Hamre, John G.

From:	Mater, Megan <Megan_Mater@kindermorgan.com>
Sent:	Wednesday, October 7, 2020 1:44 PM
To:	Fahn, Patrick J.; -Info-Public Service Commission
Subject:	PU-18-277 - Roosevelt Plant Expansion Noise and Lighting Survey
Attachments:	Roosevelt tech memo0420_Final.pdf; Roosevelt Tech Memo 3-26-19 (Draft).pdf

Hello Mr. Fahn,

Please see the attached baseline and final noise and lighting surveys for the Roosevelt Plant Expansion project (PSC Case Number PU-18-277). Let me know if you have any questions or need any additional information.

Respectfully,

KINDER MORGAN

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64 PU-18-277 Filed 10/07/2020 Pages: 54
Baseline and final noise and lighting surveys
Kinder Morgan
Megan Mater

GOLDER

TECHNICAL MEMORANDUM

DATE April 16, 2020 **Project No.** 18114729

TO Ms. Megan Mater, Environmental Specialist - Project Permitting
Kinder Morgan, Inc.

CC Jacob Trahan, Kennard F. Kosky, P.E.

FROM Gage Miller **EMAIL gage_miller@golder.com**

NOISE AND LIGHTING COMPLIANCE MONITORING – ROOSEVELT GAS PLANT EXPANSION IN MCKENZIE COUNTY, NORTH DAKOTA

1.0 INTRODUCTION

Golder Associates Inc. (Golder) was contracted by Kinder Morgan, Inc. (KM) to perform environmental sound and lighting studies in support of the Roosevelt Gas Plant expansion located in McKenzie County, North Dakota (Project). The expansion added one cryogenic turbo-extender unit, increase total net capacity of the facility from 50 to 200 million standard cubic feet of natural gas per day, and expanded operations to occupy 30 of the 38-acre parcel. Our understanding is that the North Dakota Public Service Commission (PSC) raised concerns about additional noise and lighting impacts from the expansion and has initiated several “Measures to Minimize Impact” in their approval, including conducting these environmental studies. The scope of these studies includes environmental sound and lighting monitoring during operations and comparing it to the Project baseline (existing conditions).

The baseline monitoring study on February 4 and 5, 2019 and the operational monitoring was conducted on March 23, 24, and 25, 2020. This memo is being submitted as the completion of this study.

The following attachments can be found at the end of this Technical Memorandum:

- Figure 1. Noise Study and Lighting Survey Locations
- Attachment 1. Background Information
- Attachment 2. Monitoring Methodology
- Attachment 3. Summary Tables and Figures

2.0 MONITORING AND NOISE SENSITIVE LOCATIONS

Monitoring locations are outlined in Table 1 below and illustrated in Figure 1. Monitoring conducted included:

1) Short-term noise monitoring of at least 15 minutes near the Project boundary and off-site locations near the closest noise sensitive area (NSA) conducted during the daytime and at night

2) Long-term noise monitoring of at least 24 hours at a secure on-site location approximate to the closest off site receptor to the east of the Project area
Note: The long-term baseline measurement could not be conducted due to the severe winter weather prematurely draining the batteries. The long-term measurements were completed during the operation phase as conditions were less severe.

3) Lighting measurements collected at night during a new moon phase

Methodologies for noise and lighting monitoring are attached at the end of this memo as Attachment 2.

Table 1: Monitoring Locations

Site	Coordinates (Decimal Degrees		Monitoring Dates	Sample Type	Distance and direction from Project (miles)[a]
	Latitude	Longitude			
Site 1	47.687278°	-103.258642°	February 4 & 5, 2019 March 24 & 25, 2020	Short-Term Noise, Lighting	0.42 ESE
Site 2	47.68824°	-103.2758692°	February 4 & 5, 2019 March 24 & 25, 2020	Short-Term Noise, Lighting	0.17 SW
Site 3	47.700194°	-103.283417°	February 4 & 5, 2019 March 24 & 25, 2020	Short-Term Noise, Lighting	0.84 NW
Site 4	47.702086°	-103.266793°	February 4 & 5, 2019 March 24 & 25, 2020	Short-Term Noise, Lighting	0.70 N
Site 5	47.689989°	-103.265609°	February 4 & 5, 2019 March 24 & 25, 2020	Short-Term Noise, Lighting	Boundary E
Site 6	47.689431	-103.272537	February 4, 2019 March 24 & 25, 2020	Short-Term Noise, Lighting	Boundary W
Long-term	47.689631	-103.266601	March 23 to 25, 2020	Long-Term Noise	Boundary E

[a] Distance from closest sides of the property boundary

For the Project, NSAs considered any residential dwelling within one mile from the Project boundary. There were no other NSAs identified outside of residences. A total of 6 NSAs were identified and are presented in Table 2 and the location of NSAs are shown in Figure 1.

Table 2: Noise Sensitive Area Locations

NSA	Coordinates (Decimal Degrees		Distance and direction from Project (miles)
	Latitude	Longitude	
1[a]	47.689509°	-103.262815°	0.22 E
2	47.687694°	-103.252947°	0.69 ESE
3	47.687605°	-103.255975°	0.55 ESE
4	47.687113°	-103.277006°	0.25 SW
5	47.700031°	-103.287604°	0.96 NW
6	47.702380°	-103.267812°	0.72 N

[a] Site was originally identified as an NSA, but further investigation shows it is unlikely to be a residence

3.0 NOISE MONITORING

Sound propagation involves three principal components: a noise source, a person or a group of people, and the transmission path. While two of these components, the noise source and the transmission path, are easily quantified (i.e., direct measurements or through predictive calculations), the effects of noise to humans is the most difficult to determine due to the varying responses of humans to the same or similar noise patterns. The perception of sound (noise) by humans is very subjective, and just like odors and taste, is very difficult to predict a response from one individual to another.

Measurements were collected twice during the daytime (7:00 a.m. to 10 p.m.) and once during the nighttime (10:00 p.m. to 7:00 a.m.) at each location. The two daytime measurements were collected at different times to differentiate any patters between morning (before 12:00 p.m) and afternoon (after 12:00 p.m.) when human activities could change.

3.1 Noise Level Requirements

Based on the state of North Dakota PSC Findings of Fact, Conclusions of Law and Order dated November 26, 2018, the Project specific noise standard is as follows:

> The Project "expects to keep the noise level of activities under fifty (50) decibels (A-weighted) to the nearest noise sensitive receptor during and after construction, and when the Roosevelt plant is placed into service."

This noise level was based on testimony provided to the PSC on September 27, 2018.

3.2 Noise Monitoring Results

Noise measurements were dominated by, local heavy truck and semi-truck traffic, noise from the Project, surrounding facilities, highway traffic and sounds of nature. Table 3 shows a summary for the data collected at the monitoring locations and a description of those locations. The summary includes the overall equivalent sound pressure (L_{eq}) for each measurement, the sound level that is exceeded 90 percent of the time (L_{90}), and the differences between measurements collected during baseline and during operations. The L_{90} is more appropriate for describing the noise level impacts from continuously operating equipment such as gas plant operations and reducing the impact of transient noise sources such as traffic. The day-night average sound level (L_{dn}) is the 24-hour average SPL calculated with a 10 decibel "penalty" added to nighttime hours (10 p.m. to 7 a.m.)(See Attachment 1 for complete description).

Table 3: Summary of Noise Monitoring Results in A-weighted Decibels (dBA)

Site	Time	L_{eq} (dBA)			L_{90} (dBA)			L_{dn} (dBA)[a]		
		BKG	OPS	Diff[b]	BKG	OPS	Diff[b]	BKG	OPS	Diff
1	Morning	53.4	60.5	7.1	35.9	41.8	5.9	41.5	58.6	17.1
	Afternoon	59.0	--	1.5	38.9	--	2.9			
	Night	56.8	65.0	8.2	33.9	52.8	18.9			
2	Morning	58.9	64.3	5.4	43.9	47.9	4.0	51.8	49.3	-2.5
	Afternoon	61.6	--	2.7	44.6	--	3.3			
	Night	54.9	60.0	5.1	45.5	41.0	-4.5			
3	Morning	74.3	71.5	-2.8	42.4	44.7	2.3	43.8	49.5	5.7
	Afternoon	73.2	--	-1.7	43.3	--	1.7			
	Night	72.1	63.4	-8.7	34.5	42.8	8.3			
4	Morning	59.7	54.6	-5.1	40.5	47.4	6.9	43.9	60.1	16.2
	Afternoon	47.0	49.7	2.7	37.6	42.9	5.3			
	Night	53.1	55.4	2.3	36.7	54.2	17.5			
5	Daytime	53.7	65.8	12.1	45.8	50.9	5.1	51.6	56.0	4.4
	Nighttime #1	46.7	--	19.1	44.7	--	6.2			
	Nighttime #2	47.0	59.6	12.6	45.1	49.3	4.2			
6	Morning	--	58.8	NA	--	51.8	NA	--	59.3	NA
	Afternoon	--	56.8	NA	--	54.6	NA			
	Night	--	59.8	NA	--	52.5	NA			
Long-term	Daytime	--	69.7	NA	--	66.8	NA	--	73.0	NA
	Nighttime	--	69.4	NA	--	66.6	NA			

[a] Calculated using the greater of the daytime L_{90} results
[b] If afternoon data was not available, the difference was calculated using the OPS morning data
BKG = Baseline
OPS = Operations
Diff = Deference between OPS and BKG

A more detailed summary table and octave band figures for each monitoring location can be found in Attachment 3.

4.0 LIGHTING

Outdoor lighting for the Project is necessary to satisfy requirements for worker safety and overall site security. Unconstrained lighting can cause "light pollution," which includes "sky glow" and "light trespass." Sky glow is the result of stray light being scattered in the atmosphere, brightening the natural sky background level. Light trespass is the term used to describe light or illuminance that strays from its intended purpose and potentially becomes an annoyance. To evaluate the existing nighttime light conditions at the Project, an ambient outdoor lighting study was conducted and is presented in this section.

4.1 Lighting Standards

There are no numerical lighting standards outlined by the North Dakota PSC for this Project, but the PSC does require that the Project will take reasonable measures during construction and operations to mitigate the effects of lighting on adjacent lands as to not "create significant adverse effects on adjacent land use". The comparison of operations to background conditions will indicate the effectiveness of this mitigation and their impacts.

4.2 Results

The nighttime ambient illuminance measurement results are summarized in Table 4 (See Attachment 1 for examples of sky glow for typical nighttime conditions.). The observations were collected during a new moon cycle under mostly clear conditions with some cloud cover. It should be noted that the ground was completely snow covered and it was snowing during most of the baseline measurements. These conditions could increase light trespass reflecting off the snow and increase the overall illuminance measured. The darker the sky the less illuminance, and the greater the apparent magnitude of the sky as more stars are visible, therefore the higher the value recorded by the light meter the lower the light pollution.

The baseline nighttime sky glow in the horizontal (0°) direction ranged from 15.40 mags/arcsecond^2 at Site 4 to 12.59 mags/arcsecond^2 at Site 6. The operational nighttime sky glow in the horizontal (0°) direction ranged from 18.05 mags/arcsecond^2 at Site 3 to 13.95 mags/arcsecond^2 at Site 2.

The baseline nighttime skyglow in the midpoint (45°) direction ranged from 18.64 mags/arcsecond^2 at Site 4 to 14.18 mags/arcsecond^2 at Site 6. The operational nighttime skyglow in the midpoint (45°) direction ranged from 17.98 mags/arcsecond^2 at Site 3 to 14.09 mags/arcsecond^2 at Site 5.

The baseline nighttime skyglow in the vertical (90°) direction ranged from 19.00 mags/arcsecond^2 at Site 4 to 14.71 mags/arcsecond^2 at Site 3. The operational nighttime skyglow in the vertical (90°) direction ranged from 18.71 mags/arcsecond^2 at Site 3 to 16.41 mags/arcsecond^2 at Site 2.

The difference between horizonal (0 degree) measurement and the vertical (90 degree) measurement can be used to represent the amount of light trespass impacting a monitoring site. The baseline light trespass ranged from 3.60 mags/arcsecond^2 at Site 4 to 0.03 mags/arcsecond^2 at Site 3. The operational light trespass ranged from 3.13 mags/arcsecond^2 at Site 4 to 0.66 mags/arcsecond^2 at Site 3.

Table 4: Summary of Lighting Measurements (Sky Glow)

Site	Measurement	0-degree angle (mag/arcsec^2)	45-degree angle (mag/arcsec^2)	90-degree angle (mag/arcsec^2)	Light Trespass[a] (mag/arcsec^2)
1	BKG	14.78	14.92	15.13	0.35
	OPS	15.07	15.27	17.66	2.58
	Diff	-0.29	-0.35	-2.53	-2.23
2	BKG	14.60	14.88	15.01	0.41
	OPS	13.95	14.52	16.41	2.47
	Diff	0.65	0.36	-1.40	-2.06
3	BKG	14.68	14.78	14.71	0.03
	OPS	18.05	17.98	18.71	0.66
	Diff	-3.37	-3.20	-4.00	-0.63
4	BKG	15.40	18.64	19.00	3.60
	OPS	14.98	16.05	18.11	3.13
	Diff	0.42	2.59	0.89	0.47
5	BKG	15.28	16.41	16.72	1.44
	OPS	14.05	14.09	16.62	2.57
	Diff	1.23	2.32	0.10	-1.13
6	BKG	12.59	14.18	15.15	2.56
	OPS	14.56	16.31	16.67	2.11

Site	Measurement	0-degree angle (mag/arcsec^2)	45-degree angle (mag/arcsec^2)	90-degree angle (mag/arcsec^2)	Light Trespass[a] (mag/arcsec^2)
	Diff	-1.97	-2.13	-1.52	0.45

[a] Difference between Horizonal (0 degree) and Vertical (90 degree) to indicated light trespass from Project
BKG = Baseline
OPS = Operations
Diff = Deference between OPS and BKG

5.0 CONCLUSIONS

5.1 Noise Monitoring

Sound measurements were mostly dominated by local and truck traffic, noise associated with existing and new facility operations, sounds of nature including bird and wind noise, and livestock noise. Because transient sound sources were the dominant noise source, the average (L_{eq}) can vary from hour to hour or even minute to minute; therefore, the L_{90} is more appropriate for comparing noise levels between times of day or between sites. The L_{90} also best represents the noise being generated from Project noise sources that are constant and continuous. The results show that sound levels are greatly affected by transient noise sources, such as the observed truck traffic noise, and that sound levels were generally lower during the nighttime hours, but that was not universally the case with some nighttime levels exceeding daytime levels.

For comparison to the North Dakota PSC requirement of 50 dBA, the L_{90} is the most technically appropriate parameter representative of the sound levels emanating from the existing facility without the interference of transient noise sources. The L_{90} noise levels for the background survey ranged from 33.9 dBA at Site 1 during the nighttime measurement to 45.8 dBA at Site 5 during the daytime. The L_{90} noise levels for the operations survey ranged from 41.8 dBA at Site 1 during the daytime measurement to 59.8 dBA at the long-term monitoring location. There were 2 measurements at non-boundary locations that were above the 50 dBA PSC requirement, these were at Site 1 and Site 4 during the nighttime measurements.

The L_{dn} was also calculated from the L_{90} measurements to compare to U.S. Environmental Protection Agency (EPA) and U.S. Department of Housing and Urban Development (HUD) L_{dn} guidelines of not to exceed 55 dBA. The highest L_{dn} for the background survey was calculated as 51.8 at Site 2, the highest L_{dn} for the operations survey was calculated as 60.1 at Site 4 and 58.6 dBA at Site 1. The most appropriate locations for comparing the EPA and HUD guideline to monitoring sites are those closest to the project location and NSAs. The highest Ldn for the operation survey for those monitoring locations are calculated as 49.3 at Site 2 and 56.0 at Site 5. The calculations exceed the guidelines due to the elevated nighttime noise levels and not due to constant Project operations.

Based on these comparisons to the Project specific standard and typical guidelines, the sound levels existing currently at NSAs are below levels that would commonly be considered a nuisance but would be observable during outdoor activities. The existing sound levels are also below the Project specific requirement of 50 dBA during all daytime measurements and all but two nighttime measurements at closest NSAs. These results suggest that non-Project related noise sources cause the temporary elevated nighttime noise levels at these two locations.

5.2 Lighting

Based on the results in Table 4 the overall sky glow in the Project area was minimally affected by the operations. Baseline measurements in the horizontal direction were approximately equivalent to that of a full moon or a city sky (12.59 to 15.40 mag/arcsec^2) and operations measurements similarly ranged from 13.95 to 18.05 mag/arsec^2. This would indicate light trespass from local sources in the horizontal direction are evident, but the Project did not add significantly to the light trespass.

The baseline measurements in the vertical direction are between a full moon and a bright suburban sky (14.71 to 19.00 mag/arcsec^2) and operations measurements similarly ranged from 16.41 to 18.75 mag/arsec^2. In general, the difference in light trespass decreased the further away from the Project site, with Site 3 having the lowest amount of light trespass both during the baseline and operational monitoring studies. However, Site 4 had the greatest light trespass of 3.60 mag/arcsec^2 for both monitoring periods indicating that the existing facility is likely a contributing source of light trespass, but that there are other sources of light trespass at Site 4.

Comparisons of lighting measurements directly to sky glow comparisons and classifications are complicated by the light reflecting off the snow causing increased trespass and sky glow observations. The results do indicate that the existing facility is a source of anthropogenic light contributing to light trespass and sky glow. However, the results indicate that the facility is not the only source of light trespass, and that the new facility did not significantly increase light trespass over what was observed during baseline monitoring. The vertical monitoring shows that the sky glow was not degraded by the new facility.

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Senior Scientist

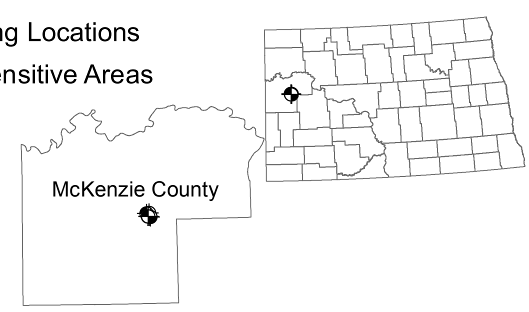
Kennard F. Kosky, P.E.
Principal

GBM

https://golderassociates.sharepoint.com/sites/106179/project files/6 deliverables/tech memo 2020/roosvelt tech memo_final.docx

LEGEND

- Monitoring Locations
- Noise Sensitive Areas



REFERENCE(S)

1. NOISE MONITORING LOCATIONS, NOISE SENSITIVE AREAS, GOLDER ASSOCIATES INC., 2019.

COORDINATE SYSTEM: NAD 1983 UTM ZONE 13N
PROJECTION: TRANSVERSE MERCATOR
DATUM: NORTH AMERICAN 1983

CLIENT
KINDER MORGAN

PROJECT
ROOSEVELT GAS PLANT EXPANNSION
MCKENZIE COUNTY, NORTH DAKOTA

TITLE
NOISE STUDY AND LIGHTING SURVEY LOCATIONS

CONSULTANT

GOLDER

YYYY-MM-DD	2019-03-15
DESIGNED	GFD
PREPARED	GFD
REVIEWED	GBM
APPROVED	JMT

PROJECT NO.	CONTROL	REV.	FIGURE
18114729	A001	0	1

PATH: G:\PROJECTS\Kinder Morgan\McKenzieCounty_ND\99_PROJECTS\18114729_RooseveltGasPlantExpansion\A_Noise_LightingStudy\02_PRODUCTION\MXD\18114729_A001_NoiseStudyLightingSurvey.mxd

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ATTACHMENT 1

BACKGROUND INFORMATION

NOISE

Acoustic values can be described in terms of noise or sound. **Sound** is generated by pressure fluctuations in air. **Noise** is genially defined as any "unwanted" sound, and is therefore based on human perception, but the terms noise and sound are often used interchangeably. Sound propagation involves three principal components: a noise source, a person or a group of people, and the transmission path. While two of these components, the noise source and the transmission path, are easily quantified (i.e., by direct measurements or through predictive calculations), the effect of noise on humans is the most difficult to determine due to the varying responses to the same or similar noise patterns and therefore it is difficult to predict a response from one individual to another.

Noise and noise levels are used to describe ambient levels perceived by off-site receptors, while sound and sound emissions describe acoustic energy emitted by activities/equipment associated with the project.

Noise data and analysis are primarily given in terms of **frequency** distribution. The levels are grouped into **octave bands**. Typically, the center frequencies for each octave band are 31.5, 63, 125, 250, 500, 1000, 2000, 4000, and 8000 Hertz (Hz). The human ear responds to the pressure variations in the atmosphere that reach the ear drum. These pressure variations are composed of different frequencies that give each sound we hear its unique character.

Due to the complexity of human ear functions, measurement of different noise sources does not always correspond to relative loudness or annoyance. It is common practice to sum sound levels over the entire audible spectrum (i.e., 20 Hz to 20 kHz) to give an overall sound level, but human hearing varies in sensitivity depending on the frequency of the sound. Specifically, the human ear is most sensitive to sound with the 1,000 Hz to 6,000 Hz frequency range. To account for the response of humans, it is common to use the "***A-weighted***" sound level (noted in units of **dBA**) in evaluating noise sources and their effects on human since it models the way in which the human hear responds to noise levels in the sensitive frequencies outlined above.

Sound pressure level is expressed on a logarithmic scale in units of **decibels (dB)**. Since the scale is logarithmic, a sound that is twice the sound pressure level as another will be 3 decibels (3 dB) higher. A change of 3 dB is generally barely perceptible by humans, while a 5 dB change is clearly perceptible and a 10 dB increase is perceived as a doubling of the sound pressure level. (Cowan, 1994)

Some noise sources and industrial activities are inherently likely to give rise to tonal noise, otherwise known as a "***pure tone***". Pure tones are more noticeable than broadband noise and therefore be more intrusive. The Identification of pure tones can be quantified by using the method developed in Annex D of ISO 1996:2007(E). This method identifies a pure tone using the time-average sounds pressure level in the one-third-octave band equal to or exceeding the time-average sound pressure levels of both adjacent one-third-octave bands in accordance to the following:

- 15 dB in low-frequency bands (25 Hz to 125 Hz)
- 8 db in middle-frequency bands (160 Hz to 400 Hz)
- 5 db in high0frequency bands (500 Hz to 10,000 Hz)

Environmental noise levels vary over time, and are described using an overall sound level known as the $\mathbf{L_{eq}}$, or equivalent sound pressure level. The L_{eq} is the energy averaged continuous sound pressure level which has the same total energy as the time varying noise level over a stated time period. The day-night average sound level

(**Ldn**) is the 24-hour average SPL calculated with a 10 dBA "penalty" added to nighttime hours (10 p.m. to 7 a.m.). This is done because residential land uses are more sensitive to nighttime noise impacts. The equation for Ldn is:

$$L_{dn} = 10 \log \frac{15 \times 10^{\frac{L_d}{10}} + 9 \times 10^{\frac{L_n + 10}{10}}}{24}$$

where: Ld = daytime Leq for the period 0700 to 2200 hours

Ln = nighttime Leq for the period 2200 to 0700 hours

The EPA recommends an outdoor Ldn of 55 dBA for residential and farming areas. For industrial areas, an Leq of 70 dBA is suggested. The HUD-recommended goal for exterior noise levels is not to exceed an Ldn of 55 dBA. However, the HUD standard for exterior noise is 65 dBA measured as Ldn.

Sound Pressure Levels of Typical Sounds Sources

Activity / Sound	Sound Pressure Level (dBA)
Air Raid Siren at 50 ft	120
Jackhammer at 15 m *	95
Loud Shout	90
Heavy Truck at 15 m *	85
Vacuum Cleaner at 3 m *	70
Automobile (100 km/hr) at 30 m *	65
Normal Conversation at 1 m	60
Quiet Living Room	40
Soft Whisper at 2 m *	35
Unoccupied Broadcast Studio	28
Threshold of Hearing	0

Notes: Source, Harris, 1998

Sound Pressure Levels of Typical Environments

Activity / Sound	Sound Pressure Level (dBA)
Rock Concert	110
Subway Platform with Passing Train	100
Sidewalk with Passing Heavy Truck or Bus	90
Sidewalk by Typical Highway	80
Sidewalk of Typical Road with Passing Traffic	70
Typical Urban Area	60 – 70

Activity / Sound	Sound Pressure Level (dBA)
Typical Suburban Area	50 – 60
Quiet Suburban Area at Night	40 – 50
Typical Rural Area at Night	30 – 40
Quiet Living Room	40
Isolated Broadcast Studio	20 - 30
Rock Concert	110
Subway Platform with Passing Train	100

Source: Harris, 1998.

Generally, the noise assessment carried out is completed on locations where it is expected noise effects from the Project activities can affect humans. Specific study areas have been identified as being representative of all sensitive receptors, which could be affected by noise emissions associated with project activities.

LIGHTING

Light is part of the electromagnetic spectrum, which ranges from radio waves to gamma rays. Electromagnetic radiation waves are fluctuations of electric and magnetic fields, which can transport energy from one location to another. Visible light is not inherently different from other parts of the electromagnetic spectrum, with the exception that the human eye has evolved to detect visible waves. The human eye responds to light based on its frequency. The frequency of light that is within the visible range establishes the observed color. While the response varies from person to person, the Commission Internationale de l'Eclairage (C.I.E., International Commission on Illumination) defined standard luminosity coefficients for the human eye in 1931.

A "candela" refers to the luminous intensity of a lighting source and is measured in candelas (cd). A "lumen" is the total luminous flux of a light source of one candela of luminous intensity. Illuminance is the total luminous flux incident on a surface per unit area. A "lux" is the measure of illumination (1 lumen) that falls on one square meter. The English measurement is the "foot-candle," which is the same illumination (1 lumen) falling on one square feet. A lux is equivalent to 0.093 foot-candle; one foot-candle is 10.76 lux. Luminance is the perceived brightness of an object which has been illuminated by a source. The luminance of an object depends on its material characteristics and reflectance and is measured in candelas per square meter (cd/m^2).

Light Trespass

Some regulators have established programs to reduce light trespass. Light trespass standards are typically based on the amount of light from a light source that is transmitted onto adjoining properties. Light trespass standards are typically different for various land uses.

Sky Glow

The earliest measures of sky glow, also called sky brightness, were based on a scale upon which the magnitude of stars visible to the human eye is divided into 6 levels. The brightest star is a magnitude 1 and the dimmest (faintest) star is a magnitude 6. More recently, the magnitude scale was modified to express astronomical surface brightness (stars, planets, etc.) in units known as magnitudes per square arcsecond (mag/arcsec^2). The measurement scale is inverse and logarithmic and is generally used in small area photometry and astronomy. Sky Glow classifications and comparisons are presented in the tables below.

Sky Glow Comparison Table

Class	Title	Approx. SQM mag/arcsec^2
1	Excellent dark-sky site	21.7–22.0
2	Typical truly dark site	21.5–21.7
3	Rural sky	21.3–21.5
4	Rural/suburban transition	20.4–21.3
5	Suburban sky	19.1–20.4
6	Bright suburban sky	18.0–19.1
7	Suburban/urban transition	
8	City sky	< 18.0
9	Inner-city Sky	

Source: https://en.wikipedia.org/wiki/Bortle_scale

Examples of Typical Illuminance and Apparent Magnitude

Location	Classification	Illuminance [a] (lux)	Sky Brightness[b] (mag/arcsec^2)
Outdoor	Bright Sun	100,000 - 130,000	>0.1
	Hazy Day	32,000	1.3
	Partly Cloudy	25,000	1.6
	Cloudy	10,000	2.6
	Overcast	1,000	5.1
	Sunrise/Sunset on Clear Day	400	6.1
	Full Moon	0.1	15.1
	Moonless Clear Night Sky	0.001	20.1
	Moonless Overcast Night Sky	0.0001	22.6
	Starlight	0.00005	23.3
Indoor	Typical TV Studio	1,000	5.1
	Bright Office with Large Contrast	400	6.1
	Hall Way	80	7.8
	Living Room	50	8.3
	Good Street Lighting	20	9.3
	Poor Street Lighting	1	12.6

a Electro-Optics Handbook,1979; Williams, 1999

b Calculated based on conversion from lux to mags/arcsecond^2

ATTACHMENT 2

MONITORING METHODOLOGIES

NOISE

Measurement techniques set forth by the American National Standards Institute (ANSI) S12.9-1993/Part 3, 1993, were used and included using a Type - 1 sound level meter set to the fast response mode to obtain consistent, integrated, A-weighted SPLs. Concurrent one-third octave band frequencies were also measured at all sites. The octave band data from each monitoring site were measured and stored during each monitoring period.

Integrated SPL data consisting of the following noise parameters were collected at each location:

- L_{eq} – The SPL averaged over the measurement period; this parameter is the continuous steady SPL that would have the same total acoustic energy as the real fluctuating noise over the same time period.
- L_{max} – The maximum SPL for the sampling period.
- L_{min} – The minimum SPL for the sampling period.
- L_n – The SPLs that were exceeded *n* percent of the time during the sampling period. For example, L_{90} is the level exceeded 90 percent of the time.

The SPL data were analyzed in both dB and dBA. The higher the decibel value, the louder the sound.

The SPL averages were calculated using the following formula:

$$\text{Average SPL} = 10\,\text{Log}\,\frac{\sum_{i=1}^{N} 10^{(SPL_i/10)}}{N}$$

where: N = number of observations

SPL_i = individual SPL in data set

The noise monitoring equipment used during the study included:

- Larson Davis Model 824 Precision Integrating Sound Level Meters with Real Time Frequency Analyzers
- Larson Davis Model PRM902 Microphone Preamplifier
- Larson Davis Model 2560 Pre-polarized ½-inch Condenser Microphone
- Windscreen, tripod, and various cables
- Larson Davis Model CAL200 Sound Level Calibrator (CAL200), 94/114 dB at 1,000 Hz

Monitoring was conducted using the sound level meter mounted on a tripod at a minimum height of 1.5 meters (5 feet) above grade. A windscreen was used since measurements were taken outdoors. The windscreen protects the microphone from interference from wind up to a constant wind speed of 12 miles per hour (mph). The microphone was positioned so that a random incidence response was achieved. The sound level meter and octave band analyzer were calibrated immediately prior to and just after each sampling period using the CAL200 to provide a quality control check of the sound level meter's operation during monitoring.

The operator recorded detailed field notes during monitoring that included major noise sources in the area. The Larson Davis sound level meters comply with Type I – Precision requirements set forth for sound level meters and for one-third octave filters.

Calibration certifications for the equipment used can be furnished upon request.

LIGHTING

Sky glow measurements were taken to assess the existing ambient conditions in the vicinity of the Project at the same locations as the noise monitoring locations.

The illumination monitoring field efforts were conducted on February 4 and 5, 2019 between the hours of 21:16 and 00:32. Measurements were taken using a calibrated Unihedron SQM-LU Sky Quality Meter and recorded in magnitudes per square arcsecond (mag/acrsec^2).

The illuminance measurements were collected at six light monitoring locations at a height of 5 ft above grade. The measurements were collected with the meter angled in three directions for a minimum of five consecutive minutes at each angle:

- 0° - Towards the horizon to measure light trespass coming from the Project site
- 90° - Vertical to measure light from celestial and reflected sources
- 45° - Midpoint measurement between the above 2

ATTACHMENT 3 SUMMARY

TABLES AND FIGURES

NOISE SUMMARY TABLE
BASELINE AMBIENT SOUND PRESSURE LEVELS OBSERVED AT THE ROOSEVELT SITE FEBRUARY 2019

Monitoring Location	Coordinates (Decimal Degrees)	Date	Time	Start Time (HH:MM)	Sound Pressure Levels (dBA)					Observations
					L_{Min}	L_{max}	L_{90}	L_{eq}	L_{dn} [a]	
Site 1	47.687278°	5-Feb-19	Morning	9:36	35.0	74.2	35.9	53.4		Light traffic, small equipment operating at nearby facility
	-103.258642°	4-Feb-19	Afternoon	16:41	37.4	79.3	38.9	59.0		Light humming from generator/compressor, light traffic 100 ft away
		5-Feb-19	Night	23:12	33.5	80.2	33.9	56.8	41.5	Light noise from gas plant and minimal traffic on road
Site 2	47.68824°	5-Feb-19	Morning	8:57	41.9	80.5	43.9	58.9		Light traffic, light humming from Roosevelt Gas Plant - Generators/compressors
	-103.2758692°	5-Feb-19	Afternoon	15:32	42.6	80.1	44.6	61.6		Heavy traffic, cloudy, light snow
		5-Feb-19	Night	21:29	43.9	77.7	45.5	54.9	51.8	Light noise coming from gas plant and surrounding facilities, humming.
Site 3	47.700194°	5-Feb-19	Morning	8:29	39.4	89.4	42.4	74.3		Traffic on highway 85, fairly light morning traffic.
	-103.283417°	5-Feb-19	Afternoon	15:09	35.0	89.8	43.3	73.2		Heavy traffic
		5-Feb-19	Night	21:06	33.7	91.4	34.5	72.1	43.8	Great horned owl, light traffic
Site 4	47.702086°	5-Feb-19	Morning	10:03	38.9	83.4	40.5	59.7		Light humming, horses nearby in pen, heavy equipment beeping approx. 0.5 miles away
	-103.266793°	5-Feb-19	Afternoon	16:34	36.0	67.5	37.6	47.0		Snow blowing, horses nearby out of pen
		5-Feb-19	Night	23:35	35.8	78.6	36.7	53.1	43.9	Horses running in pen, little to no noise around
Site 5	47.689989°	6-Feb-19	Daytime	13:43	42.3	82.9	45.8	53.7		Heavy equipment noise from gas plant, humming from nearby facilities
	-103.265609°	5-Feb-19	Nighttime 1	21:58	43.4	65.1	44.7	46.7		Light noise from surrounding gas facilities
		5-Feb-19	Nighttime 2	22:33	43.1	62.6	45.1	47.0	51.6	Light noise from surrounding gas facilities
ND PSC Noise Requirement							50.0			
EPA and HUD guideline for outdoor residential and farming area receiving land uses									55.0	

Source: Golder, 2019.

[a] Calculated using the highest daytime L90 and the nighttime L90

GOLDER

NOISE SUMMARY TABLE
OPERATIONAL AMBIENT SOUND PRESSURE LEVELS OBSERVED AT THE ROOSEVELT SITE MARCH 2020

Monitoring Location	Coordinates (Decimal Degrees)	Date	Time	Start Time (HH:MM)	Sound Pressure Levels (dBA) L_{Min}	L_{max}	L_{90}	L_{eq}	L_{dn} [a]	Observations
Site 1	47.687278°	25-Mar-20	Morning	9:19	39.3	82.2	41.8	60.5		Light traffic and light humming from Roosevelt Plant and nearby facilities
	-103.258642°	24-Mar-20	Nighttime	0:16	49.3	91.1	52.8	65.0	58.6	Minor truck traffic, geese flying overhead, constant humming from compressor station
Site 2	47.68824°	25-Mar-20	Morning	11:58	45.5	87.9	47.9	64.3		Constant truck and semi-truck traffic. Minimal humming from plant.
	-103.2758692°	24-Mar-20	Nighttime	3:57	38.8	89.0	41.0	60.0	49.3	Some semi-truck traffic, winds calm
Site 3	47.700194°	25-Mar-20	Morning	8:40	40.1	89.5	44.7	71.5		Heavy traffic throughout survey
	-103.283417°	24-Mar-20	Nighttime	4:36	40.2	84.3	42.8	63.4	49.5	Highway traffic, Roosevelt Plant inaudible during measurement
Site 4	47.702086°	25-Mar-20	Morning	9:56	45.5	78.7	47.4	54.6		Light traffic. Light humming from other gas plants. Power line work
	-103.266793°	24-Mar-20	Afternoon	19:48	40.5	74.3	42.9	49.7		Winds 9-11 mph. No traffic, minimal humming from gas plants
		24-Mar-20	Nighttime	1:23	52.7	59.9	54.2	55.4	60.1	Constant humming from multiple compressor stations, some heavy truck traffic
Site 5	47.689989°	25-Mar-20	Morning	10:35	48.0	89.3	50.9	65.8		Highway traffic, pounding noise from gas plant, humming from gas plant
	-103.265609°	24-Mar-20	Nighttime	2:36	47.5	87.9	49.3	59.6	56.0	Infrequent heavy trucks, humming from compressor stations
Site 6	47.689431	25-Mar-20	Morning	11:23	49.3	79.7	51.8	58.8		Constant truck and semi-truck traffic. Humming from plant.
	-103.272537	24-Mar-20	Afternoon	19:17	52.6	78.3	54.6	56.8		Truck traffic, humming from plant. Winds 8-10 mph.
		24-Mar-20	Nighttime	3:18	50.2	80.1	52.5	59.8	59.3	Some semi-truck traffic, infrequent humming from compressor stations
Long Term Monitoring	47.689631 -103.26601	23-Mar-20 to 25-Mar-20	Continuous	17:52	89.6	51.8	59.8	69.5	73.8	Plant noise, highway traffic, heavy trucks, wind
ND PSC Noise Requirement							50.0			
EPA and HUD guideline for outdoor residential and farming area receiving land uses									55.0	

Source: Golder, 2020.
[a] Calculated using the highest daytime L90 and the nighttime L90

SUMMARY LIGHTING TABLE
BASELINE LIGHTING MEASURED AT THE ROOSEVELT SITE FEBRUARY 2019

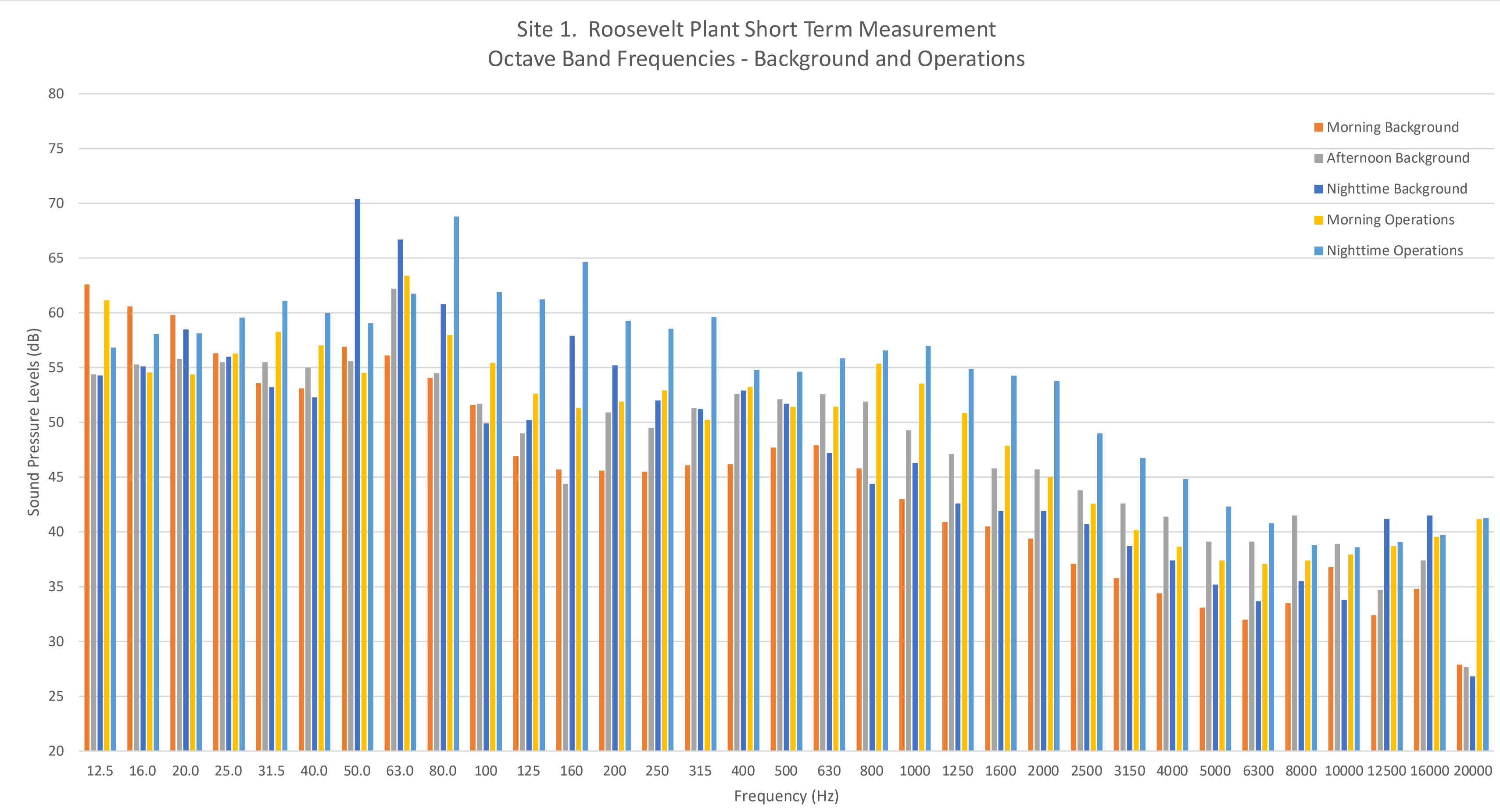
Monitoring Location	Coordinates (Decimal Degrees)	Date	Start Time	End Time	Sky Glow (mag/arcsec^2)				Observations
					0 degrees	45 degrees	90 degrees	Trespass[a]	
Site 1 - Residence southeast	47.687278° -103.258642°	4-Feb-19	21:16	21:32	14.78	14.92	15.13	0.35	Light traffic with some headlights in the distance
Site 2 - Residence southwest	47.68824° -103.2758692°	4-Feb-19	23:05	23:21	14.60	14.88	15.01	0.41	Snowing
Site 3 - Residence northwest	47.700194° -103.283417°	4-Feb-19	22:43	22:59	14.68	14.78	14.71	0.03	Snowing
Site 4 - Residence northeast	47.702086° -103.266793°	5-Feb-19	0:17	0:32	15.40	18.64	19.00	3.60	Snowing
Site 5 - Boundary east	47.689989° -103.265609°	4-Feb-19	23:51	0:07	15.28	16.41	16.72	1.44	Snowing, facility lighting
Site 6 - Boundary west	47.689431 -103.272537	4-Feb-19	23:27	23:42	12.59	14.18	15.15	2.56	Snowing, facility lighting

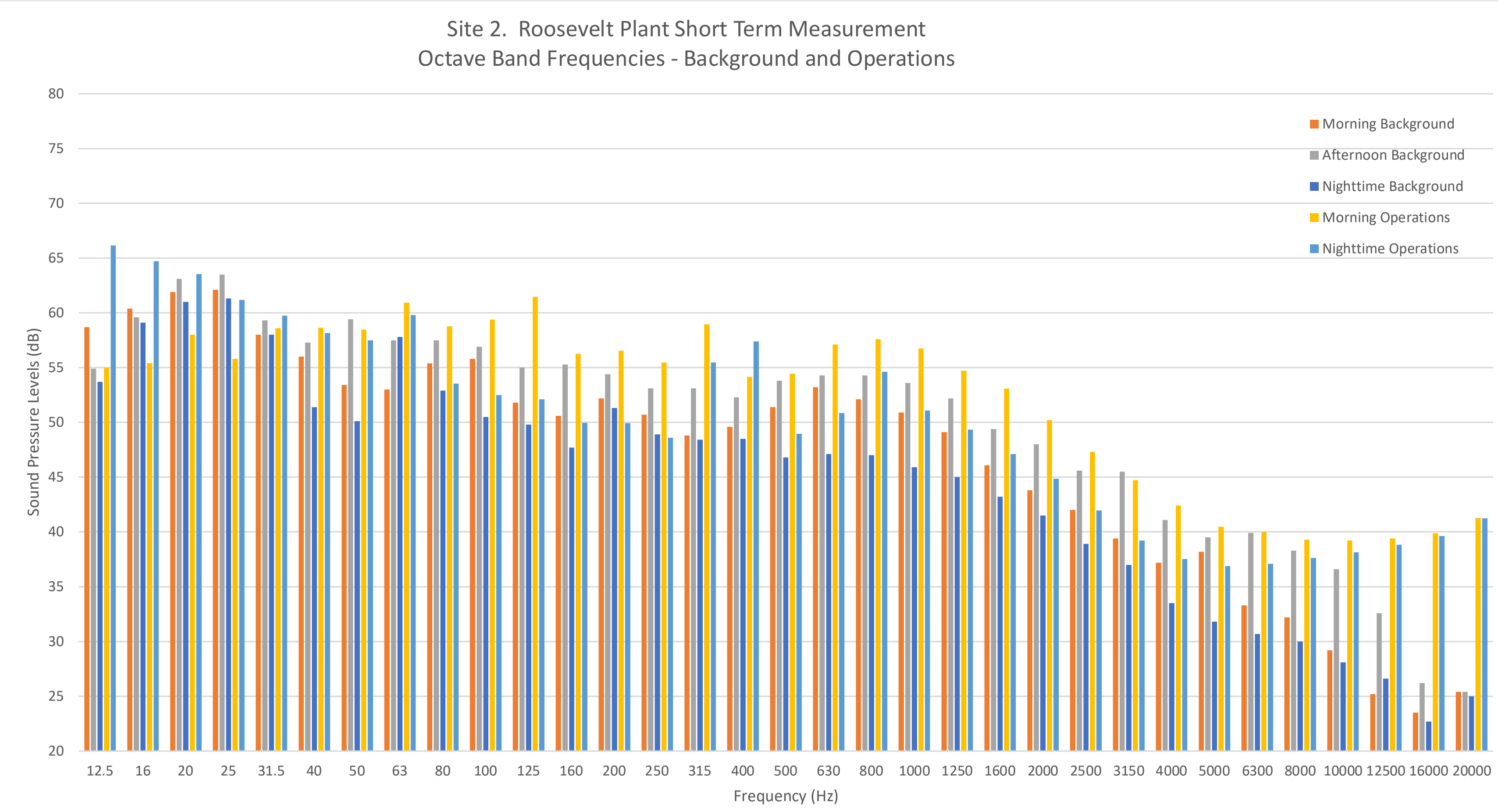
Source: Golder, 2019.

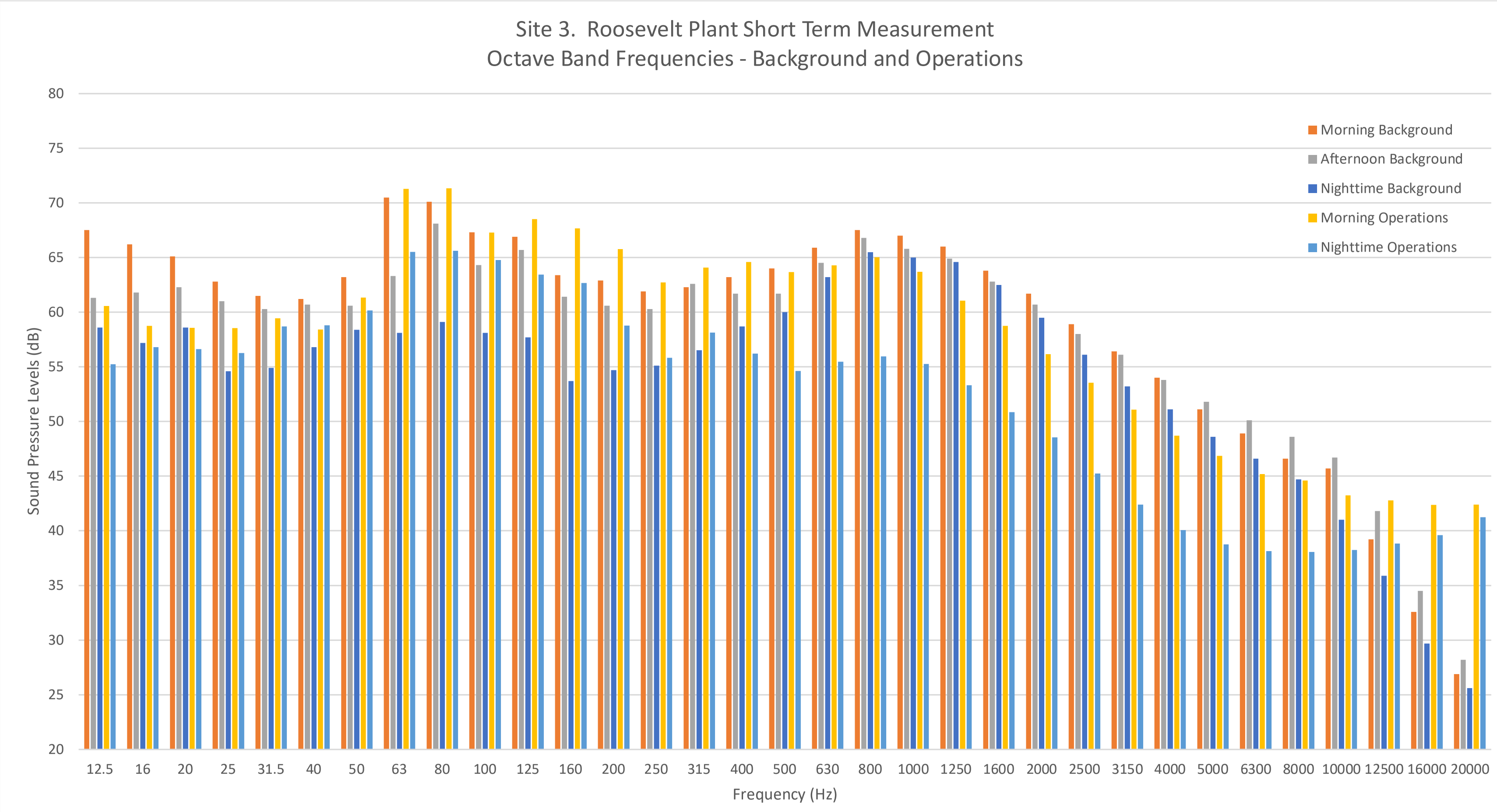
SUMMARY LIGHTING TABLE
OPERATIONAL LIGHTING MEASURED AT THE ROOSEVELT SITE MARCH 2020

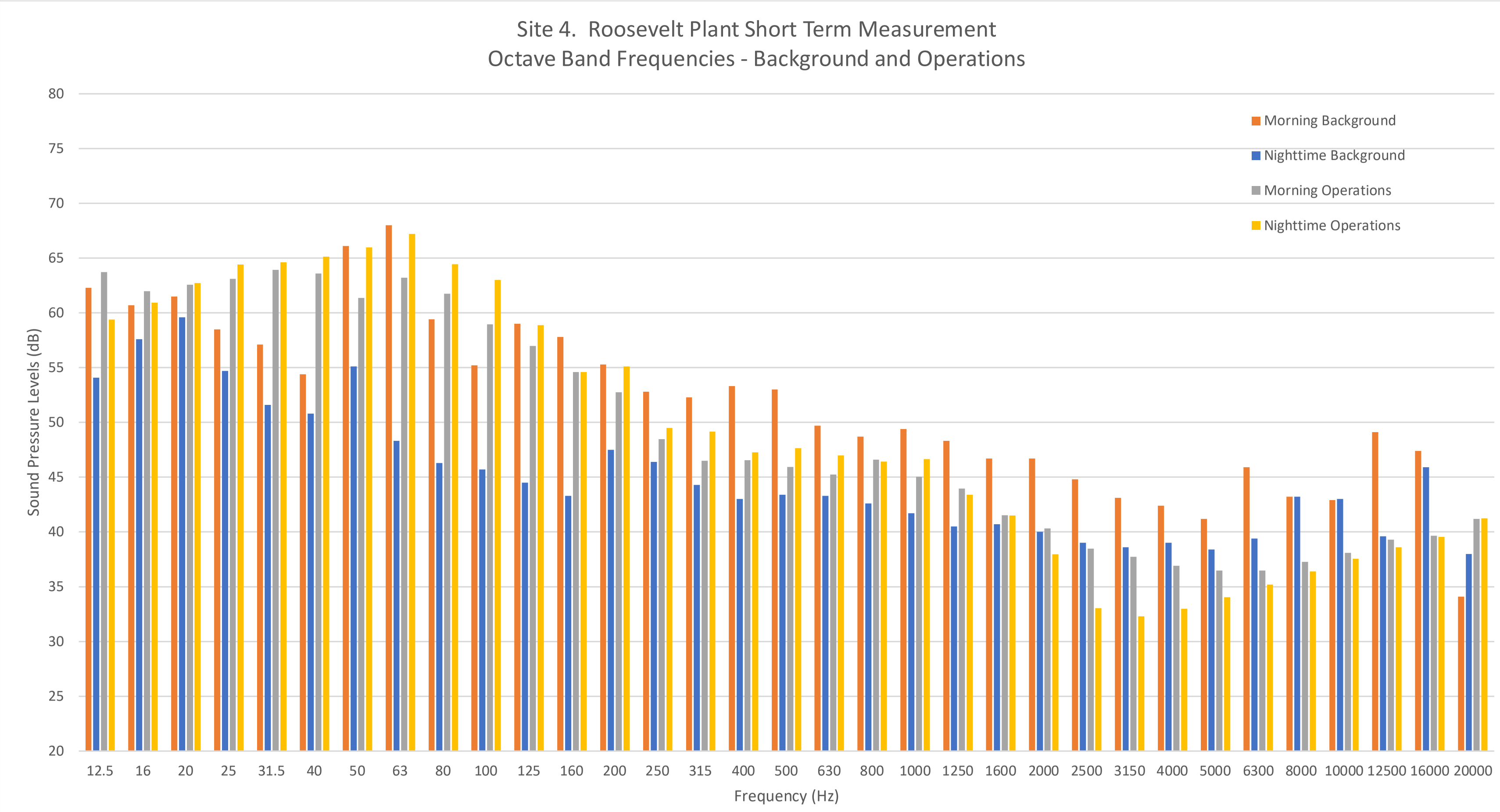
Monitoring Location	Coordinates (Decimal Degrees)	Date	Start Time	End Time	Sky Glow (mag/arcsec^2)				Observations
					0 degrees	45 degrees	90 degrees	Trespass[a]	
Site 1 - Residence southeast	47.687278° -103.258642°	24-Mar-20	1:11	1:26	15.07	15.27	17.66	2.58	Cloudy, light traffic
Site 2 - Residence southwest	47.68824° -103.2758692°	24-Mar-20	3:16	3:31	13.95	14.52	16.41	2.47	Clear skies, facility lighting
Site 3 - Residence northwest	47.700194° -103.283417°	24-Mar-20	3:54	4:09	18.05	17.98	18.71	0.66	Partly cloudy
Site 4 - Residence northeast	47.702086° -103.266793°	24-Mar-20	0:42	1:02	14.98	16.05	18.11	3.13	Light traffic with some headlights in the distance
Site 5 - Boundary east	47.689989° -103.265609°	24-Mar-20	1:56	2:11	14.05	14.09	16.62	2.57	Light traffic, facility lighting
Site 6 - Boundary west	47.689431 -103.272537	24-Mar-20	2:36	2:51	14.56	16.31	16.67	2.11	Facility lighting

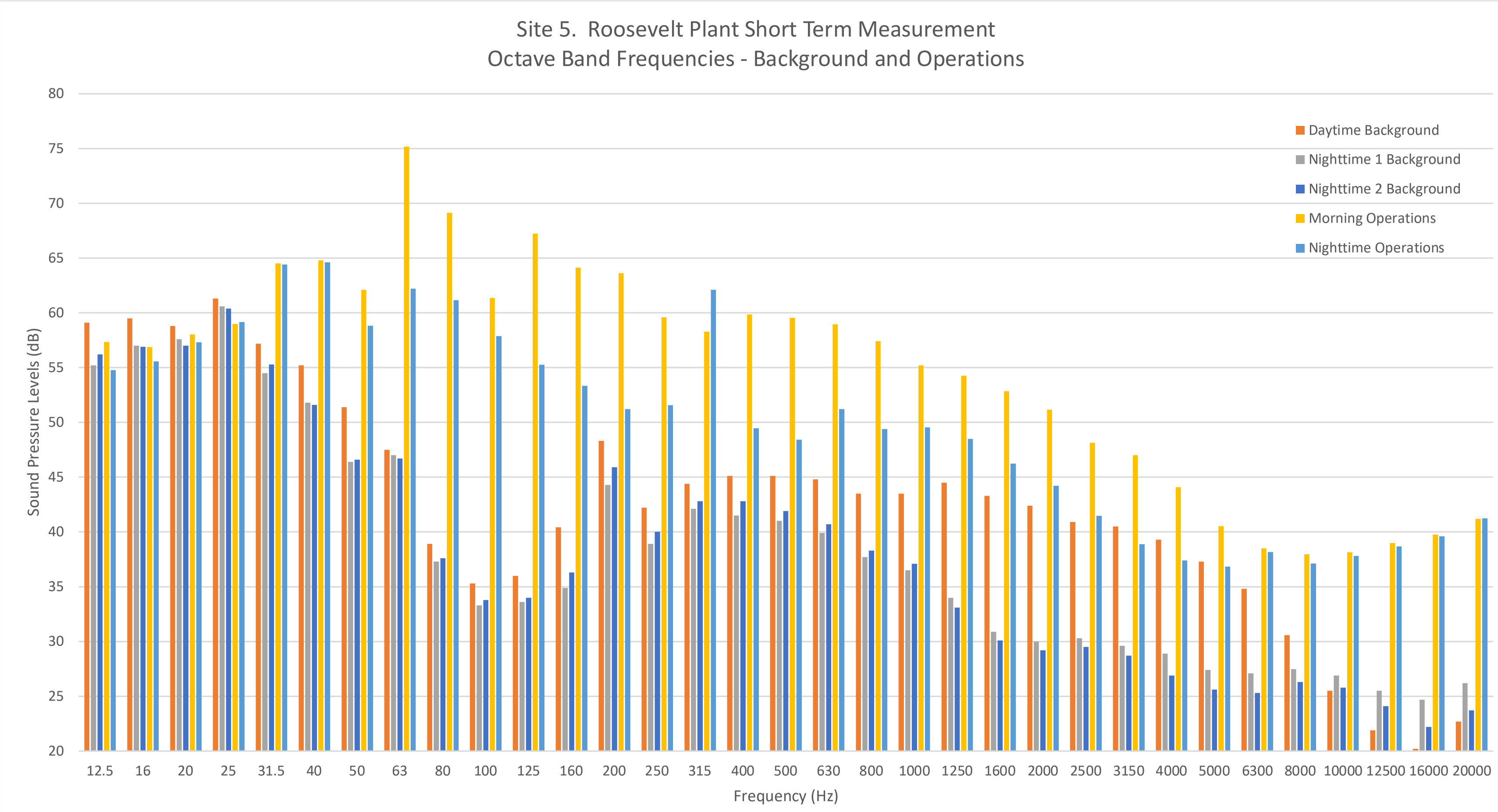
Source: Golder, 2020

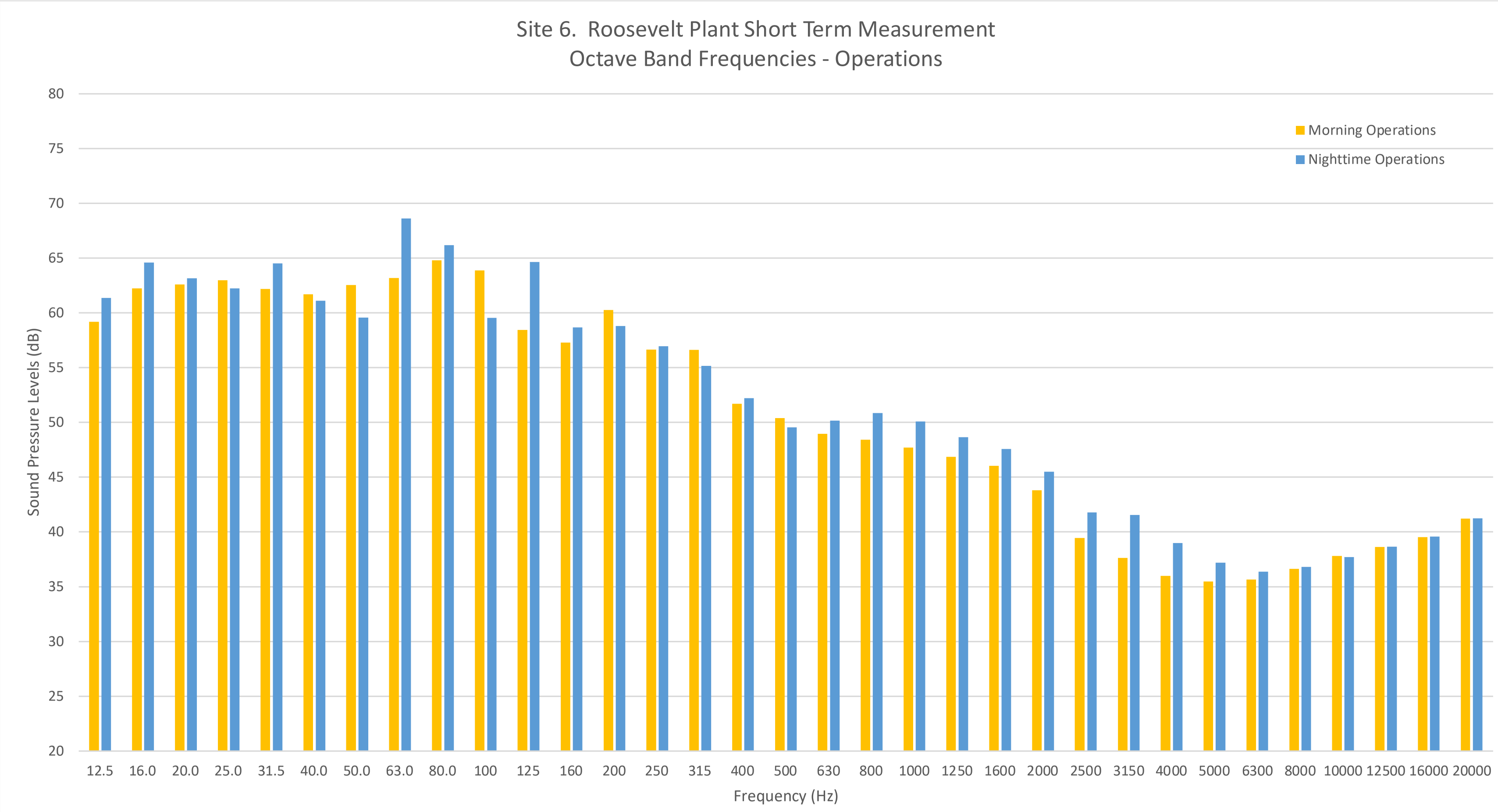

Site 1. Roosevelt Plant Short Term Measurement
Octave Band Frequencies - Background and Operations
Sound Pressure Levels (dB)
80
75
70
65
60
55
50
45
40
35
30
25
20
12.5 16.0 20.0 25.0 31.5 40.0 50.0 63.0 80.0 100 125 160 200 250 315 400 500 630 800 1000 1250 1600 2000 2500 3150 4000 5000 6300 8000 10000 12500 16000 20000
Frequency (Hz)
Morning Background
Afternoon Background
Nighttime Background
Morning Operations
Nighttime Operations

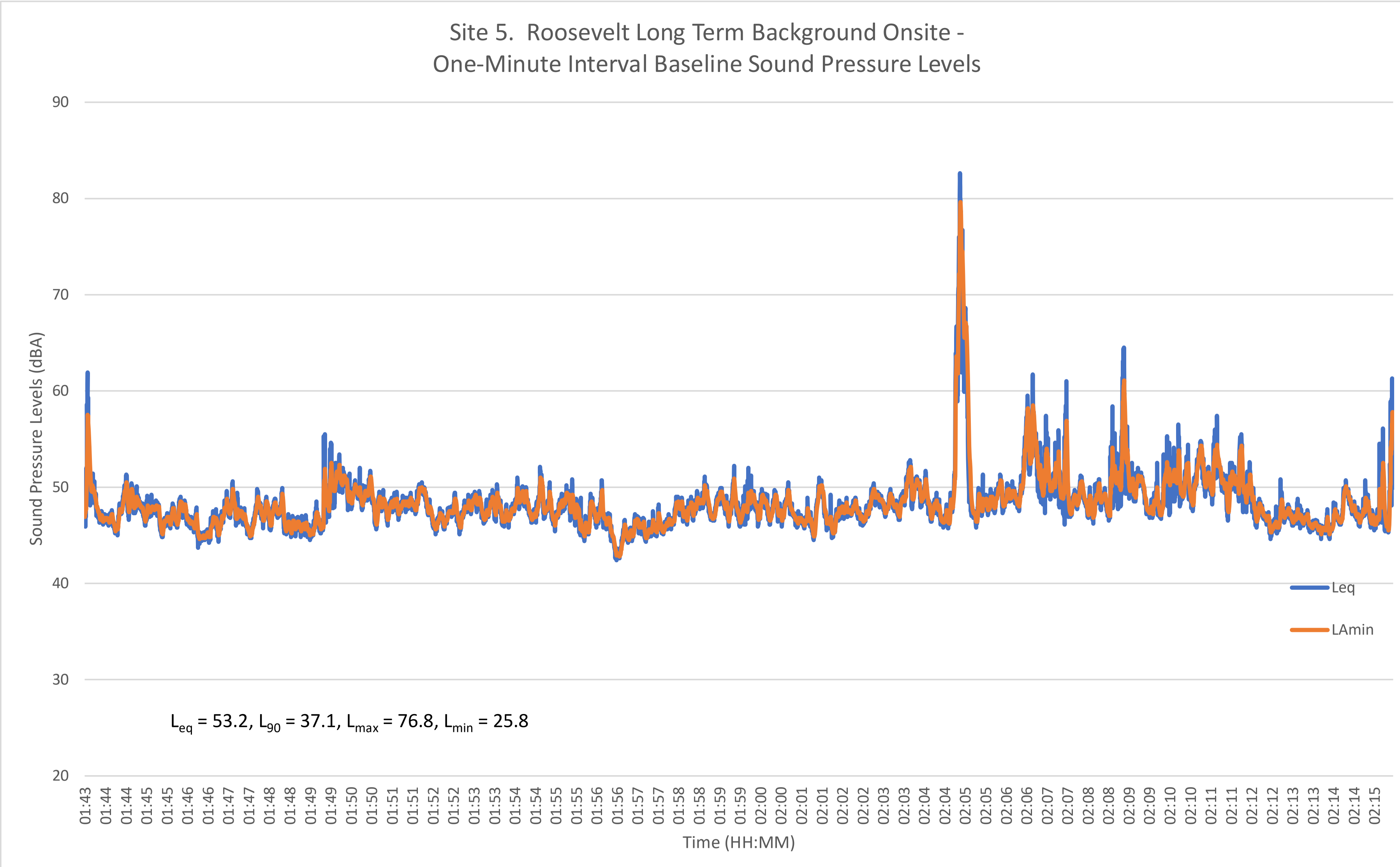

Site 2. Roosevelt Plant Short Term Measurement
Octave Band Frequencies - Background and Operations
Sound Pressure Levels (dB)
80
75
70
65
60
55
50
45
40
35
30
25
20
12.5
16
20
25
31.5
40
50
63
80
100
125
160
200
250
315
400
500
630
800
1000
1250
1600
2000
2500
3150
4000
5000
6300
8000
10000
12500
16000
20000
Frequency (Hz)
Morning Background
Afternoon Background
Nighttime Background
Morning Operations
Nighttime Operations


Site 3. Roosevelt Plant Short Term Measurement
Octave Band Frequencies - Background and Operations
Sound Pressure Levels (dB)
80
75
70
65
60
55
50
45
40
35
30
25
20
12.5
16
20
25
31.5
40
50
63
80
100
125
160
200
250
315
400
500
630
800
1000
1250
1600
2000
2500
3150
4000
5000
6300
8000
10000
12500
16000
20000
Frequency (Hz)
Morning Background
Afternoon Background
Nighttime Background
Morning Operations
Nighttime Operations

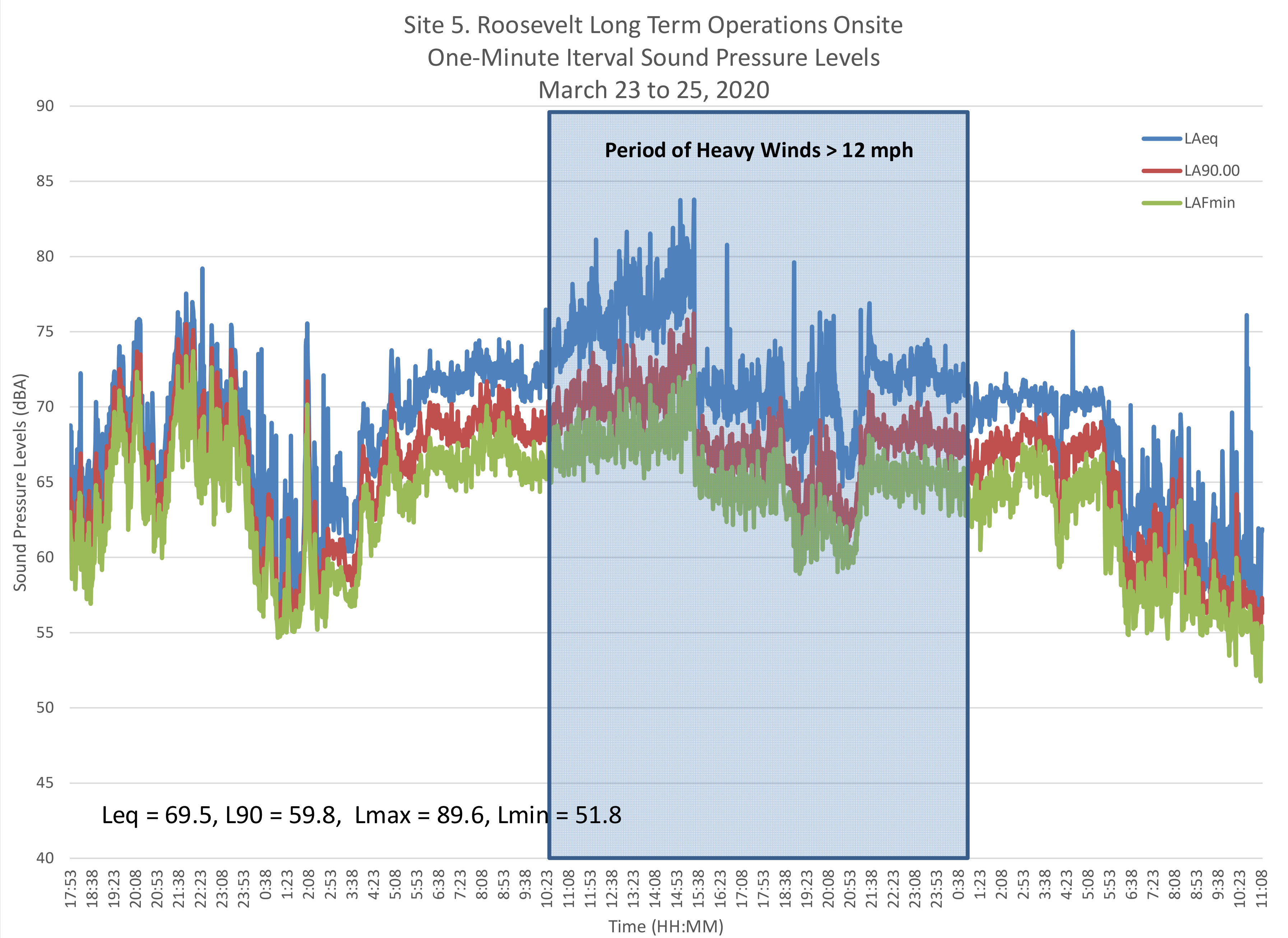

Site 4. Roosevelt Plant Short Term Measurement
Octave Band Frequencies - Background and Operations
Sound Pressure Levels (dB)
80
75
70
65
60
55
50
45
40
35
30
25
20
12.5
16
20
25
31.5
40
50
63
80
100
125
160
200
250
315
400
500
630
800
1000
1250
1600
2000
2500
3150
4000
5000
6300
8000
10000
12500
16000
20000
Frequency (Hz)
Morning Background
Nighttime Background
Morning Operations
Nighttime Operations


Site 5. Roosevelt Plant Short Term Measurement
Octave Band Frequencies - Background and Operations
Sound Pressure Levels (dB)
80
75
70
65
60
55
50
45
40
35
30
25
20
12.5
16
20
25
31.5
40
50
63
80
100
125
160
200
250
315
400
500
630
800
1000
1250
1600
2000
2500
3150
4000
5000
6300
8000
10000
12500
16000
20000
Frequency (Hz)
Daytime Background
Nighttime 1 Background
Nighttime 2 Background
Morning Operations
Nighttime Operations


Site 6. Roosevelt Plant Short Term Measurement
Octave Band Frequencies - Operations
Morning Operations
Nighttime Operations
Sound Pressure Levels (dB)
80
75
70
65
60
55
50
45
40
35
30
25
20
12.5 16.0 20.0 25.0 31.5 40.0 50.0 63.0 80.0 100 125 160 200 250 315 400 500 630 800 1000 1250 1600 2000 2500 3150 4000 5000 6300 8000 10000 12500 16000 20000
Frequency (Hz)


Site 5. Roosevelt Long Term Background Onsite -
One-Minute Interval Baseline Sound Pressure Levels
Sound Pressure Levels (dBA)
90
80
70
60
50
40
30
20
Leq
LAmin
L_{eq} = 53.2, L_{90} = 37.1, L_{max} = 76.8, L_{min} = 25.8
01:43 01:44 01:44 01:45 01:45 01:46 01:46 01:47 01:47 01:48 01:48 01:49 01:49 01:50 01:50 01:51 01:51 01:52 01:52 01:53 01:53 01:54 01:54 01:55 01:55 01:56 01:56 01:57 01:57 01:58 01:58 01:59 01:59 02:00 02:00 02:01 02:01 02:02 02:02 02:03 02:03 02:04 02:04 02:05 02:05 02:06 02:06 02:07 02:07 02:08 02:08 02:09 02:09 02:10 02:10 02:11 02:11 02:12 02:12 02:13 02:13 02:14 02:14 02:15
Time (HH:MM)

GOLDER


Site 5. Roosevelt Long Term Operations Onsite
One-Minute Iterval Sound Pressure Levels
March 23 to 25, 2020
Period of Heavy Winds > 12 mph
LAeq
LA90.00
LAFmin
Sound Pressure Levels (dBA)
90
85
80
75
70
65
60
55
50
45
40
Leq = 69.5, L90 = 59.8, Lmax = 89.6, Lmin = 51.8
17:53 18:38 19:23 20:08 20:53 21:38 22:23 23:08 23:53 0:38 1:23 2:08 2:53 3:38 4:23 5:08 5:53 6:38 7:23 8:08 8:53 9:38 10:23 11:08 11:53 12:38 13:23 14:08 14:53 15:38 16:23 17:08 17:53 18:38 19:23 20:08 20:53 21:38 22:23 23:08 23:53 0:38 1:23 2:08 2:53 3:38 4:23 5:08 5:53 6:38 7:23 8:08 8:53 9:38 10:23 11:08
Time (HH:MM)

DRAFT

TECHNICAL MEMORANDUM

DATE March 26, 2019 **Project No.** 18114729

TO Ms. Megan Mater, Environmental Specialist - Project Permitting
Kinder Morgan, Inc.

CC Jeremy L. Yeglin, Kennard F. Kosky, P.E.

FROM Gage Miller **EMAIL gage_miller@golder.com**

BASELINE NOISE AND LIGHTING COMPLIANCE MONITORING – ROOSEVELT GAS PLANT EXPANSION IN MCKENZIE COUNTY, NORTH DAKOTA

1.0 INTRODUCTION

Golder Associates Inc. (Golder) was contracted by Kinder Morgan, Inc. (KM) to perform environmental sound and lighting studies in support of the Roosevelt Gas Plant expansion located in McKenzie County, North Dakota (Project). The expansion would add one cryogenic turbo-extender unit, increase total net capacity of the facility from 50 to 200 million standard cubic feet of natural gas per day, and expand operations to occupy 30 of the 38 acre parcel. Our understanding is that the North Dakota Public Service Commission (PSC) raised concerns about additional noise and lighting impacts from the expansion and has initiated several "Measures to Minimize Impact" in their approval, including conducting these environmental studies. The scope of these studies includes environmental sound and lighting monitoring during three Project phases:

1. Baseline or existing conditions

2. Construction

3. Operations

This memo is being submitted as the baseline monitoring study on February 4 and 5, 2019 . The construction and operations monitoring results will be submitted in future studies as the Project moves through those phases.

The following attachments can be found at the end of this Technical Memorandum:

- Figure 1. Baseline Noise Study and Lighting Survey Locations
- Attachment 1. Background Information
- Attachment 2. Monitoring Methodology
- Attachment 3. Summary Tables and Figures

2.0 MONITORING AND NOISE SENSITIVE LOCATIONS

Monitoring locations are outlined in Table 1 below and illustrated in Figure 1. Monitoring conducted included:

1) Short-term noise monitoring of at least 15 minutes at off-site locations near the closest noise sensitive area (NSA) conducted during the daytime and at night
2) Long-term noise monitoring of approximately 24 hours at a secure on-site location approximate to the closest NSA to the east of the Project area
3) Lighting measurements collected at night during a new moon phase

Note: The 24-hour measurement could not be conducted due to the severe winter weather prematurely draining the batteries. The 24-hour measurement was replaced with 30 minute measurements similar to the short-term measurements. The 24-hour measurements are planned to resume during construction and operations phases when conditions are less severe.

Methodologies are attached at the end of this memo as Attachment 2.

Table 1: Monitoring Locations

Site	Coordinates (Decimal Degrees		Monitoring Dates	Sample Type	Distance and direction from Project (miles)
	Latitude	Longitude			
Site 1	47.687278°	-103.258642°	February 4 & 5, 2019	Short Term Noise, Lighting	0.42 ESE
Site 2	47.68824°	-103.2758692°	February 4 & 5, 2019	Short Term Noise, Lighting	0.17 SW
Site 3	47.700194°	-103.283417°	February 4 & 5, 2019	Short Term Noise, Lighting	0.84 NW
Site 4	47.702086°	-103.266793°	February 4 & 5, 2019	Short Term Noise, Lighting	0.70 N
Site 5	47.689989°	-103.265609°	February 4 & 5, 2019	Long term Noise, Lighting	Boundary E
Site 6	47.689431	-103.272537	February 4, 2019	Lighting	Boundary W

[a] Distance from closest sides of the property boundary

For the Project, NSAs considered any residential dwelling within one mile from the Project boundary. There were no other NSAs identified outside of residences. A total of 6 NSAs were identified and are presented in Table 2 and illustrated in Figure 1.

Table 2: Noise Sensitive Area Locations

NSA	Coordinates (Decimal Degrees		Distance and direction from Project (miles)
	Latitude	Longitude	
1	47.689509°	-103.262815°	0.22 E
2	47.687694°	-103.252947°	0.69 ESE
3	47.687605°	-103.255975°	0.55 ESE
4	47.687113°	-103.277006°	0.25 SW
5	47.700031°	-103.287604°	0.96 NW
6	47.702380°	-103.267812°	0.72 N

3.0 NOISE MONITORING

Sound propagation involves three principal components: a noise source, a person or a group of people, and the transmission path. While two of these components, the noise source and the transmission path, are easily quantified (i.e., direct measurements or through predictive calculations), the effects of noise to humans is the most difficult to determine due to the varying responses of humans to the same or similar noise patterns. The perception of sound (noise) by humans is very subjective, and just like odors and taste, is very difficult to predict a response from one individual to another.

Measurements were collected twice during the daytime (7:00 a.m. to 10 p.m.) and once during the nighttime (10:00 p.m. to 7:00 a.m.) at each location. The two daytime measurements were collected at different times to differentiate any patters between morning (before 12:00 p.m) and afternoon (after 12:00 p.m.) when human activities could change.

3.1 Noise Level Requirements

Based on the state of North Dakota PSC Findings of Fact, Conclusions of Law and Order dated November 26, 2018, the Project specific noise standard is as follows:

> The Project “expects to keep the noise level of activities under fifty (50) decibels (A-weighted) to the nearest noise sensitive receptor during and after construction, and when the Roosevelt plant is placed into service.”

This noise level was based on testimony provided to the PSC.

3.2 Noise Monitoring Results

Noise measurements were dominated by local traffic noise, noise from existing facility, surrounding facilities, and sound of nature. Table 3 shows a summary for the data collected at the monitoring locations and a description of those locations. The summary includes the overall equivalent sound pressure (L_{eq}) for each measurement and the sound level that is exceeded 90 percent of the time (L_{90}). The L_{90} is better used for describing the noise level impacts from continuously operating equipment such as gas plant operations and reducing the impact of transient noise sources such as traffic noise. The day-night average sound level (L_{dn}) is the 24-hour average SPL calculated with a 10 decibel "penalty" added to nighttime hours (10 p.m. to 7 a.m.).

Table 3: Summary of Noise Monitoring Results in A-weighted Decibels (dBA)

Site	Time	L_{eq} (dBA)	L_{90} (dBA)	L_{dn} (dBA)[a]
1	Morning	53.4	35.9	41.5
	Afternoon	59.0	38.9	
	Night	56.8	33.9	
2	Morning	58.9	43.9	51.8
	Afternoon	61.6	44.6	
	Night	54.9	45.5	
3	Morning	74.3	42.4	43.8
	Afternoon	73.2	43.3	
	Night	72.1	34.5	
4	Morning	59.7	40.5	43.9
	Afternoon	47.0	37.6	
	Night	53.1	36.7	
5	Daytime	53.7	45.8	51.6
	Nighttime #1	46.7	44.7	
	Nighttime #2	47.0	45.1	

[a] Calculated using the greater of the daytime/nighttime L_{90} results

A more detailed summary table and octave band figures for each monitoring location can be found in Attachment 3.

4.0 LIGHTING

Outdoor lighting for the Project is necessary to satisfy requirements for worker safety and overall site security. Unconstrained lighting can cause "light pollution," which includes "sky glow" and "light trespass." Sky glow is the result of stray light being scattered in the atmosphere, brightening the natural sky background level. Light trespass is the term used to describe light or illuminance that strays from its intended purpose and potentially becomes an annoyance. To evaluate the existing nighttime light conditions at the Site, an ambient outdoor lighting study was conducted and is presented in this section.

4.1 Lighting Standards

There are no numerical lighting standards outlined by the North Dakota PSC for this Project, but the PSC does require that the Project will take reasonable measures during construction and operations to mitigate the effects of lighting on adjacent lands as to not “create significant adverse effects on adjacent land use”. The comparison of construction and operations to existing conditions will indicate the effectiveness of this mitigation and their impacts.

4.2 Results

The nighttime ambient illuminance measurement results are summarized in Table 4. The observations were collected during a new moon cycle under mostly clear conditions with some cloud cover. It should be noted that the ground was completely snow covered and it was snowing during most of the measurements. These conditions could increase light trespass reflecting off the snow and increase the overall illuminance measured. The nighttime sky glow in the horizontal (0°) direction ranged from 15.40 mags/arcsecond^2 at Site 4 to 12.59 mags/arcsecond^2 at Site 6.

The nighttime skyglow in the midpoint (45°) direction ranged from 18.64 mags/arcsecond^2 at Site 4 to 14.18 mags/arcsecond^2 at Site 6.

The nighttime skyglow in the vertical (90°) direction ranged from 19.00 mags/arcsecond^2 at Site 4 to 15.01 mags/arcsecond^2 at Site 2.

The difference between horizonal (0 degree) measurement and the vertical (90 degree) measurement can be used to represent the amount of light trespass impacting a monitoring site. The light trespass ranged from 3.60 mags/arcsecond^2 at Site 4 to 0.03 mags/arcsecond^2 at Site 3.

Table 4: Summary of Lighting Measurements (Sky Glow)

Site	0-degree angle (mag/arcsec^2)	45-degree angle (mag/arcsec^2)	90-degree angle (mag/arcsec^2)	Light Trespass[a] (mag/arcsec^2)
1	14.79	14.92	15.13	0.35
2	14.60	14.88	15.01	0.41
3	14.68	14.78	14.71	0.03
4	15.40	18.64	19.00	3.60
5	15.28	16.41	16.72	1.44
6	12.59	14.18	15.15	2.56

[a] Difference between Horizonal (0 degree) and Vertical (90 degree) to indicated light trespass from Project

5.0 CONCLUSIONS

5.1 Noise Monitoring

Sound measurements were mostly dominated by local traffic, noise associated with existing facility operations, sounds of nature including bird and wind noise, and livestock noise. Because transient sound sources were the dominant noise source, the average (L_{eq}) can vary from hour to hour or even minute to minute; therefore, the L_{90} is better used for comparing noise levels between times of day or between sites. The L_{90} also best represents the noise being generated from the existing facility noise sources that are constant and continuous. The results show that sound levels are greatly affected by transient noise sources, such as the observed truck traffic noise, and that sound levels were generally lower during the nighttime hours, but that was not universally the case with some nighttime levels exceeding daytime levels.

Table 2 includes several statistical metrics, but for comparison to the North Dakota PSC requirement of 50 dBA, the L_{90} is the most representative of the sound levels emanating from the existing facility without the interference of transient noise sources. The L_{90} noise levels ranged from 33.9 dBA at Site 1 during the nighttime measurement to 45.8 dBA at Site 5 during the daytime. These sound levels are below the PSC requirement.

The L_{dn} was also calculated from the L_{90} measurements to compare to U.S. Environmental Protection Agency (EPA) and U.S. Department of Housing and Urban Development (HUD) L_{dn} guidelines of not to exceed 55 dBA. The highest L_{dn} was calculated as 51.8 at Site 2, which is below the EPA and HUD guidelines.

Based on these comparisons to the Project specific standard and typical guidelines, the sound levels existing currently at NSAs are below levels that would commonly be considered a nuisance but would be observable during outdoor activities. The existing sound levels are also below the Project specific requirement of 50 dBA.

5.2 Lighting

The darker the sky the less illuminance, and the greater the apparent magnitude of the sky as more stars are visible. Based on the results in Table 4 and the comparison standards presented in Attachment 1, the measurements in the horizontal direction are approximately equivalent to that of a full moon or a city sky (12.59 to 15.40 mag/arcsec^2). This would indicate light trespass from local sources in the horizontal direction are evident, but the magnitude is most likely affected by light reflected off the snow-covered landscape. The measurements in the vertical direction are between a full moon and a bright suburban sky (14.71 to 19.00 mag/arcsec^2). In general, the difference in light trespass decreased the further away from the Project site, from a 2.56 mag/arcsec^2 at boundary Site 6 to 0.03 mag/arcsec^2 at the furthest Site 3. However, Site 4 had the greatest light trespass of 3.60 mag/arcsec^2, indicating that the existing facility is likely a contributing source of light trespass, but that there are other sources of light trespass at Site 4.

Comparisons of lighting measurements directly to sky glow comparisons and classifications are complicated by the light reflecting off the snow causing increased trespass and sky glow observations. The results do indicate that the existing facility is a contributing source of anthropogenic light contributing to light trespass and sky glow. However, the results indicate that the facility is not the only source of light trespass.

Additional monitoring may be advantageous for direct comparisons to sky glow observations and classifications, and for comparisons between existing conditions and construction and operations impacts. This monitoring would need to occur during a full moon, without snow covering the landscape, and without sources of light related to construction activities.

Gage Miller
Senior Scientist

Kennard F. Kosky, P.E.
Principal

GBM

https://golderassociates.sharepoint.com/sites/106179/project files/6 deliverables/tech memo/roosvelt tech memo 3-26-19.docx

FIGURE

REFERENCE(S)
1. MONITORING LOCATIONS, NOISE SENSITIVE AREAS, GOLDER ASSOCIATES INC., 2019.

COORDINATE SYSTEM: NAD 1983 UTM ZONE 13N
PROJECTION: TRANSVERSE MERCATOR
DATUM: NORTH AMERICAN DATUM OF 1983

CLIENT
KINDER MORGAN, INC.

PROJECT
ROOSEVELT GAS PLANT EXPANSION
MCKENZIE COUNTY, NORTH DAKOTA

TITLE
BASELINE NOISE STUDY AND LIGHTING SURVEY LOCATIONS

CONSULTANT
GOLDER

YYYY-MM-DD	2019-03-15
DESIGNED	GFD
PREPARED	GFD
REVIEWED	GBM
APPROVED	JMT

PROJECT NO.	CONTROL	REV.	FIGURE
18114729	A001	0	1

ATTACHMENT 1
BACKGROUND INFORMATION

ATTACHMENT 1

BACKGROUND INFORMATION

NOISE

Acoustic values can be described in terms of noise or sound. **Sound** is generated by pressure fluctuations in air. **Noise** is genially defined as any “unwanted” sound, and is therefore based on human perception, but the terms noise and sound are often used interchangeably. Sound propagation involves three principal components: a noise source, a person or a group of people, and the transmission path. While two of these components, the noise source and the transmission path, are easily quantified (i.e., by direct measurements or through predictive calculations), the effect of noise on humans is the most difficult to determine due to the varying responses to the same or similar noise patterns and therefore it is difficult to predict a response from one individual to another.

Noise and noise levels are used to describe ambient levels perceived by off-site receptors, while sound and sound emissions describe acoustic energy emitted by activities/equipment associated with the project.

Noise data and analysis are primarily given in terms of **frequency** distribution. The levels are grouped into **octave bands**. Typically, the center frequencies for each octave band are 31.5, 63, 125, 250, 500, 1000, 2000, 4000, and 8000 Hertz (Hz). The human ear responds to the pressure variations in the atmosphere that reach the ear drum. These pressure variations are composed of different frequencies that give each sound we hear its unique character.

Due to the complexity of human ear functions, measurement of different noise sources does not always correspond to relative loudness or annoyance. It is common practice to sum sound levels over the entire audible spectrum (i.e., 20 Hz to 20 kHz) to give an overall sound level, but human hearing varies in sensitivity depending on the frequency of the sound. Specifically, the human ear is most sensitive to sound with the 1,000 Hz to 6,000 Hz frequency range. To account for the response of humans, it is common to use the “***A-weighted***” sound level (noted in units of **dBA**) in evaluating noise sources and their effects on human since it models the way in which the human hear responds to noise levels in the sensitive frequencies outlined above.

Sound pressure level is expressed on a logarithmic scale in units of **decibels (dB)**. Since the scale is logarithmic, a sound that is twice the sound pressure level as another will be 3 decibels (3 dB) higher. A change of 3 dB is generally barely perceptible by humans, while a 5 dB change is clearly perceptible and a 10 dB increase is perceived as a doubling of the sound pressure level. (Cowan, 1994)

Some noise sources and industrial activities are inherently likely to give rise to tonal noise, otherwise known as a “***pure tone***”. Pure tones are more noticeable than broadband noise and therefore be more intrusive. The Identification of pure tones can be quantified by using the method developed in Annex D of ISO 1996:2007(E). This method identifies a pure tone using the time-average sounds pressure level in the one-third-octave band equal to or exceeding the time-average sound pressure levels of both adjacent one-third-octave bands in accordance to the following:

- 15 dB in low-frequency bands (25 Hz to 125 Hz)
- 8 db in middle-frequency bands (160 Hz to 400 Hz)
- 5 db in high0frequency bands (500 Hz to 10,000 Hz)

Environmental noise levels vary over time, and are described using an overall sound level known as the $\mathbf{L_{eq}}$, or equivalent sound pressure level. The L_{eq} is the energy averaged continuous sound pressure level which has the same total energy as the time varying noise level over a stated time period. The day-night average sound level

(L_{dn}) is the 24-hour average SPL calculated with a 10 dBA "penalty" added to nighttime hours (10 p.m. to 7 a.m.). This is done because residential land uses are more sensitive to nighttime noise impacts. The equation for L_{dn} is:

$$L_{dn} = 10 \log \frac{15 \times 10^{\frac{L_d}{10}} + 9 \times 10^{\frac{L_n + 10}{10}}}{24}$$

where: Ld = daytime Leq for the period 0700 to 2200 hours

Ln = nighttime Leq for the period 2200 to 0700 hours

The EPA recommends an outdoor Ldn of 55 dBA for residential and farming areas. For industrial areas, an Leq of 70 dBA is suggested. The HUD-recommended goal for exterior noise levels is not to exceed an Ldn of 55 dBA. However, the HUD standard for exterior noise is 65 dBA measured as Ldn.

Sound Pressure Levels of Typical Sounds Sources

Activity / Sound	Sound Pressure Level (dBA)
Air Raid Siren at 50 ft	120
Jackhammer at 15 m *	95
Loud Shout	90
Heavy Truck at 15 m *	85
Vacuum Cleaner at 3 m *	70
Automobile (100 km/hr) at 30 m *	65
Normal Conversation at 1 m	60
Quiet Living Room	40
Soft Whisper at 2 m *	35
Unoccupied Broadcast Studio	28
Threshold of Hearing	0

Notes: Source, Harris, 1998

Sound Pressure Levels of Typical Environments

Activity / Sound	Sound Pressure Level (dBA)
Rock Concert	110
Subway Platform with Passing Train	100
Sidewalk with Passing Heavy Truck or Bus	90
Sidewalk by Typical Highway	80
Sidewalk of Typical Road with Passing Traffic	70
Typical Urban Area	60 – 70

Activity / Sound	Sound Pressure Level (dBA)
Typical Suburban Area	50 – 60
Quiet Suburban Area at Night	40 – 50
Typical Rural Area at Night	30 – 40
Quiet Living Room	40
Isolated Broadcast Studio	20 - 30
Rock Concert	110
Subway Platform with Passing Train	100

Source: Harris, 1998.

Generally, the noise assessment carried out is completed on locations where it is expected noise effects from the Project activities can affect humans. Specific study areas have been identified as being representative of all sensitive receptors, which could be affected by noise emissions associated with project activities.

LIGHTING

Light is part of the electromagnetic spectrum, which ranges from radio waves to gamma rays. Electromagnetic radiation waves are fluctuations of electric and magnetic fields, which can transport energy from one location to another. Visible light is not inherently different from other parts of the electromagnetic spectrum, with the exception that the human eye has evolved to detect visible waves. The human eye responds to light based on its frequency. The frequency of light that is within the visible range establishes the observed color. While the response varies from person to person, the Commission Internationale de l'Eclairage (C.I.E., International Commission on Illumination) defined standard luminosity coefficients for the human eye in 1931.

A “candela” refers to the luminous intensity of a lighting source and is measured in candelas (cd). A “lumen” is the total luminous flux of a light source of one candela of luminous intensity. Illuminance is the total luminous flux incident on a surface per unit area. A “lux” is the measure of illumination (1 lumen) that falls on one square meter. The English measurement is the “foot-candle,” which is the same illumination (1 lumen) falling on one square feet. A lux is equivalent to 0.093 foot-candle; one foot-candle is 10.76 lux. Luminance is the perceived brightness of an object which has been illuminated by a source. The luminance of an object depends on its material characteristics and reflectance and is measured in candelas per square meter (cd/m^2).

Light Trespass

Some regulators have established programs to reduce light trespass. Light trespass standards are typically based on the amount of light from a light source that is transmitted onto adjoining properties. Light trespass standards are typically different for various land uses.

Sky Glow

The earliest measures of sky glow, also called sky brightness, were based on a scale upon which the magnitude of stars visible to the human eye is divided into 6 levels. The brightest star is a magnitude 1 and the dimmest (faintest) star is a magnitude 6. More recently, the magnitude scale was modified to express astronomical surface brightness (stars, planets, etc.) in units known as magnitudes per square arcsecond ($mag/arcsec^2$). The measurement scale is inverse and logarithmic and is generally used in small area photometry and astronomy. Sky Glow classifications and comparisons are presented in the tables below.

Sky Glow Comparison Table

Class	Title	Approx. SQM mag/arcsec^2
1	Excellent dark-sky site	21.7–22.0
2	Typical truly dark site	21.5–21.7
3	Rural sky	21.3–21.5
4	Rural/suburban transition	20.4–21.3
5	Suburban sky	19.1–20.4
6	Bright suburban sky	18.0–19.1
7	Suburban/urban transition	
8	City sky	< 18.0
9	Inner-city Sky	

Source: https://en.wikipedia.org/wiki/Bortle_scale

Examples of Typical Illuminance and Apparent Magnitude

Location	Classification	Illuminance [a] (lux)	Sky Brightness[b] (mag/arcsec^2)
Outdoor	Bright Sun	100,000 - 130,000	>0.1
	Hazy Day	32,000	1.3
	Partly Cloudy	25,000	1.6
	Cloudy	10,000	2.6
	Overcast	1,000	5.1
	Sunrise/Sunset on Clear Day	400	6.1
	Full Moon	0.1	15.1
	Moonless Clear Night Sky	0.001	20.1
	Moonless Overcast Night Sky	0.0001	22.6
	Starlight	0.00005	23.3
Indoor	Typical TV Studio	1,000	5.1
	Bright Office with Large Contrast	400	6.1
	Hall Way	80	7.8
	Living Room	50	8.3
	Good Street Lighting	20	9.3
	Poor Street Lighting	1	12.6

a Electro-Optics Handbook,1979; Williams, 1999

b Calculated based on conversion from lux to mags/arcsecond^2

ATTACHMENT 2
MONITORING METHODOLOGY

ATTACHMENT 2

MONITORING METHODOLOGIES

NOISE

Measurement techniques set forth by the American National Standards Institute (ANSI) S12.9-1993/Part 3, 1993, were used and included using a Type - 1 sound level meter set to the fast response mode to obtain consistent, integrated, A-weighted SPLs. Concurrent one-third octave band frequencies were also measured at all sites. The octave band data from each monitoring site were measured and stored during each monitoring period.

Integrated SPL data consisting of the following noise parameters were collected at each location:

- L_{eq} – The SPL averaged over the measurement period; this parameter is the continuous steady SPL that would have the same total acoustic energy as the real fluctuating noise over the same time period.
- L_{max} – The maximum SPL for the sampling period.
- L_{min} – The minimum SPL for the sampling period.
- L_n – The SPLs that were exceeded *n* percent of the time during the sampling period. For example, L_{90} is the level exceeded 90 percent of the time.

The SPL data were analyzed in both dB and dBA. The higher the decibel value, the louder the sound.

The SPL averages were calculated using the following formula:

$$\text{Average SPL} = 10\,\text{Log}\,\frac{\sum_{i=1}^{N} 10^{(SPL_i/10)}}{N}$$

where: N = number of observations

SPL_i = individual SPL in data set

The noise monitoring equipment used during the study included:

- Larson Davis Model 824 Precision Integrating Sound Level Meters with Real Time Frequency Analyzers
- Larson Davis Model PRM902 Microphone Preamplifier
- Larson Davis Model 2560 Pre-polarized ½-inch Condenser Microphone
- Windscreen, tripod, and various cables
- Larson Davis Model CAL200 Sound Level Calibrator (CAL200), 94/114 dB at 1,000 Hz

Monitoring was conducted using the sound level meter mounted on a tripod at a minimum height of 1.5 meters (5 feet) above grade. A windscreen was used since measurements were taken outdoors. The windscreen protects the microphone from interference from wind up to a constant wind speed of 12 miles per hour (mph). The microphone was positioned so that a random incidence response was achieved. The sound level meter and octave band analyzer were calibrated immediately prior to and just after each sampling period using the CAL200 to provide a quality control check of the sound level meter's operation during monitoring.

The operator recorded detailed field notes during monitoring that included major noise sources in the area. The Larson Davis sound level meters comply with Type I – Precision requirements set forth for sound level meters and for one-third octave filters.

Calibration certifications for the equipment used can be furnished upon request.

LIGHTING

Sky glow measurements were taken to assess the existing ambient conditions in the vicinity of the Project at the same locations as the noise monitoring locations.

The illumination monitoring field efforts were conducted on February 4 and 5, 2019 between the hours of 21:16 and 00:32. Measurements were taken using a calibrated Unihedron SQM-LU Sky Quality Meter and recorded in magnitudes per square arcsecond (mag/acrsec^2).

The illuminance measurements were collected at six light monitoring locations at a height of 5 ft above grade. The measurements were collected with the meter angled in three directions for a minimum of five consecutive minutes at each angle:

- 0° - Towards the horizon to measure light trespass coming from the Project site
- 90° - Vertical to measure light from celestial and reflected sources
- 45° - Midpoint measurement between the above 2

ATTACHMENT 3
SUMMARY TABLES AND FIGURES

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NOISE SUMMARY TABLE
AMBIENT SOUND PRESSURE LEVELS OBSERVED AT THE ROOSEVELT SITE FEBRUARY 2019

Monitoring Location	Coordinates (Decimal Degrees)	Date	Time	HH:MM	Sound Pressure Levels (dBA) L_{Min}	L_{max}	L_{90}	L_{eq}	L_{dn} [a]	Observations
Site SE -	47.687278°	5-Feb-19	Morning	9:36	35.0	74.2	35.9	53.4		Light traffic, small equipment operating at nearby facility
	-103.258642°	4-Feb-19	Afternoon	16:41	37.4	79.3	38.9	59.0		Light humming from generator/compressor, light traffic 100 ft away
		5-Feb-19	Night	23:12	33.5	80.2	33.9	56.8	41.5	Light noise from gas plant and minimal traffic on road
Site SW -	47.68824°	5-Feb-19	Morning	8:57	41.9	80.5	43.9	58.9		Light traffic, light humming from Roosevelt Gas Plant - Generators/compressors
	-103.2758692°	5-Feb-19	Afternoon	15:32	42.6	80.1	44.6	61.6		Heavy traffic, cloudy, light snow
		5-Feb-19	Night	21:29	43.9	77.7	45.5	54.9	51.8	Light noise coming from gas plant and surrounding facilities, humming.
Site 03	47.700194°	5-Feb-19	Morning	8:29	39.4	89.4	42.4	74.3		Traffic on highway 85, fairly light morning traffic.
	-103.283417°	5-Feb-19	Afternoon	15:09	35.0	89.8	43.3	73.2		Heavy traffic
		5-Feb-19	Night	21:06	33.7	91.4	34.5	72.1	43.8	Greated horned owl, light traffic
Site 04 -	47.702086°	5-Feb-19	Morning	10:03	38.9	83.4	40.5	59.7		Light humming, horses nearby in pen, heavy equipment beeping approx. 0.5 miles away
	-103.266793°	5-Feb-19	Afternoon	16:34	36.0	67.5	37.6	47.0		Snow blowing, horses nearby out of pen
		5-Feb-19	Night	23:35	35.8	78.6	36.7	53.1	43.9	Horses running in pen, little to no noise around
Long Term Onsite	47.689989°	6-Feb-19	Daytime	13:43	42.3	82.9	45.8	53.7		Heavy equipment noise from gas plant, humming from nearby facilties
	-103.265609°	5-Feb-19	Nighttime 1	21:58	43.4	65.1	44.7	46.7		Light noise from surrounding gas facilites
		5-Feb-19	Nighttime 2	22:33	43.1	62.6	45.1	47.0	51.6	Light noise from surrounding gas facilites
EPA and HUD guideline for outdoor residental and farming area receiving land uses									55.0	

Source: Golder, 2019.

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SUMMARY LIGHTING TABLE
BASELINE LIGHTING MEASURED AT THE ROOSEVELT SITE FEBRUARY 2019

Monitoring Location	Coordinates (Decimal Degrees)	Date	Start Time	End Time	Sky Glow ($mag/arcsec^2$)				Observations
					0 degrees	45 degrees	90 degrees	Trespass[a]	
Site 1 - Residence southeast	47.687278° -103.258642°	4-Feb-19	21:16	21:32	14.78	14.92	15.13	0.35	Light traffic with some headlights in the distance
Site 2 - Resident southwest	47.68824° -103.2758692°	4-Feb-19	23:05	23:21	14.60	14.88	15.01	0.41	Snowing
Site 3 - Residence northwest	47.700194° -103.283417°	4-Feb-19	22:43	22:59	14.68	14.78	14.71	0.03	Snowing
Site 04 - Residence northeast	47.702086° -103.266793°	5-Feb-19	0:17	0:32	15.40	18.64	19.00	3.60	Snowing
Site 5 - Boundary east	47.689989° -103.265609°	4-Feb-19	23:51	0:07	15.28	16.41	16.72	1.44	Snowing, facility lighting
Site 6 - Boundary west	47.689431 -103.272537	4-Feb-19	23:27	23:42	12.59	14.18	15.15	2.56	Snowing, facility lighting

EPA and HUD guideline for outdoor residental and farming area receiving land uses

Source: Golder, 2019.

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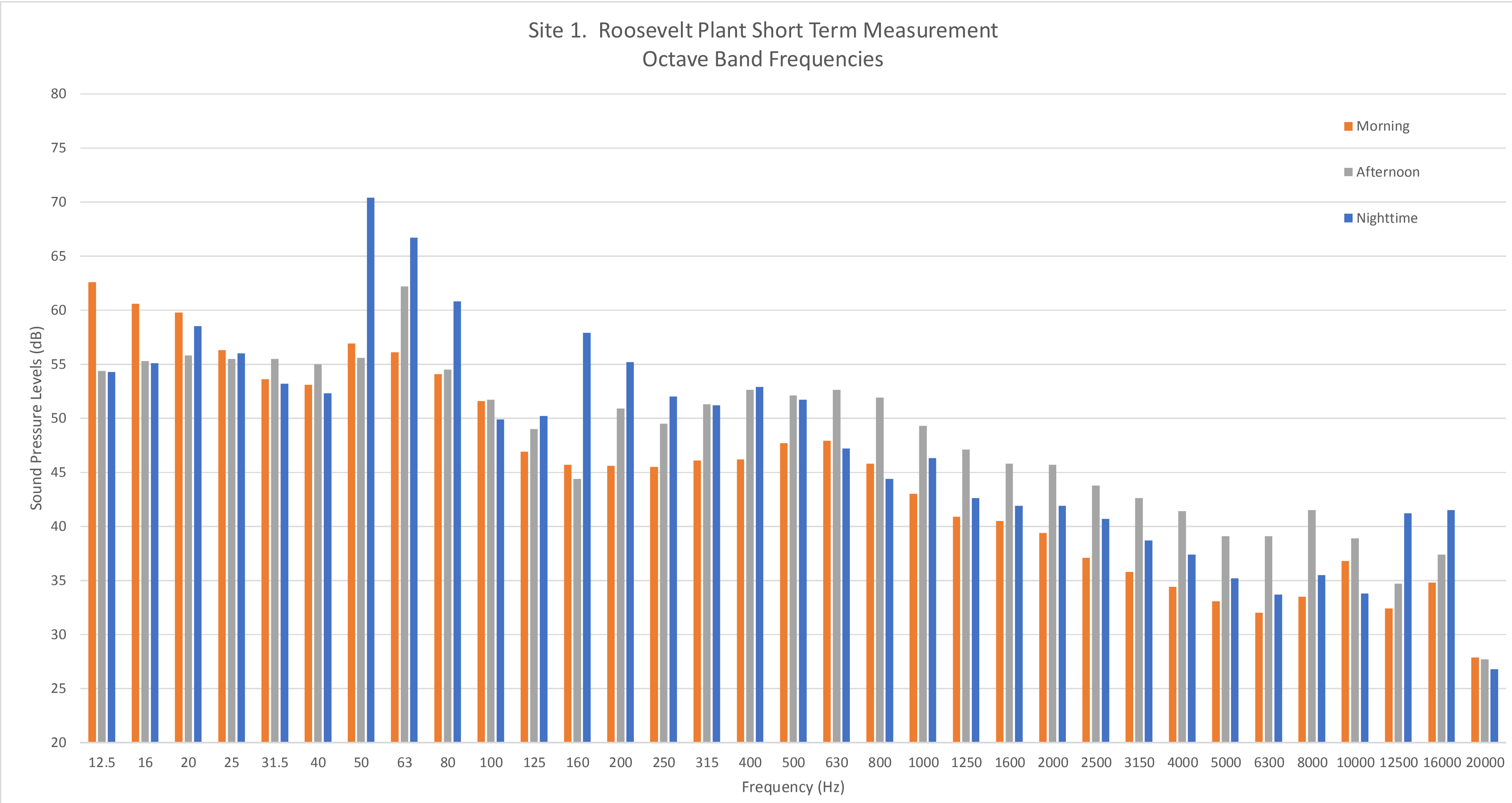
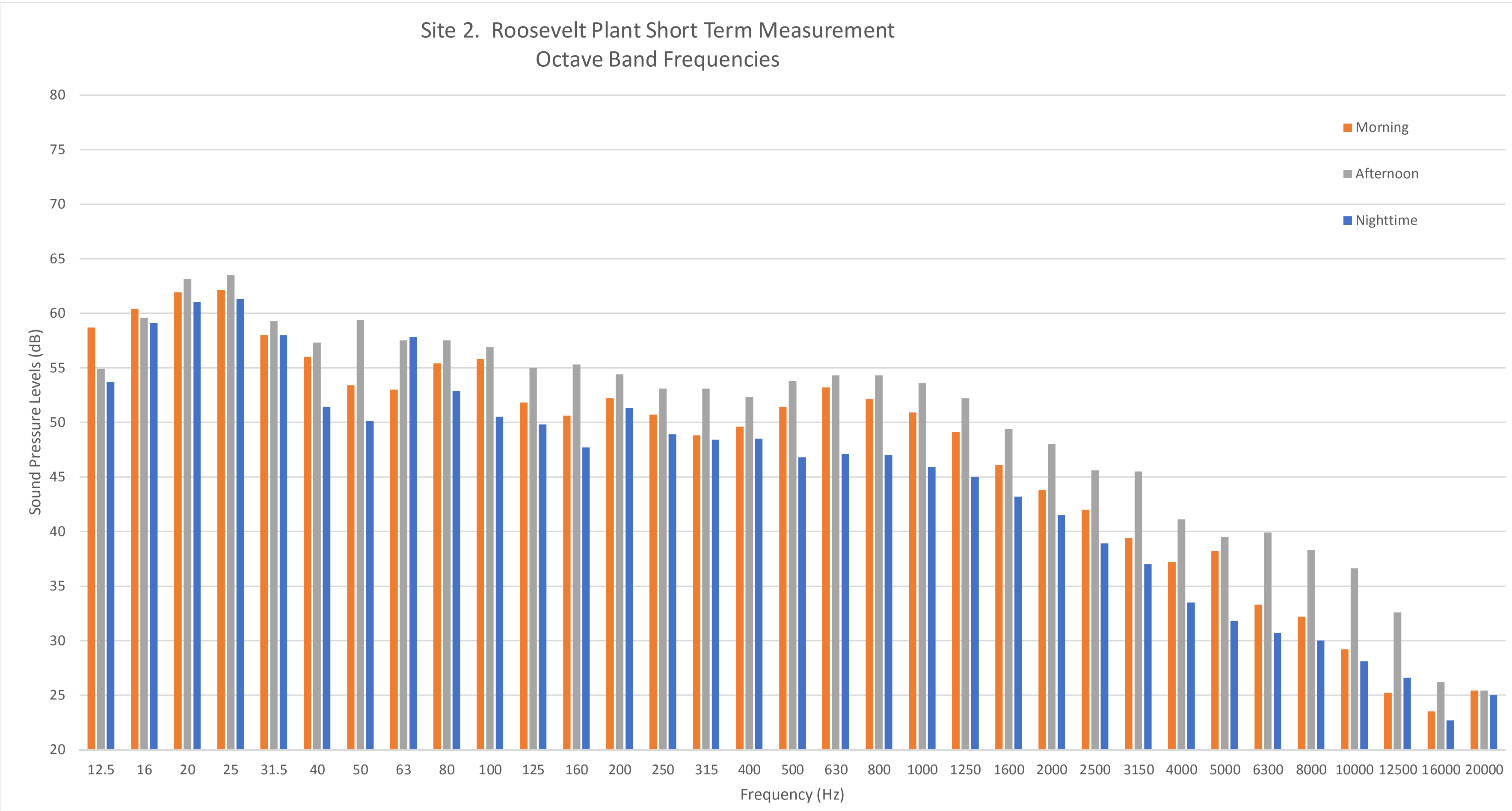

Site 1. Roosevelt Plant Short Term Measurement
Octave Band Frequencies
Sound Pressure Levels (dB)
80
75
70
65
60
55
50
45
40
35
30
25
20
12.5
16
20
25
31.5
40
50
63
80
100
125
160
200
250
315
400
500
630
800
1000
1250
1600
2000
2500
3150
4000
5000
6300
8000
10000
12500
16000
20000
Frequency (Hz)
Morning
Afternoon
Nighttime

DRAFT


Site 2. Roosevelt Plant Short Term Measurement
Octave Band Frequencies
Sound Pressure Levels (dB)
80
75
70
65
60
55
50
45
40
35
30
25
20
Morning
Afternoon
Nighttime
12.5
16
20
25
31.5
40
50
63
80
100
125
160
200
250
315
400
500
630
800
1000
1250
1600
2000
2500
3150
4000
5000
6300
8000
10000
12500
16000
20000
Frequency (Hz)

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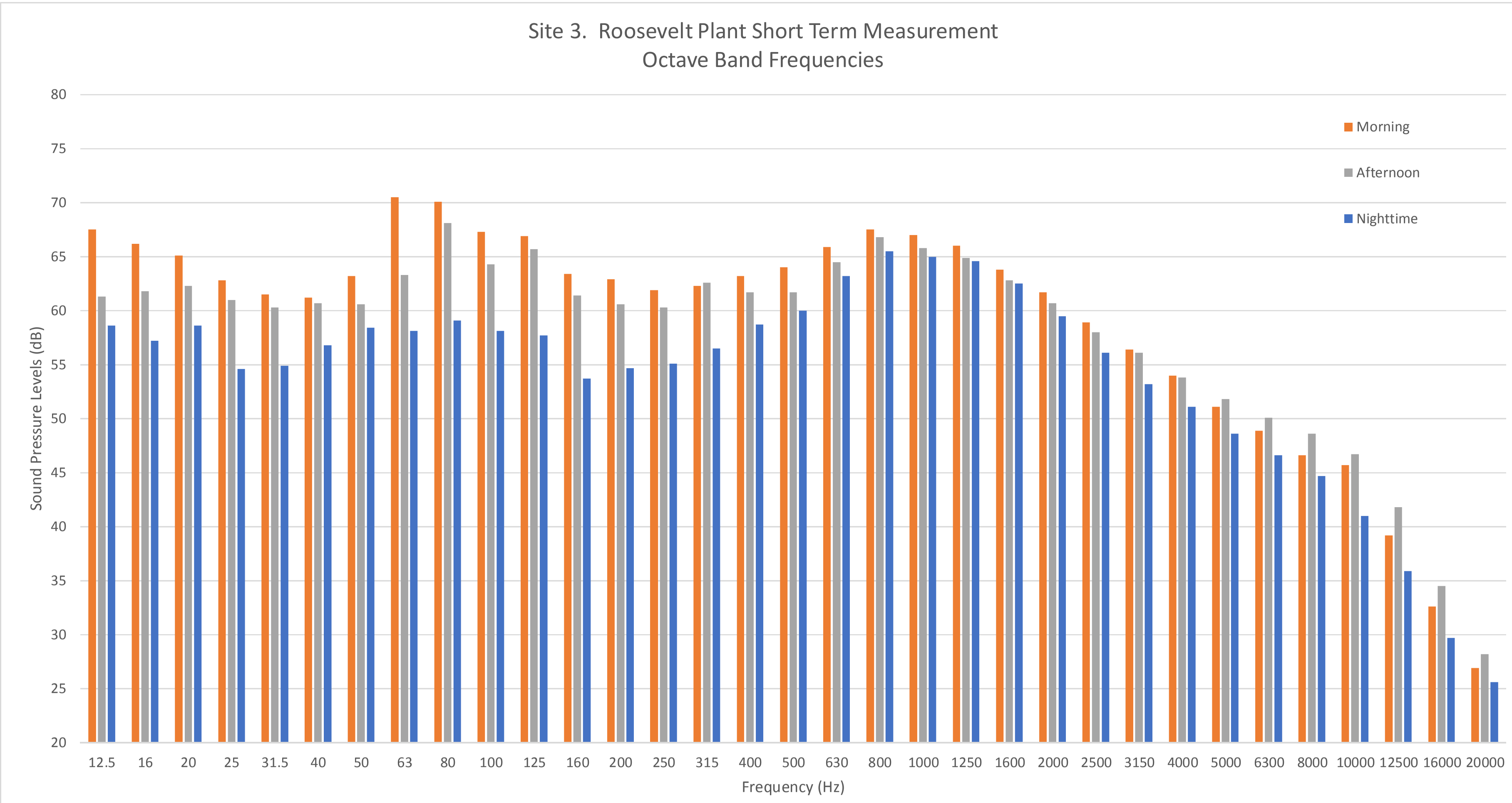
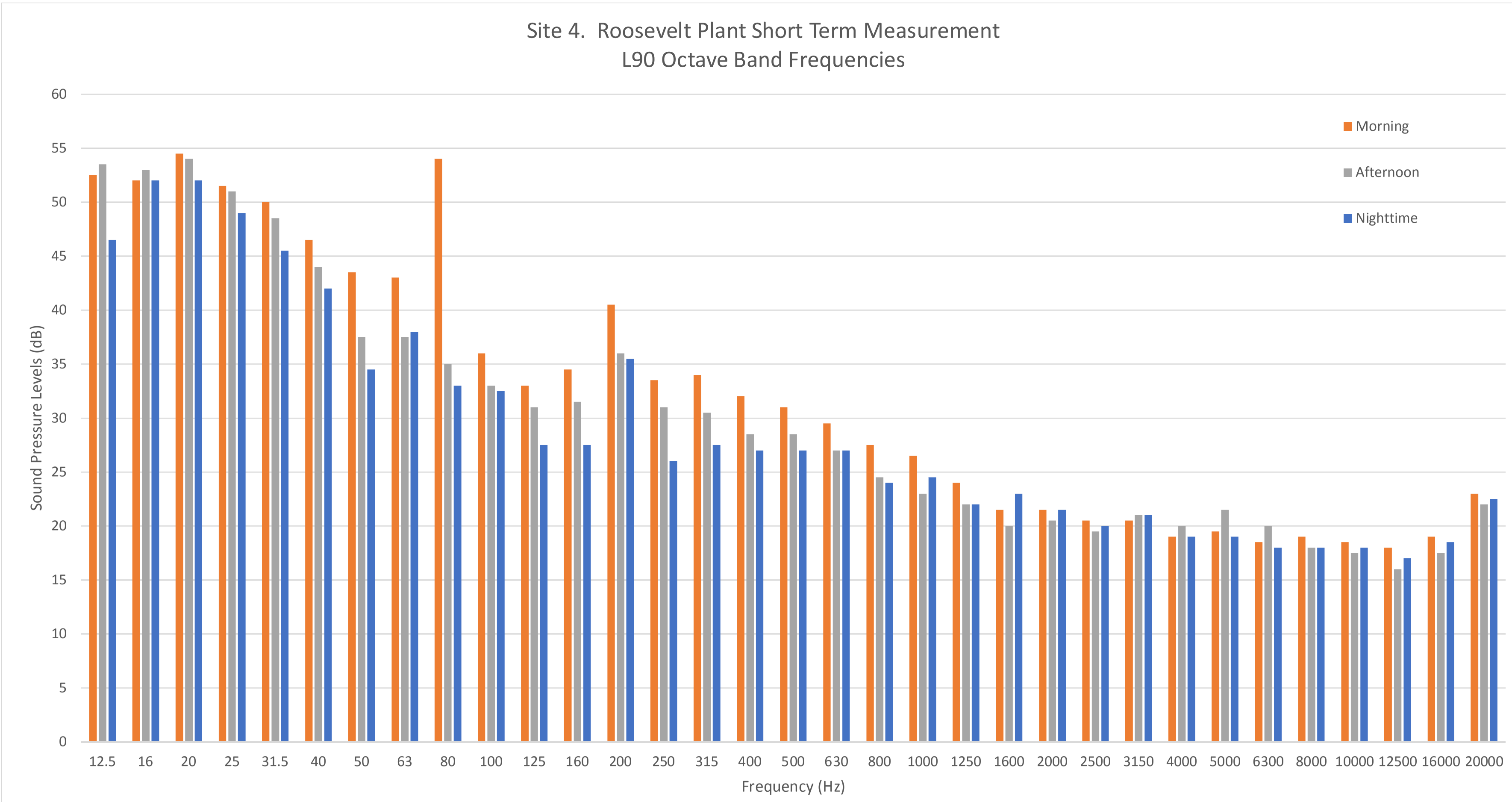

Site 3. Roosevelt Plant Short Term Measurement
Octave Band Frequencies
Sound Pressure Levels (dB)
80
75
70
65
60
55
50
45
40
35
30
25
20
12.5
16
20
25
31.5
40
50
63
80
100
125
160
200
250
315
400
500
630
800
1000
1250
1600
2000
2500
3150
4000
5000
6300
8000
10000
12500
16000
20000
Frequency (Hz)
Morning
Afternoon
Nighttime

DRAFT


Site 4. Roosevelt Plant Short Term Measurement
L90 Octave Band Frequencies
Morning
Afternoon
Nighttime
Sound Pressure Levels (dB)
0
5
10
15
20
25
30
35
40
45
50
55
60
12.5
16
20
25
31.5
40
50
63
80
100
125
160
200
250
315
400
500
630
800
1000
1250
1600
2000
2500
3150
4000
5000
6300
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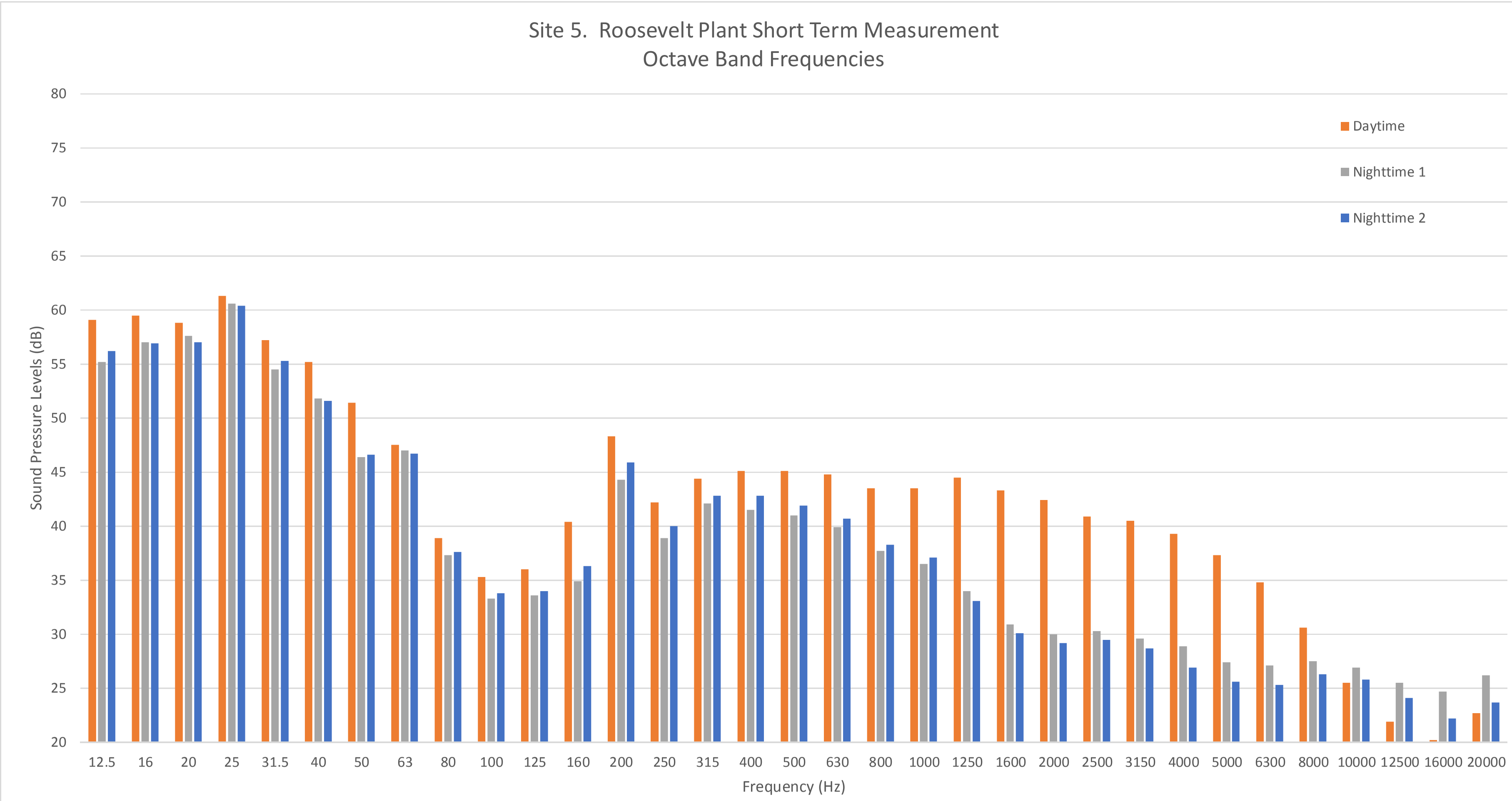
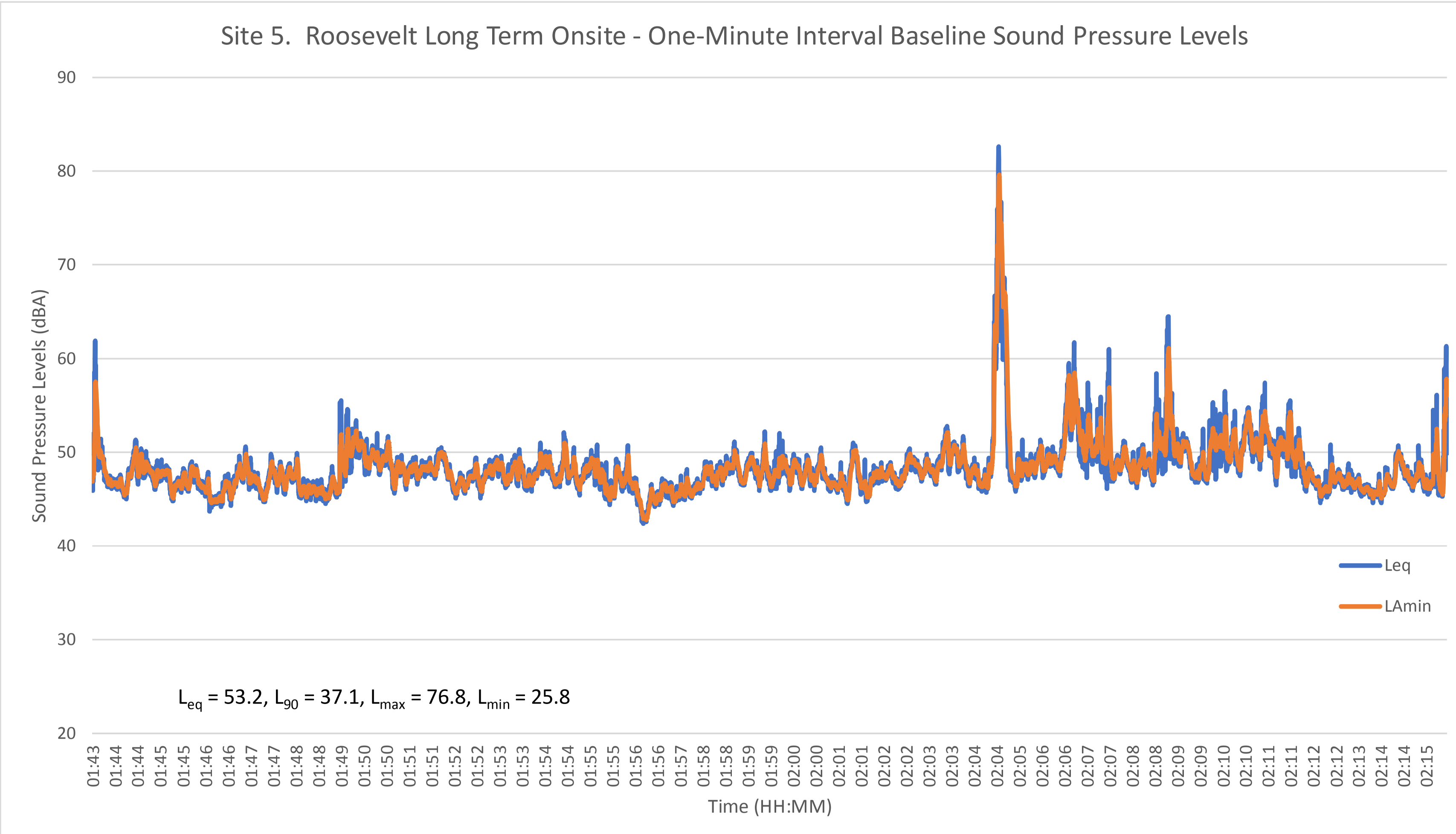
10000
12500
16000
20000
Frequency (Hz)

DRAFT


Site 5. Roosevelt Plant Short Term Measurement
Octave Band Frequencies
Sound Pressure Levels (dB)
80
75
70
65
60
55
50
45
40
35
30
25
20
12.5
16
20
25
31.5
40
50
63
80
100
125
160
200
250
315
400
500
630
800
1000
1250
1600
2000
2500
3150
4000
5000
6300
8000
10000
12500
16000
20000
Frequency (Hz)
Daytime
Nighttime 1
Nighttime 2


Site 5. Roosevelt Long Term Onsite - One-Minute Interval Baseline Sound Pressure Levels
Sound Pressure Levels (dBA)
90
80
70
60
50
40
30
20
Leq
LAmin
L_{eq} = 53.2, L_{90} = 37.1, L_{max} = 76.8, L_{min} = 25.8
01:43 01:44 01:44 01:45 01:45 01:46 01:46 01:47 01:47 01:48 01:48 01:49 01:50 01:50 01:51 01:51 01:52 01:52 01:53 01:53 01:54 01:54 01:55 01:55 01:56 01:56 01:57 01:58 01:58 01:59 01:59 02:00 02:00 02:01 02:01 02:02 02:02 02:03 02:03 02:04 02:04 02:05 02:06 02:06 02:07 02:07 02:08 02:08 02:09 02:09 02:10 02:10 02:11 02:11 02:12 02:12 02:13 02:14 02:14 02:15
Time (HH:MM)