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ATCO Project # 762900-SD

TransCanada Pipeline Ltd.

Keystone Pipeline – South Dakota Pump Stations

Keystone Pipeline Phases 1 & 2
Acoustic Monitoring Report for South Dakota – U.S. Pump Stations

ATCO Structures & Logistics

EXECUTIVE SUMMARY

ATCO Structures & Logistics (ATCO) has completed noise monitoring for 4 pump stations of the Keystone Pipeline in South Dakota currently owned and operated by TransCanada Pipeline Ltd. (TCPL).

The South Dakota portion of Keystone Pipeline extends from Ferney to Freeman, SD. ATCO personnel visited all four South Dakota pump stations to conduct environmental noise monitoring at the corresponding critical receptor location. The operating condition of the pump stations during the noise monitoring has been obtained from the Keystone Pipeline Control Center. Published meteorological data was collected from the nearby weather stations. The collected sound level data was analyzed and the sound level results were compared with the noise criteria to determine compliance. The noise level limit of each pump station is established from the South Dakota Public Utility Commission's (PUC) condition in the order granting permit.

The noise monitoring indicates that the South Dakota pump stations of Keystone Pipeline comply with the noise criteria. The result summary is shown in the table below.

Pump Station #	Pump Station Name	Measurement Result L_{10}, dBA	Calculated L_{10} of Max. Load Operation, dBA	Noise Level Limit L_{10}, dBA	Compliance
PS20	Ferney	30	31	55	Yes
PS21	Carpenter	42	43	55	Yes
PS22	Roswell	45	46	55	Yes
PS23	Freeman	41	42	55	Yes

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1. INTRODUCTION

1.1 Background

The Keystone Pipeline transports crude oil from Alberta, Canada to Illinois, the United States. The South Dakota portion extends from Ferney to Freeman, SD. Figure 1 shows the pipeline route map.

Figure 1: Keystone Pipeline Route Map

Keystone Project has retained ATCO Structures & Logistics (ATCO) to conduct noise monitoring for the four pump stations in South Dakota.

1.2 Site Description

There are four pump stations in South Dakota. Table 1 below lists the name and location of each South Dakota pump station.

Table 1: Keystone Pipeline South Dakota Pump Stations

Pump Station #	Pump Station Name	Pump Station GPS Coordinates		County
PS20	Ferney	45°17'50.3"	-97°56'58.4"	Day
PS21	Carpenter	44°37'24.7"	-97°55'17.7"	Beadle
PS22	Roswell	43°57'58.5"	-97°41'29.3"	Miner
PS23	Freeman	43°17'34.6"	-97°28'51.4"	Hutchinson

The surrounding area of each pump station is primarily used for agriculture. A previous noise impact study at the pipeline planning stage identified the most impacted receptor by the pump station noise as critical noise receptor. For each South Dakota pump station, the noise monitoring location is at the critical receptor location except the Roswell pump station. There is no noise receptor within 1 mile from the Roswell pump station; for the security of the sound measurement equipment, the monitoring location at 0.56 mile east of the pump station was selected. The monitoring location for each pump station is presented in Table 2.

Table 2: Critical Receptor Location of South Dakota Pump Stations

Pump Station #	Pump Station Name	Acoustic Monitoring Locations GPS Coordinates	Distance between Monitoring Location and Pump Station	Distance between Critical Receptor Location and Pump Station
PS20	Ferney	45°18'43.1",-97°56'23.3"	1 mile NE	1 mile NE
PS21	Carpenter	44°37'3.1",-97°54'39.8"	0.65 mile SE	0.65 mile SE
PS22	Roswell	43°57'55.8",-97°40'47.1"	0.56 mile E	1 mile (hypothetic)
PS23	Freeman	43°17'55.3",-97°29'31.5"	0.7 mile NW	0.7 mile NW

1.3 Noise Criteria

The noise level limit of the South Dakota pump stations is established from an agreement between Keystone Project and South Dakota Public Utilities Commission. Details of the agreement are presented below.

"Except to the extent waived by the owner or lessee in writing or to the extent the noise levels already exceed such standard, the noise levels associated with Keystone's pump station and other noise-producing facilities will not exceed the L_{10}=55 dBA standard at the nearest occupied, existing residence, office, hotel/motel or non-industrial business not owned by Keystone. The point of measurement will be within 100 feet of the residence or business in the direction of the pump station facility. Post-construction operational noise assessments will be completed by an independent third-party noise consultant, approved by the Commission, to show compliance with the noise level at each pump station or other noise-producing facility. The noise assessments will be performed in accordance with applicable American National Standards Institute standards. The results of the assessments will be filed with the Commission. In the event the noise level exceeds the limits set forth in this condition at any pump station or other noise producing facility, Keystone shall promptly implement noise mitigation measures to bring the facility into compliance with the limits set forth in this condition and shall report to the Commission concerning the measures taken and the results of post-mitigation assessments demonstrating that the noise limits have been met."

The noise level limit at the critical receptor location of each South Dakota pump station is shown in Table 3.

Table 3: Noise Level Limit of South Dakota Pump Stations

Pump Station #	Pump Station Name	Critical Receptor Location	Noise Level Limit
PS20	Ferney	1 mile NE	L_{10}=55 dBA
PS21	Carpenter	0.65 mile SE	L_{10}=55 dBA
PS22	Roswell	1 mile E (hypothetic)	L_{10}=55 dBA
PS23	Freeman	0.7 mile NW	L_{10}=55 dBA

2. ACOUSTIC MONITORING PROTOCOL

2.1 Instrumentation

The noise monitoring was conducted utilizing two Type 1 sound level meters, Bruel & Kjaer Type 2250. Table 4 presents the instrumentation setup.

Table 4: Sound Level Meter Instrumentation Setup

Instrumentation	Sound Level Meter - Bruel & Kjaer 2250	
Bandwidth	1/3 Octave	
Range	20 – 140 dB	
Broad-band	Slow, A-weighted & C-weighted	
Spectral measurement	Slow, Linear	
SLM Serial Number	2505916	2506114
Microphone Serial Number	2503182	2509067
Calibration Level	94.0 dB	

The sound level meters logged continuously in one-minute intervals. The one-minute interval was chosen in order to isolate sound contamination by individual noise events, such as airplane flyover and traffic noise. The sound level meter was set to slow response, and spectral L_{eq} levels in one-third octave bands were measured and recorded. Digital audio recording was conducted throughout the whole noise monitoring period. L_n statistical exceedance levels were also collected, including L_{10}. L_{10} is the noise level exceeded for 10% of the measurement time. It is often used to give an indication of the upper limit of fluctuating noise.

The measurements were made with the sound level meter set on A-weighting scale. The A-weighting scale simulates the response of the human ear to environmental sounds.

The sound level meters have current laboratory certification. These current laboratory certificates are presented in Appendix B.

2.2 Test Procedure

Measurements were taken in accordance with the American National Standards Institute (ANSI) standard ANSI S12.9-R 1993, *Quantities and Procedures for Description and Measurement of Environmental Sound*.

The sound level meter was set up 50 ft from the nearest or most impacted dwelling unit in the direction of the pump station and 50 ft away from any reflective façade. The point of measurement was also within 100 feet of the residence or business in the direction of the pump station facility. The microphone was placed at a height between 5 ft and 7 ft above ground. An outdoor-type windscreen was placed on the microphone during monitoring in order to reduce the effects of wind-induced noise. The sound level meter was field calibrated immediately before and after the measurement series and after any change in equipment conditions such as a battery replacement. Sound levels were measured during daytime and nighttime periods with the pump stations in a representative load condition.

2.3 Site Operating Condition

Each South Dakota pump station includes four pump/motor units.

Table 5: Number of Units in Each Pump Station

Pump Station #	Pump Station Name	Total Number of Units Installed	Power Rating of Each Unit, hp
PS20	Ferney	4	5000
PS21	Carpenter	4	5000
PS22	Roswell	4	5000
PS23	Freeman	4	5000

The designed nominal oil flow is 591 kbpd (3,915 m^3/hr). During the noise monitoring period, the actual oil flow was between 3,231 m^3/hr and 3,437 m^3/hr. At each pump station, there were three pump/motor units in operation to achieve this flow rate. The detailed load log of each pump station is presented together with the sound level results in Section 3.

2.4 Meteorological Condition

The published meteorological data was collected throughout the survey from the weather station in the nearest town/city where such data is available. Temperature, wind speed, wind direction, and relative humidity are presented in Section 3. Sound level measurements taken during periods of unfavorable weather conditions were excluded during data analysis. According to the ANSI Standards, no sound level measurement should be made when the average wind velocity exceeds 16.5 ft/s (11 mi/hr).

3. DATA ANALYSIS AND RESULTS

At each South Dakota pump station, one long-term noise measurement was conducted at the critical noise receptor location. The obviously contaminated sound data was excluded based on digital audio recording and published weather data. The main noise measurement contamination factors include:

1) exceedance of maximum wind speed;
2) precipitation;
3) natural sounds, typically at dawn or dusk, such as birdsongs, dog barks, frog sound etc.;
4) abnormal noise events, including aircraft flyovers and vehicular traffic.

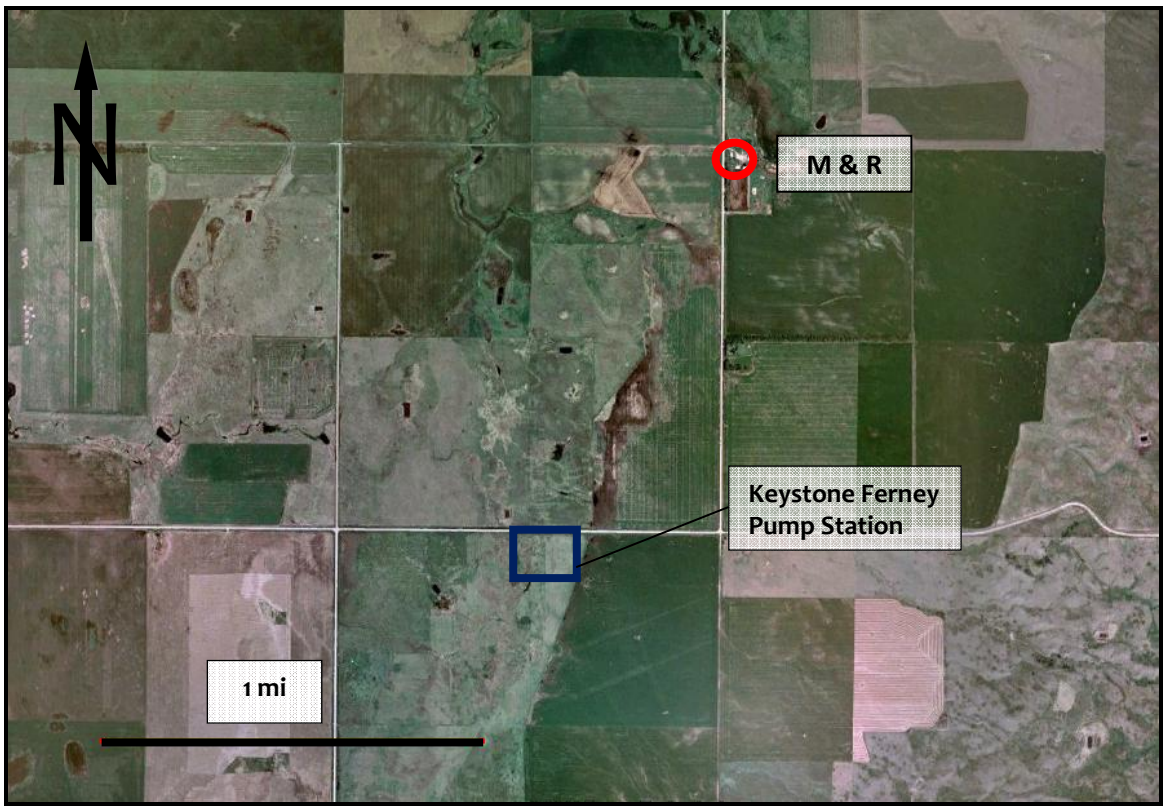
After the data exclusion, valid data was compared with the applicable noise criteria to determine noise compliance. All of the four South Dakota pump stations were monitored during their partial load operation. When the pump station is in partial load operating condition, not all the available motor/pump units are operating, however each motor/pump unit in operation is running at full speed. Corrections have been applied to take into account the total number of units to predict the maximum noise level at the critical receptor location. The estimated noise level of maximum load operation is calculated with one of the following approaches:

1) if the valid data indicates the pump station was the dominant noise source, a correction was added to take into account the difference between maximum number of units and the number of units monitored;
2) if the sound data indicates there was continuous dominant background noise contamination and was only pronounced at certain frequency bands where the pump station's contribution is minor, e.g. high frequency noise contamination by birdsongs, these bands were adjusted to portray a more typical spectrum. Then a correction is added to take into account the difference between maximum number of units and the number of units monitored.

The results of the noise monitoring are presented below for each individual pump station.

3.1 PS20 Ferney Pump Station

An aerial map in Figure 2 shows the pump station location, the critical receptor location, the noise measurement location and other area features.



M – Measurement Location; R – Critical Receptor Location.

Figure 2: Aerial Map – PS20 Ferney Pump Station

The recorded data of the L_{10} of each 1-minute logging period at the monitoring location of the Ferney pump station from 7:28 p.m. May 4 to 8:21 a.m. May 5, 2011 is presented in Figure 3.

The obviously contaminated data by natural sounds, tree noise, local traffic noise, aircraft flyover, intrusive highway noise or human activities nearby the sound level meter have been excluded. Also excluded is data in the periods when the pump station was turned off or the weather condition was unfavorable. The published weather data and the pump station load log are shown in Figure 4, Figure 5 and Table 6.

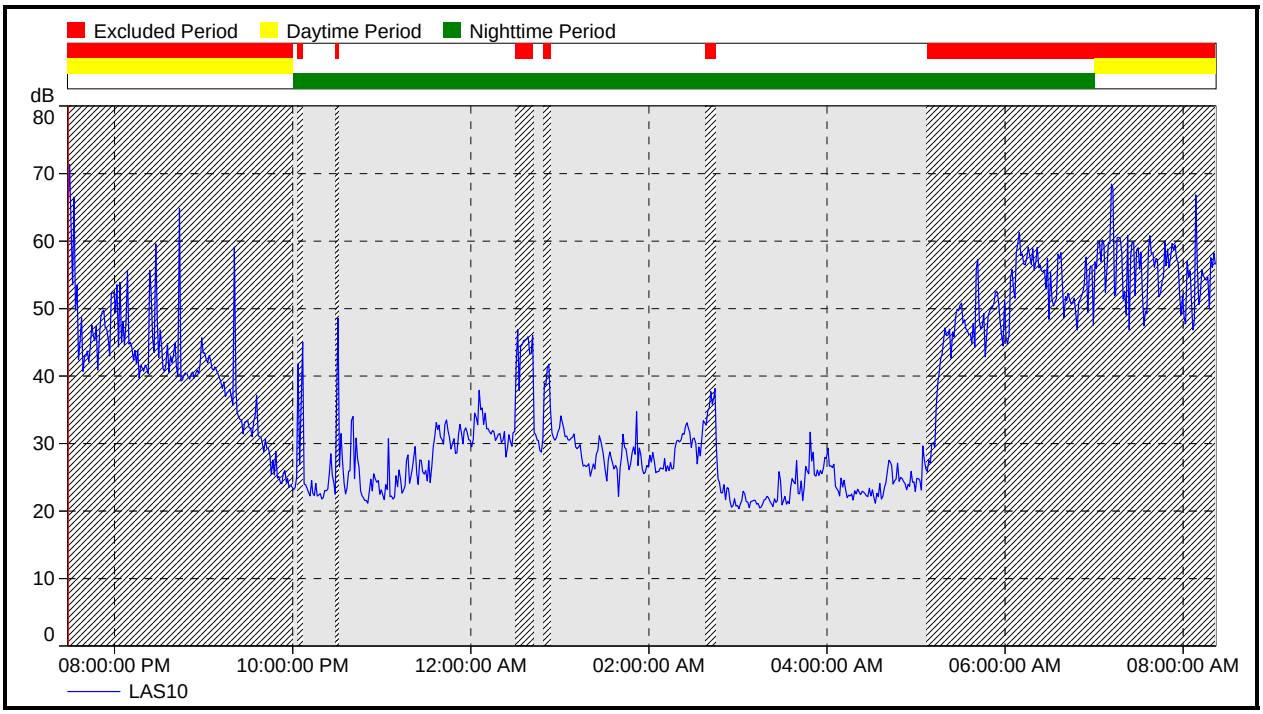


Figure 3: Time History Logged L_{10} Sound Data – PS20 Ferney Pump Station

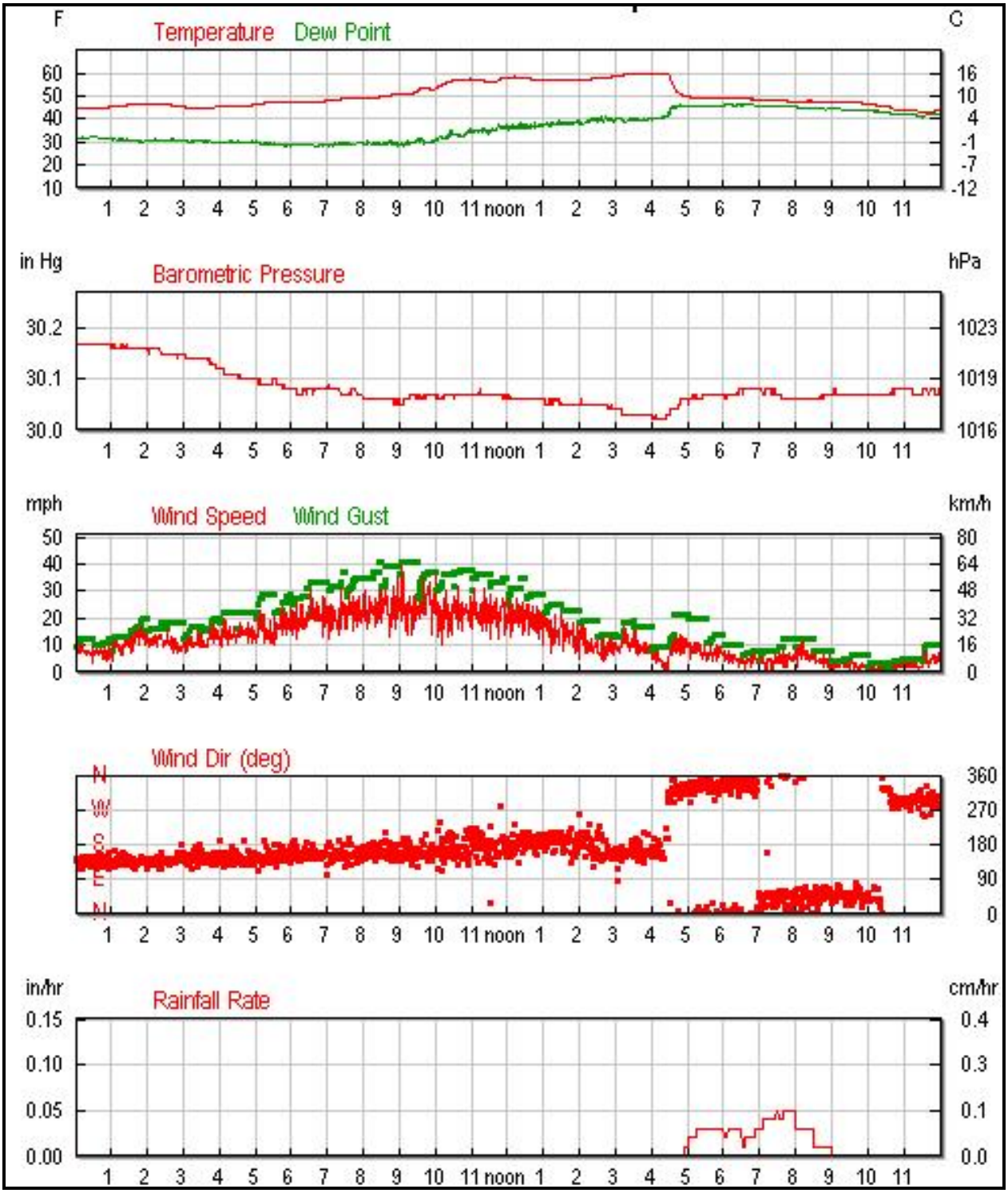


Figure 4: Published Weather Data May 4, 2011 - PS20 Ferney Pump Station

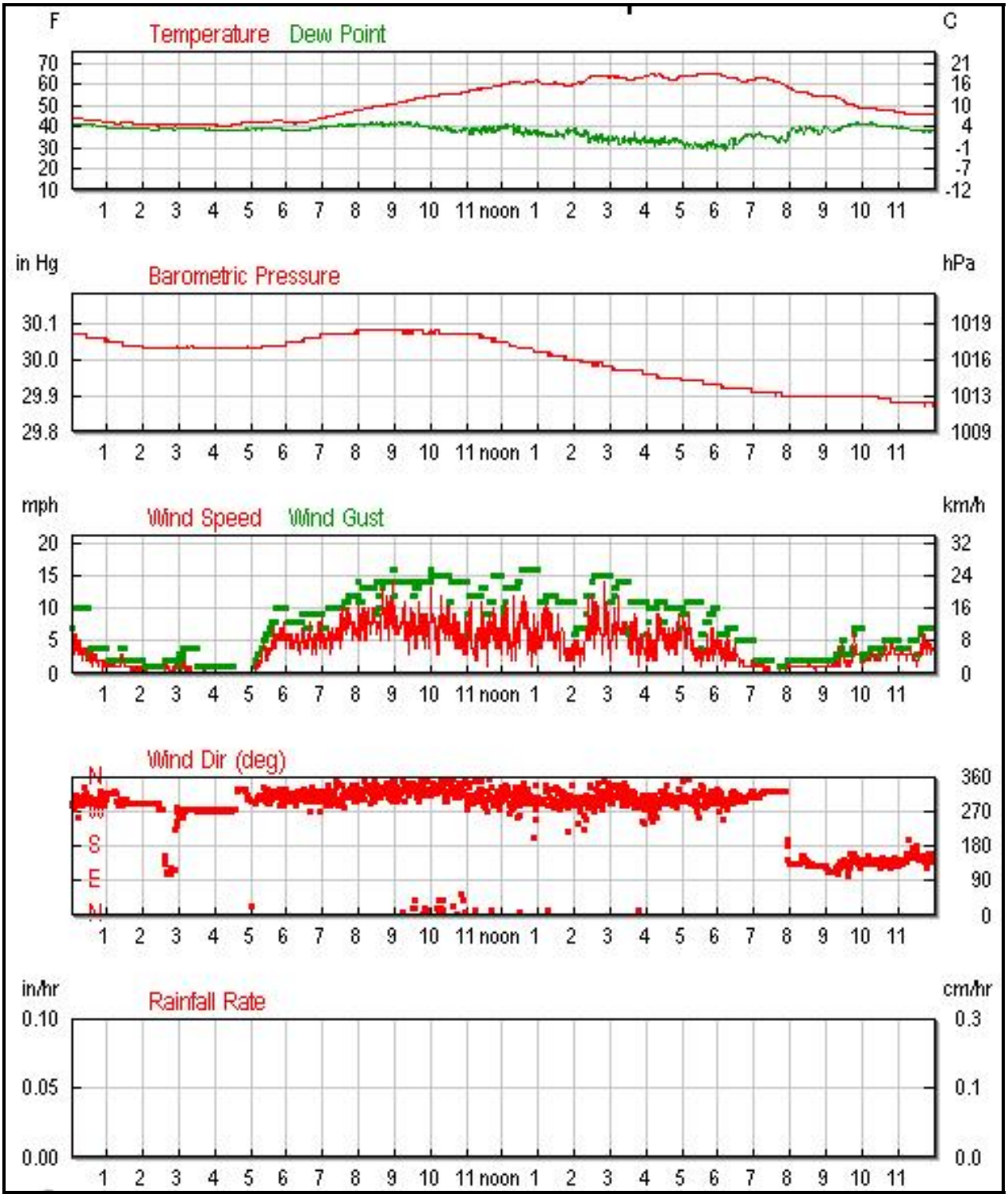


Figure 5: Published Weather Data May 5, 2011 - PS20 Ferney Pump Station

Table 6: Facility Load Log - PS20 Ferney Pump Station

Date (MM/DD/YY CDT)	Actual Oil Flow (m^3/h)	Unit 1	Unit 2	Unit 3	Unit 4
05/04/11 19:00	3246	On	On	On	Off
05/04/11 20:00	3286	On	On	On	Off
05/04/11 21:00	3169	On	On	On	Off
05/04/11 22:00	3287	On	On	On	Off
05/04/11 23:00	3314	On	On	On	Off
05/05/11 00:00	3374	On	On	On	Off
05/05/11 01:00	3362	On	On	On	Off
05/05/11 02:00	3281	On	On	On	Off
05/05/11 03:00	3357	On	On	On	Off
05/05/11 04:00	3337	On	On	On	Off
05/05/11 05:00	3313	On	On	On	Off
05/05/11 06:00	3307	On	On	On	Off
05/05/11 07:00	3353	On	On	On	Off
05/05/11 08:00	3367	On	On	On	Off

There was 6 hours and 37 minutes of valid data during the monitoring period after isolation analysis. The measurement result, the estimated noise level of maximum load operation and the determination of compliance are presented in Table 7.

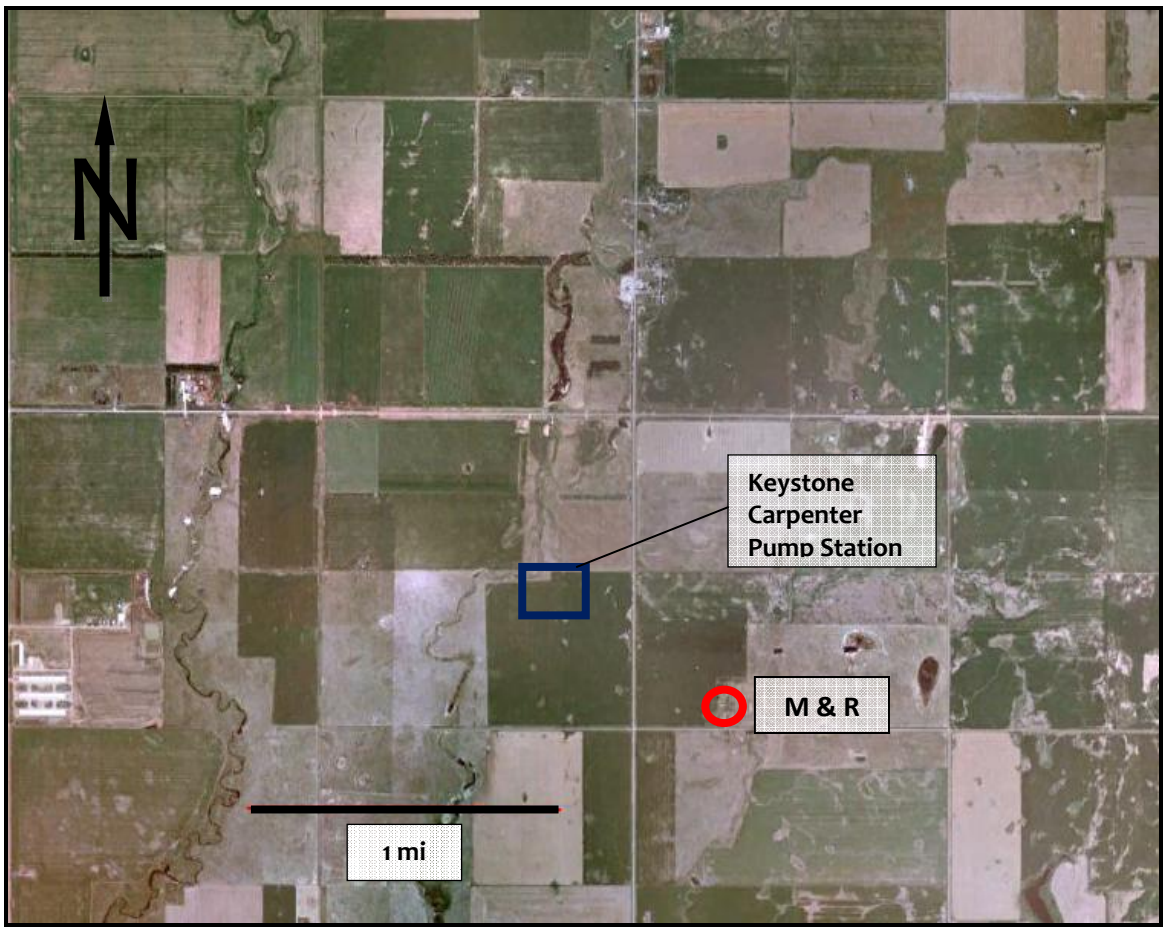
Table 7: Noise Monitoring Result – PS20 Ferney Pump Station

Period	Measurement Result L_{10} (3 Units), dBA	Calculated L_{10} of Max. Load Operation (4 Units), dBA	Noise Criterion, dBA	Compliance
May 4-5, 2011 Nighttime	30	31	L_{10}=55	Yes

The results indicate that the Ferney pump station is in compliance with the noise criterion.

3.2 PS21 Carpenter Pump Station

An aerial map in Figure 6 shows the pump station location, the critical receptor location, the noise measurement location and other area features.



M – Measurement Location; R – Critical Receptor Location.

Figure 6: Aerial Map – PS21 Carpenter Pump Station

The recorded data of the L_{10} of each 1-minute logging period at the monitoring location of the Carpenter pump station from 5:52 p.m. May 4 to 9:24 a.m. May 5, 2011 is presented in Figure 7.

The obviously contaminated data by natural sounds, tree noise, local traffic noise, aircraft flyover, intrusive highway noise or human activities nearby the sound level meter have been excluded. Also excluded is data in the periods when the pump station was turned off or the weather condition was unfavorable. The published weather data and the pump station load log are shown in Figure 8, Figure 9 and Table 8.

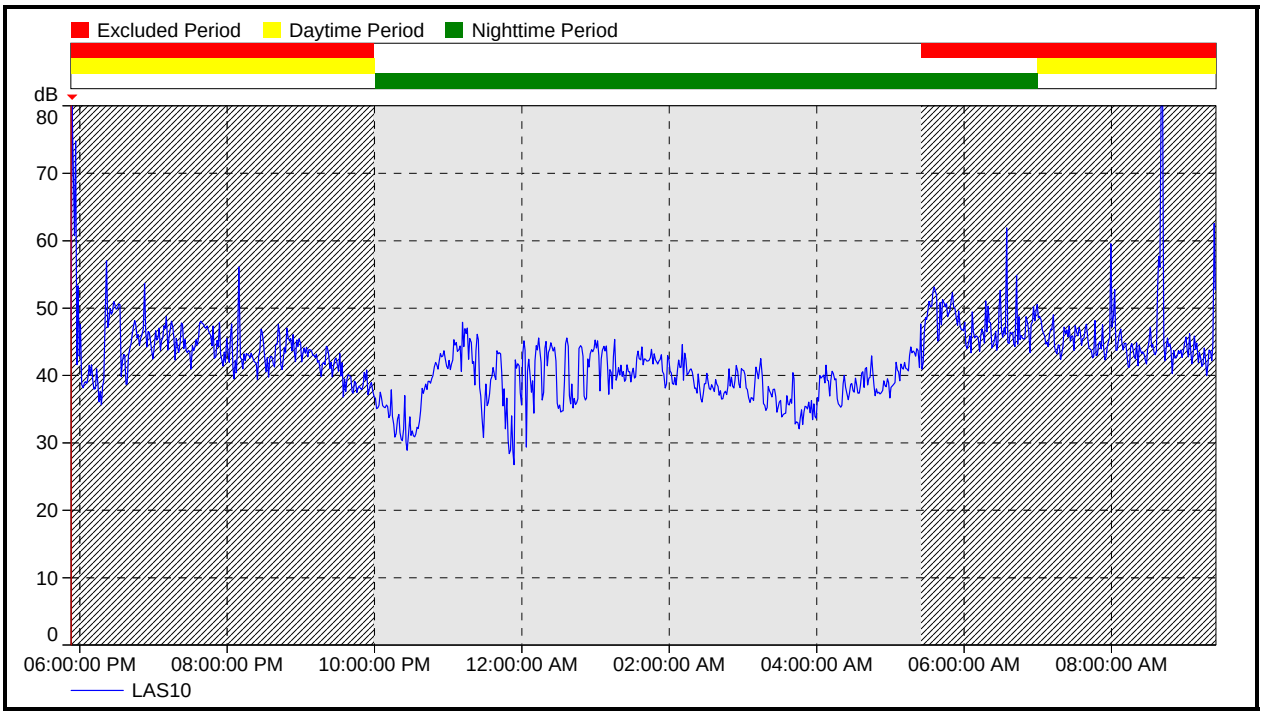


Figure 7: Time History Logged L_{10} Sound Data – PS21 Carpenter Pump Station

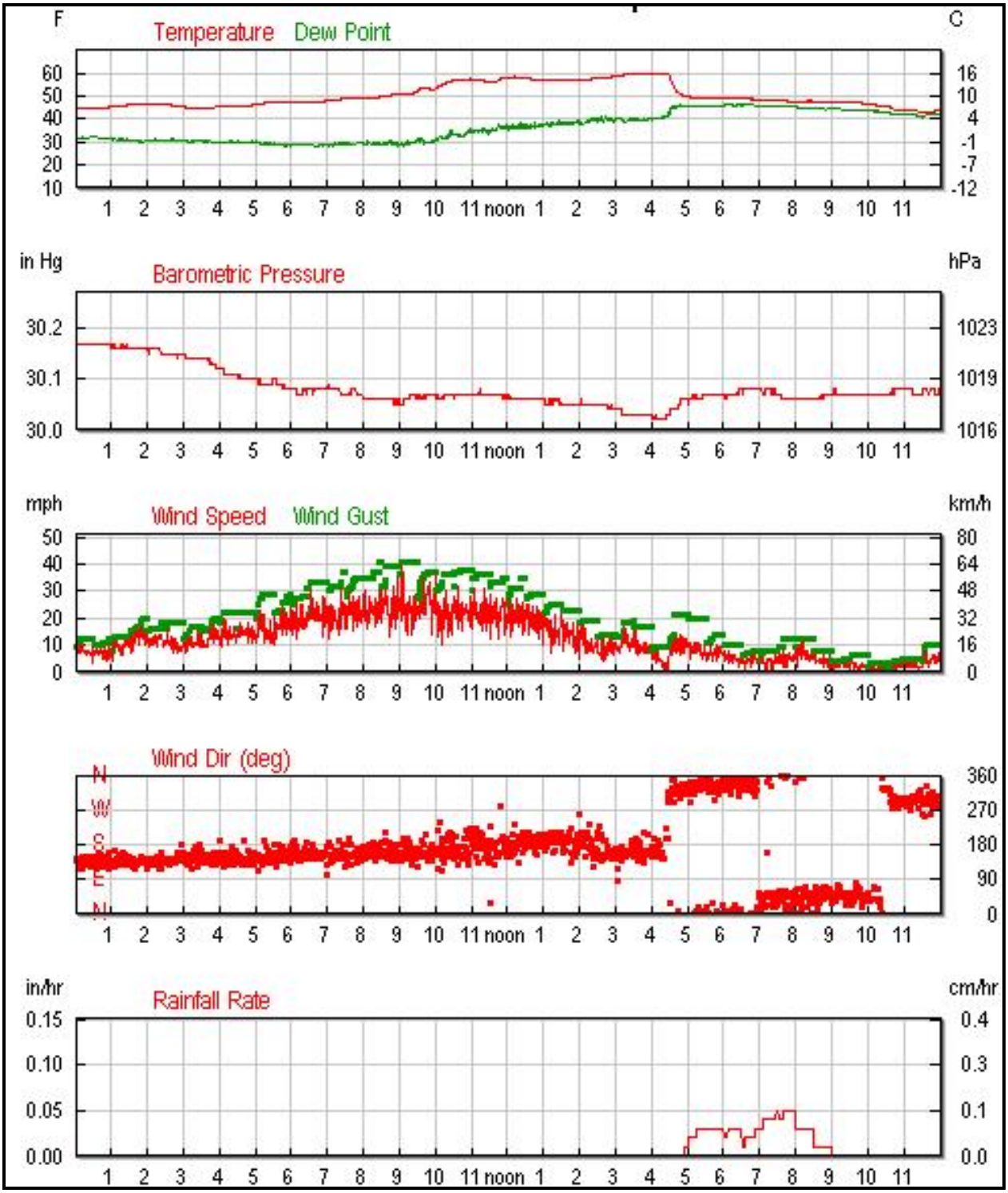


Figure 8: Published Weather Data May 4, 2011 - PS21 Carpenter Pump Station

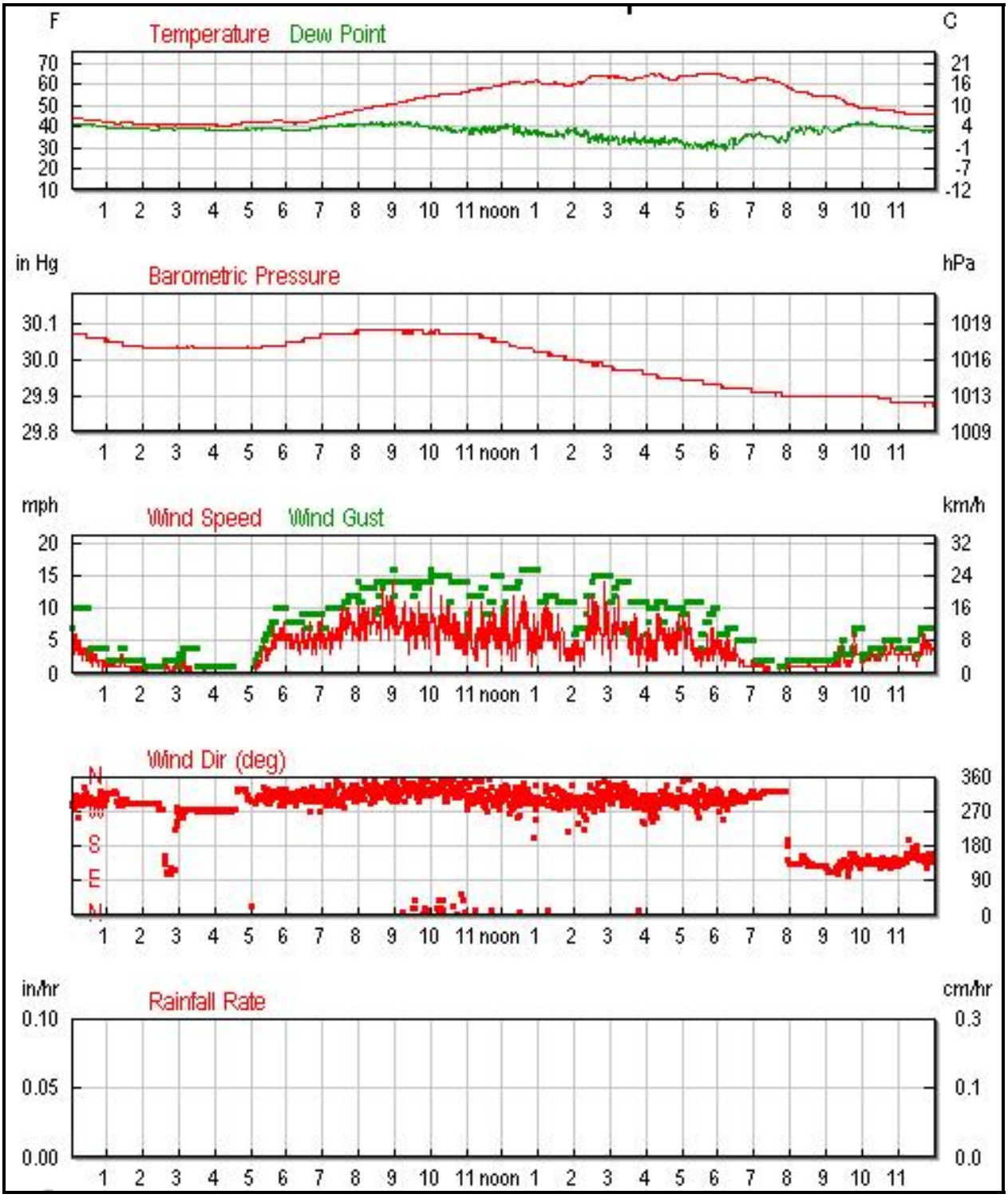


Figure 9: Published Weather Data May 5, 2011 - PS21 Carpenter Pump Station

Table 8: Facility Load Log - PS21 Carpenter Pump Station

Date (MM/DD/YY CDT)	Actual Oil Flow (m^3/h)	Unit 1	Unit 2	Unit 3	Unit 4
05/04/11 17:00	3272	On	On	On	Off
05/04/11 18:00	3268	On	On	On	Off
05/04/11 19:00	3282	On	On	On	Off
05/04/11 20:00	3315	On	On	On	Off
05/04/11 21:00	3231	On	On	On	Off
05/04/11 22:00	3311	On	On	On	Off
05/04/11 23:00	3321	On	On	On	Off
05/05/11 00:00	3363	On	On	On	Off
05/05/11 01:00	3407	On	On	On	Off
05/05/11 02:00	3302	On	On	On	Off
05/05/11 03:00	3379	On	On	On	Off
05/05/11 04:00	3358	On	On	On	Off
05/05/11 05:00	3330	On	On	On	Off
05/05/11 06:00	3326	On	On	On	Off
05/05/11 07:00	3369	On	On	On	Off
05/05/11 08:00	3376	On	On	On	Off
05/05/11 09:00	3321	On	On	On	Off

There was 7 hours and 26 minutes of valid data during the monitoring period after isolation analysis. The measurement result, the estimated noise level of maximum load operation and the determination of compliance are presented in Table 9.

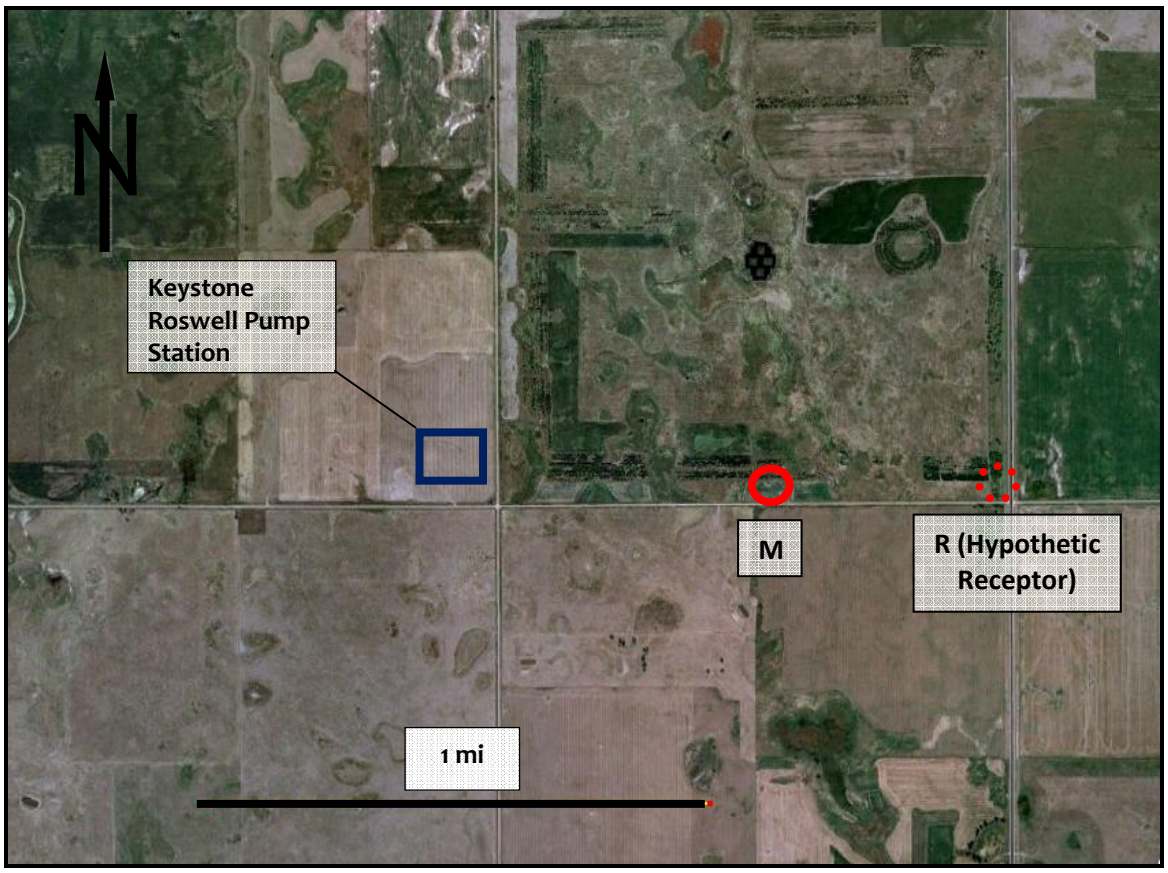
Table 9: Noise Monitoring Result – PS21 Carpenter Pump Station

Period	Measurement Result L_{10} (3 Units), dBA	Calculated L_{10} of Max. Load Operation (4 Units), dBA	Noise Criterion, dBA	Compliance
May 4-5, 2011 Nighttime	42	43	L_{10}=55	Yes

The results indicate that the Carpenter pump station is in compliance with the noise criterion.

3.3 PS22 Roswell Pump Station

An aerial map in Figure 10 shows the pump station location, the critical receptor location, the noise measurement location and other area features.



M – Measurement Location; R – Critical Receptor Location.

Figure 10: Aerial Map – PS22 Roswell Pump Station

The recorded data of the L_{10} of each 1-minute logging period at the monitoring location of the Roswell pump station from 3:19 p.m. May 5 to 8:56 a.m. May 6, 2011 is presented in Figure 11.

The obviously contaminated data by natural sounds, tree noise, local traffic noise, aircraft flyover, intrusive highway noise or human activities nearby the sound level meter have been excluded. Also excluded is data in the periods when the pump station was turned off or the weather condition was unfavorable. The published weather data and the pump station load log are shown in Figure 12, Figure 13 and Table 10.

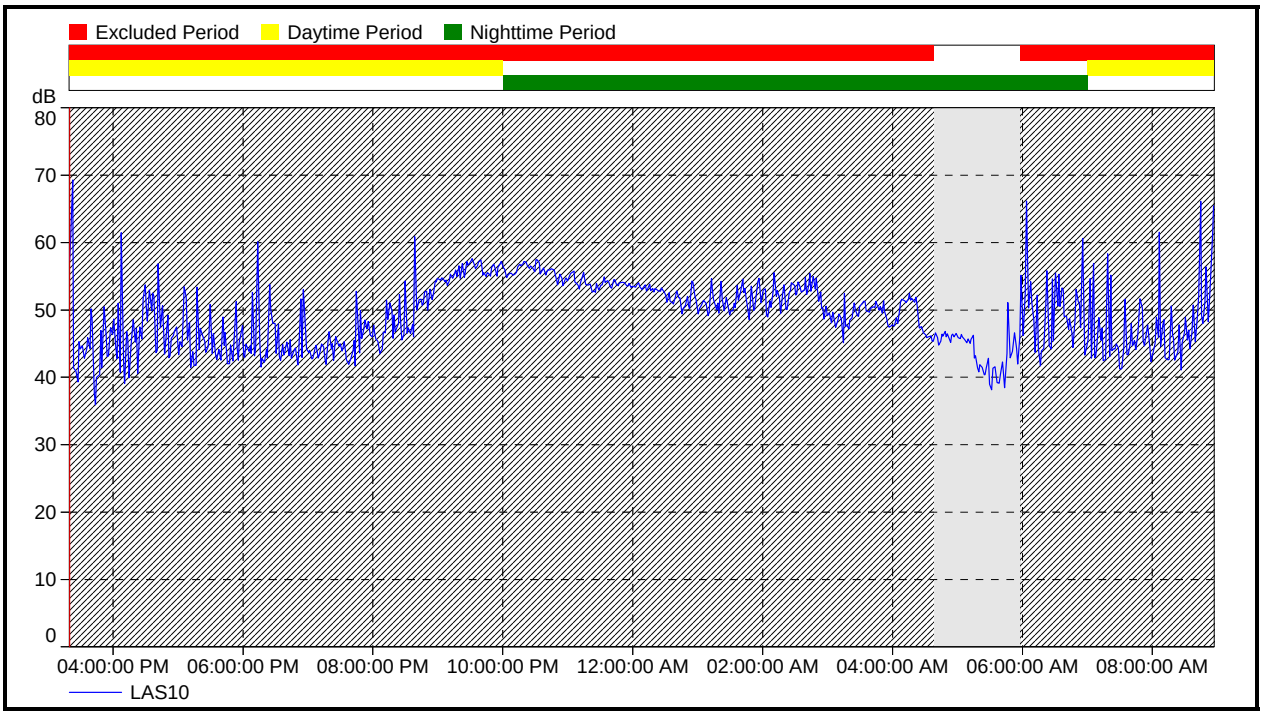


Figure 11: Time History Logged L_{10} Sound Data – PS22 Roswell Pump Station

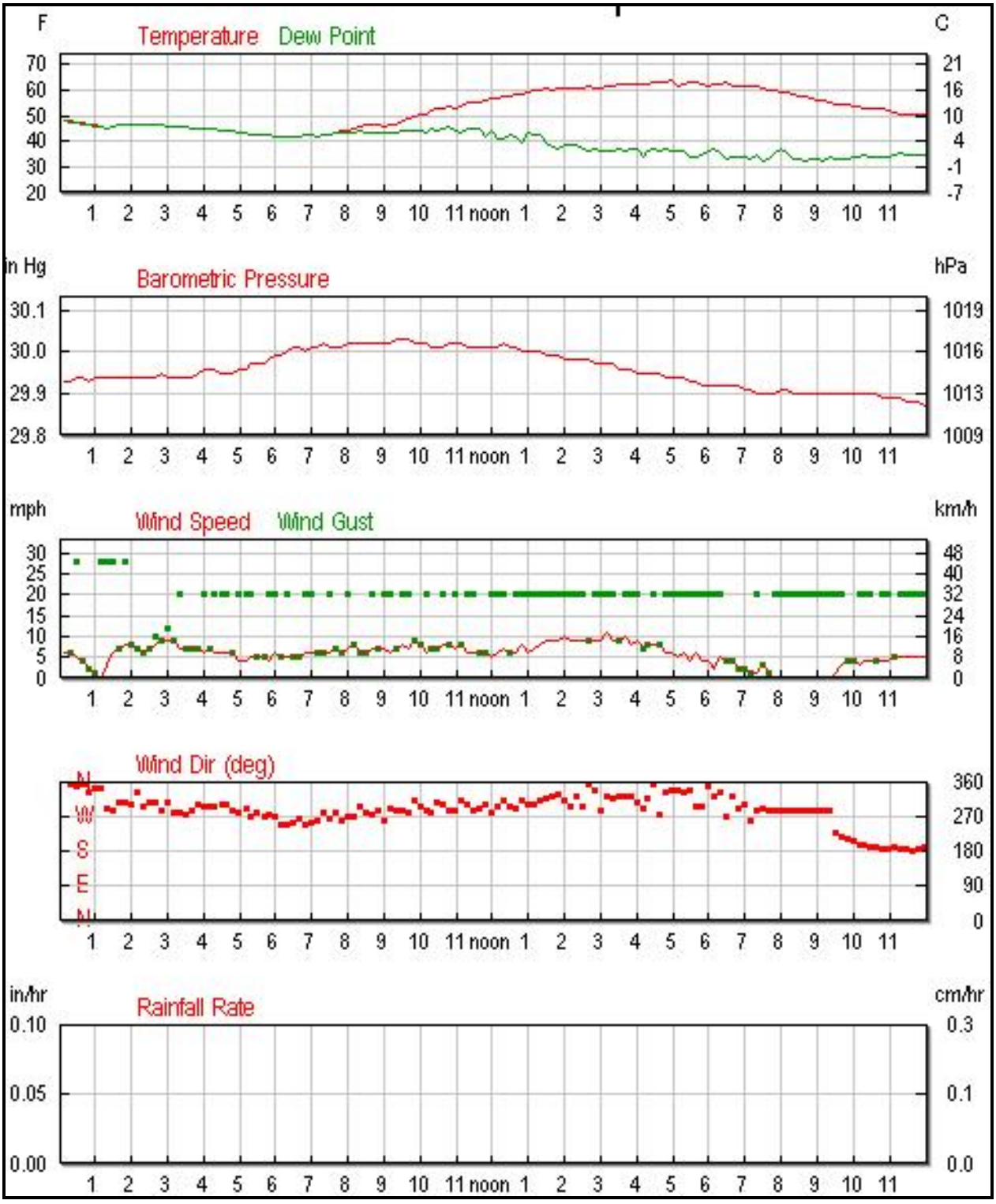


Figure 12: Published Weather Data May 5, 2011 - PS22 Roswell Pump Station

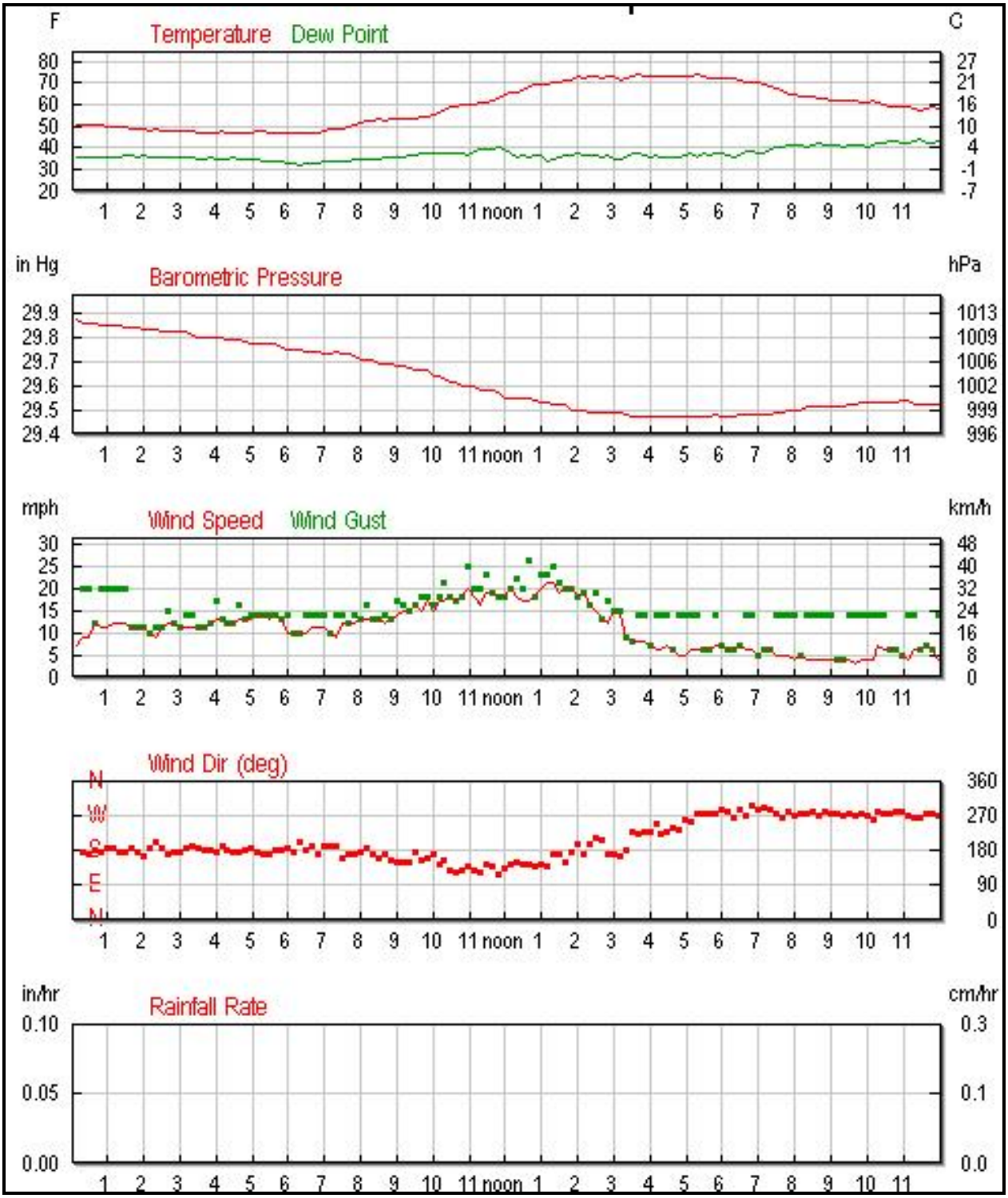


Figure 13: Published Weather Data May 6, 2011 - PS22 Roswell Pump Station

Table 10: Facility Load Log - PS22 Roswell Pump Station

Date (MM/DD/YY CDT)	Actual Oil Flow (m^3/h)	Unit 1	Unit 2	Unit 3	Unit 4
05/05/11 15:00	3161	On	Off	On	On
05/05/11 16:00	3354	On	Off	On	On
05/05/11 17:00	3333	On	Off	On	On
05/05/11 18:00	3264	On	Off	On	On
05/05/11 19:00	3329	On	Off	On	On
05/05/11 20:00	3343	On	Off	On	On
05/05/11 21:00	3354	On	Off	On	On
05/05/11 22:00	3407	On	Off	On	On
05/05/11 23:00	3392	On	Off	On	On
05/06/11 00:00	3403	On	Off	On	On
05/06/11 01:00	3386	On	Off	On	On
05/06/11 02:00	3422	On	Off	On	On
05/06/11 03:00	3405	Off	On	On	On
05/06/11 04:00	3437	Off	On	On	On
05/06/11 05:00	3417	Off	On	On	On
05/06/11 06:00	3413	Off	On	On	On
05/06/11 07:00	3404	Off	On	On	On
05/06/11 08:00	3403	Off	On	On	On

There was 1 hour and 20 minutes of valid data during the monitoring period after isolation analysis. The measurement result, the estimated noise level of maximum load operation and the determination of compliance at the monitoring location are presented in Table 11.

Table 11: Noise Monitoring Result – PS22 Roswell Pump Station

Period	Measurement Result L_{10} (3 Units), dBA	Calculated L_{10} of Max. Load Operation (4 Units), dBA	Noise Criterion, dBA	Compliance
May 5-6, 2011 Nighttime	45	46	L_{10}=55	Yes

The measurement location is 0.56 mile east of the pump station and the hypothetic critical noise receptor is located 1 mile east of the pump station. Due to this distance difference, a 5 dB noise reduction is expected. Therefore, the Roswell pump station will also be in compliance at the hypothetic critical receptor, as shown in Table 12.

Table 12: Calculated Result at Hypothetic Critical Noise Receptor – PS22 Roswell Pump Station

Calculated L_{10} of Max. Load Operation (4 Units), dBA	Noise Criterion, dBA	Compliance
41	L_{10}=55	Yes

The results indicate that the Roswell pump station is in compliance with the noise criterion.

3.4 PS23 Freeman Pump Station

An aerial map in Figure 14 shows the pump station location, the critical receptor location, the noise measurement location and other area features.

M – Measurement Location; R – Critical Receptor Location.

Figure 14: Aerial Map – PS23 Freeman Pump Station

The recorded data of the L_{10} of each 1-minute logging period at the monitoring location of the Roswell pump station from 4:50 p.m. May 5 to 7:35 a.m. May 6, 2011 is presented in Figure 15.

The obviously contaminated data by natural sounds, tree noise, local traffic noise, aircraft flyover, intrusive highway noise or human activities nearby the sound level meter have been excluded. Also excluded is data in the periods when the pump station was turned off or the weather condition was unfavorable. The published weather data and the pump station load log are shown in Figure 16, Figure 17 and Table 13.

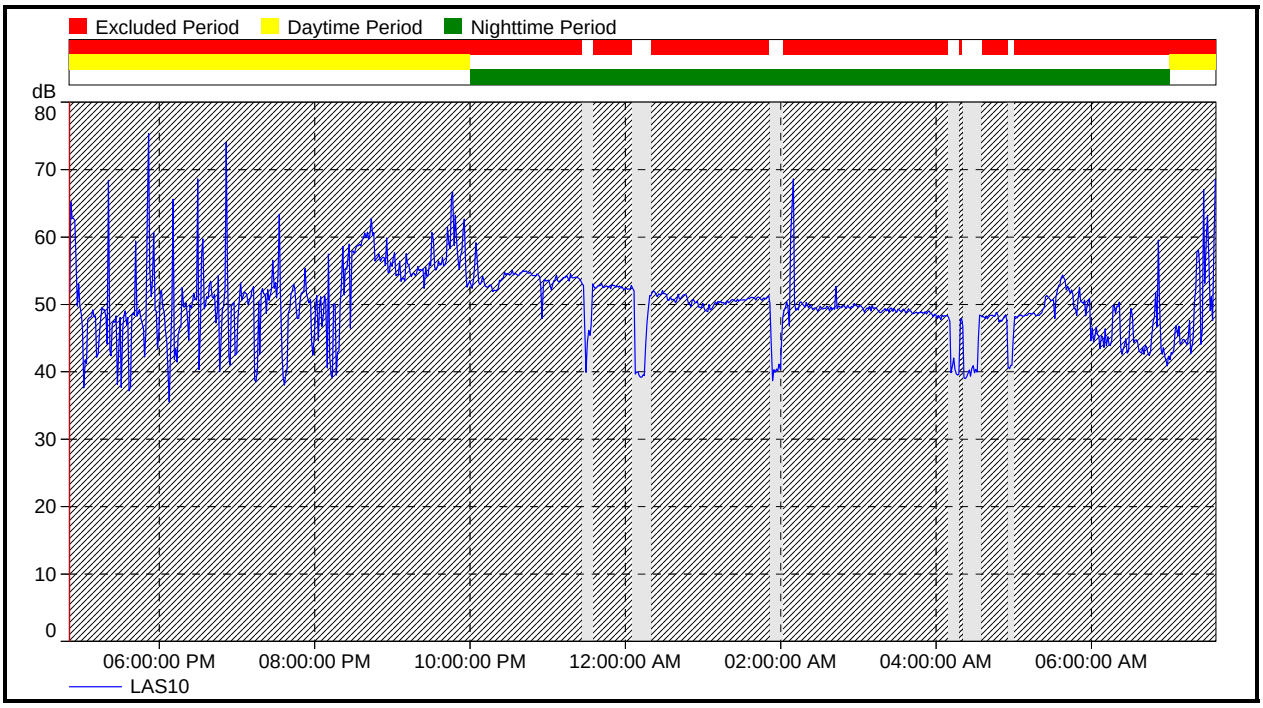


Figure 15: Time History Logged L_{10} Sound Data – PS23 Freeman Pump Station

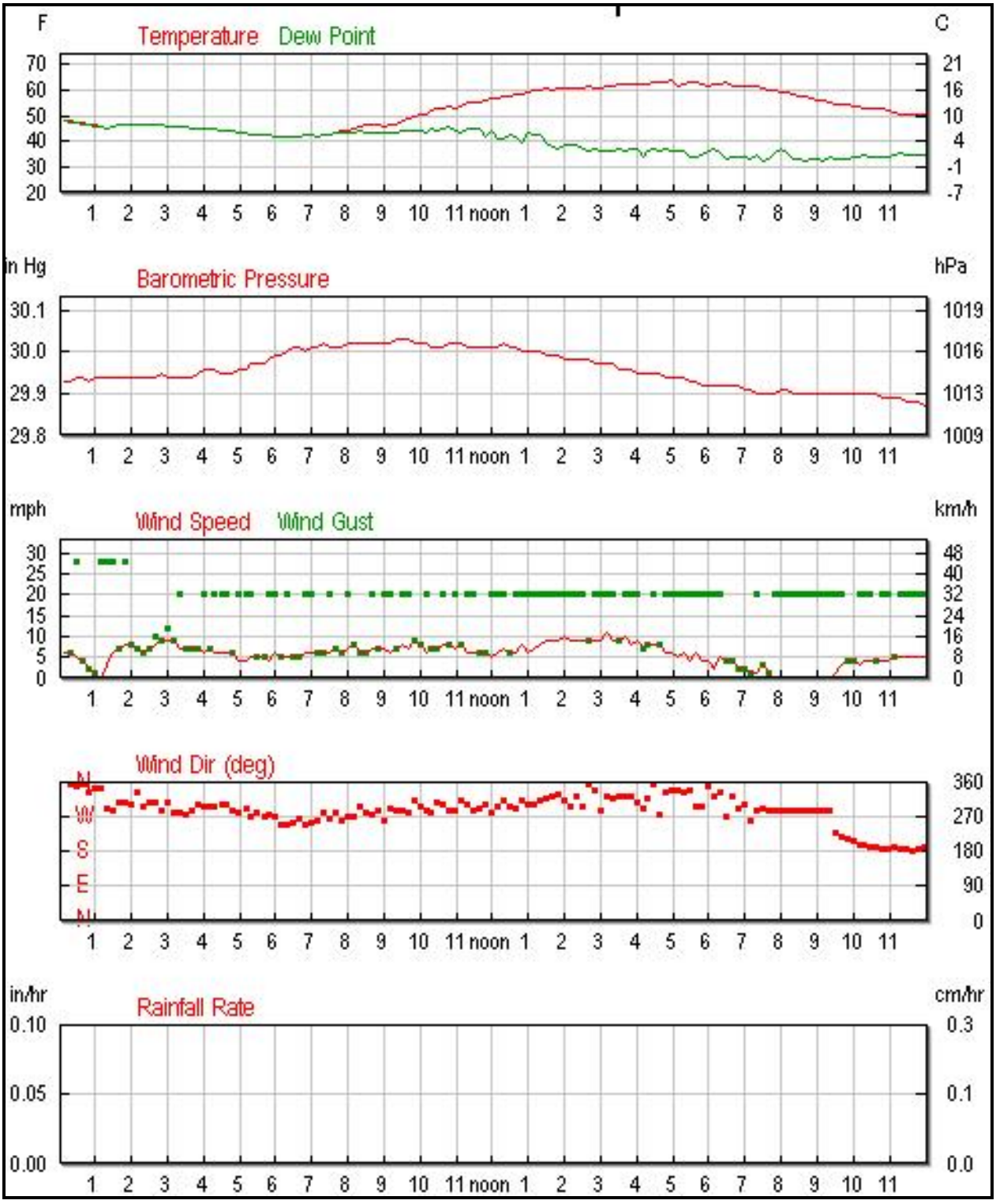


Figure 16: Published Weather Data May 5, 2011 - PS23 Freeman Pump Station

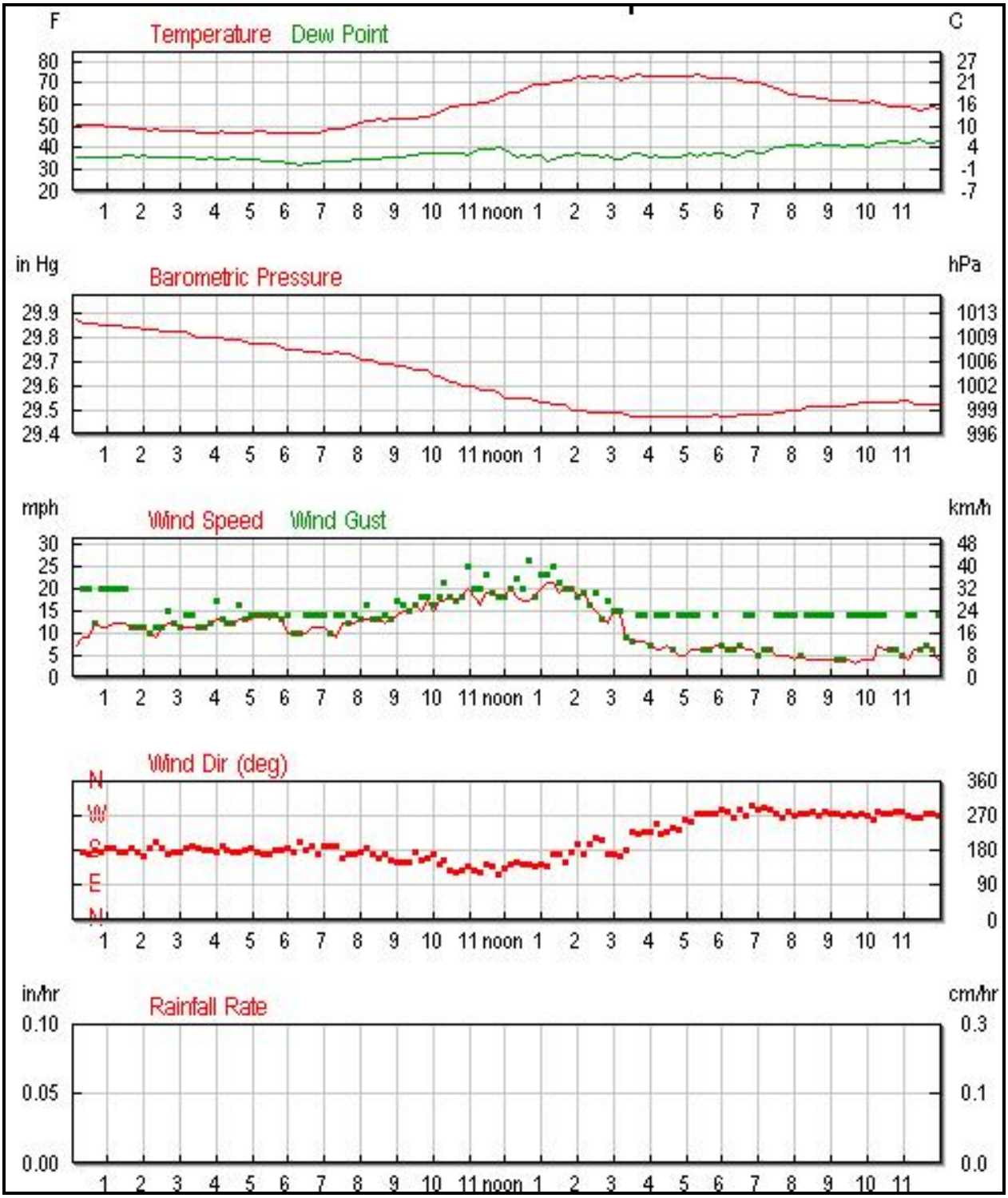


Figure 17: Published Weather Data May 6, 2011 - PS23 Freeman Pump Station

Table 13: Facility Load Log - PS23 Freeman Pump Station

Date (MM/DD/YY CDT)	Actual Oil Flow (m^3/h)	Unit 1	Unit 2	Unit 3	Unit 4
05/05/11 16:00	3365	Off	On	On	On
05/05/11 17:00	3350	Off	On	On	On
05/05/11 18:00	3269	Off	On	On	On
05/05/11 19:00	3325	Off	On	On	On
05/05/11 20:00	3344	Off	On	On	On
05/05/11 21:00	3352	Off	On	On	On
05/05/11 22:00	3399	Off	On	On	On
05/05/11 23:00	3391	Off	On	On	On
05/06/11 00:00	3400	Off	On	On	On
05/06/11 01:00	3419	Off	On	On	On
05/06/11 02:00	3426	Off	On	On	On
05/06/11 03:00	3434	Off	On	On	On
05/06/11 04:00	3424	Off	On	On	On
05/06/11 05:00	3419	Off	On	On	On
05/06/11 06:00	3423	Off	On	On	On
05/06/11 07:00	3414	Off	On	On	On

There was 1 hour and 4 minutes of valid data during the monitoring period after isolation analysis. The measurement result is presented in Table 14.

Table 14: Noise Monitoring Result – PS23 Freeman Pump Station (Measured Result)

Period	Measurement Result L_{10} (3 Units), dBA
May 5-6, 2011 Nighttime	49

However, the valid data still contains continuous contamination from frogs and birdsongs in the background. Such contamination is dominant at 3,150 Hz and 4,000 Hz bands. Contamination exclusion was performed at these two bands, as shown in Figure 18 below.

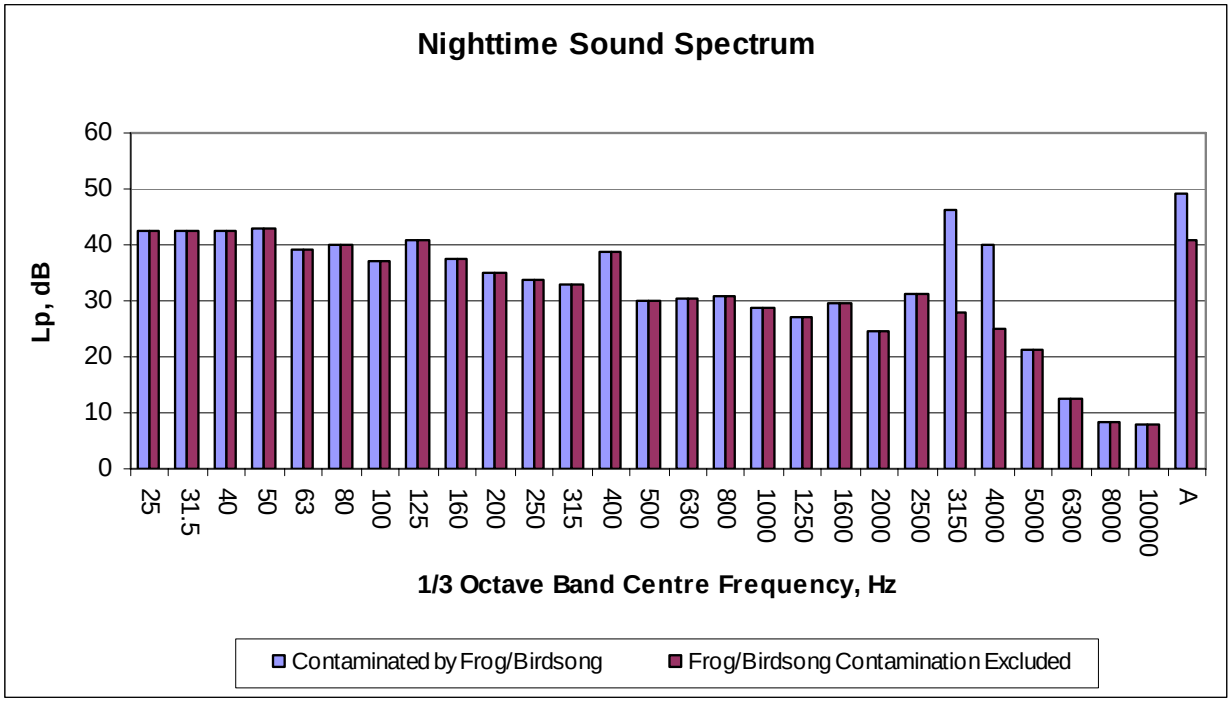


Figure 18: Averaged Nighttime 1/3 Octave Band Spectra before and after Exclusion – PS23 Freeman Pump Station

The results after removing the contamination at 3,150 Hz and 4,000 Hz bands are presented in Table 15, together with calculated noise level of maximum load operation and the determination of compliance.

Table 15: Noise Monitoring Result – PS23 Freeman Pump Station (Adjusted Levels)

Period	Measurement Result L_{10} (3 Units), dBA	Calculated L_{10} of Max. Load Operation (4 Units), dBA	Noise Criterion, dBA	Compliance
May 5-6, 2011 Nighttime	41	42	L_{10}=55	Yes

The results indicate that the Freeman pump station is in compliance with the noise criterion.

4. CONCLUSIONS

The results of the noise monitoring indicate that the South Dakota pump stations of Keystone Pipeline are in compliance with the noise criterion. The results are summarized in the table below.

Pump Station #	Pump Station Name	Measurement Result L_{10}, dBA	Calculated L_{10} of Max. Load Operation, dBA	Noise Level Limit L_{10}, dBA	Compliance
PS20	Ferney	30	31	55	Yes
PS21	Carpenter	42	43	55	Yes
PS22	Roswell	45	46	55	Yes
PS23	Freeman	41	42	55	Yes

5. DISCLAIMER

This "Acoustic Monitoring", which is reported in the preceding pages, has been prepared in response to a specific request for service from the Client to whom it is addressed. The information contained in this noise monitoring is not intended for the use of, nor is it intended to be relied upon, by any person, firm, or corporation other than the Client to whom it is addressed, with the exception of the applicable regulating authority to whom this document may be submitted for planning permission purposes. We deny any liability whatsoever to other parties who may obtain access to the information contained in this noise monitoring for any damages or injury suffered by such third parties arising from the use of this noise monitoring by them without the express prior written permission from ATCO and its Client who has commissioned this noise monitoring.

ATCO STRUCTURES & LOGISTICS

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Appendix A GLOSSARY

Ambient sound level – the background sound level. It is the sound level that is present in the acoustic environment of a defined area. Aircraft fly over and rail noise may be excluded in some jurisdictions.

A-weighted sound level, dBA – the sound level as measured on a sound level meter using a setting that emphasizes the middle frequency components, similar to the frequency response of the human ear.

Frequency – the number of cycles per unit interval of time. *Units Hz (Hertz).*

C-weighted sound level, dBC – the C-weighting approximates the sensitivity of human hearing at industrial noise levels (above about 85 dBA). The C-weighted sound level is more sensitive to sounds at low frequencies than the A-weighted sound level, and is sometimes used to assess the low-frequency content of complex sound environments.

dB (Decibel) – the standard unit of measure, in acoustics, for level or level difference. The decibel scale is based on the ratio $10^{1/10}$; multiplying a power-like quantity (such as sound power or mean square) by this factor increases its level by 1 decibel. If a power-like quantity is increased by a factor $10^{n/10}$, its level goes up by n decibels. *Unit symbol for dB.*

Equivalent Sound Level (L_{eq}) – the prime descriptor used in assessing most types of sounds heard in a community. The L_{eq} is an average of sounds measured over time. It is strongly influenced by occasional loud, intrusive noises.

Sound Power – the rate of acoustic energy flow across a specified surface, or emitted by a specified sound source. *Units W (Watt).*

Sound Power Level (PWL, L_W) – the level of sound power expressed in decibels relative to a stated reference value. The quantity L_w is defined by $L_w = 10\ Log_{10}(W/W_{ref})$. Here W_{ref} is the reference sound power. *Units dB re 1pW.*

Sound Pressure (Pa) – the difference between the instantaneous pressure at a fixed point in a sound field, and the pressure at the same point with the sound absent. *Units Pa (Pascal).*

Sound Pressure Level (SPL, L_p) – or sound pressure-squared level, at a given point the quantity L_p defined by $L_p = 10\ Log_{10}(P_{rms}/P_{ref})^2 = 20\ Log_{10}(P_{rms}/P_{ref})$. Here P_{rms} is the root mean square sound pressure, and P_{ref} is the reference rms sound pressure, 20µPa. *Units dB re 20µPa.*

Statistical (Exceedance or Percentile) Sound Levels, L_N - since the noise levels in a community vary with time in a more or less random manner, the descriptors of these time varying noise levels may be defined in statistical terms. The statistical descriptors are referred to as the percentile sound levels, L_N; with L_N defined as the level exceeded N% of the time. The descriptors often used are:

L_0, Highest Level - this is the highest noise level, also known as L_{max}.

L_1, Level of Highly Intrusive Sounds – the level exceeded 1% of the time, is a measure of the highly intrusive sounds.

L_{10}, Level of Intrusive Sounds - The level exceeded 10% of the time, and is used to indicate the average level of the intrusive sounds.

L_{50}, Median Level - The level exceeded 50% of the time or the median level. A useful measure of the average noise conditions on a site.

L_{90}, Background Level – The level exceeded 90% of the time. It provides a good indication of the steady background noise level on a site.

Appendix B NSTRUMENTATION CALIBRATION RECORDS

edi engineering dynamics incorporated

Certificate of Compliance and Calibration

Calibrated for:

Mr. Patrick Saussus
ATCO Structures & Logistics
8 West Dry Creek Circle
Suite 207
Littleton, CO 80120

P.O.#
Client#A-106
EDI Job#CR-4840-1

ID# 6

Model Number: 2250 SOUND LEVEL ANALYZER w/ Microphone 4189 SN: 2503182

Serial No.: 2505916

Calibration Date: 01/018/11
Calibration Due Date: 01/18/12

Calibration Conditions:

Pre-Calibration: Initial testing found the equipment to be **IN-SPECIFICATION** at the points tested.
@94.0dB/1KHz= 93.7dB

Post-calibration: At the completion of the calibration, measured values were **IN-SPECIFICATION** at the points tested
@94.0dB/1KHz= 94.0dB

PRESSURE: 834.2 hPa. TEMPERATURE: 22.0 deg. C HUMIDITY: 17.3 %

Engineering Dynamics, Inc. does hereby certify that the above referenced SOUND LEVEL ANALYZER meets the requirements of the American National Standards Institute and/or, if applicable; OSHA, MSHA, and the Manufacturer's Specifications, and is traceable to NIST.

Standards Used and Their Due Dates:

Measuring Amp	**B&K 2636**	**SN: 1943590**	**Cert # 1-221160117-101**	**06/23/11**
Piston Phone	**B&K 4228**	**SN: 1747024**	**Cert # 1-179928959-501**	**06/28/11**
Calibrator	**B&K 4231**	**SN: 1850369**	**Cert # 1-179928959-501**	**06/28/11**

Certification for this instrument is valid for
***one year* from the calibration date of this certificate.**

CALIBRATED BY

Tuesday, January 18, 2011
DATE

This certificate shall not be reproduced, except in full, without the written approval of Engineering Dynamics, Inc.

Engineering Dynamics, Inc.
3925 S. Kalamath Street
Englewood, CO 80110
303-761-4367 ♦ 303-761-4379 Fax
www.engdynamics.com ♦ john@engdynamics.com

edi engineering dynamics incorporated

Certificate of Compliance and Calibration

Calibrated for:

Mr. Patrick Saussus
ATCO Structures & Logistics
8 West Dry Creek Circle
Suite 207
Littleton, CO 80120

P.O.#
Client#A-106
EDI Job#CR-4813-1

ID# 6

Model Number: 2250 SOUND LEVEL ANALYZER w/B&K4189 Mic. SN: 2509067

Serial No.: 2506114

Calibration Date: 11/05/10
Calibration Due Date: 11/05/11

Calibration Conditions:

Pre-Calibration: Initial testing found the equipment to be **IN-SPECIFICATION** at the points tested.
@94.0dB/1KHz= 94.1dB

Post-calibration: At the completion of the calibration, measured values were **IN-SPECIFICATION** at the points tested
@94.0dB/1KHz= 94.0dB

PRESSURE: 848.7 hPa. TEMPERATURE: 22.8 deg. C HUMIDITY: 21.8 %

Engineering Dynamics, Inc. does hereby certify that the above referenced SOUND LEVEL ANALYZER meets the requirements of the American National Standards Institute and/or, if applicable; OSHA, MSHA, and the Manufacturer's Specifications, and is traceable to NIST.

Standards Used and Their Due Dates:

Measuring Amp	**B&K 2636**	**SN: 1943590**	**Cert # 1-221160117-101**	**06/23/11**
Piston Phone	**B&K 4228**	**SN: 1747024**	**Cert # 1-179928959-501**	**06/28/11**
Calibrator	**B&K 4231**	**SN: 1850369**	**Cert # 1-179928959-501**	**06/28/11**

Certification for this instrument is valid for
***one year* from the calibration date of this certificate.**

CALIBRATED BY

Friday, November 05, 2010
DATE

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