

November 3, 2017

**Noise Monitoring Adjacent to the Common Completions Pad  
September 12, 2017, to October 14, 2017**

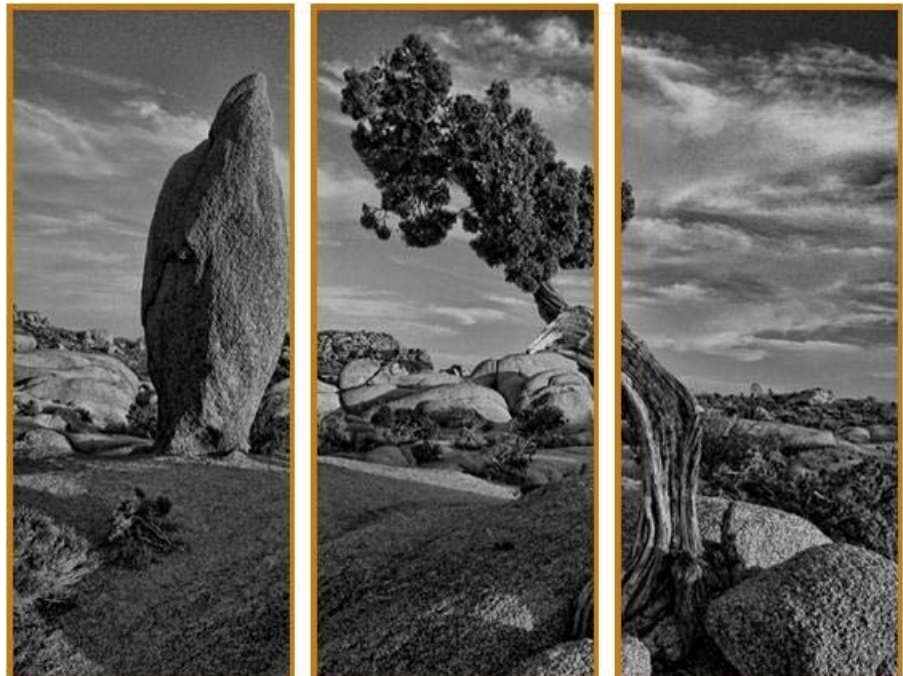
Noise Monitoring of Crestone Peak Resources Operations  
Erie, Colorado

**Prepared For:**

Town of Erie  
645 Holbrook Street  
Erie, Colorado 80516

**Pinyon Project No.:**

1/17-695-02.1200



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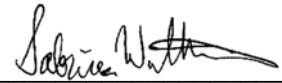
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**Pinyon Project No.:**

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## I. Introduction

The Town of Erie (Town) has contracted with Pinyon Environmental, Inc. (Pinyon), to perform noise monitoring near the Crestone Peak Resources (Crestone) Common Completions Pad (Completions Pad). The Completions Pad site is used by Crestone for well completion activities for both the Waste Connections and Pratt well sites. Pinyon collected continuous noise measurements at four locations adjacent to the well site (Figure 1). Completions Site 1 is located approximately 350 feet to the south of the Completions Pad and was used to collect A-weighted noise measurements from September 12, 2017, at 11:00 AM to October 14, 2017, at 7:00 AM. Waste Connections Site 2 is located near a residential neighborhood approximately 3,475 feet to the southwest of the Completions Pad and was used to collect A-weighted and C-weighted noise measurements from September 12, 2017, at 11:00 AM to October 14, 2017, at 7:00 AM. Pratt Site 2 is located near a residential neighborhood approximately 3,600 feet to the southeast of the Completions Pad and was used to collect A-weighted and C-weighted noise from September 12, 2017, at 7:00 AM to September 26, 2017, at 10:00 AM when measurement collection ceased at this location per the direction of the Town.

Completions Site 2 was selected by the Town to replace Pratt Site 2. Completions Site 2 is located near a residential neighborhood approximately 2,430 feet to the south of the Completions Pad and was used to collect A-weighted and C-weighted measurements from September 26, 2017, at 11:00 AM to October 14, 2017, at 7:00 AM. C-weighted noise was not collected at Sampling Site 1 as is not located near any occupied structures. Crestone began well completion activities at the Completions Pad the week of September 11, 2017, and continued activities at this location throughout the reporting period. This report details noise measurements collected during well completions activities, from September 12, 2017, at 11:00 AM through October 14, 2017. The noise monitoring data was analyzed to evaluate noise levels at the four locations during Crestone's well completions activities.

**Figure I-1 Noise Monitoring Locations**



## 2. Methodology

### 2.1 Noise Monitoring Approach

In accordance with Colorado Oil and Gas Conservation Committee (COGCC) Rule 802, well production facilities may not exceed the maximum permissible noise levels established in accordance to Section 802.b of the rule (Table 2-1). COGCC Rule 802 specifies that during well completion activities the industrial zone maximum permissible noise level should be used. In addition to the maximum permissible A-weighted noise levels, expressed in A-weighted decibels (dBA) (Table 2-1), COGCC Rule 802 specifies that operators may not exceed 65 C-weighted decibels (dBC) measured from the exterior wall of the residence or occupied structure nearest to the noise source, at a distance of 25 feet from the structure.

**Table 2-1 COGCC Maximum Permissible Noise Levels**

Zone	Maximum Permissible Noise Level	
	7:00am to 7:00pm	7:00pm to 7:00am
Residential/Agricultural/Rural	55 dBA	50 dBA
Commercial	60 dBA	55 dBA
Light Industrial	70 dBA	65 dBA
Industrial	80 dBA	75 dBA

dBA A-weighted decibel

Pinyon mobilized to the four sites and monitored for noise at these locations using 3M Quest SoundPro DL Type I datalogging sound level meters. The sound level meters collected continuous measurements of both A-weighted and C-weighted decibels, as applicable to the location. At Completions Site 1, the sound level meter monitored continuously for A-weighted noise. At Waste Connections Site 2, Pratt Site 2 and Completions Site 2, continuous A-weighted and C-weighted noise measurements were collected. The monitoring period for this report lasted from September 12, 2017, at 11:00 AM through October 14, 2017, at 7:00 AM. Crestone began well completion activities at the Completions Pad the week of September 11, 2017, and has continued well completion activities throughout this reporting period.

The sound level meters are configured with a data logging system that uploads one minute time resolved measurements to a secure online database at 10-minute intervals. The sound level meters are configured with an alert system that will send a message to Pinyon’s noise specialist as soon as the data is uploaded, whenever established noise criteria levels have been exceeded, based on the monitored equivalent continuous noise level (Leq). Leq is the preferred method to describe noise levels that vary over time, resulting in a single decibel value that takes into account the total sound energy over the period of time of interest. The Town and Pinyon agreed to set the alert system at 75 Leq dBA for A-weighted noise and 65 Leq dBC for C-weighted noise at Pratt Site 2 and Completions Site 2. The alert system for Waste Connections Site 2 was set to 70 Leq for C-weighted noise. These noise criteria levels were established based on the COGCC’s maximum permissible noise levels, as well as baseline noise monitoring data collected prior to Crestone mobilizing to the well site. The C-weighted noise alert criteria level at Waste Connections Site 2 is set higher than the COGCC’s maximum permissible noise level because baseline noise measurements collected prior to Crestone beginning operations at the well site exceeded this level.

### 2.2 Noise Monitoring Data Analysis

Pinyon’s noise specialist downloaded the noise monitoring data from the online database for this collection period. The data was then formatted into spreadsheets that allowed for analysis of the noise monitoring data.

Pinyon utilized statistical methods, as well as graphical representations of the data, to evaluate baseline noise levels at the two sampling locations during the monitoring period. COGCC's Rule 802 specifies different maximum permissible noise levels based on time of day (Table 2-1). Therefore, for the statistical analysis of the noise measurements, the monitor data was split into two discrete analytical groups based on time of day:

- Daytime: 7:00 AM—6:59 PM
- Nighttime: 7:00 PM—6:59 AM

The daytime and nighttime analytical groups ended at 6:59 PM and 6:59 AM, respectively, in order to not complete a duplicate analysis of the 7:00 AM and 7:00 PM noise measurements.

To evaluate how noise levels may change over time during Crestone's operations at the well site, the monitoring data was separated into the following discrete analysis periods with each monitoring period then subdivided by time of day:

- September 12, 2017, at 11:00 AM to September 15, 2017, at 7:00 AM
- September 15, 2017, at 7:00 AM to September 22, 2017, at 7:00 AM
- September 22, 2017, at 7:00 AM to September 30, 2017, at 7:00 AM
- September 30, 2017, at 7:00 AM to October 7, 2017, at 7:00 AM
- October 7, 2017, at 7:00 AM to October 14, 2017, at 7:00 AM

Section 3-2 describes how differences in the statistical mean between these monitoring periods were analyzed to confirm the existence of statistically significant increases in average observed noise levels as compared to the baseline monitoring period. To evaluate the distribution of the noise monitoring data, the statistical mean, median and mode were calculated. The statistical mean, median and mode are used to evaluate the statistical distribution of the noise monitoring data. Large data sets, such as several days of continuous noise monitoring data, tend to follow the normal distribution, which is referred to as the central limit theorem (Shao, 2004). Evaluating the distribution of the noise monitoring data is important because this distribution is used to assess the appropriate statistical methods for further analysis. The observed relationship between the statistical mean, median and mode for the monitored datasets was evaluated to follow the normal distribution. The standard deviation for each monitoring periods was also calculated to evaluate the amount of variation in the baseline noise monitoring data and allow for a test of significance in differences between mean noise levels as compared to the initial monitoring period.



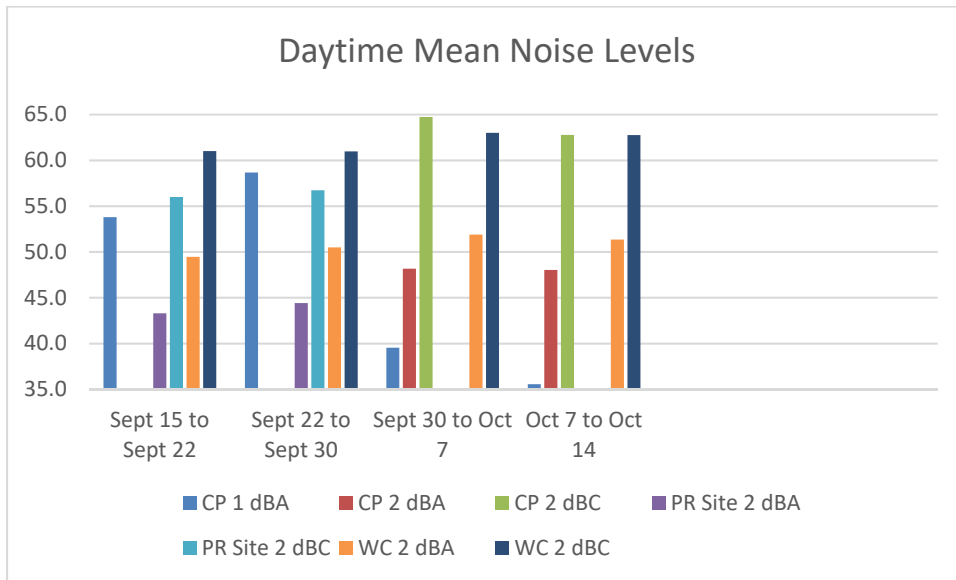
### 3. Data Analysis Results

#### 3.1 Graphical Representations of Data

##### 3.1.1 Average Daytime Noise Levels

The statistical mean for each noise monitoring period was calculated for the daytime hours (7:00 AM to 6:59 PM) (Figure 3-1). The highest mean daytime A-weighted noise levels were generally observed at Waste Connections Site 2. The highest mean daytime C-weighted noise levels were observed at Completions Pad Site 2.

**Figure 3-1 Daytime Mean Noise Levels**

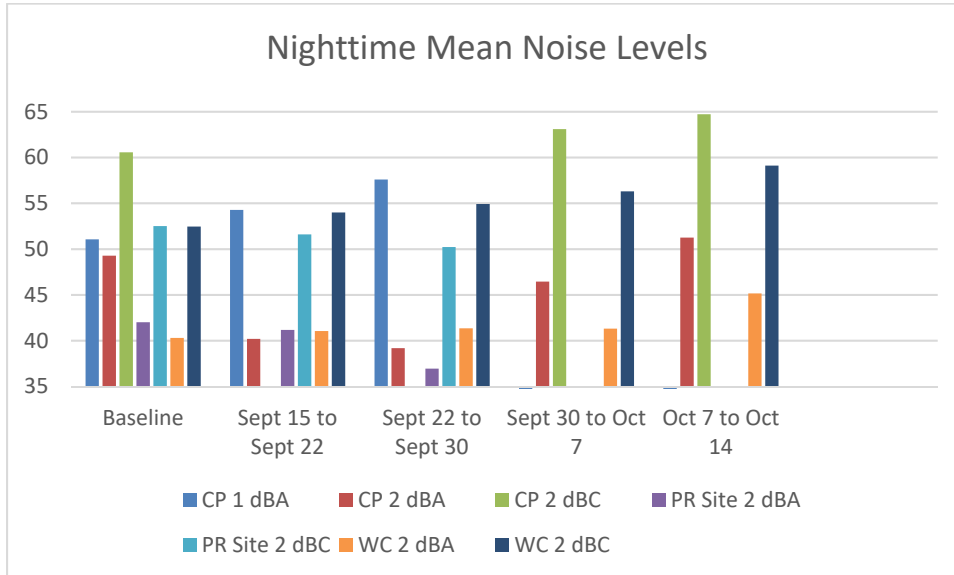


dBA A-weighted noise levels  
 dBC C-weighted noise levels  
 CP Completions Pad  
 PR Pratt  
 WC Waste Connections

##### 3.1.2 Average Nighttime Noise Levels

Figure 3-2 shows the statistical mean of noise monitoring data collected during the nighttime period (7:00 PM to 6:59 AM). The highest observed A-weighted mean noise levels generally occurred at Completions Pad Site 1. The highest observed C-weighted mean noise levels occurred at Completions Pad Site 2.

**Figure 3-2 Nighttime Mean Noise Levels**

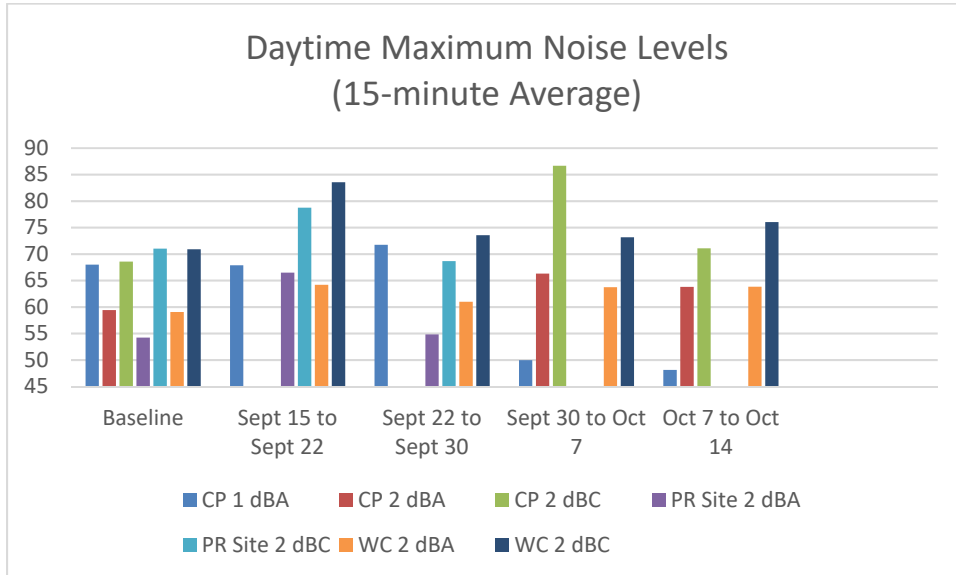


dBA A-weighted noise levels  
dBC C-weighted noise levels  
CP Completions Pad  
PR Pratt  
WC Waste Connections

**3.1.3 Maximum Observed Daytime Noise Levels**

Figure 3-3 shows the maximum 15-minute average noise measurements collected during the daytime condition for the monitoring periods. The maximum observed A-weighted noise levels were highest at Completions Site 1 and Completions Site 2, which are located closer to the Completions Pad than the other monitoring locations. The maximum observed C-weighted noise levels were highest at Waste Connections Site 2, which is located the farthest from the Completions Pad.

**Figure 3-3 Daytime Maximum Noise Levels**

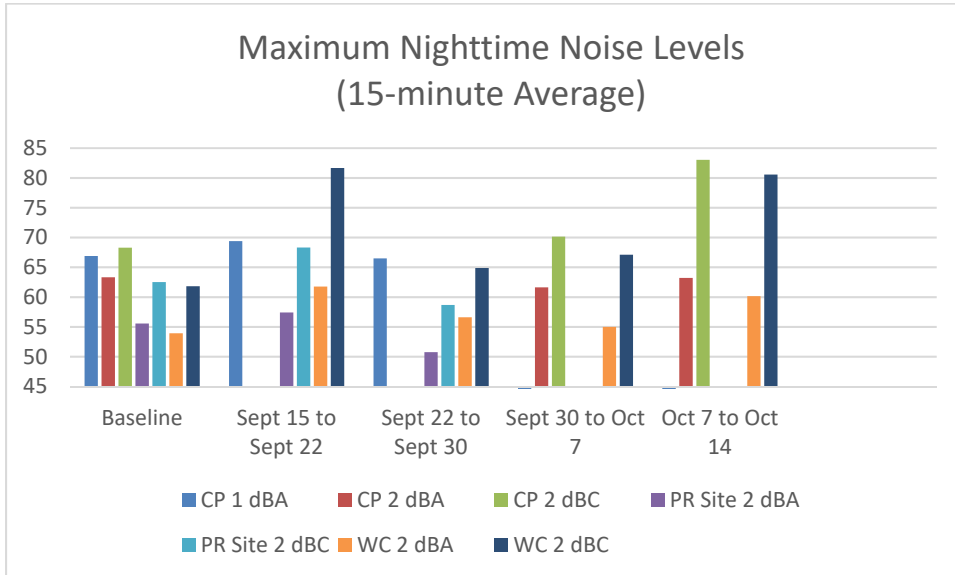


dBA A-weighted decibels  
 dBC C-weighted decibels  
 CP Completions Pad  
 PR Pratt  
 WC Waste Connections

**3.1.4 Maximum Observed Nighttime Noise Levels**

Figure 3-4 shows the maximum 15-minute average nighttime noise levels. The highest observed 15-minute average nighttime noise levels were observed at Completions Site 2, which is the closest C-weighted noise monitoring location to the Completions Pad. Elevated levels of C-weighted noise were observed during the September 15, 2017 to September 22, 2017, and October 7, 2017 to October 14, 2017 monitoring periods. Pinyon provided this monitoring data to the Town in tabular format. It was assumed that the elevated noise levels observed during the September 15, 2017 to September 22, 2017 monitoring period occurred when wind speeds were greater than five miles per hour. COGCC Rule 802 specifies that for noise measurements to be considered valid wind speeds must be less than five miles per hour and that the elevated noise levels measured during this period did not constitute an exceedance of the maximum permissible noise criteria.

**Figure 3-4 Maximum Nighttime Noise Levels**



dBA A-weighted noise levels  
dBC C-weighted noise levels  
CP Completions Pad  
PR Pratt  
WC Waste Connections

### 3.2 Statistical Analysis of Noise Monitor Data

Pinyon observed a statistically significant change in the mean measured noise values from the baseline and/or initial monitoring period while analyzing the monitoring data. Furthermore, this difference was also observed when generating graphical representations of the measured noise values at the three noise monitors for this reporting period, which was separated into 10 analysis periods for each monitor. A t-test was performed to evaluate whether the difference in calculated mean values were statistically significant. A t-test is a statistical method for evaluating the difference in means between two sample groups (Davis, 2003). The higher the t-value the greater the difference between the two means. To assess the level of confidence in the calculated t-value, a p-value is calculated. The p-value is based on the magnitude of the t-value and the total number of samples collected between the two monitoring periods. A p-value of less than or equal to 0.001 means that there is a 99.9% confidence level that the difference between means is statistically significant. The variation in statistical mean, the t-value and the p-value was calculated for the seven noise monitors for each analysis period. The calculated p-values were less than 0.001 for all comparisons meaning that the means are statistically significantly different at the 99.9% confidence interval. A 99.9% confidence interval indicates that there is less than a 0.01% likelihood that the calculated differences in statistical means are insignificant.

At Completions Site I there was a statistically significant decrease in A-weighted noise relative to the initial noise measurements for the daytime monitoring periods except for September 22, 2017 to September 30, 2017, when an average increase of 4.3 dBA was measured (Table 3-1). During the nighttime monitoring periods, statistically significant increases in mean values were initially observed through September 30, 2017, followed by decreases in the mean A-weighted noise values (Table 3-2).

**Table 3-1 Variation in Daytime Statistical Mean for A-weighted Noise at Completions Site 1**

Period	Mean (dBA)	Change (dBA)	t-value	p-value
Sept 12 to Sept 15	54.4	NA	NA	NA
Sept 15 to Sept 22	53.8	-0.6	-3.94	<0.0001
Sept 22 to Sept 30	58.7	4.3	20.0	<0.0001
Sept 30 to Oct 7	39.5	-14.9	-71.5	<0.0001
Oct 7 to Oct 14	35.5	-18.9	-119	<0.0001

dBA A-weighted decibels

**Table 3-2 Variation in Nighttime Statistical Mean for A-weighted Noise at Completions Site 1**

Period	Mean (dBA)	Change (dBA)	t-value	p-value
Sept 12 to Sept 15	51.1	NA	NA	NA
Sept 15 to Sept 22	54.3	3.2	14.8	<0.0001
Sept 22 to Sept 30	57.6	6.5	26.5	<0.0001
Sept 30 to Oct 7	32.1	-18.9	-94.9	<0.0001
Oct 7 to Oct 14	32.1	-19.0	-95.1	<0.0001

dBA A-weighted decibels

At Completions Site 2, a statistically significant increase in daytime mean noise values was observed during this reporting period relative to the initial monitoring period (Table 3-3). The nighttime statistical mean was variable during this reporting period showing both increasing and decreasing measured values (Table 3-4). Crestone had already commenced operations at the Completions Pad during the initial monitoring period at Completions Site 2. Therefore, the t-values calculated in this reporting period represent a change in mean levels between the initial and subsequent monitoring periods rather than a comparison to baseline data.

**Table 3-3 Variation in Daytime Statistical Mean for A-weighted Noise at Completions Site 2**

Period	Mean (dBA)	Change (dBA)	t-value	p-value
Sept 26 to Sept 30	46.7	NA	NA	NA
Sept 30 to Oct 7	46.4	1.5	10.3	<0.0001
Oct 7 to Oct 14	48.0	1.4	9.81	<0.0001

dBA A-weighted decibels

**Table 3-4 Variation in Nighttime Statistical Mean for A-weighted Noise at Completions Site 2**

Period	Mean (dBA)	Change (dBA)	t-value	p-value
Sept 26 to Sept 30	49.3	NA	NA	NA
Sept 30 to Oct 7	46.5	-2.8	-9.61	<0.0001
Oct 7 to Oct 14	51.3	2.0	6.77	<0.0001

dBA A-weighted decibels

At Completions Site 2, measured mean C-weighted noise values were statistically significantly higher than the initial monitoring period for both subsequent monitoring periods for both the daytime and nighttime hours (Table 3-5 and Table 3-6). This indicates that average C-weighted noise levels are increasing at this location during the Crestone's completion operations.

**Table 3-5 Variation in Daytime Statistical Mean for C-weighted Noise at Completions Site 2**

Period	Mean (dBC)	Change (dBC)	t-value	p-value
Sept 26 to Sept 30	61.2	NA	NA	NA
Sept 30 to Oct 7	64.7	3.5	29.6	<0.0001
Oct 7 to Oct 14	62.8	1.6	16.1	<0.0001

dBC C-weighted decibels

**Table 3-6 Variation in Nighttime Statistical Mean for C-weighted Noise at Completions Site 2**

Period	Mean (dBC)	Change (dBC)	t-value	p-value
Sept 26 to Sept 30	60.6	NA	NA	NA
Sept 30 to Oct 7	63.1	2.5	-52.0	<0.0001
Oct 7 to Oct 14	64.7	4.2	-30.4	<0.0001

dBC C-weighted decibels

At Pratt Site 2, a statistically significant increase in mean A-weighted noise levels was observed relative to the baseline mean noise levels during the daytime hours (Table 3-7). During the nighttime hours, a statistically significant decrease in mean A-weighted noise levels was observed relative to the baseline monitoring period (Table 3-8).

**Table 3-7 Variation in Daytime Statistical Mean for A-weighted Noise at Pratt Site 2**

Period	Mean (dBA)	Change (dBA)	t-value	p-value
Baseline	43.1	NA	NA	NA
Sept 15 to Sept 22	43.3	0.2	2.49	<0.0001
Sept 22 to Sept 26	44.4	1.3	14.5	<0.0001

dBA A-weighted decibels

**Table 3-8 Variation in Nighttime Statistical Mean for A-weighted Noise at Pratt Site 2**

Period	Mean (dBA)	Change (dBA)	t-value	p-value
Baseline	42.0	NA	NA	NA
Sept 15 to Sept 22	41.2	-0.8	-6.27	<0.0001
Sept 22 to Sept 26	36.9	-5.1	-33.1	<0.0001

dBA A-weighted decibels

At Pratt Site 2 a statistically significant decrease in mean C-weighted noise levels was observed relative to the baseline monitoring period during both the daytime and nighttime hours (Table 3-9 and Table 3-10).

**Table 3-9 Variation in Daytime Statistical Mean for C-weighted Noise at Pratt Site 2**

Period	Mean (dBC)	Change (dBC)	t-value	p-value
Baseline	57.7	NA	NA	NA
Sept 15 to Sept 22	56.0	-1.7	-22.0	<0.0001
Sept 22 to Sept 26	56.7	-0.9	-11.5	<0.0001

dBC C-weighted decibels

**Table 3-10 Variation in Nighttime Statistical Mean for C-weighted Noise at Pratt Site 2**

Period	Mean (dBC)	Change (dBC)	t-value	p-value
Baseline	52.5	NA	NA	NA
Sept 15 to Sept 22	51.6	-0.9	-8.82	<0.0001
Sept 22 to Sept 26	50.2	-2.3	-21.9	<0.0001

dBC C-weighted decibels

At Waste Connections Site 2 there were small, but statistically significant increases in the mean value for A-weighted noise relative to the baseline measurements for all monitoring periods except for the daytime monitoring period from September 15, 2017 to September 22, 2017, when the difference in means was shown to not be statistically significant (Table 3-11 and Table 3-12).

**Table 3-11 Variation in Daytime Statistical Mean for A-weighted Noise at Waste Connections Site 2**

Period	Mean (dBA)	Change (dBA)	t-value	p-value
Baseline	49.5	NA	NA	NA
Sept 15 to Sept 22	49.5	-0.1	-0.795	0.4266
Sept 22 to Sept 30	50.5	1.0	10.1	<0.0001
Sept 30 to Oct 7	51.9	2.4	24.6	<0.0001
Oct 7 to Oct 14	51.3	1.8	19.1	<0.0001

dBA A-weighted decibels

**Table 3-12 Variation in Nighttime Statistical Mean for A-weighted Noise at Waste Connections Site 2**

Period	Mean (dBA)	Change (dBA)	t-value	p-value
Baseline	40.3	NA	NA	NA
Sept 15 to Sept 22	41.0	0.7	4.65	<0.0001
Sept 22 to Sept 30	41.3	1.0	6.66	<0.0001
Sept 30 to Oct 7	41.3	1.0	6.36	<0.0001
Oct 7 to Oct 14	45.2	4.9	29.9	<0.0001

dBA A-weighted decibels

At Waste Connections Site 2, there were statistically significant increases in mean C-weighted noise values relative to the baseline measurements for both daytime and nighttime hours for all monitoring periods during this reporting period (Table 3-13 and Table 3-14).

**Table 3-13 Variation in Daytime Statistical Mean for C-weighted Noise at Waste Connections Site 2**

Period	Mean (dBC)	Change (dBC)	t-value	p-value
Baseline	60.0	NA	NA	NA
Sept 15 to Sept 22	61.0	1.0	12.9	<0.0001
Sept 22 to Sept 30	61.0	1.0	14.9	<0.0001
Sept 30 to Oct 7	63.0	3.0	45.4	<0.0001
Oct 7 to Oct 14	62.8	2.8	42.1	<0.0001

dBC C-weighted decibels

**Table 3-14 Variation in Nighttime Statistical Mean for C-weighted Noise at Waste Connections Site 2**

Period	Mean (dBC)	Change (dBC)	t-value	p-value
Baseline	52.5	NA	NA	NA
Sept 15 to Sept 22	54.0	1.5	14.0	<0.0001
Sept 22 to Sept 30	54.9	2.5	25.2	<0.0001
Sept 30 to Oct 7	56.3	3.8	37.4	<0.0001
Oct 7 to Oct 14	59.1	6.7	61.1	<0.0001

dBC C-weighted decibels



## 4. Conclusions

Pinyon collected continuous noise measurements at four monitoring locations adjacent to Crestone's Completions Pad from September 12, 2017 at 11:00 AM, to October 14, 2017 at 7:00 AM. Crestone commenced well completions activities at the Completions Pad the week of September 11, 2017, and has continued activities throughout this reporting period.

An evaluation of the noise measurements collected showed increases in ambient C-weighted noise levels that are likely attributable to Crestone's activities during this reporting period. A-weighted noise levels were variable during this reporting period with both increases and decreases observed. Analysis of the noise measurements indicated statistically significant differences between observed mean values between the baseline and/or initial monitoring period and subsequent monitoring periods that captured Crestone's completion activities, which were broken down between daytime and nighttime hours.

Elevated levels of C-weighted noise were measured during this reporting period. However, during some of these instances measured wind speeds invalidated the noise measurements used to determine whether an exceedance of the COGCC's maximum permissible noise criteria has been demonstrated.

Pinyon will continue to monitor continuously for noise at locations determined by the Town throughout Crestone's operations at the Completions Pad and will compare measured levels of A-weighted and C-weighted noise to baseline levels, to assess potential changes in ambient noise levels during various phases of activity and evaluate whether potential exceedances of the COGCC's maximum permissible noise levels are observed.

## **5. References**

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Shao, J. 2004. "Mathematical Statistics." Second Edition. Springer Texts in Statistics. ISBN-13: 978-0387953823