 Sound Level Measurements

Ambient sound level measurements have not been conducted at the Liberty site. However, sound level measurements were conducted at the previous alternative Campbellsville site which is approximately 22 miles northwest of the Liberty site. Since both sites are rural areas in a similar region, relatively close to each other, and both similar distances away from rural highways and major interstates, the ambient measurements at Campbellsville have been used to approximate the existing ambient sound levels at Liberty. The following Table 3-1 shows the estimated ambient sound levels at the nearby residents to the Project, based on previous measurements conducted at the Campbellsville site.

Table 3-1: Estimated Ambient Sound Levels (from Campbellsville Measurements)

Location	Average Ambient Sound Level (dBA)			
	Daytime L_{eq}	Daytime L_{90}	Nighttime L_{eq}	Nighttime L_{90}
Nearby Residents	43	33	38	32

**Daytime hours are 7:00 AM to 10:00 PM*

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 supplier provided data and in-house data based on experience with similar make and sized 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 using worst-case directivity factors, 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 and 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.

The Project general is included as Figure A-1 of Appendix A. The modeled equipment octave-band sound levels for each piece of equipment are included in Appendix B. A summary of the Project's expected acoustical design is shown in Table 4-2.

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%

Table 4-2: Project Expected Acoustical Design

Equipment	QTY	Base Sound Level[a,b]	Notes
Wartsila Equipment			
RICE Engine	12	L_w = 128 dBA	Inside RICE Hall, Roof - STC 50 Min, Walls - STC 55 Min + Absorptive Layer
RICE Exhaust Exit	2	L_w = 99 dBA	Includes SCR + Resonator + 45 dBA Silencer
RICE Exhaust Duct	12	$L_{w''}$ = 93 dBA/m	Insulated Duct
Charge Air Intake	24 (2 ea.)	L_w = 96 dBA	Intake 45 dB Silencer
Radiator	12 (1 ea.)	L_w = 96 dBA	Noise Level 4
Roof Ridge Vent	1	L_w = 108 dBA	From RICE Hall Interior Calc'd SPL w/ Ridge Vent Silencer
MAU/Relief	24	L_w = 99 dBA	From RICE Hall Interior Calc'd SPL
BOP Equipment			
GSU Transformer	3	L_p = 85 dBA at 3 feet	Estimated
Small Transformers	4	L_p = 70 dBA at 3 feet	Estimated
HVAC Units	2	L_w = 95 dBA	Estimated
Misc. Pumps, Heaters, etc.		L_p = 85 dBA at 3 feet	Estimated

(a) L_p – Sound pressure level at specified distance

(b) L_w – Sound power level, $L_{w''}$ – Sound power level per unit area

4.2 Sound Modeling Results

The Project will operate at fairly constant sound levels when operational. Therefore, steady-state sound level predictions were completed. A worst-case, full-load scenario with all 12 engines operating at 100% load was used for the modeling scenario. The predicted overall steady-state operational A-weighted sound levels, which do not include contributions from ambient sound sources, are shown with 5-dB contours in Figure A-2 of Appendix A.

The Project-generated sound levels were calculated at the nearest residential properties. Table 4-3 includes the predicted Project sound levels at the nearest residential receptors.

Table 4-3: Modeled Sound Level Results

Receptor Location	Assumed Ambient Sound Level[a] (dBA)	Model Predicted Sound Level[b] (dBA)
R1	32	50
R2	32	43
R3	32	42
R4	32	45
R5	32	52

(a) Lowest of the daytime/nighttime average measured L_{90} sound levels from Campbellsville measurements
(b) Model-predicted Project sound level

5.0 Conclusions

Burns & McDonnell conducted a preliminary sound study for the proposed Liberty Project. This preliminary study consists of predictive sound modeling of the Project to analyze potential offsite sound impacts from operation of the Project. Ambient sound levels for this site have been estimated based on previous ambient monitoring of a nearby site with a similar environment near rural highways.

There were no identified regulatory noise limits for the Project. The Project as currently designed is expected to contribute a maximum sound level of approximately 52 dBA at the nearest identified residential receptor, R5, located west of the Project site.

APPENDIX A – FIGURES

EQUIP COORDS

ITEM	NORTHING	EASTING	HEIGHT
N	N: 2018106.704	E: 1870322.119	25'-0"
P	N: 2018684.617	E: 1870617.902	25'-0"
Q	N: 2018532.597	E: 1870469.324	15'-0"

STACK COORDS

ITEM	NORTHING	EASTING
A	N: 2018810.868	E: 1870267.759
B	N: 2018681.917	E: 1870317.258

BUILDING HEIGHTS

ITEM	HEIGHT
1	34'-0"
2	45'-0"
3	NOT USED
4	25'-0"
5	23'-0"
6	15'-0"

SITE KEY

1	ENGINE HALL
2	LOW VOLTAGE ROOM
3	ADMIN-CONTROL AREA
4	MECHANICAL ROOM
5	BATTERY ROOM
6	MEDIUM VOLTAGE BLDG
7	SILENCERS - STACKS
8	SELECTIVE CATALYTIC REDUCER
9	CHARGE AIR FILTER
10	RADIATORS
11	STEP-UP TRANSFORMER AND CONTAINMENT
12	GAS CONDITIONING
13	OIL-UREA CONTAINMENT
14	UREA TANK
15	NEW LUBE OIL TANK
16	SERVICE LUBE OIL TANK
17	WASTE LUBE OIL TANK
18	OIL-UREA / AMMONIA UNLOADING STATION
19	STATION TRANSFORMER
20	HVAC UNITS
21	HEAVY HAUL
22	FIRE WATER TANK
23	FIRE PUMPS
24	FUEL PUMPS
25	LIQUID FUEL TANKS WITH CONTAINMENT
26	AUX GENERATOR
27	WAREHOUSE
28	OIL WATER SEPARATOR
29	GAS FILTER/SEPARATOR
30	RESONATOR
31	HORIZONTAL SILENCER
32	SEAL AIR FAN

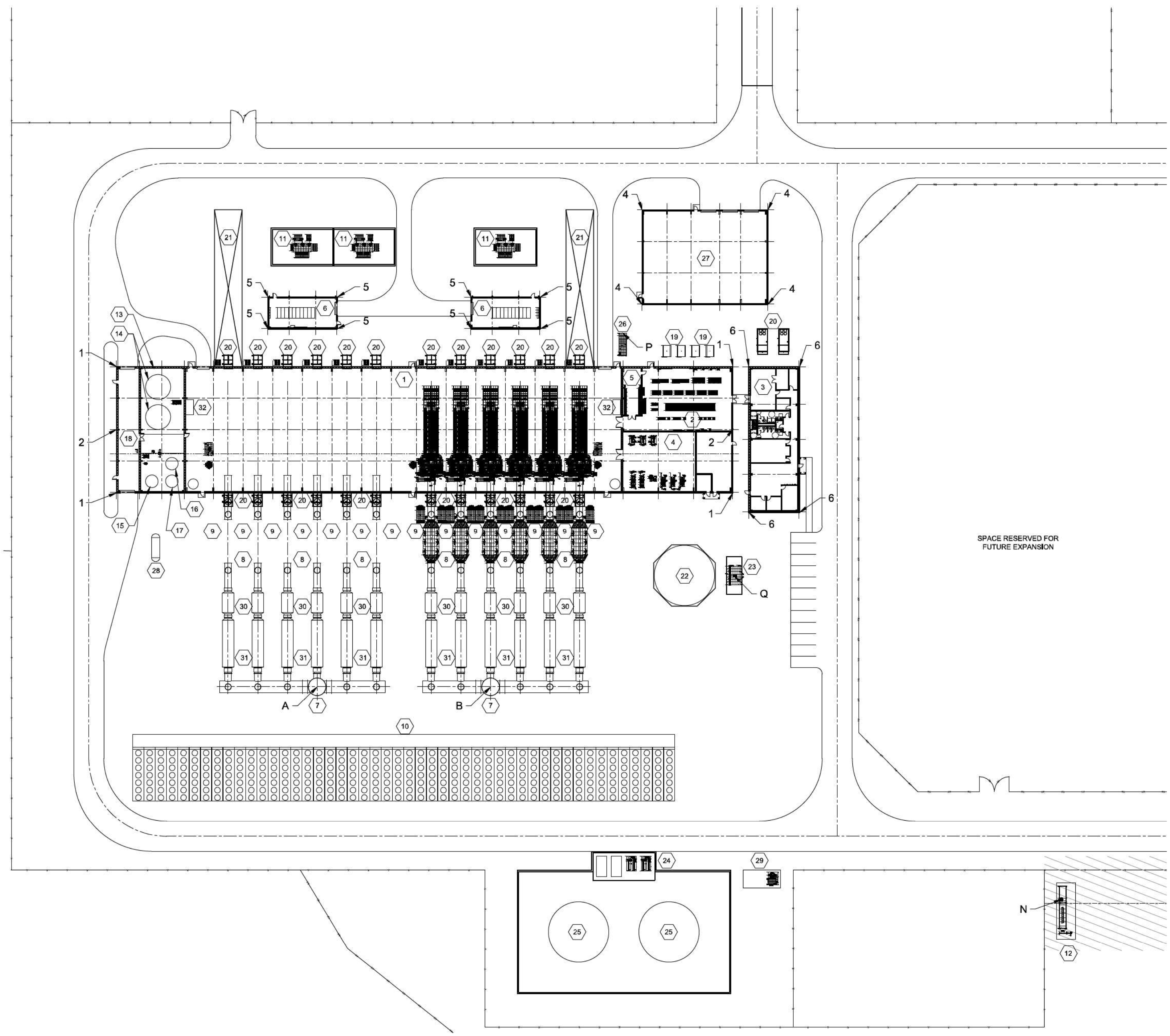

Figure A-1 General Arrangement

PRELIMINARY - NOT FOR CONSTRUCTION

no.	date	by	ckd	description
D	08/23/24	WRL		ADJUSTED PLANT LOCATION FOR 1000'-0" SETBACK
C	06/04/24	WRL		ADDED SEAL AIR FAN
B	04/29/24	WRL		ADDED COORDINATES FOR STACKS AND EQUIPMENT
A	03/04/24	WRL		PRELIMINARY MIRRORED SINGLE STACK LAYOUT

POWER BLOCK ENLARGED PLAN

0 16' 32' 64'
SCALE IN FEET

TRUE NORTH 21°0'0"
PLAN NORTH
NORTH

BURNS McDONNELL

designed | detailed W. LESNIAK

EAST KENTUCKY POWER COOPERATIVE

LIBERTY SITE 3
12 x 18MW GAS RECIP ENGINE PLANT
SINGLE STACK OPTION B
ENLARGED PLAN

project 157785 | contract
drawing GA122 – rev. D
sheet of sheets
file 157785_12X18MW-GA122-LIBRTY3-SNGLESTK-OPTB.

Z:\CLIENTS\ENR\EKPC\157785_RECIPSTUDY\2_DESIGN\MECH\DWGS\GNRL_ARRANGMNT\157785_12X18MW-GA122-LIBRTY3-SNGLESTK-OPTB.DWG 6/4/2024 3:07 PM WLESNIAK

LEGEND

40 dBA	55 dBA
45 dBA	60 dBA
50 dBA	65 dBA

- Property Boundary
- Structures
- Receivers

REFERENCE

0 — 0.08 — 0.16 MILES

0 — 0.08 — 0.16 KILOMETERS

N

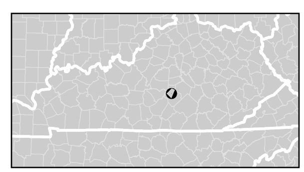

Figure A-2 - RICE 100% Load (12 Units)
Project Design Sound Level Contours (dBA)

LOCATION:	Casey County, KY
CLIENT:	EKPC
PROJ. NO.:	168547
CREATED:	11/13/2024

BURNS McDONNELL
www.burnsmcd.com

Path: Z:\Clients\ENR\EKPC\157785_RECIPSTUDY\7_Studies\Permitting\Modeling\Noise\GIS\Liberty GIS\Liberty GIS.aprx • Coordinate System: • Units:

APPENDIX B – MODELED SOUND POWER LEVELS

Appendix B - Base Design Modeled Sound Power Levels

EKPC

Liberty RICE - 12 Engine Layout

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		
Fuel Pump	2	79	91	87	90	91	94	89	77	58	**97**	Estimated
Gas Heater	2	104	101	99	94	91	87	80	76	72	**93**	Estimated
MAU Intake	12	107	98	98	96	95	93	93	88	83	**99**	Calculated from interior equipment
MAU Relief	12	107	98	98	96	95	93	93	88	83	**99**	Calculated from interior equipment
Small Transformer	4	90	87	88	85	88	85	80	78	68	**90**	Estimated
Stack Exit	2	114	112	109	103	96	78	64	67	69	**99**	Wartsila Stack + Res Silencer + SCR + 45 dB Silencer
Combined Exhaust Ducts (dB/m)	4	71	70	54	46	48	42	29	33	22	**63**	Calculated from combined duct sound levels
RICE Exhaust Duct - Resonator Section (dB/m)	12	78	83	77	73	76	79	66	66	55	**91**	Wartsila Duct + Res Silencer + SCR
RICE Exhaust Duct - SCR Section (dB/m)	12	99	91	77	73	76	79	66	66	55	**91**	Wartsila Duct + SCR
RICE Exhaust Duct - Silencer Section (dB/m)	12	63	62	46	39	40	34	21	25	14	**52**	Wartsila Duct + Res Silencer + SCR + 45 dB Sil.
RICE Exhaust Duct - Pre SCR (dB/m)	12	102	97	86	85	88	91	78	78	67	**103**	Wartsila Insulated Exhaust Duct
Ridge Vent	1	108	96	91	80	77	76	83	82	79	**108**	Calculated from RICE Hall Interior Sources + Silencer
Engine Hall Roof	1	118	100	93	89	93	72	66	60	55	**91**	Calc from RICE Hall Interior (includes TL losses from roof assembly)
HVAC Unit	2	73	78	83	93	93	90	88	83	73	**95**	Estimated
Radiator (Total)	1	125	112	112	107	104	102	97	92	84	**107**	In-house sound levels
Step Up Transformer	3	103	100	101	98	101	98	93	91	81	**102**	Estimated
Engine Hall Walls	1	104	91	88	82	75	67	64	56	45	**78**	Calc from RICE Hall Interior (includes TL losses from wall assembly)
Exhaust Stack Wall	2	95	91	87	81	72	53	12	9	5	**76**	Estimated combined in-duct levels
RICE Hall	1	112	104	104	103	103	101	102	98	93	**108**	Calculated from interior equipment and wall/roof absorption
RICE Unit	12	132	124	124	124	123	122	123	119	113	**128**	In-house, housed inside building

Notes:

1. All sound levels are inclusive of mitigation included in the base design only

BURNS McDONNELL®