UPPER GREEN RIVER OZONE INVESTIGATION
(O3i)

MOBILE MONITORING OF OZONE PRECURSORS

OLSON RANCH MONITORING SITE

10/14/2009– 06/30/2010

Operational Overview
Data Summaries, Data Plots and Data Review

Prepared for

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1.0 INTRODUCTION

The University of Wyoming's (UW) Atmospheric Science Department (ATSC) designed and constructed a custom Mobile Air Quality Monitoring Laboratory (MAQML) during the period October 2009 to June 2010. Monitoring was conducted through a contract with the Wyoming Department of Environmental Quality, Air Quality Division (DEQ-AQD). This report describes work performed at the Olson Ranch monitoring site during the period 10/14/2009 – 06/30/2010.

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1.1 Background

A mobile laboratory provides the opportunity for monitoring at sites not covered by established network locations. For the purpose of this study the Olson Ranch site was selected as it represented an area not covered through established DEQ monitoring networks. This site is situated in the Upper Green River basin, in the vicinity of the Pinedale Anticline Development Area (PAPA) and Jonah Field oil and gas developments. The data gathered at the Olson Ranch site was used in conjunction with other data collected during AQD's Upper Green Winter Ozone Study (UGWOS) 2010 project to provide an understanding of ambient air concentrations and meteorological conditions. The Olson Ranch site is at a lower elevation than many of the AQD's monitoring sites and was intended to provide a comparison to ambient air concentrations at other monitoring sites. Figure 1-1 gives the location of the Olson Ranch site relative to established continuous WDEQ-AQD monitoring sites.

Table 1-1 gives detailed information regarding the position and monitoring period at the Olson Ranch site.

Figure 1-1. Olson Ranch monitoring location.

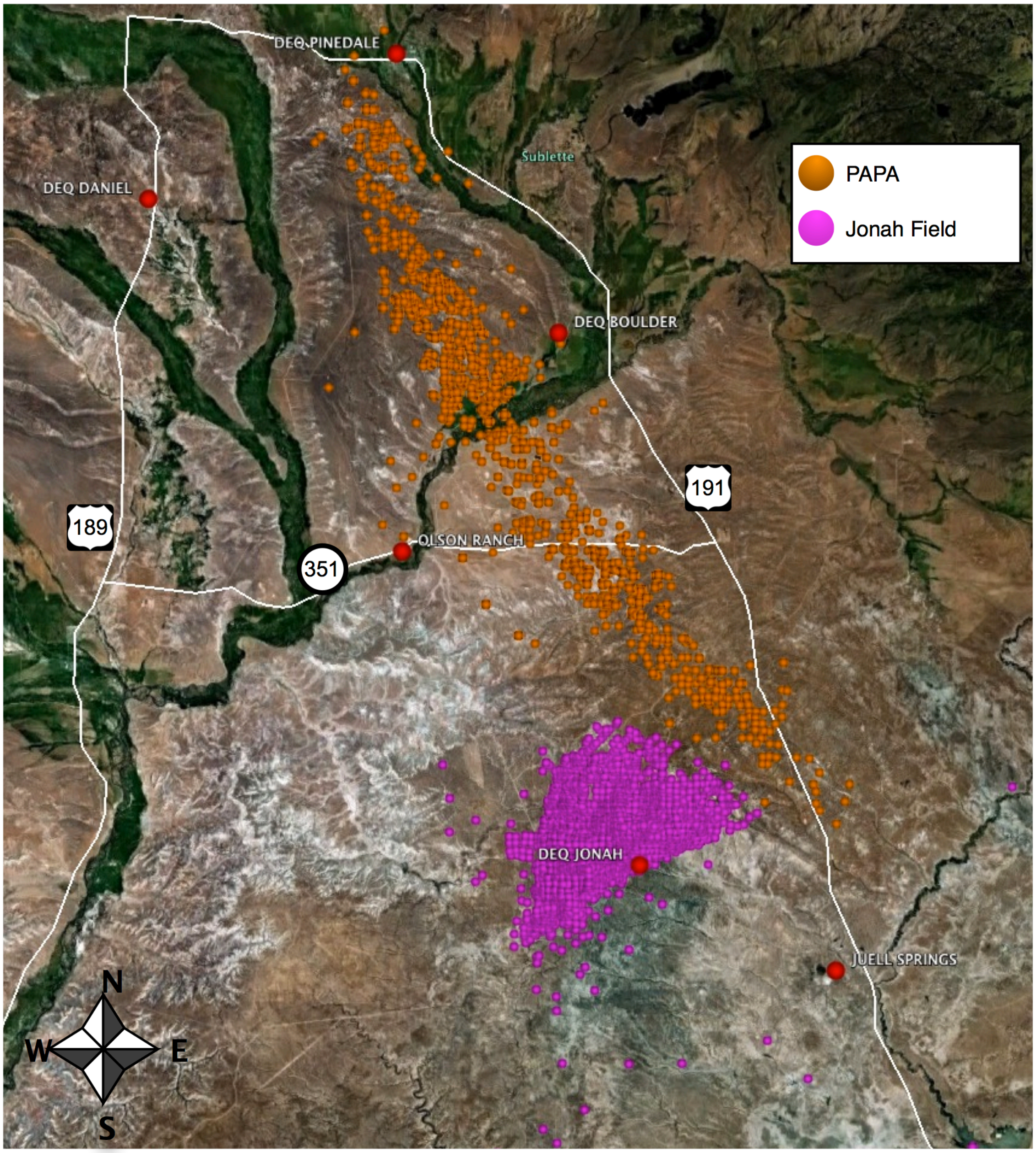


Table 1-1. Geographic specifications of Olson Ranch site.

University of Wyoming Mobile Air Quality Monitoring Laboratory 10/14/2009 – 06/30/2010	
Olson Ranch	
Elevation:	6872 ft
Longitude:	W109.869483°
Latitude:	N42.600201°
Monitoring Period:	October 14, 2009 – June 30, 2010

The MAQML is equipped with several gaseous pollutant analyzers as well as a meteorological monitoring station. As given in Table 1-2 the following parameters were measured: ozone (O_3), nitric oxide (NO), nitrogen dioxide (NO_2), and oxides of nitrogen (NO_x), carbon monoxide (CO), methane (CH_4), and non-methane hydrocarbons (NMHC). This report presents data collected at Olson Ranch for the period October 14, 2009 through June 30, 2010. Ambient concentrations of ozone, CO, NO, NO_2, and NO_x, CH_4 and NMHC are continuously monitored according to EPA approved methods.

Wind speed, wind direction, temperature, barometric pressure and relative humidity were monitored to understand local meteorological conditions. Project performance goals included adherence to EPA monitoring guidelines. Details of the monitoring design and quality assurance program plan are given in the Quality Assurance Project Plan for the Upper Green River Ozone Investigation (O3i) (Rev 2.2, April 2010).

Table 1-2. Mobile Air Quality Monitoring Laboratory monitored parameters.

University of Wyoming Mobile Air Quality Monitoring Laboratory 10/14/2009 – 06/30/2010	
Gaseous Parameters	**Meteorological Parameters**
• Ozone (O_3) • Nitric Oxide (NO) • Nitrogen Dioxide (NO_2) • Oxides of Nitrogen (NO_x) • Methane (CH_4) • Non-Methane Hydrocarbons (NMHC) • Carbon Monoxide (CO)	• Wind Speed (WS) • Wind Direction (WD) • Barometric Pressure • Temperature • Relative Humidity (RH)

1.2 UW MAQML Site Photograph

Figure 1-2. Olson Ranch UW Mobile Air Quality Monitoring Laboratory site location.

1.3 Instrumentation and Sampling Protocols

Table 1-3 shows key characteristics of monitoring instrumentation in the MAQML. Measurement frequencies of 1-minute or 5-minute for gaseous parameters were used. A sampling rate of 1 minute was used for the 55i and 48i instrument to maximize the number of samples for analysis of CH_4/NMHC and CO. For the former this was due to the importance of these parameters. For the latter it was to ensure that blank span corrections did not result in excessive loss of possible ambient measurements of CO. The National Oceanic and Atmospheric Administration's Earth System Research Laboratory co-ordinates measurements of CH_4 at a number of background sites in the United States, as part of the activity of the Global monitoring Division. Data for 2009 at the Trinidad Head site on the coast of California reveals an annual average of 1.859 ppm. This compares to values of 1.845 ppm at Niwot Ridge Colorado, 1.858 ppm at Point Arena California and 1.853 ppm at Wendover Utah. In the United States background methane concentration can be estimated to be approximately 1.85 ppm.

Table 1-3. UW MAQML instrumentation and sampling protocols.

University of Wyoming Mobile Air Quality Monitoring Laboratory 01/31/2009 – 07/31/2009				
Component	**Instrumentation**	**Height**	**Frequency**	**Parameter**
Gaseous	Thermo-Fisher 49i	5 meters	5 minute	O_3
	Thermo-Fisher 42i	5 meters	5 minute	NO, NO_2, NO_x
	Thermo-Fisher 48i	5 meters	1 minute	CO
	Thermo-Fisher 55i	5 meters	1 minute	CH_4, NMHC
Meteorology	Vaisala Weather Transmitter WXT510	5 meters	1 minute	Wind Speed Wind Direction Temperature Barometric Pressure Relative Humidity

1.4 Quality Assurance

Quality assurance procedures are provided in the QAPP for O3i. Of particular importance is the initial set-up of the MAQML, site operating protocols and post processing procedures. Proper site operation includes calibration, instrument maintenance and trouble-shooting. Independent auditing of the gaseous instrumentation was conducted by an independent contractor of the WDEQ-AQD (T&B Systems). The results of these audits are given in Appendix A, B, and C. The audits revealed no significant issues with excellent performance for all instrumentation. There were no occasions with non-compliant performance. One highlighted issue related to calibration coefficients for the 42i instrument. These were adjusted after the third quarter audit upon recommendation by the auditor. All routine operations and data collection activities are systematic and follow written procedures as detailed in instrument-specific manuals.

2.0 DATA COLLECTION AND VALIDATION

2.1 Gaseous and Meteorology

2.1.1 Data Collection

Raw data were uploaded daily via cellular phone service to the ATSC ftp server. Data were also collected during monthly site visits. Latest data values are available via the project website to review operational status and measurement parameters. The purpose of daily uploads is to perform preliminary data quality checks and to concatenate current data to previously collected data.

2.1.2 Data Validation

This project employs a two-level data validation process. These levels, and the validation codes that designate them, are defined in Tables 2-1 and 2-2, respectively.

Table 2-1. Gaseous Validation Process Summary.

Level 0 Validation
These data are obtained directly from the data loggers that acquire the data in the field. Averaging times represent the minimum intervals recorded by the data logger, which do not necessarily correspond to the averaging periods specified for the database files. Level 0 data have not been edited for instrument downtime, nor have procedural adjustments for baseline and span changes been applied. Level 0 data are consulted on a regular basis to ascertain instrument functionality and to identify potential episodes prior to receipt of Level 1 data.
Level 1 Validation
These data have passed several validation tests applied by the measurement investigator prior to data submission. The general features of Level 1 are: 1) removal of values when monitoring instruments fail specified validation criteria; 2) flagging measurements when significant deviations from measurement assumptions have occurred; 3) verifying computer file entries against data sheets, where appropriate; 4) replacement of data from a backup data acquisition system in the event of failure of the primary system; and 5) adjustment of measurement values for quantifiable baseline and span or interference biases.
Level 2 Validation
These data have been assembled into a collated data file. Level 2 validation is the first step in data analysis. Level 2 validation involves the testing of measurement assumptions, comparison of collocated instruments, and internal consistency tests.

Table 2-2. Gaseous data validation flags.

Code	Meaning
a	Valid ambient data
C	Valid span calibration data for calculation of response factors
C2	Gas phase titration calibration
c	Transition span calibration data
B	Valid zero calibration data for calculation of response factors
b	Transition zero data
Z	Audit
nd	No data
r	Re-location
rw	Warm-up after re-location
w	Warm up after malfunction
m	Maintenance
mq	Maintenance of data acquisition system
mf	Malfunction of flame
mi	Malfunction of integration
mp	Malfunction of external power supply
mv	Malfunction of valve switch
fo	Flame out

3.0 OPERATIONAL SUMMARY

3.1 Gaseous and Meteorological

Table 3-1. Gaseous and meteorological operational timeline.

University of Wyoming
Mobile Air Quality Monitoring Laboratory 10/14/2009 – 06/30/2010

Date	Summary
10/14/2009	Initial Olson Ranch site startup
10/15/2009	Initial Olson Ranch site startup
10/16/2009	Initial Olson Ranch site startup
10/20/2009	Site visit. Adjust 48i auto-zero parameters. Recalibrate 55i.
10/22/2009	Power outage. Site reboot.
11/09/2009	Site visit. Zero/span operations. Adjust 55i time & date parameters. Repair 48i pressure transducer.
11/10/2009	Site visit. Audit with T&B Systems, David Yoho.
11/11/2009	Site visit. Run zero/span chromatograms to verify performance of 55i.
11/17/2009	Site visit. Install in-line scrubbers, 1160-B to 55i. Remove 1160-A for converter replacement. Adjust 42i calibration factors.
11/18/2009	Site visit. Zero/span operations. Replace Ultrapure Nitrogen carrier gas.
12/15/2009	Site visit. Zero/span operations. Replace repaired 1160-A.
01/18/2010	Site visit. 55i analyzer flameout. Run column burn-in procedure overnight.
01/19/2010	Site visit. 55i analyzer resume normal operations.
02/02/2010	Site visit. Internal audit.
02/03/2010	Site visit. Troubleshooting system power to resolve instrument display issue.
02/04/2010	Site visit. System inspection.
02/10/2010	Site visit. Troubleshooting system power to resolve instrument display issue.
02/11/2010	Site visit. Troubleshooting system power to resolve instrument display issue.
02/12/2010	Site visit. Internal audit.
02/15/2010	Site visit. System inspection.
02/16/2010	Site visit. T& B Systems audit with David Yoho.
03/10/2010	Site visit. Internal audit.
03/11/2010	Site visit. Calibration.
03/12/2010	Site visit. System maintenance.
03/26/2010	Site visit (coincidental). Support gas replacement.
04/19/2010	Site visit. Internal audit.
04/21/2010	Site visit. T& B Systems audit with David Yoho.
05/17/2010	Site visit. Internal audit.
06/14/2010	Site visit. Internal audit.
06/30/2010	Site visit. Internal audit.
07/01/2010	Site shutdown. Return mobile laboratory to Laramie.

4.0 GASEOUS STANDARDS SUMMARY

Ambient concentrations of O_3 and NO_2 are regulated by DEQ-AQD and EPA under Wyoming Ambient Air Quality Standards (WAAQS) and EPA National Ambient Air Quality Standards (NAAQS) provisions of the Clean Air Act. Values measured by O3i are presented with corresponding NAAQS/WAAQS in Table 4-1. This table is intended for comparative purposes as the O3i study was conducted over a period of nine months. As such any comparison is for context and does not have direct applicability to NAAQS or WAAQS.

The NAAQS for O_3 was updated by EPA in March 2008, and is 0.075 ppm over an 8-hour period. An exceedance of the standard occurs when an 8-hour average O_3 concentration is greater than or equal to 0.075 ppm. A violation of the standard occurs when the three-year average of the fourth highest daily maximum 8-hour average ozone concentration exceeds 0.075 ppm. The NAAQS for NO_2 is an annual arithmetic mean of the one-hour NO_2 values, 0.053 ppm, or 53 ppb.

While a comparison value cannot be calculated for NO_2, Table 4-1 shows that ozone levels did not exceed the standard value for the rolling 8-hour average.

Table 4-1. UW MAQML Standards Summary Report.

University of Wyoming Mobile Air Quality Monitoring Laboratory 10/14/2009 – 06/30/2009					
Parameter	**NAAQS**		**Measured**		
	Averaging Time	**Standard**	**Measured Value**		**Date(s) and locations**
Ozone	Rolling 8-hour	0.075 ppm	Highest Daily Max:	0.071	06/08/2010
			4th Highest Daily Max:	0.070	04/09/2010
Nitrogen Dioxide	Annual	0.053 ppm	Arithmetic Mean	n/a	n/a

5.0 DATA SUMMARY PRODUCTS

The following sections present summary information for O3i monitoring performed during the period of October 2009 through June 2010. These sections assess data recovery and each of the parameters considered in O3i.

Section 5.1 considers data recovery for all measured parameters. Section 5.2 considers meteorological parameters with particular attention given to wind speed and wind direction. Section 5.3 assesses gaseous pollutant behavior. This section illustrates behavior through pollution rose diagrams and temporal plots. The latter plots indicate short-term, diurnal, and longer-term behavior at the monitoring site, respectively.

5.1 Data Collection Summaries

Data recovery information presented in Table 5-1 is calculated from 5-minute average data. For Table 5-1 the total number of possible data points, in relation to the total number of valid ambient data points, are shown. The number possible is the period from when data is produced from the instrument, i.e. from switch on until switch off. Collected data excludes the time taken for equipment to warm-up after relocation. The percent collected value is equal to number collected divided by the number possible. Valid data is ambient data that has not been excluded through data validation. Table 2-2 lists the codes and associated cause of invalidation. For all instruments, data is removed due to calibration. Other important causes of data removal include instrument malfunction and instrument behavior outside of preferred diagnostic limits. The ultimate indication of completeness criteria is given by the calculation of the percentage of valid data. This value is the number of valid ambient data points divided by the number collected.

Completeness criteria were exceeded for all of the eleven measurement parameters.

Table 5-1. UW MAQML data collection statistics.

University of Wyoming Mobile Air Quality Monitoring Laboratory Data Collection Statistics Final Validation 10/14/2009 – 06/30/2010							
Parameter	**Interval**	**Par Code**	**Data Recovery**			**Valid Data**	
			No. Possible	No. Collected	% Collected	No. Valid	% Valid
Ozone	**5-minute**	**O3**	74,679	71,790	96%	71,030	99%
Nitric Oxide	**5-minute**	**NO**	74,679	71,845	96%	71,103	99%
Oxides of Nitrogen	**5-minute**	**NOx**	74,679	71,845	96%	71,103	99%
Nitrogen Dioxide	**5-minute**	**NO2**	74,679	71,845	96%	71,103	99%
Carbon Monoxide	**5-minute**	**CO**	156,105	137,017	88%	126,929	93%
Methane	**5-minute**	**CH4**	164,876	159,180	97%	151,021	95%
Non-Methane Hydrocarbons	**5-minute**	**NMHC**	164,876	159,180	97	151,021	95%
Wind Direction	**5-minute**	**WD**	74,676	73,595	98.6%	73,595	98.6%
Wind Speed	**5-minute**	**WS**	74,676	73,595	98.6%	73,595	98.6%
Temperature	**5-minute**	**TEMP**	74,676	73,595	98.6%	73,595	98.6%
Relative Humidity	**5-minute**	**RH**	74,676	73,595	98.6%	73,595	98.6%
Pressure	**5-minute**	**PRES**	74,676	73,595	98.6%	73,595	98.6%

Performance Goals: Completeness Criteria Listing from QAAP

O_3	75%
NO | NO_x | NO_2	75%
CO	75%
CH_4 | NMHC	75%
Wind Speed	80%
Wind Direction	80%

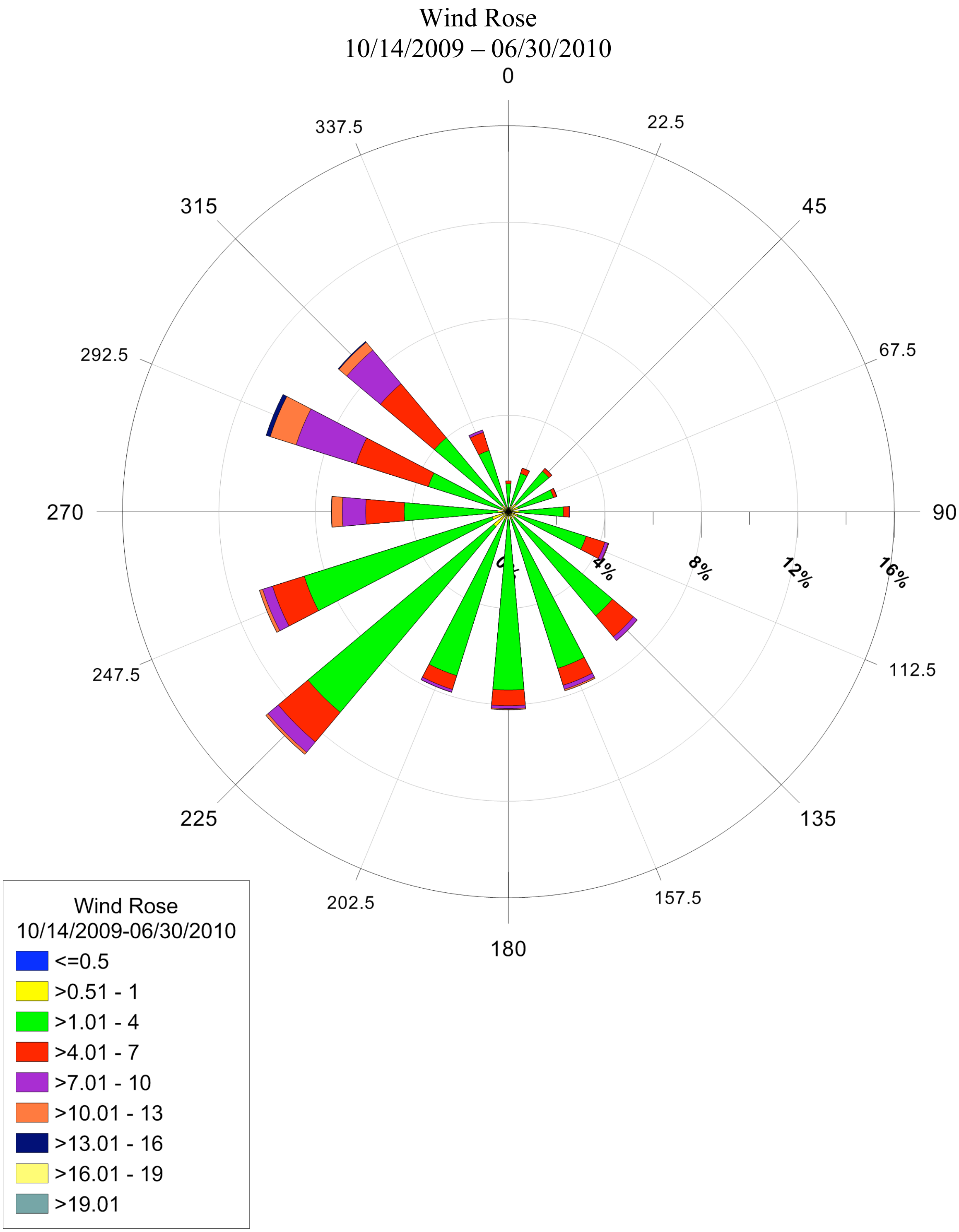
5.2 Meteorological Parameter Measurement Summaries

Continuous air temperature, barometric pressure, wind speed and wind direction values are measured using the Vaisala WXT510 Weather Transmitter. Summaries of air temperature, barometric pressure, wind speed and wind direction are presented in this section.

5.2.1 Meteorological Data Summaries

Table 5-3 shows the meteorological data summary for the Olson Ranch monitoring site. Data collection commenced on October 14, 2009, and concluded June 30, 2010. The site is located on open ground without significant influence from proximate structures. Wind speed and direction data are presented in Figure 5-1. This figure indicates the wind field behavior of this site. This figure shows the dominant air movement at this site. The area of investigation exhibits a complex wind field with seasonal and diurnal variations.

Figure 5-1. Olson Ranch Wind Rose for the period 10/14/2009 – 06/30/2010.



The Olson Ranch site was located on open ground south of US Highway 351 (Figure 1-2). Figure 5-1 shows that there were infrequent winds from 337.5° to 112.5°. There also appears to be two different wind regimes. The first, 270° to 315°, is associated with a greater proportion of relatively high wind speeds above 4 m/s. The second, 135° to 247.5°, is associated with a greater proportion of relatively slow wind speeds of less than 4 m/s. The PAPA is located to the northeast of the Olson Ranch monitoring location..

The Northwest direction is associated with airflow from the Gros Ventre Range. The Southerly direction may be linked with airflow from the southern end of the Wyoming Range, and also associated with the wind field of the southern end of the Upper Green River Basin. This is anticipated given the position of Olson Ranch. During this monitoring period Figure 5-3 shows that Olson Ranch can be considered as upwind site of PAPA and sometimes a downwind site for the Jonah Field development. However, as indicated in subsequent sections, during low wind speed conditions wind direction may be less reflective of the origin of air parcels.

As indicated by Table 5-3, meteorological conditions are typical for the nine-month monitoring period that included the winter months. The Olson Ranch site is anticipated to have cold winter temperatures and the average for this 9-month period was -2.3°C. Average wind speed, pressure and relative humidity are comparable to other data from WDEQ-AQD monitoring sites.

Table 5-3. Olson Ranch UW MAQML meteorological data summary for the period 10/14/2009 – 06/30/2010.

University of Wyoming Mobile Air Quality Monitoring Laboratory *Meteorological Data Summary* Final Validation 10/14/2009 – 06/30/2010				
Parameter	**Value**	**Units**	**Number**	**Standard Deviation**
WIND SPEED				
Average	3.3	m/s	73595	2.5
Maximum	15.9			
TEMPERATURE				
Average	-2.3	°C	73595	10.9
Maximum	29.1			
Minimum	-36.9			
RELATIVE HUMIDITY				
Average	65.3	%	73595	20.9
Maximum	99			
Minimum	11			
PRESSURE				
Average	787.9	mmHg	73595	6
Maximum	802			
Minimum	762			

5.3 Gaseous Pollutant Measurement Summaries

Continuous CH_4 and NMHC values were measured using Thermo-Fisher 55i Direct Methane, Non-Methane Hydrocarbon Analyzer. Summaries of CH_4 and NMHC measurements are presented in sections 5.3.2.1 and 5.3.2.2.

Continuous NO_x, NO_2 and NO values are measured using a Thermo-Fisher 42i Chemiluminescence NO_x-NO_2-NO Analyzer. Summaries of NO_x, NO and NO_2 measurements are presented in sections 5.3.3, 5.3.4 and 5.3.5, respectively. NO_2 is a regulated pollutant with an annual average standard value.

Continuous O_3 values are measured using a Thermo-Fisher 49i UV Photometric O_3 Analyzer. A summary of ozone measurements is presented in section 5.3.6. Ozone is a regulated air pollutant with a rolling 8-hour standard value.

Continuous CO values were measured using Thermo-Fisher 48i Analyzer. Summaries of CO measurements are presented in section 5.3.7.

Summaries of gaseous pollutant measurements for each monitoring site are presented. Section 5.3.1 explores pollutant roses. Pollutant measurements are displayed on a temporal basis in section 5.3.2 to 5.3.7 by pollutant.

5.3.1 Spatial Gaseous Pollutant Roses

In light of anticipated benefits of the site location, a brief overview of pollution roses provides context for considering the temporal behavior shown by diurnal and longer-term temporal data plots in the subsequent sub-sections.

Figure 5-2 illustrates the pollution rose for CH_4 at Olson Ranch. Wind directions of 135º to 247.5° were associated with the greatest proportion of CH_4 levels equal to or greater than 2.6 ppm. By contrast, wind directions from 315° to 90° showed the greatest proportion of CH_4 concentrations equal to or below 2 ppm. Figure 5-3 shows that the pollution rose for NMHC at Olson Ranch mirrors that of CH_4. As indicated by Figures 5-4, 5-5 and 5-6 NO_x, NO and NO_2 pollution roses all exhibit similar behavior.

Figure 5-7 for ozone, contrasts with the other pollution roses, with a more even distribution of higher ozone concentrations. Southerly wind directions have a greater proportion of ozone concentrations below 25 ppb, compared to all other wind directions. Figure 5-8 for CO shows a relatively even distribution of concentrations from all wind directions indicating the dominance of background for this pollutant.

Figure 5-2. Olson Ranch CH_4 pollutant rose for the period 10/14/2009 – 06/30/2010.

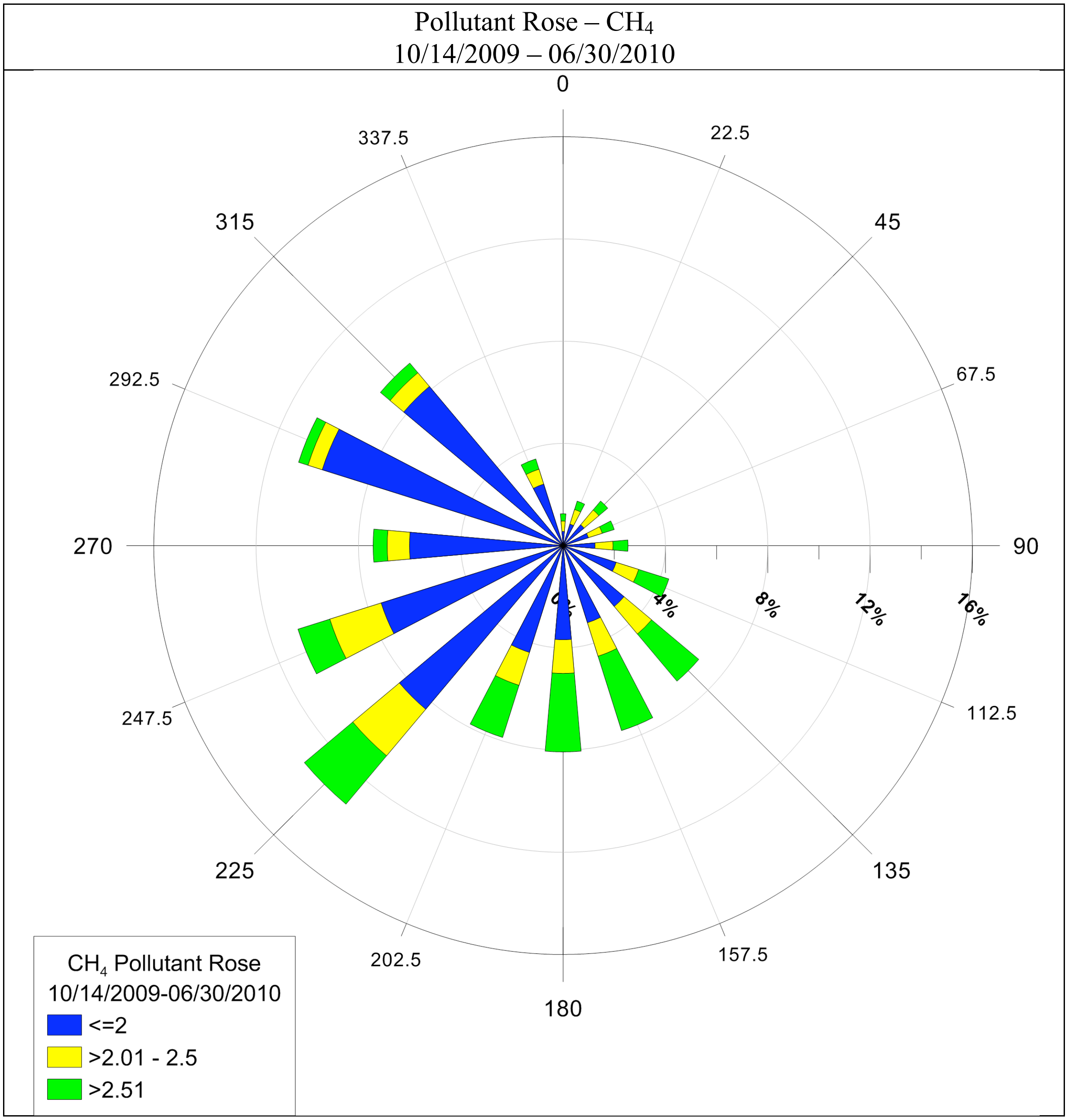


Figure 5-3. Olson Ranch NMHC pollutant rose for the period 10/14/2009 – 06/30/2010.

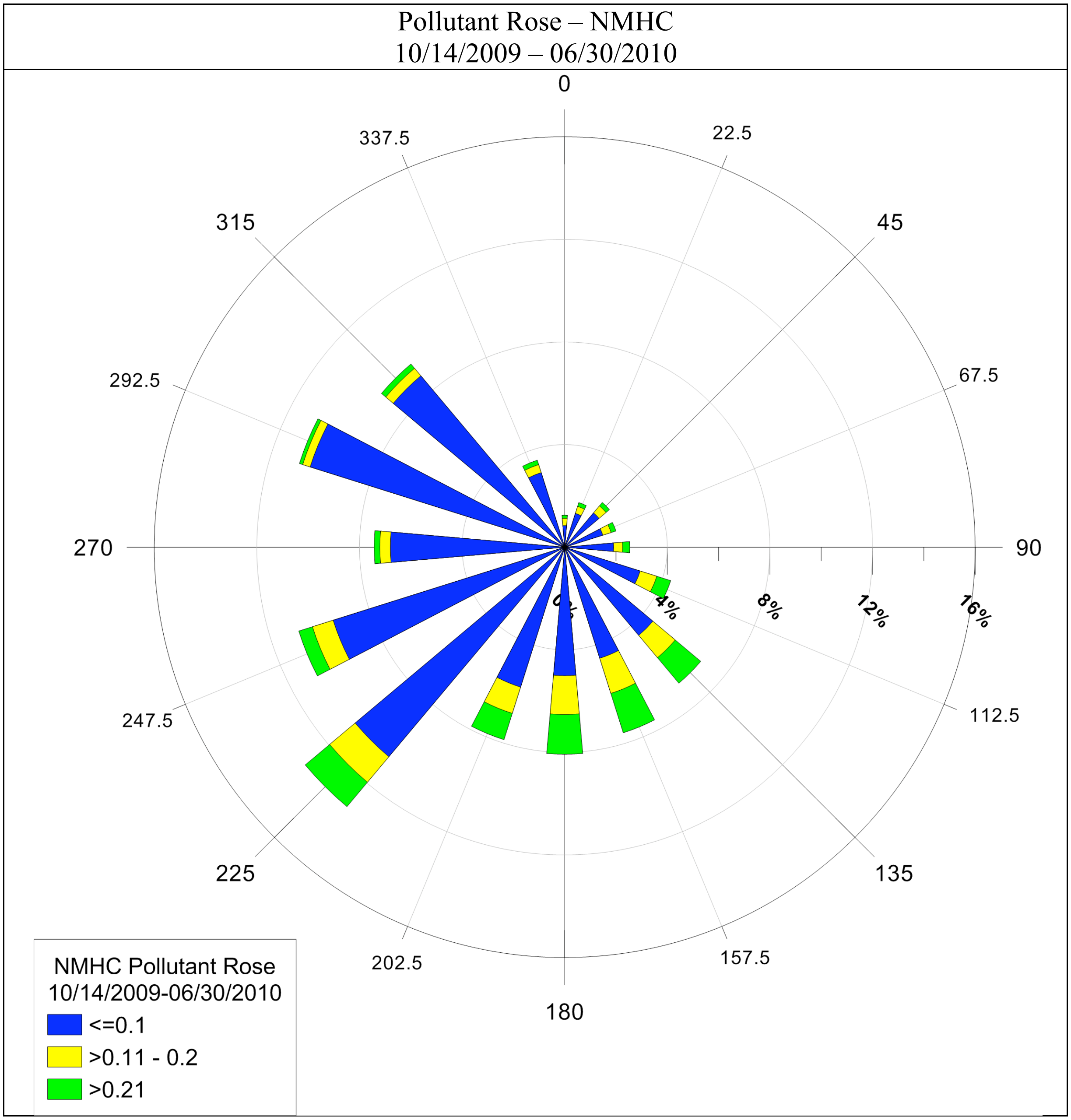


Figure 5-4. Olson Ranch NO_x pollutant rose for the period 10/14/2009 – 06/30/2010.

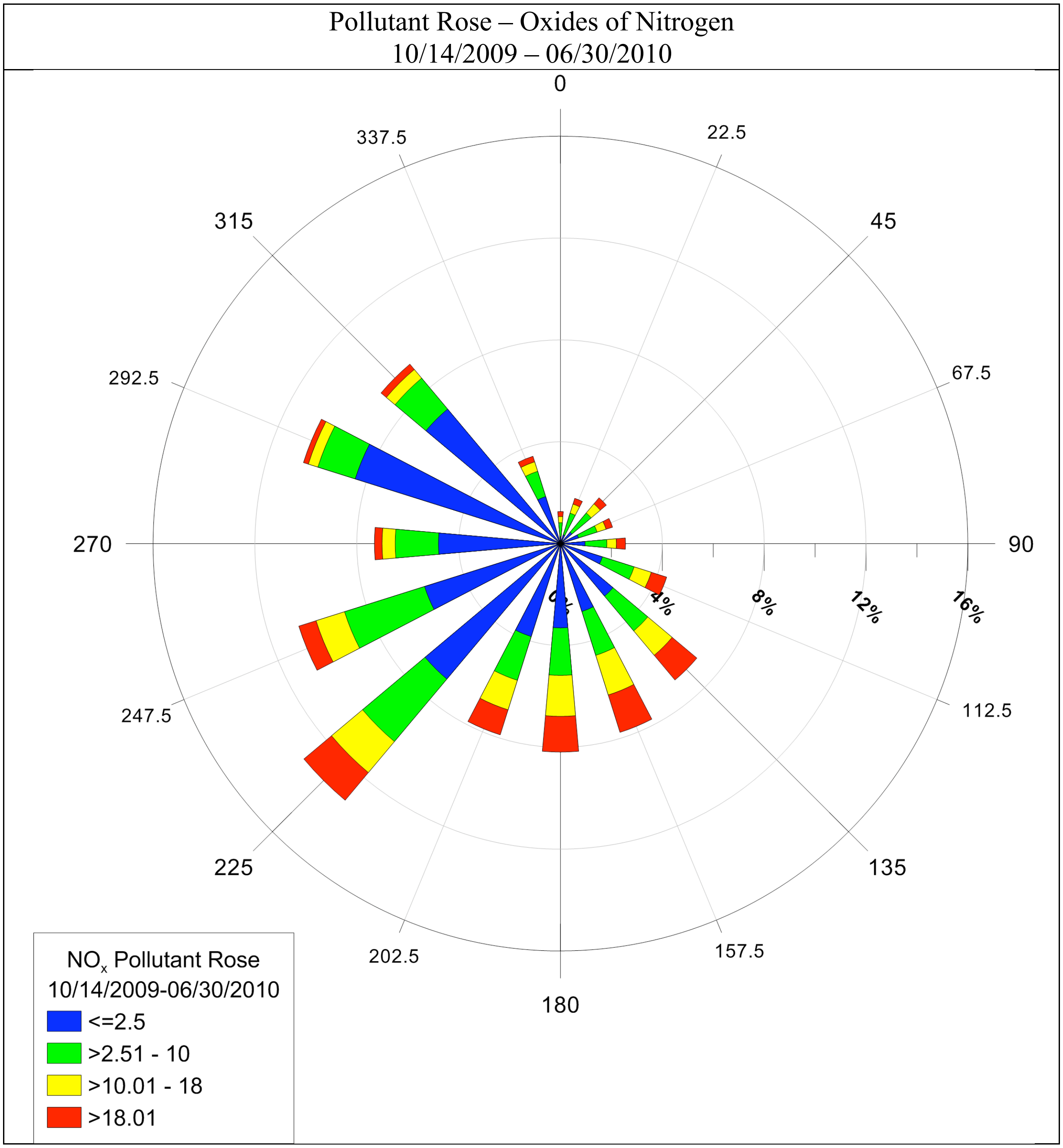


Figure 5-5. Olson Ranch NO pollutant rose for the period 10/14/2009 – 06/30/2010.

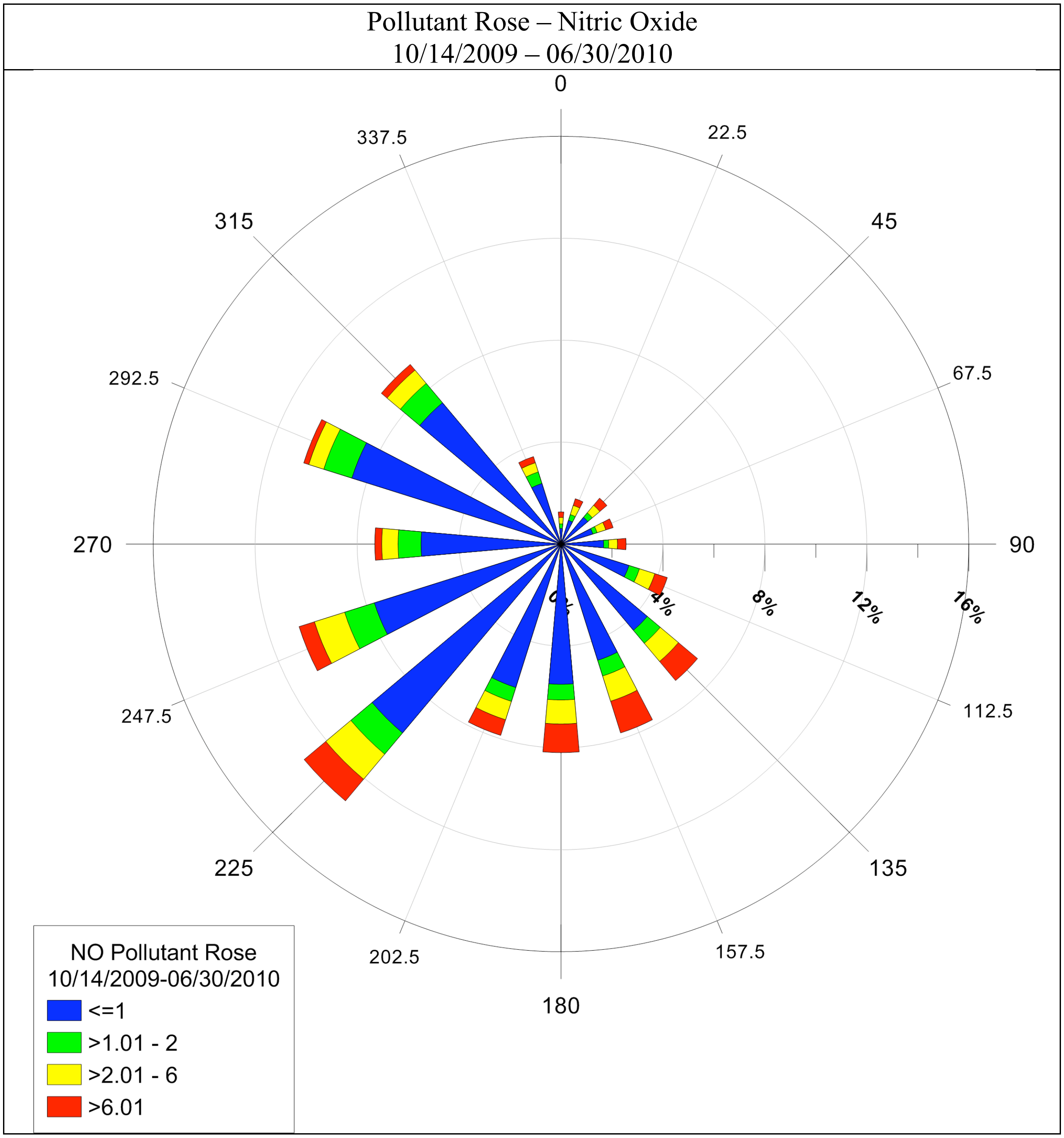


Figure 5-6. Olson Ranch NO_2 pollutant rose for the period 10/14/2009 – 06/30/2010.

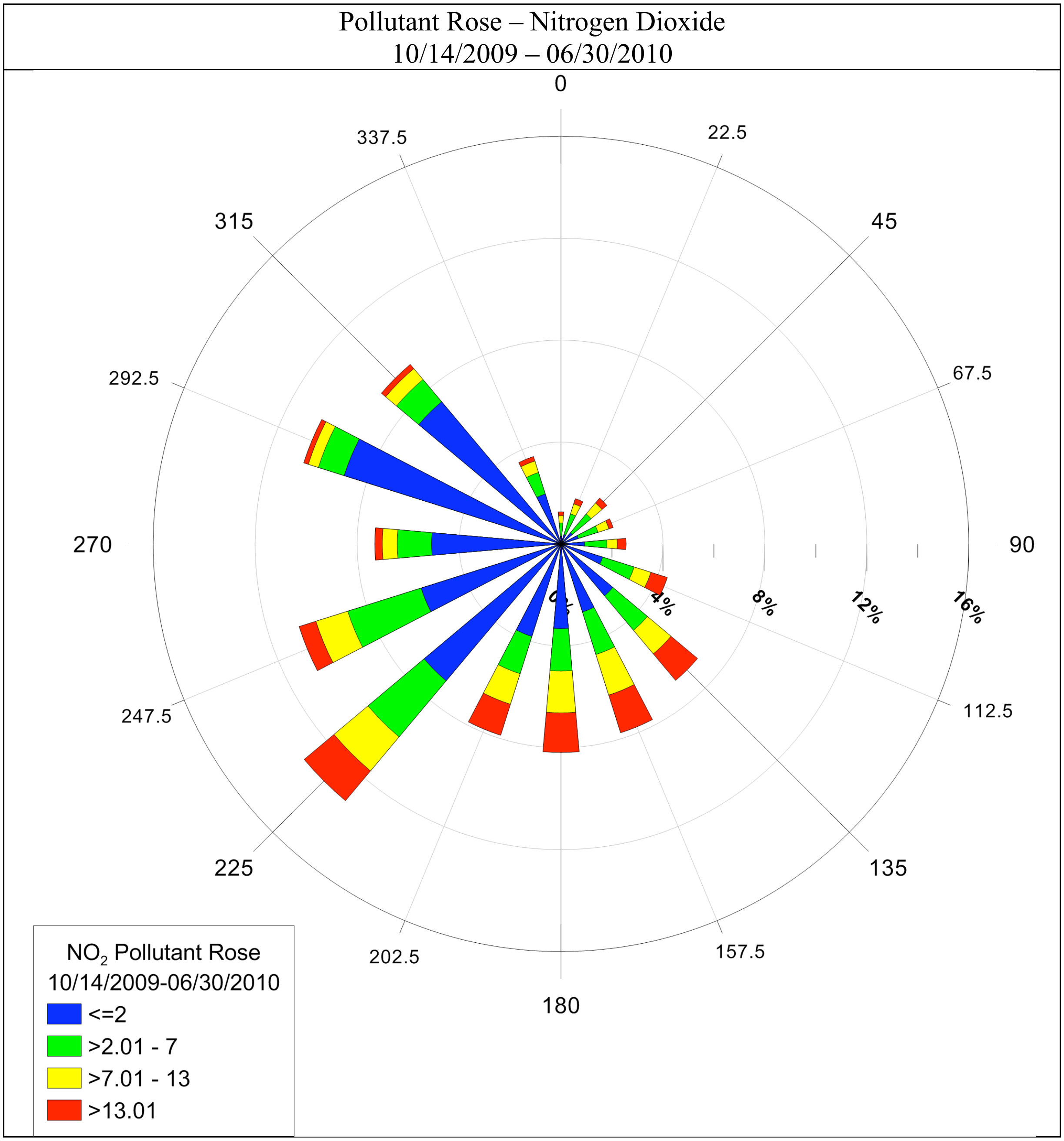


Figure 5-7. Olson Ranch O_3 pollutant rose for the period 10/14/2009 – 06/30/2010.

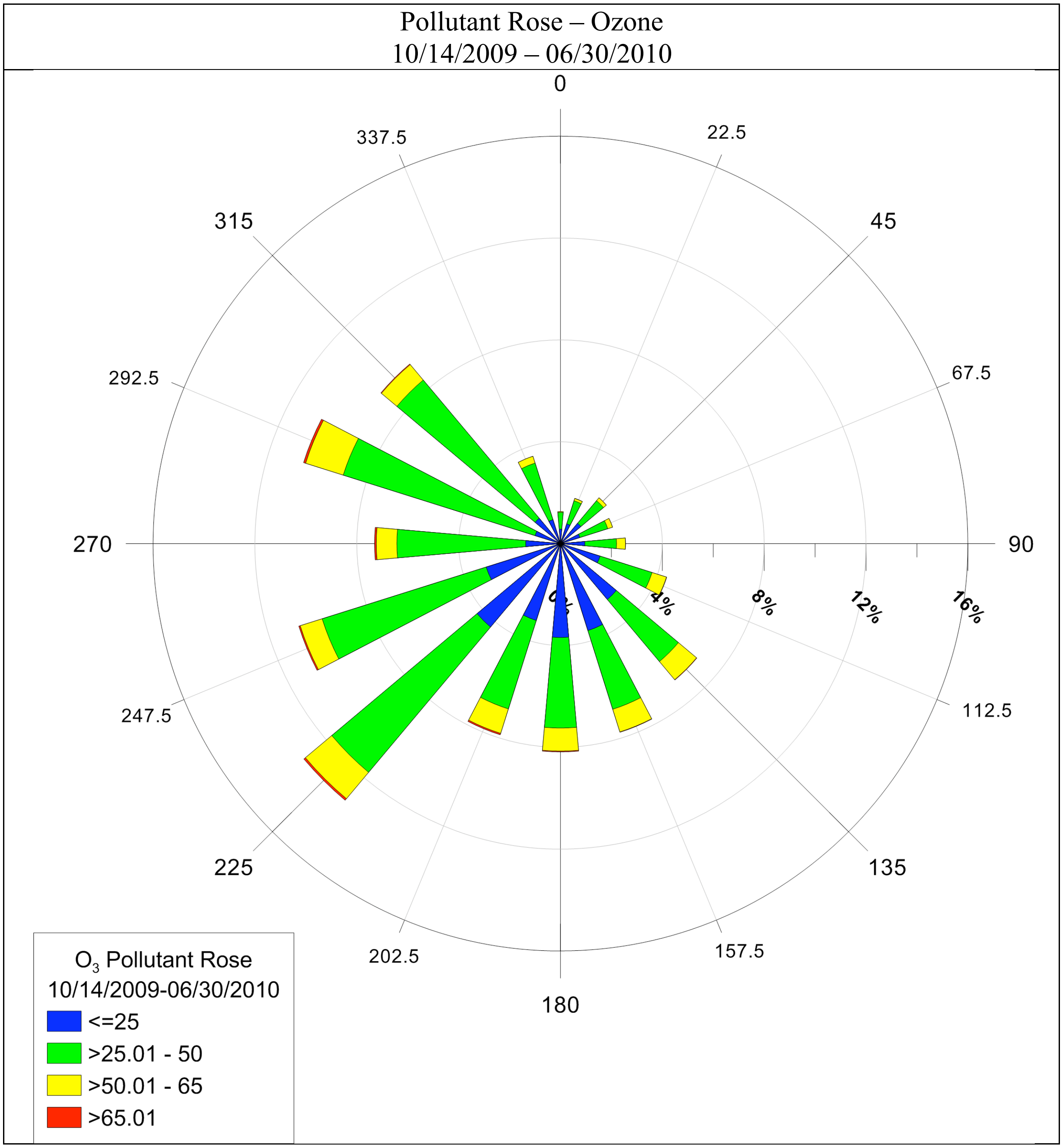
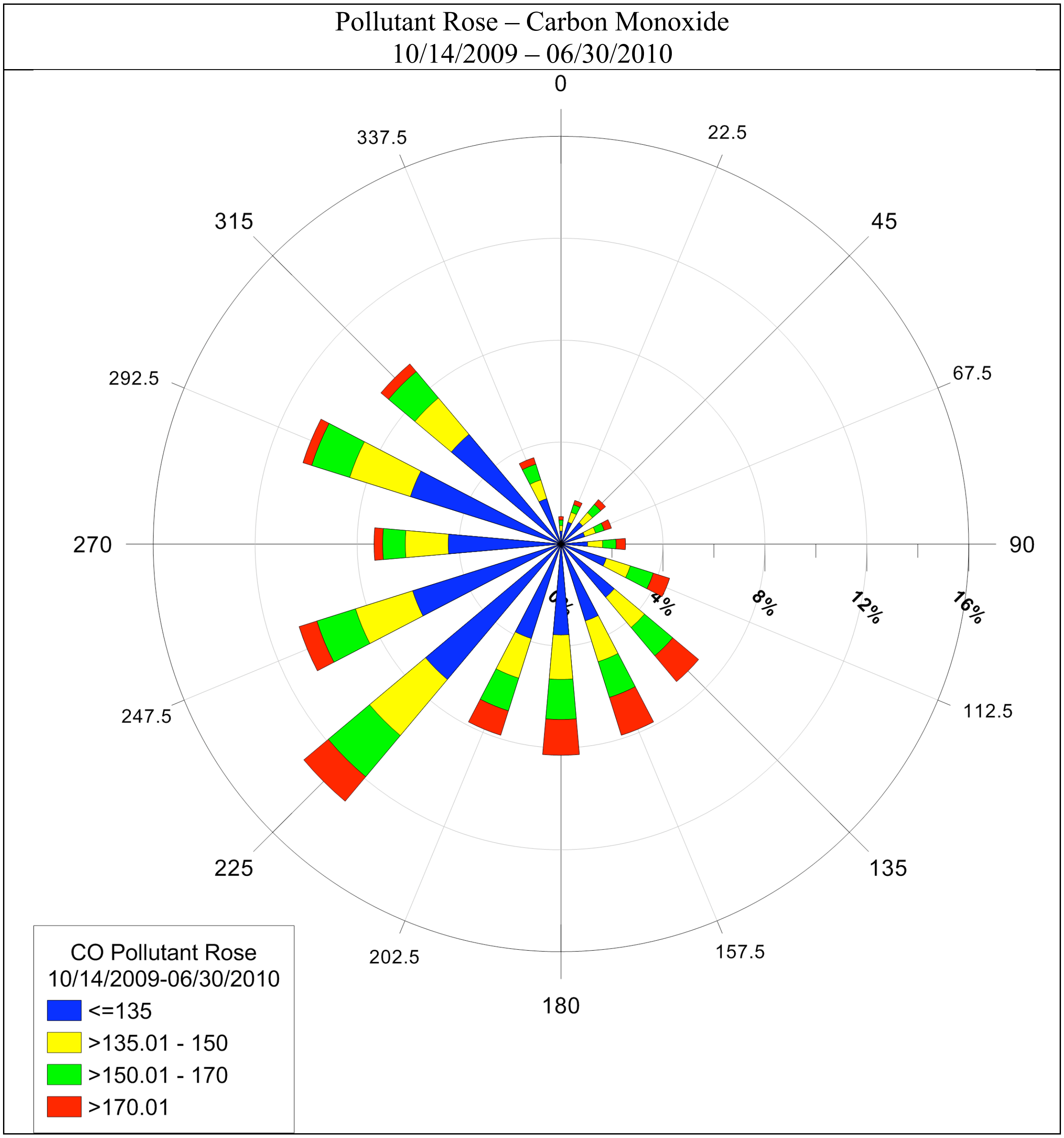


Figure 5-8. Olson Ranch CO pollutant rose for the period 10/14/2009 – 06/30/2010.



5.3.2 Gaseous Pollutant Time Series Plots

The following subsections describe data generated for each pollutant. Data are displayed in table form and graphically.

Diurnal plots, influenced by changing dispersion conditions throughout the day, are useful for gaining an insight into the contributions of various emission sources upon meteorologically driven variation. This section includes diurnal behavior plots constructed from hourly averaged values, an approach that enables hourly variations to be visualized. This section also displays time series plots of five-minute time averaged data. Longer time series plots that display sequential data are more useful to illustrate trends and deviations from normal conditions during the given monitoring period.

5.3.2.1 Methane

Table 5-8 presents highest and second highest daily 1-hour average CH_4 concentrations and highest daily twenty-four hour averages. As indicated by the pollution rose diagrams for CH_4, elevated concentrations were most associated with southerly wind directions. Table 5-8 shows that elevated hourly averages were present during months with colder temperatures. Dispersion conditions are generally poorest during colder conditions and consequently ambient concentrations are elevated. As shown by Table 5-8, the highest values are observed at times expected to have greater atmospheric stability and less vertical mixing and dilution.

Figure 5-9 shows the diurnal plot and Figure 5-10 shows the time series plot of ambient CH_4 concentrations over the whole of the operational period.

A noticeable feature of the diurnal plots is that the lowest ambient concentrations are consistently observed in the early afternoon and highest ambient concentrations are found early in the morning and late at night. Such behavior is consistent with the interaction of local emissions and meteorologically driven mixing. Mixing is less effective when inversion heights are lowest. This is the case for night-time conditions when cold ground temperatures do not warm the atmosphere and as such do not allow for greater mixing. During such conditions local ground level emission sources are more likely to contribute to ground level measurements. As CH_4 background is known to be approximately 1.85 ppm an increase above this value must reflect additional sources. Local ground level sources will have a lesser impact when emissions occur at times with greater mixing as the inversion height is much greater, leading to more dilution and lower ambient measurements. Given the reported level of CH_4, above background local emission sources are anticipated to contribute to the measured values.

The time series plot for CH_4 expands the diurnal behavior and displays longer-term trends and intermittent episodes unrelated to diurnal patterns. This possibility is enhanced by the use of five-minute, as opposed to hourly averaged, data for the time series plots. Figure 5-9 shows that levels of methane are frequently above background with a contribution from emission sources. The role of meteorology is important, as previously indicated, with elevated concentrations most evident from late–November to mid–March. The lack of any period with stable background levels is striking, with the month of May having the longest periods with background concentrations. This figure also shows that elevated concentrations are evident even during the warmer month of June.

Table 5-8. UW MAQML five highest daily 1-hour averages, 2nd highest daily 1-hour averages, and 24-hour averages for CH_4.

University of Wyoming Mobile Air Quality Monitoring Laboratory *5 Highest Daily 1-Hour Averages, 2nd Highest Daily 1-Hour Averages, and 24-Hour Averages for CH_4* Final Validation 10/14/2009 – 06/30/2010			
Highest Daily 1-Hour Averages			
Value	**Date**	**Hour**	**Concentration ppm**
1	12/11/09	9:00	5.76
2	12/05/09	2:00	5.47
3	01/11/10	9:00	5.45
4	12/12/09	4:00	5.41
5	12/15/09	9:00	5.32
2nd Highest Daily 1-Hour Averages			
1	12/05/09	3:00	5.40
2	12/11/09	8:00	5.27
3	12/15/09	8:55	5.26
4	03/29/10	7:00	5.23
5	01/12/10	8:00	5.22
Highest Daily 24-Hour Averages			
1	12/11/09	0-23:00	3.67
2	01/12/10	0-23:00	3.54
3	01/11/10	0-23:00	3.53
4	12/15/09	0-23:00	3.46
5	12/12/09	0-23:00	3.40

Figure 5-9. Olson Ranch CH_4 diurnal plot for the period 10/14/2009 – 06/30/2010.

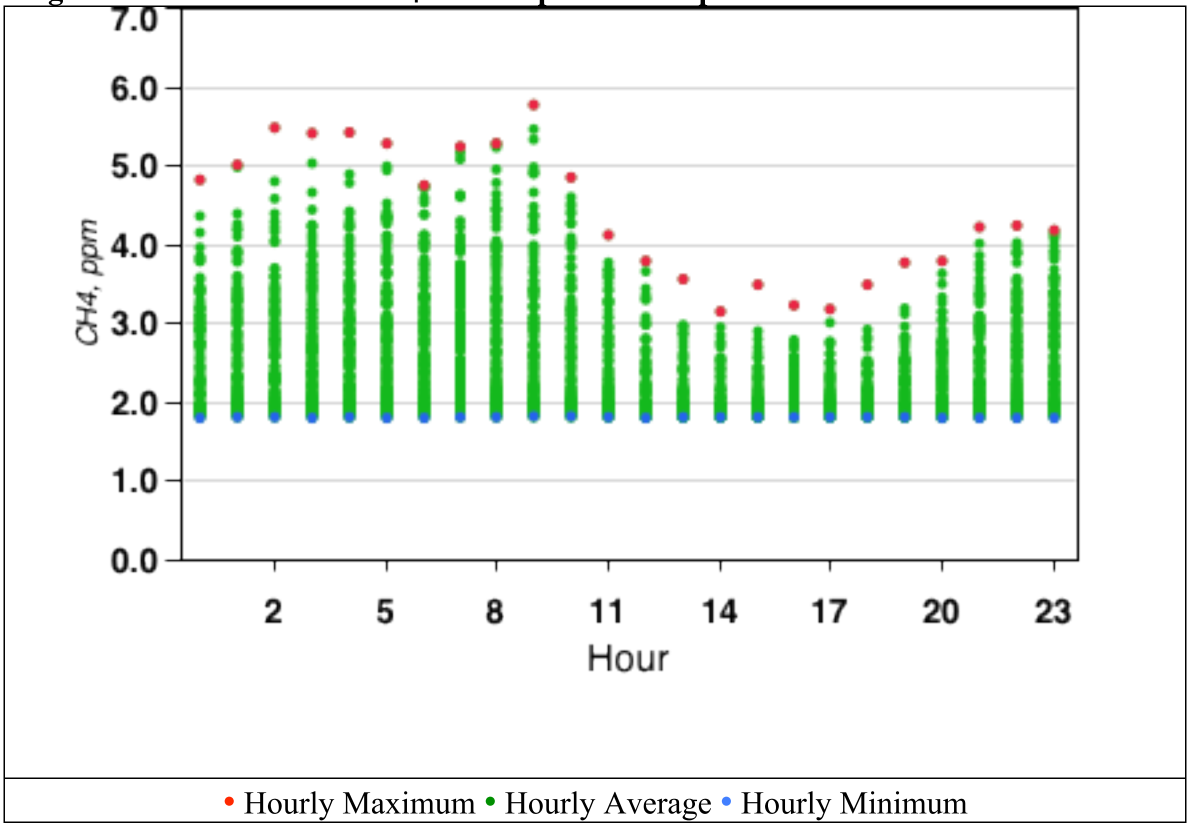
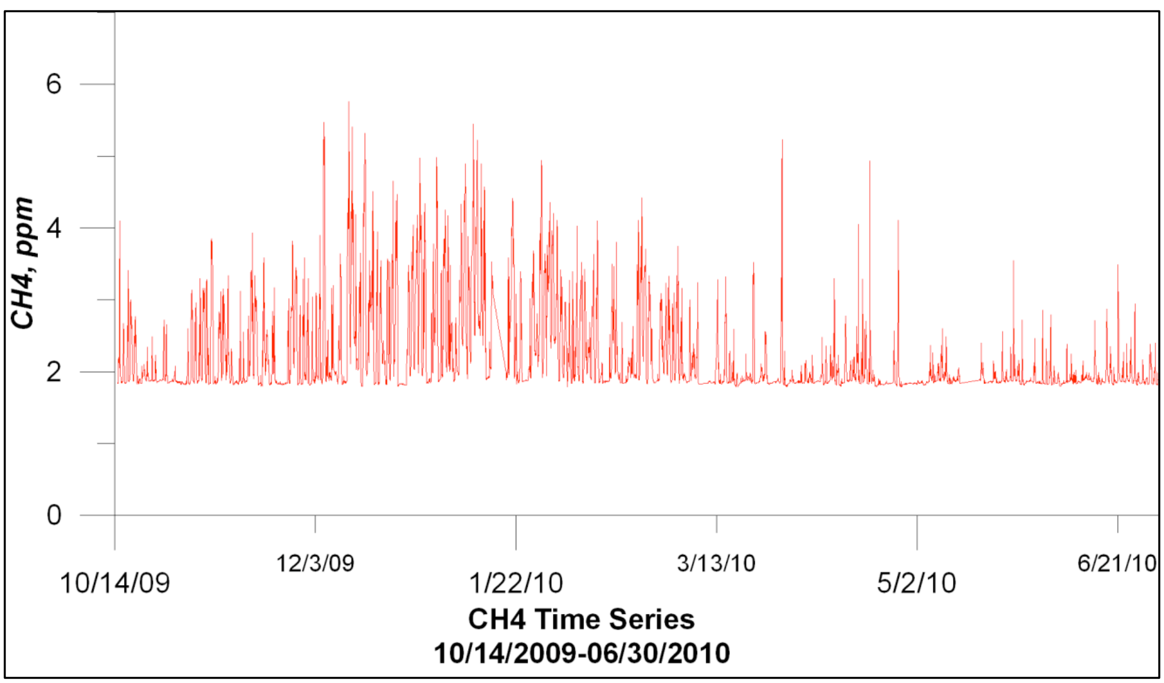


Figure 5-10. Olson Ranch CH_4 time series for the period 10/14/2009 - 06/30/2010.



5.3.2.2 Non-Methane Hydrocarbons

Table 5-9 presents highest and second highest daily one-hour average NMHC concentrations and highest daily twenty-four hour averages. Three of the five highest 24–hour average values for NMHC in Table 5-9 are on the same day as for CH_4. The strong relationship between CH4 and NHMC is explored in greater detail in the discussion section.

With respect to the diurnal plots, again a similarity to CH_4 is evident. There is one dominant pattern, lowest concentrations in the early afternoon hours. In addition to emission source variation, the influence of the relatively low concentrations of NMHC is of importance. Levels are often not measurable with values of 0.00 ppb frequently reported.

The time series plot for NMHC expands the diurnal behavior and allows for visualization of longer-term trends and intermittent episodes unrelated to diurnal patterns. This possibility is enhanced by the use of five-minute, as opposed to hourly averaged data for the time series plots. The time series figure for NMHC mirrors the behavior evident for CH_4.

Table 5-9. UW MAQML five highest daily 1-hour averages, 2nd highest daily 1-hour averages, and 24-hour averages for NMHC.

University of Wyoming Mobile Air Quality Monitoring Laboratory *5 Highest Daily 1-Hour Averages, 2nd Highest Daily 1-Hour Averages, and 24-Hour Averages for NMHC* Final Validation 10/14/2009 – 06/30/2010			
Highest Daily 1-Hour Averages			
Value	**Date**	**Hour**	**Concentration ppm**
1	1/11/10	9:00	0.53
2	12/12/09	3:00	0.51
3	12/29/09	1:00	0.50
4	01/02/10	3:00	0.50
5	01/13/10	9:00	0.48
2nd Highest Daily 1-Hour Averages			
1	01/12/10	8:00	0.50
2	12/12/09	4:00	0.49
3	12/29/09	0:00	0.48
4	01/28/10	8:00	0.47
5	01/02/10	5:00	0.46
Highest Daily 24-Hour Averages			
1	01/11/10	0-23:00	0.27
2	01/12/10	0-23:00	0.26
1	12/11/09	0-23:00	0.26
2	12/12/09	0-23:00	0.25
3	01/30/10	0-23:00	0.24

Figure 5-11. Olson Ranch NMHC diurnal plot for the period 10/14/2009 – 06/30/2010.

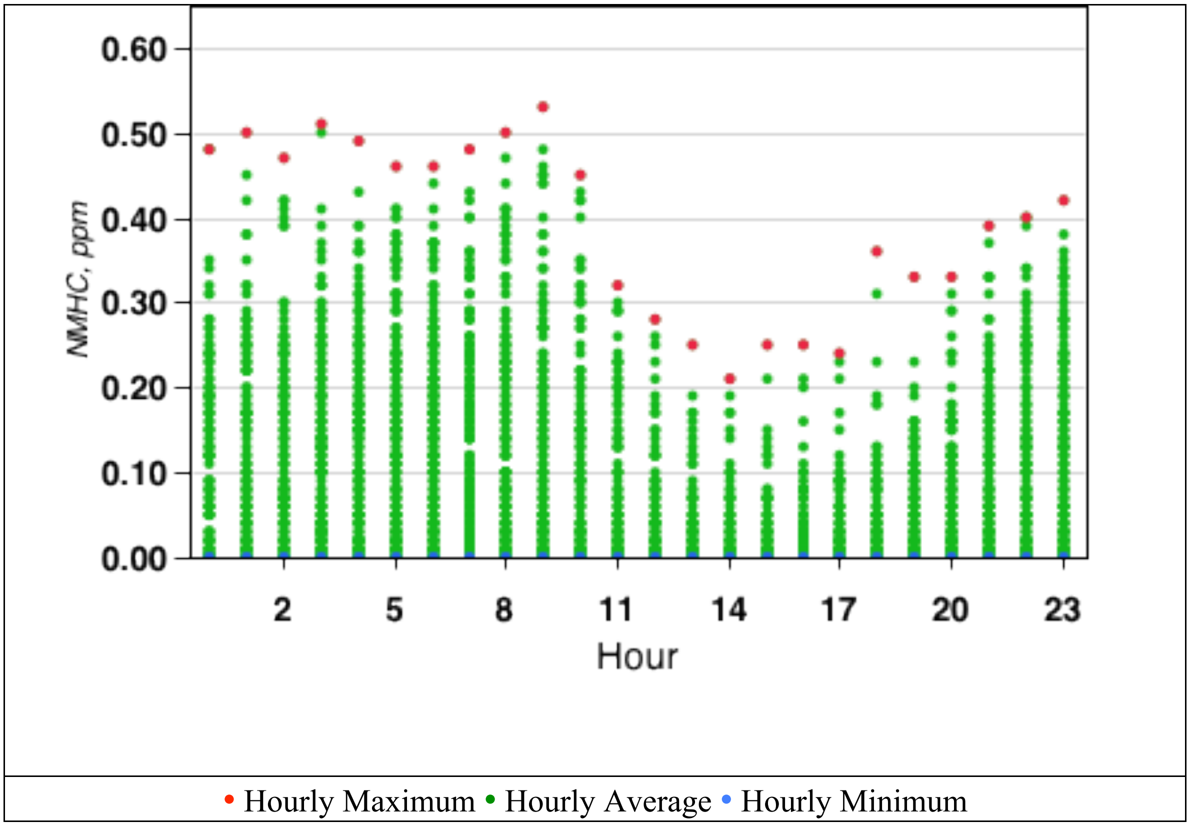
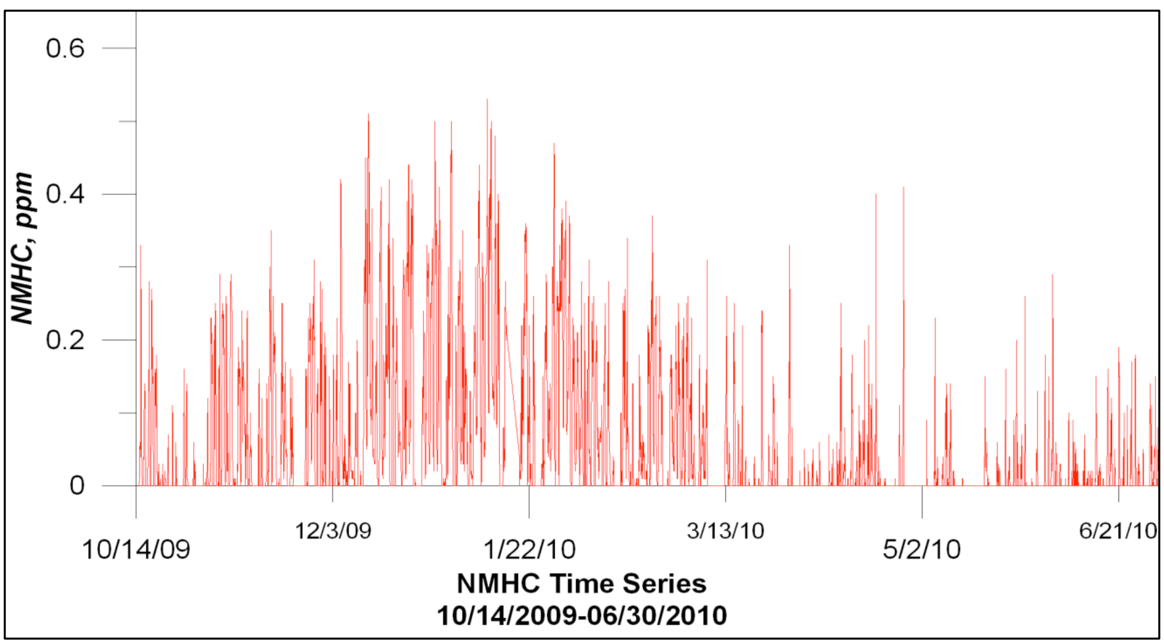


Figure 5-12. Olson Ranch NMHC time series for the period 10/14/2009 – 06/30/2010.



5.3.3 Oxides of Nitrogen

Table 5-10 presents highest and second highest daily one-hour average NO_x concentrations, and highest daily 24–hour averages. The times associated with the highest concentrations in this table are different to the times of the highest concentrations for the hydrocarbon measurements. Since the measurements are simultaneous this behavior could be due to having a different balance of contributing emission sources for NO_x than for methane and NMHC. NO_x measurements, as the combination of NO and NO_2, can be considered a hybrid of a primary and a secondary pollutant. NO is considered a primary pollutant of combustion systems. While some combustion systems can directly produce NO_2, more often this pollutant is formed from the reaction of NO to form NO_2. NO_2 is classed as a secondary pollutant. This reaction may occur during the emission process or at a position downwind. Measured NO_x concentrations can indicate the influence of both emission sources and reaction chemistry, therefore the position of sampling relative to emission sources is an important consideration. Ignoring of seasonal influences upon emissions and atmospheric chemistry, locations close to direct emission sources will tend to have relatively high NO compared to those at sites downwind of emission sources. All of the five highest and second highest 1-hour values occur during time associated with motor traffic movement. While the hours of 07:00, 08:00, 18:00 and 19:00 are assumed to be times of maximum traffic movement this is an assumption that is not based on systematic traffic counting data. When considering the highest daily average values again the importance of seasonality is shown with highest values in colder months.

With respect to the diurnal plots, Figure 5-13, the typical behavior is a morning peak followed by a mid–day trough and a late afternoon peak. While there are some similarity with respect to night-time high and mid–afternoon low, it is clear that hours associated with traffic flow have the highest concentrations. The NO_x concentration during morning peak hours is generally not more than 30 ppb.

The time series plot for $NO_{x,}$ Figure 5-14, reinforces the benefits indicated earlier of viewing short time averaged data over relatively long times. Again, highest concentrations are during winter months.

Table 5-10. UW MAQML 5 highest daily 1-hour averages, 2nd highest daily 1-hour averages, and 24-hour averages for NO_x.

University of Wyoming Mobile Air Quality Monitoring Laboratory *5 Highest Daily 1-Hour Averages, 2nd Highest Daily 1-Hour Averages, and 24-Hour Averages for NO_x* Final Validation 10/14/2009 – 06/30/2010			
Highest Daily 1-Hour Averages			
Value	**Date**	**Hour**	**Concentration ppb**
1	1/20/10	17:00	71.0
2	1/28/10	08:00	70.2
3	11/03/09	07:00	64.3
4	11/04/09	18:00	62.9
5	11/18/09	07:00	61.4
2nd Highest Daily 1-Hour Averages			
1	01/28/10	07:00	61.4
2	12/15/09	08:00	57.0
3	11/19/09	18:00	56.2
4	12/11/09	19:00	51.5
5	02/04/10	07:00	51.1
Highest Daily 24-Hour Averages			
1	12/11/09	0-23:00	30.1
2	01/28/10	0-23:00	23.6
3	12/16/09	0-23:00	23.5
4	01/11/10	0-23:00	21.4
5	12/12/09	0-23:00	20.9

Figure 5-13. Olson Ranch NO_x diurnal plot for the period 10/14/2009 – 06/30/2010.

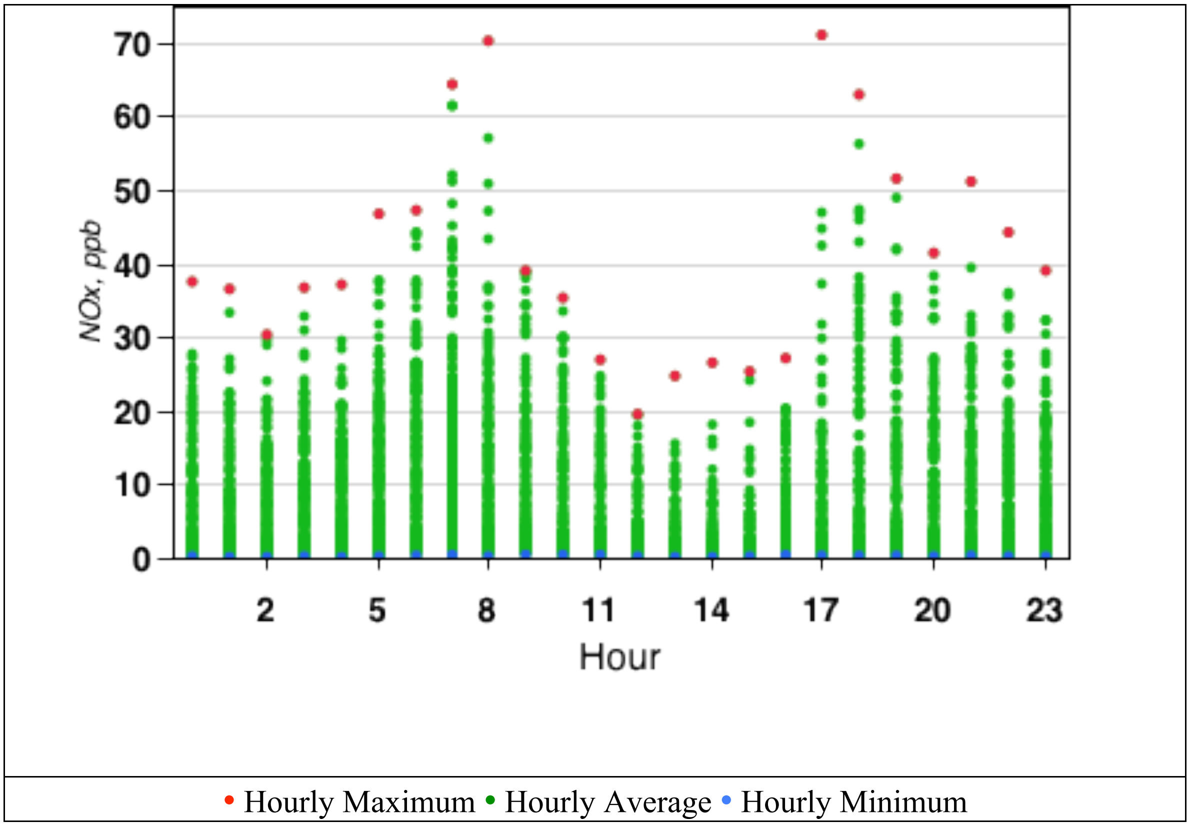
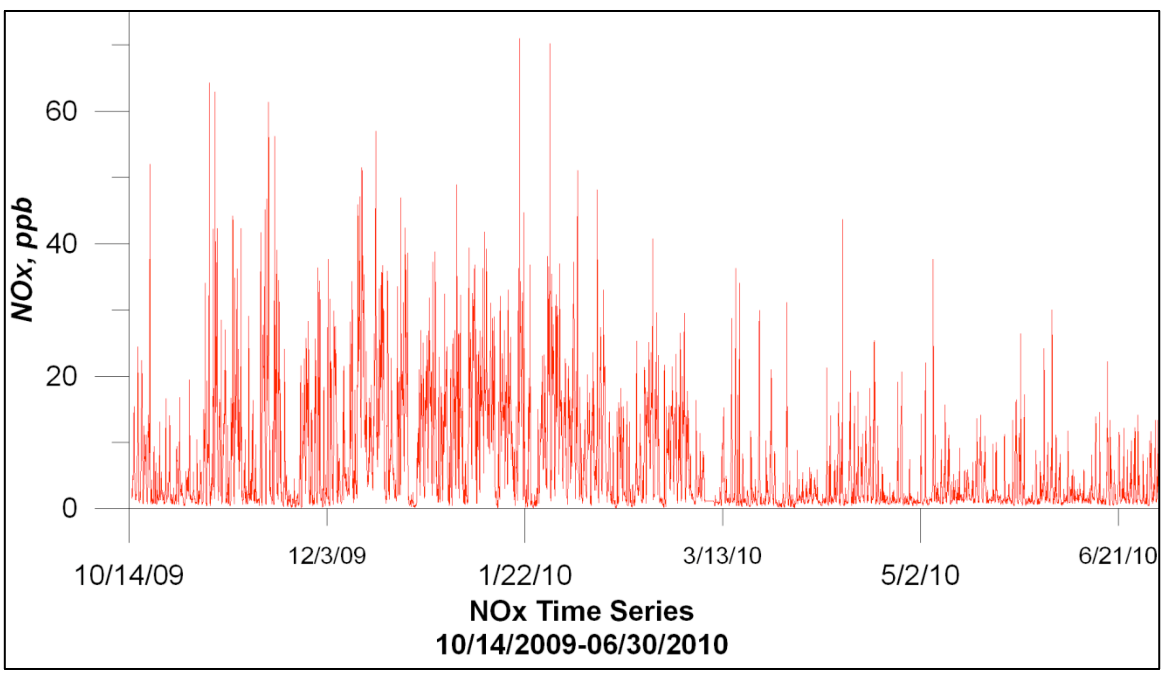


Figure 5-14. Olson Ranch NO_x time series for the period 10/14/2009 – 06/30/2010.



5.3.4 Nitric Oxide

Table 5-11 presents highest and second highest daily one–hour average NO concentrations, and highest daily 24–hour averages. The times that are represented in this table are similar to those given in Table 5-10, in particular for one-hour maximum values. This is no surprise given that NO is a one of the two components of the NO_x measurement. Three of the five highest one-hour average values for NO in Table 5-11 are the exact same hour as for NO_x. Figures 5-15 through 5-16 represent the diurnal plot and time series plot of ambient NO concentrations the monitoring site over the O3i operational period.

With respect to the diurnal plot for NO, Figure 5-15, the typical behavior is a morning peak followed by a mid day trough and a late afternoon rise in concentrations. The afternoon pattern shows divergence from that for NO_x. with a more pronounced morning compared to afternoon peak.

The time series plot for NO, Figure 5-16, indicates a behavior similar to that of NO_x, albeit with a lower magnitude.

Table 5-11. UW MAQML five highest daily 1-hour averages, 2nd highest daily 1-hour averages, and 24-hour averages for NO.

University of Wyoming Mobile Air Quality Monitoring Laboratory *5 Highest Daily 1-Hour Averages, 2nd Highest Daily 1-Hour Averages, and 24-Hour Averages for NO* Final Validation 10/14/2009 – 06/30/2010			
Highest Daily 1-Hour Averages			
Value	**Date**	**Hour**	**Concentration ppb**
1	11/03/09	07:00	58.5
2	11/18/09	07:00	55.1
3	01/28/10	08:00	49.3
4	11/04/09	18:00	44.2
5	10/19/09	07:00	39.7
2nd Highest Daily 1-Hour Averages			
1	11/18/09	08:00	44.8
2	11/09/09	07:00	38.3
3	11/17/09	07:00	37.3
4	01/28/10	07:00	36.9
5	11/03/09	06:00	36.1
Highest Daily 24-Hour Averages			
1	11/18/09	0-23:00	12.3
2	12/11/09	0-23:00	10.1
3	11/17/09	0-23:00	9.7
4	11/05/09	0-23:00	8.8
5	01/28/10	0-23:00	8.6

Figure 5-15. Olson Ranch NO diurnal plot for the period 10/14/2009 – 06/30/2010.

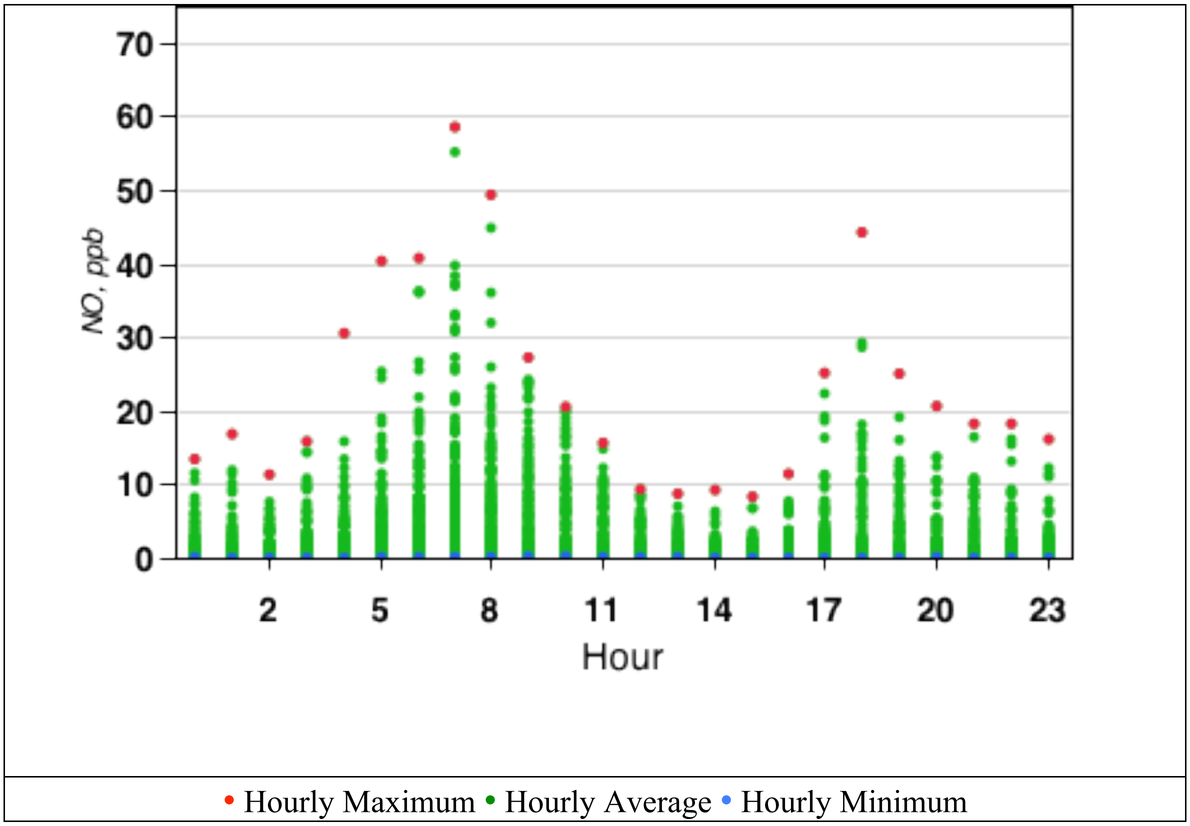
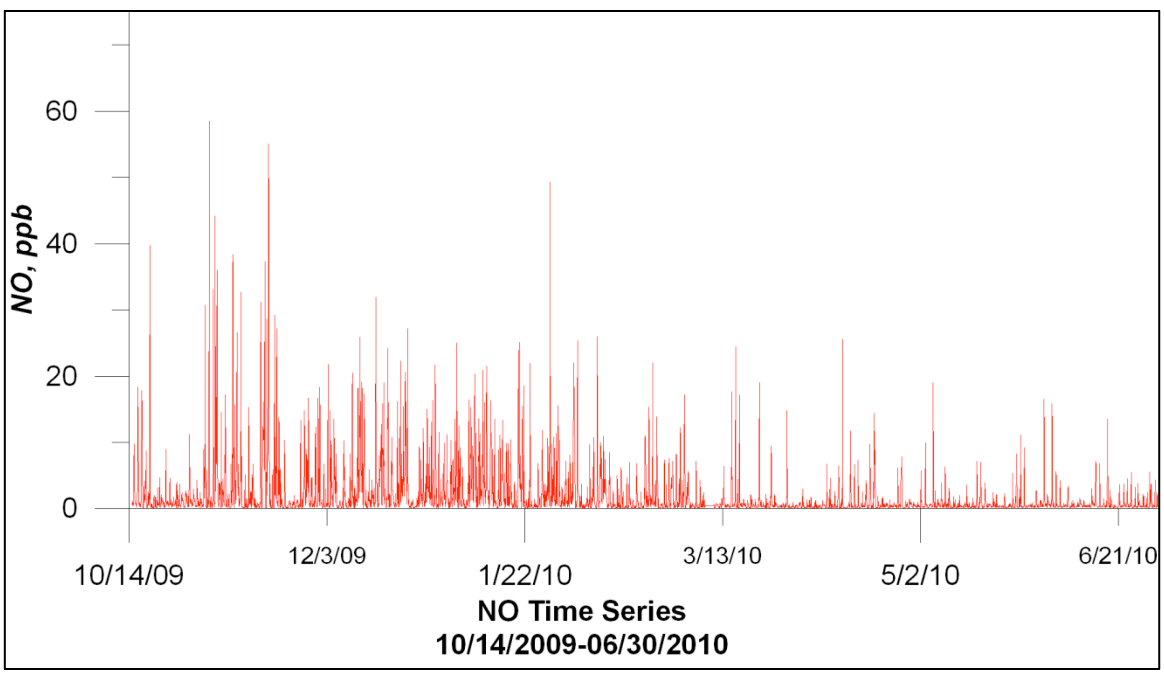


Figure 5-16. Olson Ranch NO time series for the period 10/14/2009 – 06/30/2010.



5.3.5 Nitrogen Dioxide

Table 5-12 presents highest and second highest daily 1-hour average NO_2 concentrations, and highest daily twenty-four hour averages. The times of day that are represented in this table show that NO_2 1-hour maximum values occur at different times of day to those of NO. This may be expected given NO_2 is a secondary pollutant. Figures 5-17 and Figure 5-18 represent the diurnal and time series plots of ambient NO_2 concentrations during operational period.

With respect to the diurnal plot for NO_2, the typical behavior is a morning peak followed by a mid–day trough and a late–afternoon peak in concentration. The afternoon pattern shows divergence from that shown for NO_x and NO. This can be expected for a secondary pollutant whose main production route is through daytime photochemical reaction. NO_2 is a product from the reaction:

$NO + O_3 \rightarrow NO_2 + O_2$.

This reaction consumes O_3. NO_2 is produced via a photochemical production during which it may serve as an ozone precursor.

NO_2 + sunlight $\rightarrow NO + O$, then $O + O_2 \rightarrow O_3$

When peroxy and hydro-peroxy radical chemistry is considered, there is net production of NO_2 which does not consume O_3. During this time NO_2 may also serve as a precursor to O_3 based on the above reaction.

The time series plots of NO_2 indicate a similar behavior as that of NO_x, albeit with a lower magnitude.

Table 5-12. UW MAQML five highest daily 1-hour averages, 2nd highest daily 1-hour averages, and 24-hour averages for NO_2.

University of Wyoming Mobile Air Quality Monitoring Laboratory *5 Highest Daily 1-Hour Averages, 2nd Highest Daily 1-Hour Averages, and 24-Hour Averages for NO_2* Final Validation 10/14/2009 – 06/30/2010			
Highest Daily 1-Hour Averages			
Value	**Date**	**Hour**	**Concentration ppb**
1	01/20/10	17:00	45.9
2	12/11/09	21:00	32.9
3	12/12/09	00:00	31.6
4	01/30/10	19:00	28.4
5	12/15/09	07:00	27.9
2nd Highest Daily 1-Hour Averages			
1	12/11/09	19:00	32.4
2	01/20/10	18:00	30.9
3	12/10/09	18:00	27.8
4	01/29/10	18:00	27.8
5	01/27/10	18:00	27.5
Highest Daily 24-Hour Averages			
1	12/11/09	0-23:00	20.0
2	12/12/09	0-23:00	17.4
3	12/16/09	0-23:00	17.4
4	12/15/09	0-23:00	15.4
5	01/30/10	0-23:00	15.3

Figure 5-17. Olson Ranch NO_2 diurnal plot for the period 10/14/2009 – 06/30/2010.

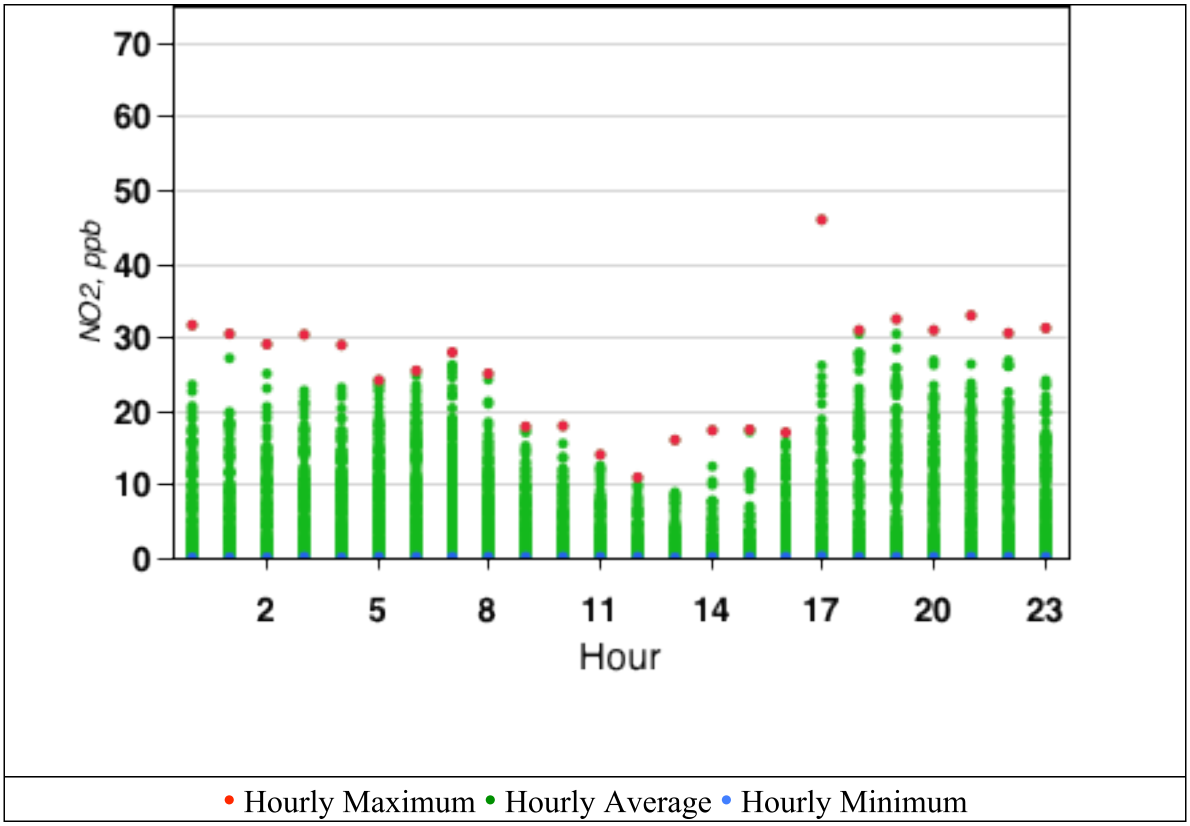
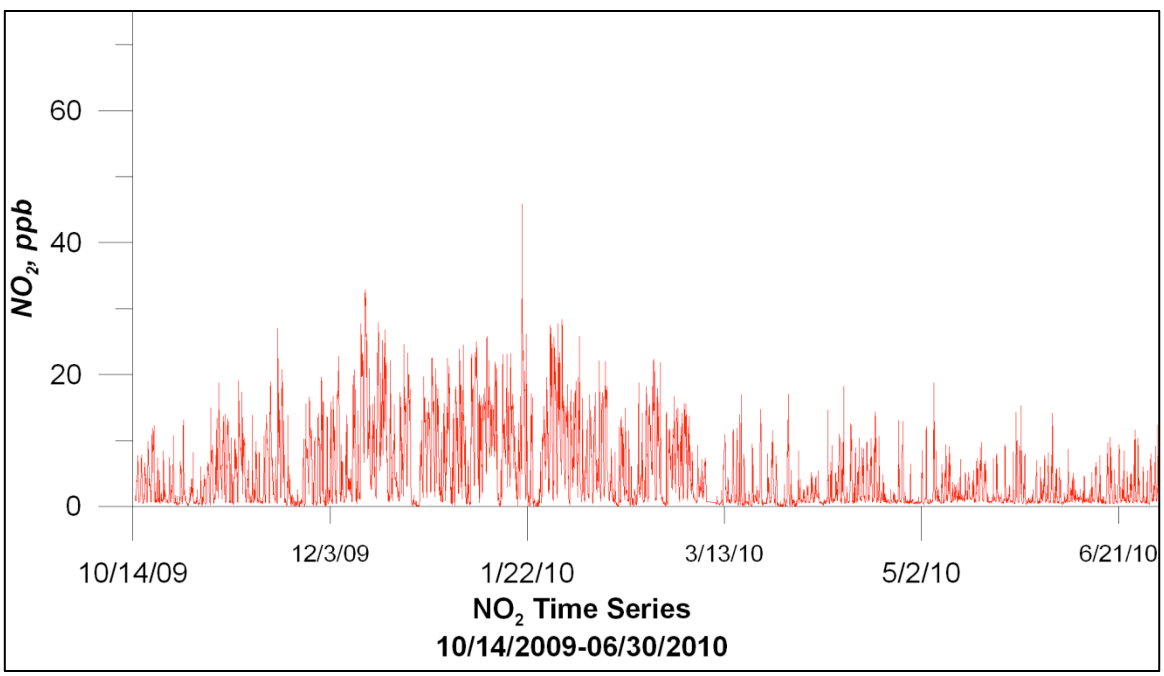


Figure 5-18. Olson Ranch NO_2 time series for the period 10/14/2009 – 06/30/2010.



5.3.6 Ozone Data Summaries

Table 5-13 presents the ten highest daily one-hour average O_3 concentrations that occurred. Three days are represented as 1/30/2010, 4/9/2010 and 6/8/2101. It is noteworthy that two of these days are outside the monitoring period used by the Upper Green River Ozone Study. These days are explored in greater detail in the discussion section of this report. Table 5-14 presents the ten highest daily 8-hour average O_3 concentrations. Again, all of these values are during the aforementioned days. The concentrations are below the standard value of 0.075 ppm but three values are 0.070 and two values are 0.071. A new ozone standard is currently under consideration by the US EPA. These values may exceed the revised standard that is due be announced on October 31, 2010.

Figures 5-19 through 5-20 represent the diurnal plot and time series plot of ambient O_3 concentrations for the O3i operational period. With respect to the diurnal plot the typical behavior is a rise from an early morning trough to an afternoon peak followed by a decline.

The time series plots for O_3 once again reinforce the benefits indicated earlier of viewing short time averaged data over relatively long time periods. Once more, the three days with elevated concentrations are clearly visible. It is interesting to note that spring months have more elevated values than winter months.

Table 5-13. UW MAQML ten highest daily 1-hour average concentrations for O_3.

University of Wyoming Mobile Air Quality Monitoring Laboratory 10 Highest Daily 1-Hour Average Maximum Concentrations 10/14/2009 – 06/30/2010			
Value	**Date**	**Hour**	**Concentration ppb**
1	06/08/10	17:00	78
2	06/08/10	18:00	77
3	04/09/10	15:00	76
4	06/08/10	16:00	76
5	01/30/10	14:00	74
6	04/09/10	16:00	74
7	04/09/10	14:00	73
8	01/30/10	15:00	73
9	04/09/10	17:00	73
10	06/08/10	15:00	71

Table 5-14. UW MAQML summary of the ten highest daily maximum 8-hour averages.

University of Wyoming Mobile Air Quality Monitoring Laboratory Summary of the 10 Highest Daily Maximum 8-Hour Averages 10/14/2009 – 06/30/2010			
Value	**Date**	**Hour**	**Concentration ppb**
1	06/08/10	18:00	71
2	06/08/10	19:00	71
3	06/08/10	20:00	70
4	04/09/10	18:00	70
5	04/09/10	19:00	70
6	06/08/10	17:00	69
7	06/08/10	21:00	69
8	04/09/10	17:00	69
9	04/09/10	20:00	68
10	04/09/10	16:00	67

Figure 5-19. Olson Ranch O_3 diurnal chart for the period 10/14/2009 – 06/30/2010.

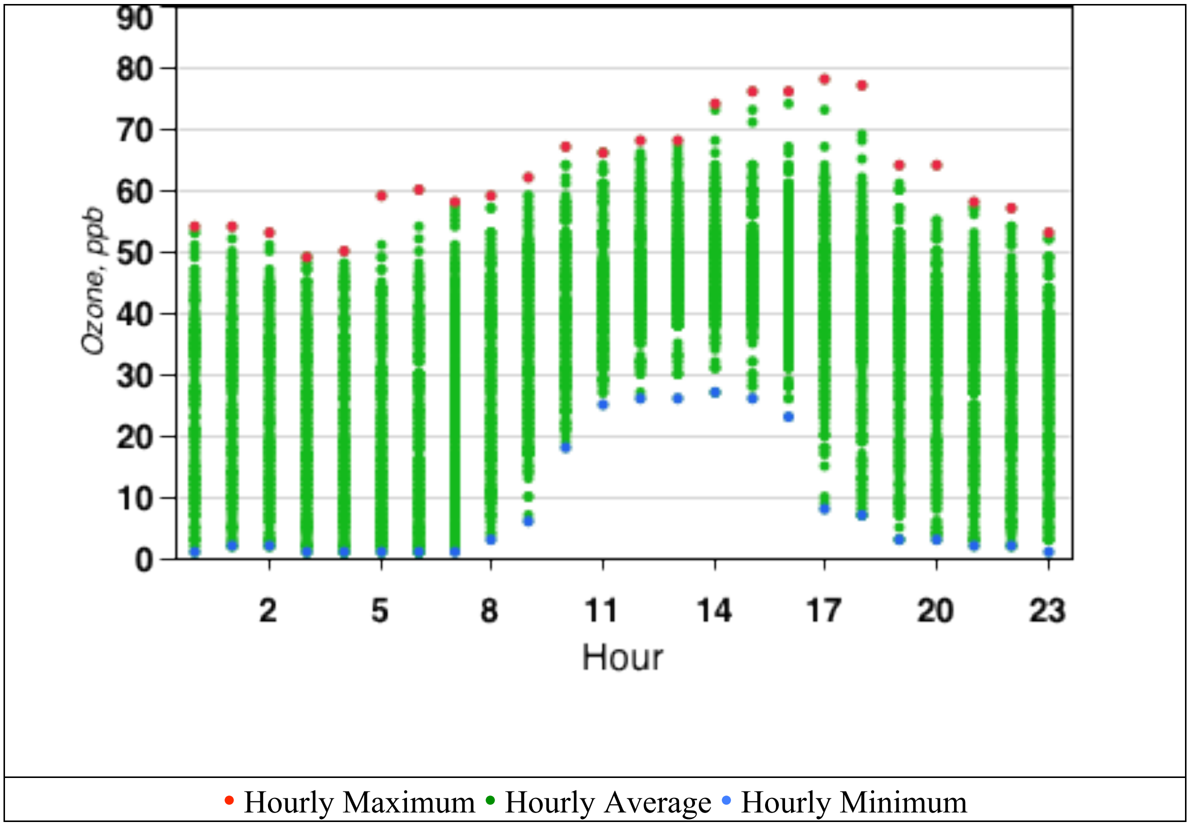
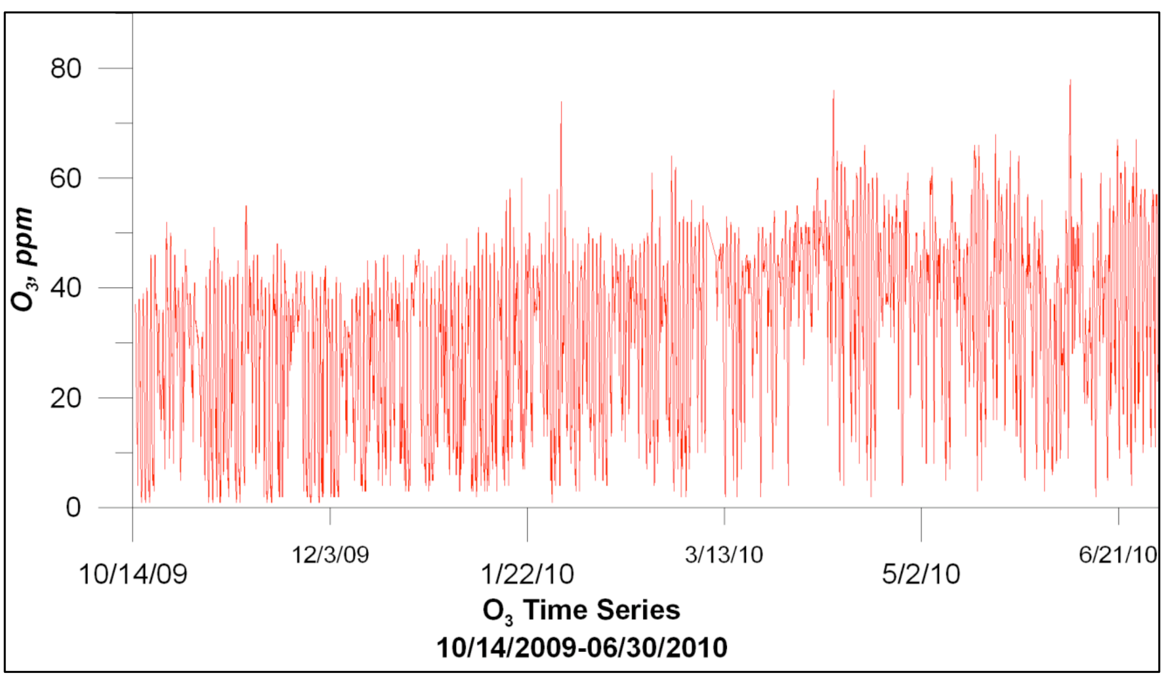


Figure 5-20. Olson Ranch O_3 time series for the period 10/14/2009 – 06/30/2010.



5.3.7 Carbon Monoxide

Table 5-12 presents highest and second highest daily 1-hour average CO concentrations, and highest daily twenty-four hour averages that occurred. Levels show the dominance of tropospheric background throughout the monitoring period. While the highest levels are relatively low these values are associated with morning traffic hours. A slight morning contribution could be interpreted from Figure 5-21. The time series plot of CO shows a classic background rise during the winter.

Table 5-12. UW MAQML five highest daily 1-hour averages, 2nd highest daily 1-hour averages, and 24-hour averages for CO.

University of Wyoming Mobile Air Quality Monitoring Laboratory *5 Highest Daily 1-Hour Averages, 2nd Highest Daily 1-Hour Averages, and 24-Hour Averages for NO_2* Final Validation 10/14/2009 – 06/30/2010			
Highest Daily 1-Hour Averages			
Value	**Date**	**Hour**	**Concentration ppb**
1	12/12/09	10:00	291
2	02/24/10	08:00	285
3	02/22/10	09:00	283
4	01/09/10	07:00	282
5	12/11/09	08:00	282
2nd Highest Daily 1-Hour Averages			
1	02/28/10	10:00	280
2	01/18/10	09:00	267
3	01/12/10	07:00	267
4	01/13/10	09:00	263
5	02/17/10	08:00	260
Highest Daily 24-Hour Averages			
1	01/18/10	0-23:00	196
2	01/20/10	0-23:00	189
3	12/12/09	0-23:00	187
4	01/12/10	0-23:00	185
5	12/11/110	0-23:00	184

Figure 5-21. Olson Ranch CO diurnal plot for the period 10/14/2009 – 06/30/2010.

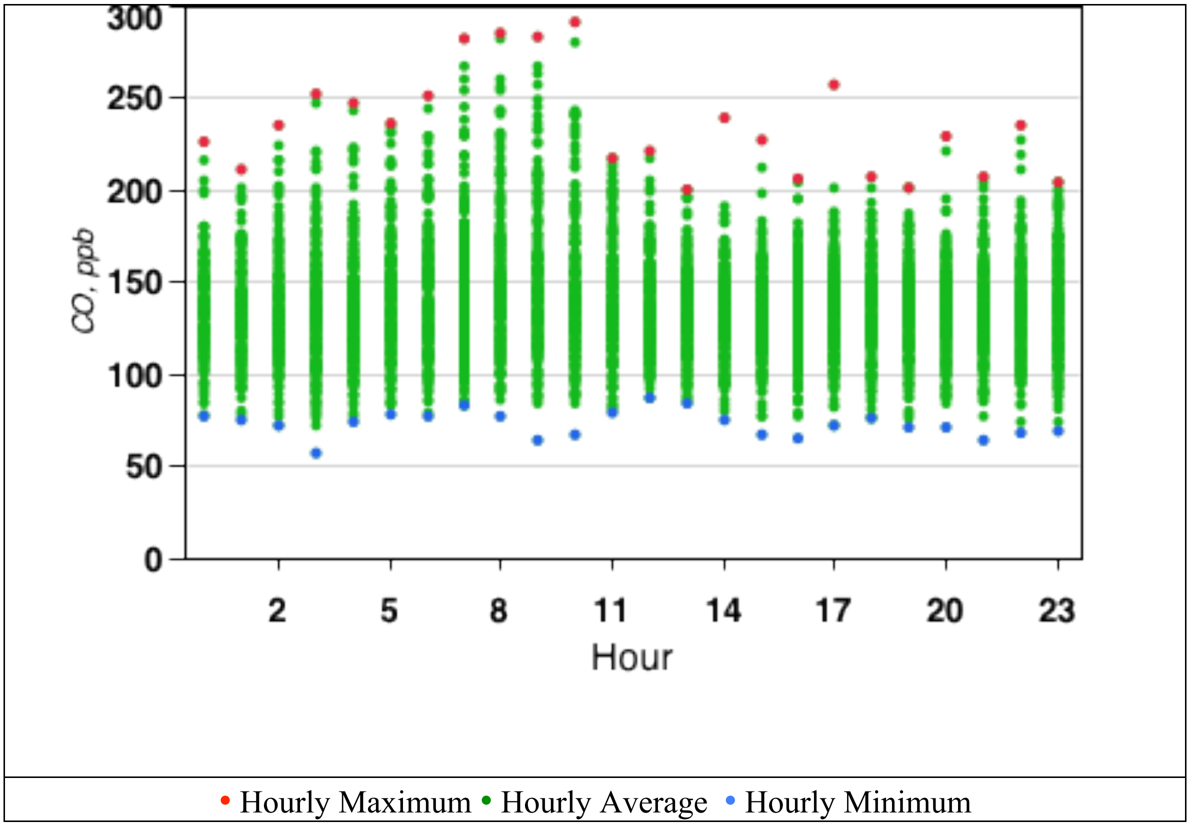
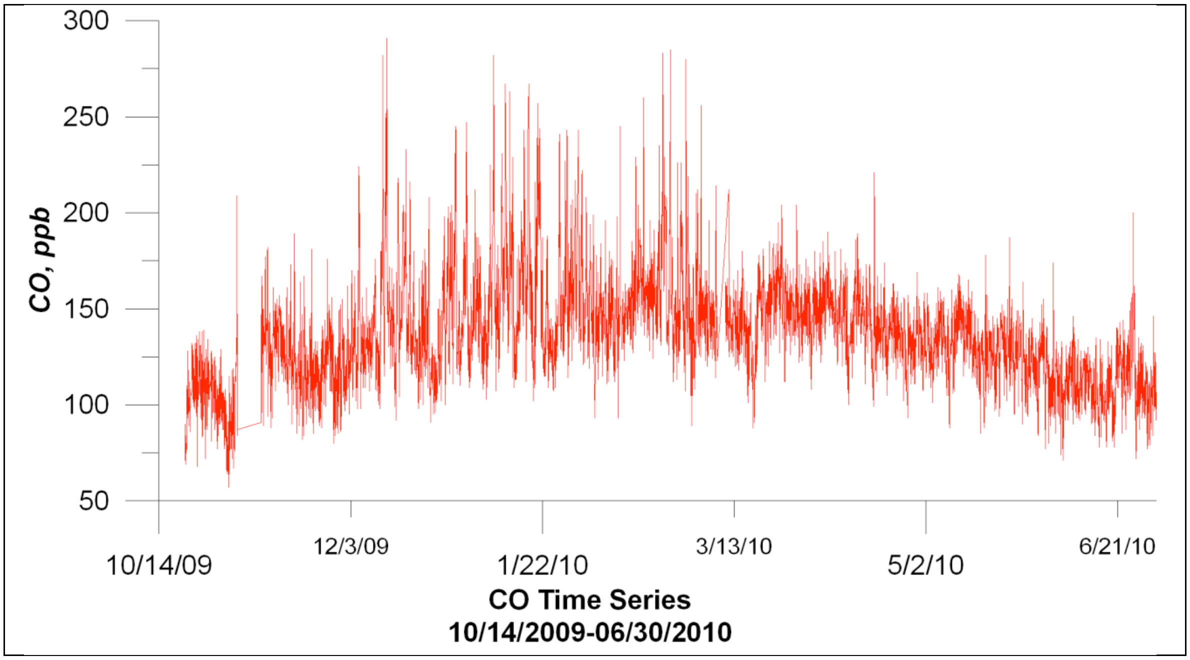


Figure 5-22. Olson Ranch CO time series for the period 10/14/2009 – 06/30/2010.



6.0 DISCUSSION

The purpose of our final report for the second year of the O3i study is to present the main monitoring findings. As such, analysis presented in this section is intended to further elaborate the behavior of the air pollutants measured through the operation of the MAQML for O3i. Particular attention is given to CH_4 and NMHC since these measurements are unique for the region.

Three ozone episodes (one-hour average greater than 70 ppb) occurred at Olson Ranch during the first 6 months of 2010, on January 30, April 9, and June 8. For each of these days, ozone (O_3) was observed to peak in mid-afternoon. The measured mixing ratio data for ozone, methane (CH_4), non-methane hydrocarbons (NMHC), total oxides of nitrogen (NO_x), nitric oxide (NO), and nitrogen dioxide (NO_2) have been reviewed for the five day periods that encompass the episode days. This analysis results in the following observations.

6.0.1 JANUARY EPISODE

This episode has been acknowledged by the WDEQ-AQD as a winter-time ozone episode. As indicated by Figure 6-1 CH_4 and NMHC concentrations show frequent periods of elevated concentration throughout the period January 28 – February 1, 2010 with only late afternoon time periods showing levels close to background concentrations. Methane and NMHC mixing ratios are approximately constant throughout the five day period, except during the afternoon hours when they are regularly reduced by almost a factor of two, down to background levels. As CH_4 is largely un-reactive over time scales of a few hours, the observed variability probably has its origin in meteorological influencing factors, such as changes in wind direction and speed or vertical ventilation efficiency. The mixing ratio rise after sunset can be explained by continuing emissions into a developing stable surface inversion layer accompanying nocturnal cooling coupled with a simultaneous reduction in wind speeds. Meteorological analyses are required to elucidate the validity of this hypothesis.

Figure 6-2 shows that NO_x, NO and NO_2 concentrations followed the broad episodic behavior of the hydrocarbon measurements with addition spiking. This indicates both commonality of contributing emission sources and the influence of diurnal meteorologically driven changes, with a likely additional source of oxides of nitrogen. CH_4 and NO_x, averaged over a few hours, also show a positive correlation, with minima during the afternoon hours. This may be due to ventilation effects, but it may also arise in part from reactive removal of NO_x, and diminutions in source strengths of these species.

Figure 6-3 shows that ozone behavior was relatively consistent during the presented period with the afternoon of January 30 showing a steep rise of concentrations. The divergent behavior of ozone and NO_2 is shown; as ozone concentrations rise NO_2 is depleted. Figure 6-4 shows the behavior of key species during the event of January 30. The spiking of oxides of nitrogen concentrations is apparent at the start of the production of ozone and also signals the rapid depletion of ozone late in the day.

Ozone mixing ratios peaked each day at approximately the same time in mid-afternoon throughout the period January 28 – February 1, 2010. Minima were observed around sunrise. NO_x and NO_2 contrastingly peaked on average during the hours of darkness, with the lowest values being observed in mid-afternoon. There is consequently a strong general anti-correlation of O_3 with NO_x. Detailed examination of the mixing ratio time series in Figure 6-4 on January 30 shows that the diurnal pattern of O_3, NO, and NO_2 conforms to that observed in classic photochemical smog episodes. Thus before sunrise, NO_2 exceeds NO, except during very short lived NO injection intervals. After sunrise, NO_2 declines to be replaced by NO as the dominant NO_x species. Simultaneously O_3 begins to increase, ultimately leading to NO suppression during the afternoon and NO_2 formation, which again becomes the preeminent NO_x species.

Figure 6-1. Time series of CH_4 and NMHC January 28 – February 1, 2010.

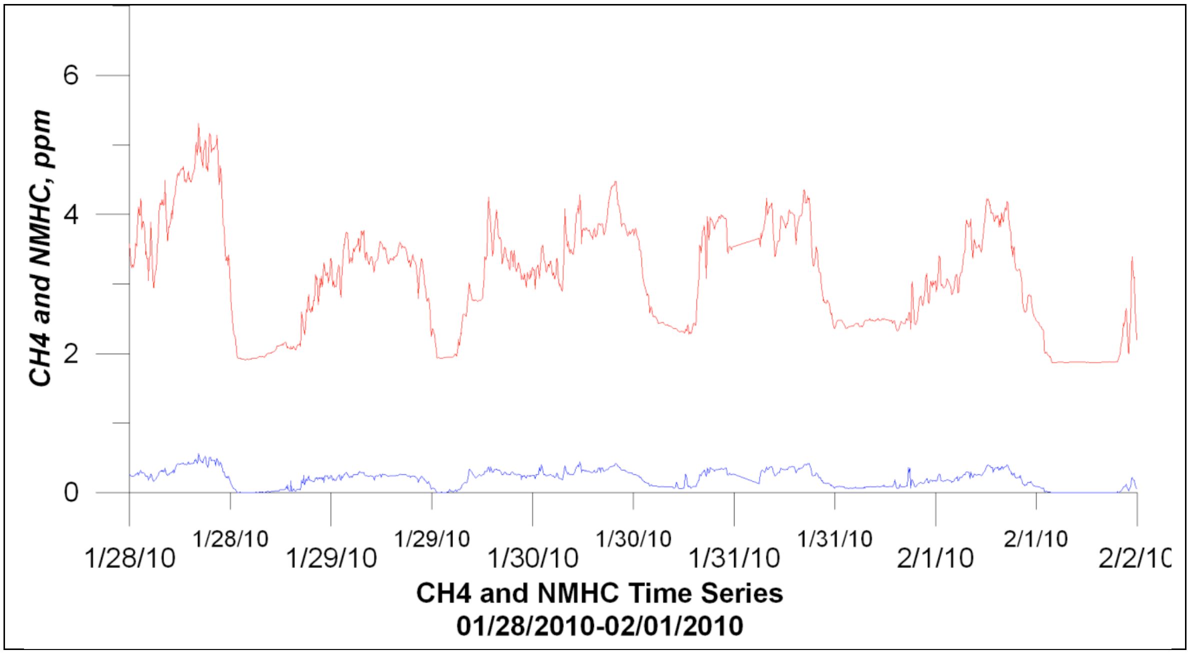


Figure 6-2. Time series of NO_X, NO, and NO_2 January 28 – February 1, 2010.

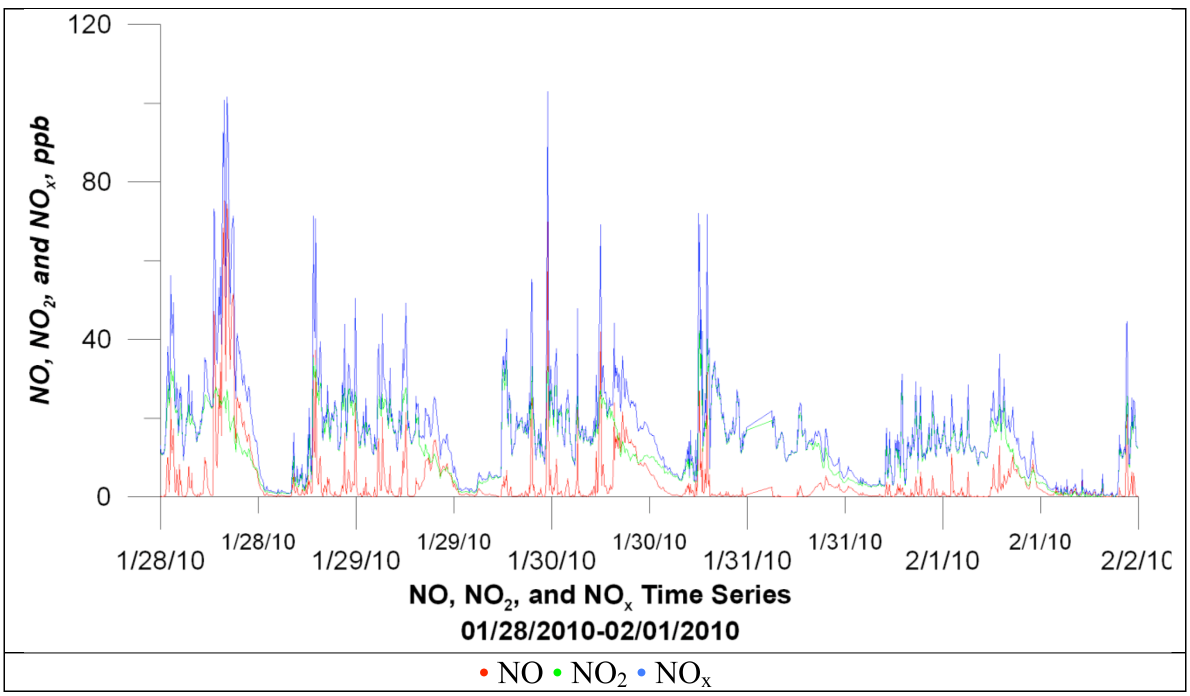


Figure 6-3. Time series of O_3 and NO_2 January 28 – February 1, 2010.

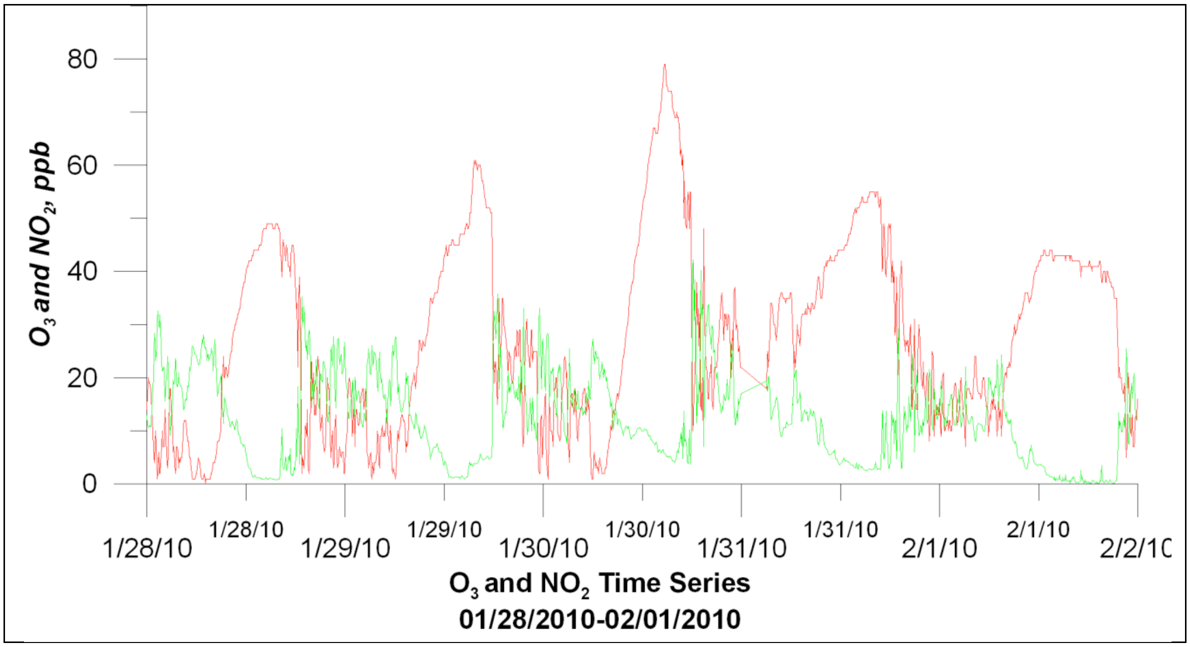
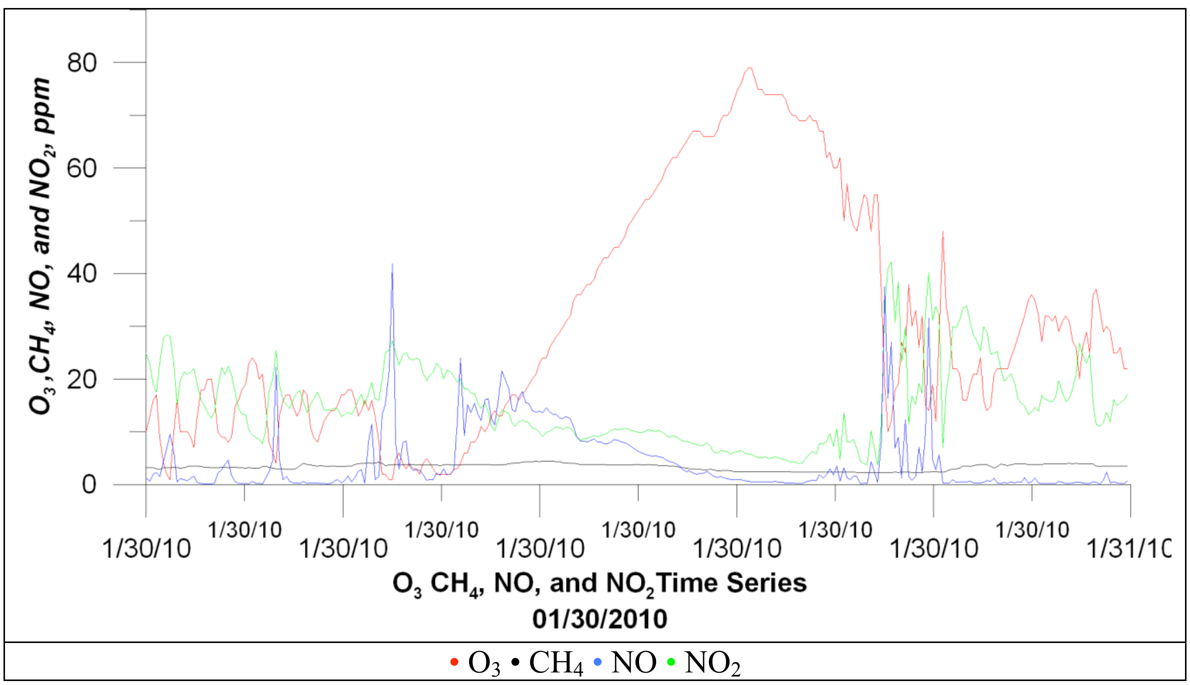


Figure 6-4. Time series of CH_4, NO, NO_2, and O_3 January 30, 2010.



6.0.2 APRIL EPISODE

This episode is under review by the WDEQ-AQD as a stratospheric ozone incursion episode. Compared to the January period Figures 6-5 and 6-6 show less pronounced episodes during the period April 7 – April 11. Methane, NMHC, and NO_x mixing ratios are all lower on average than during the January episode. Figure 6-7 shows a similar behavior for O_3 and NO_2. The start of the period is characterized by low concentrations of NO_2 with a relatively high background of ozone concentrations that persist at a background of around 40 ppb from April 6 – April 8. Subsequent days appear to show the influence of standard behavior upon an elevated background with nighttime ozone concentrations reaching normal levels on April 11. Figure 6-8 shows the spiking behavior of oxides of nitrogen at the start of the production of O_3 on April 9. The difference is that the background level of O_3 is elevated by 20 ppb, compared to the January episode, and high relatively concentrations persist. The last four days of the episode period display the same pattern of O_3 maxima as in January, albeit with slightly higher minima at night. This may be due to the lower NO_x levels. NO_x and O_3 are again strongly anti-correlated, while CH_4 and NO_x exhibit positive correlation. The first two or so days of the displayed period, display different behavior, with background levels of CH_4, NMHC, and NO_x, and minimally varying O_3, at 50±8 ppb. The very low levels of O_3 precursors provide an explanation for the absence of afternoon O_3 maxima until April 8, subsequent to the first significant detected emissions of NO_x and hydrocarbon species. Similarly, nighttime minima on April 6 and April 7 are essentially absent, possibly as a result of very low NO_x levels. The high O_3 maxima on April 9 may result from NO_2 levels that are sufficient to promote O_3 formation, but too low to promote subsequent O_3 removal, especially given the low NMHC concentrations.

Figure 6-5. Time series for CH_4 and NMHC April 6 – 11, 2010.

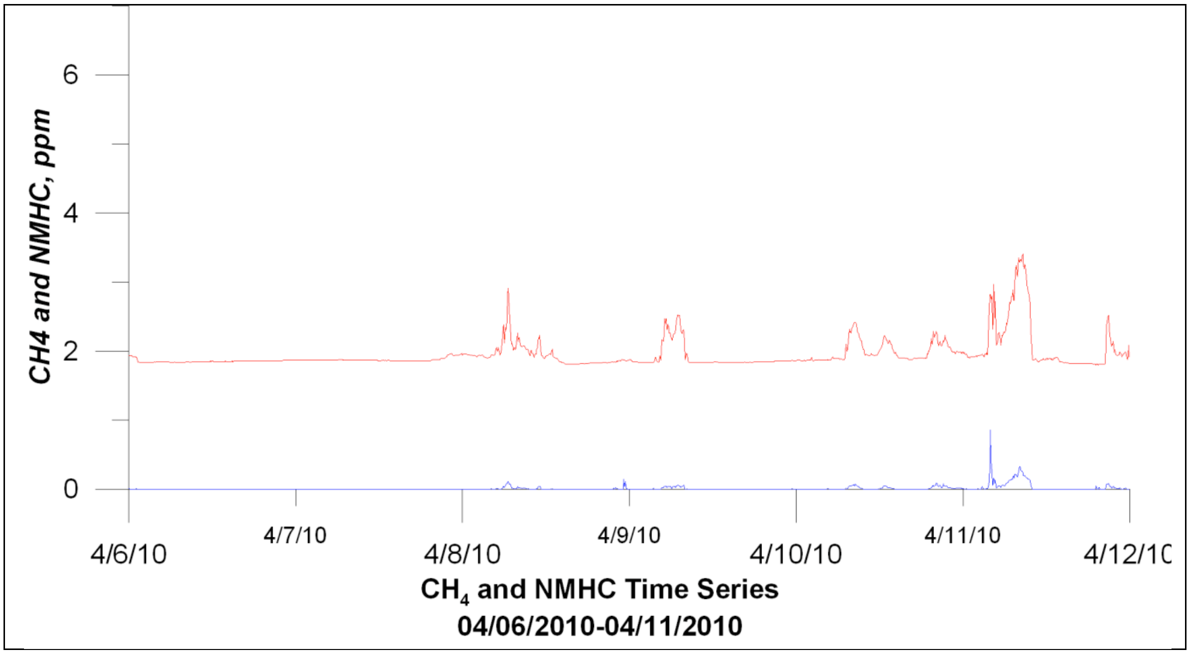


Figure 6-6. Time series for NO_X, NO, and NO_2 April 6 – 11, 2010.

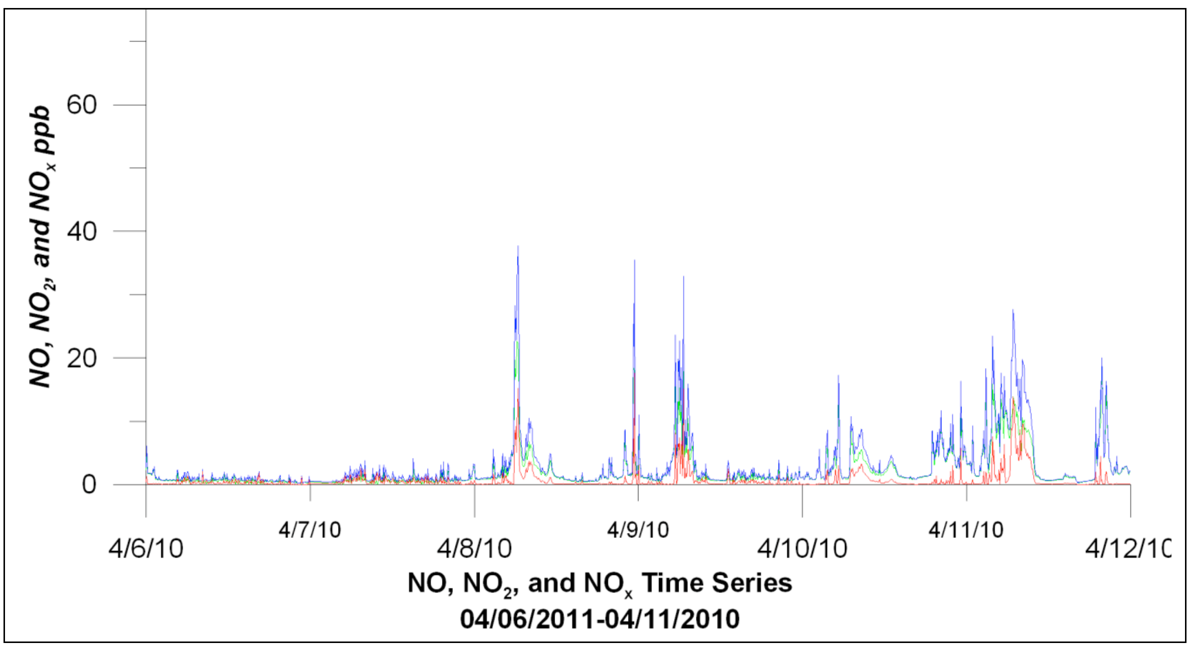


Figure 6-7. Time series for O_3 and NO_2 April 6 – 11, 2010.

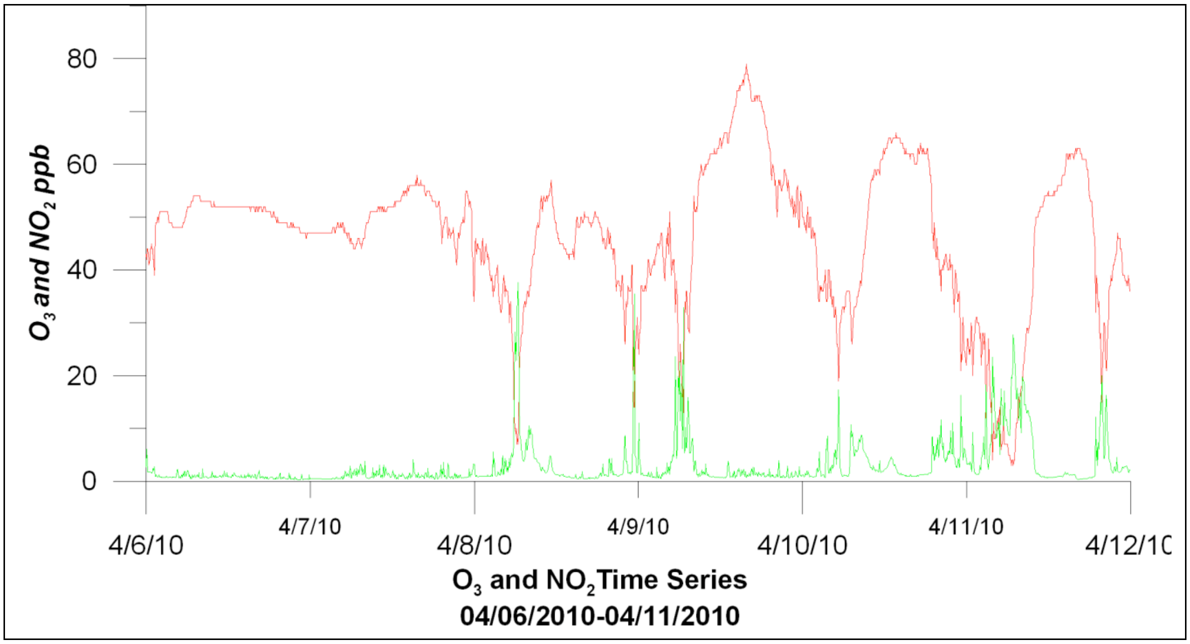
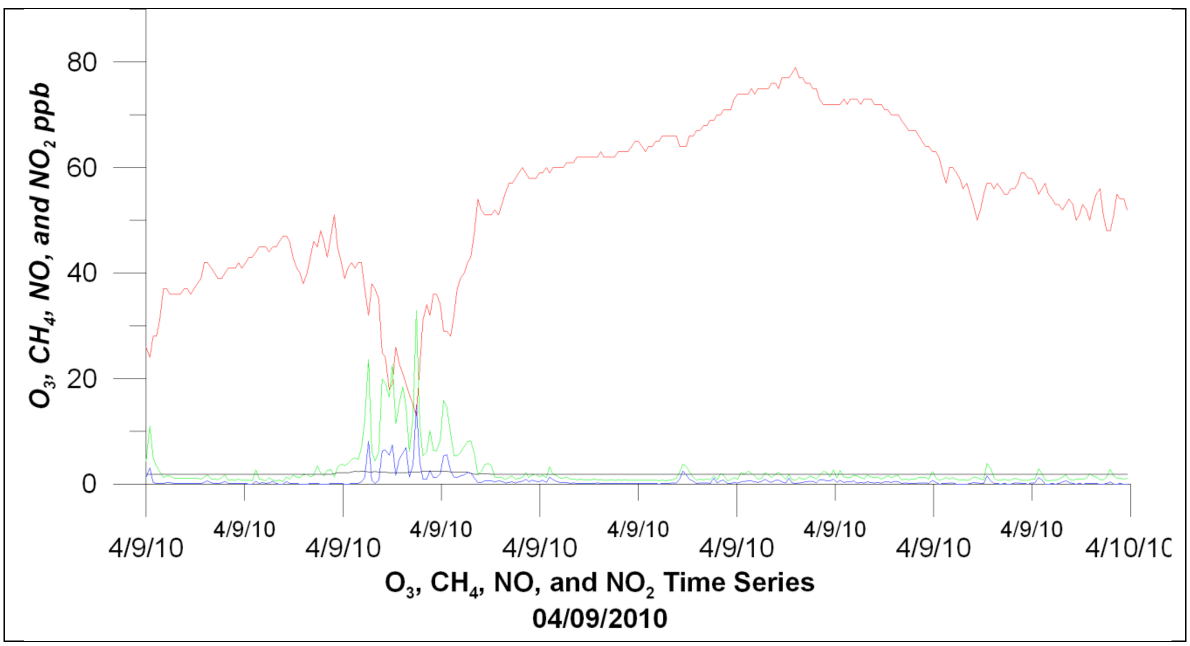


Figure 6-8. Time series for CH_4, NO, NO_2, and O_3 April 9, 2010.



6.0.3 JUNE EPISODE

This episode is under review by the WDEQ-AQD as a stratospheric ozone incursion episode. Compared to the April period, Figures 6-9 and 6-10 show similar behavior during the period June 6 – June 11, again less pronounced than the January observations. Mixing ratios of hydrocarbons and NO_x resemble those for the April episode, but with even lower NO_x values on average. Figure 6-11 again shows a similar relationship, as previously noted between O_3 and NO_2, albeit NO_2 concentrations appear relatively low and ozone concentrations are relatively high. Again, NO_x is anti-correlated with O_3, and positively correlated with CH_4, though the mixing ratios are low. O_3 maxima occur in mid-afternoon on June 7 – 9, but thereafter, when NO_x levels are generally low, the pattern is less clear. Figure 6-12 shows the spiking behavior of oxides of nitrogen at the start of the production of ozone on June 8. The difference is that the background level of O_3 is not elevated at the start of ozone production while relatively concentrations persist at the end of the day.

During the peak O_3 period on the afternoon of June 8, mixing ratios of NO_x and hydrocarbons are very low, which may result in inefficient O_3 removal, resulting in the relatively high O_3. Indeed, it is not until NO_x emissions are again observed late in the day, that O_3 levels decline.

Figure 6-9. Time series for CH4 and NMHC June 6 – 10, 2010.

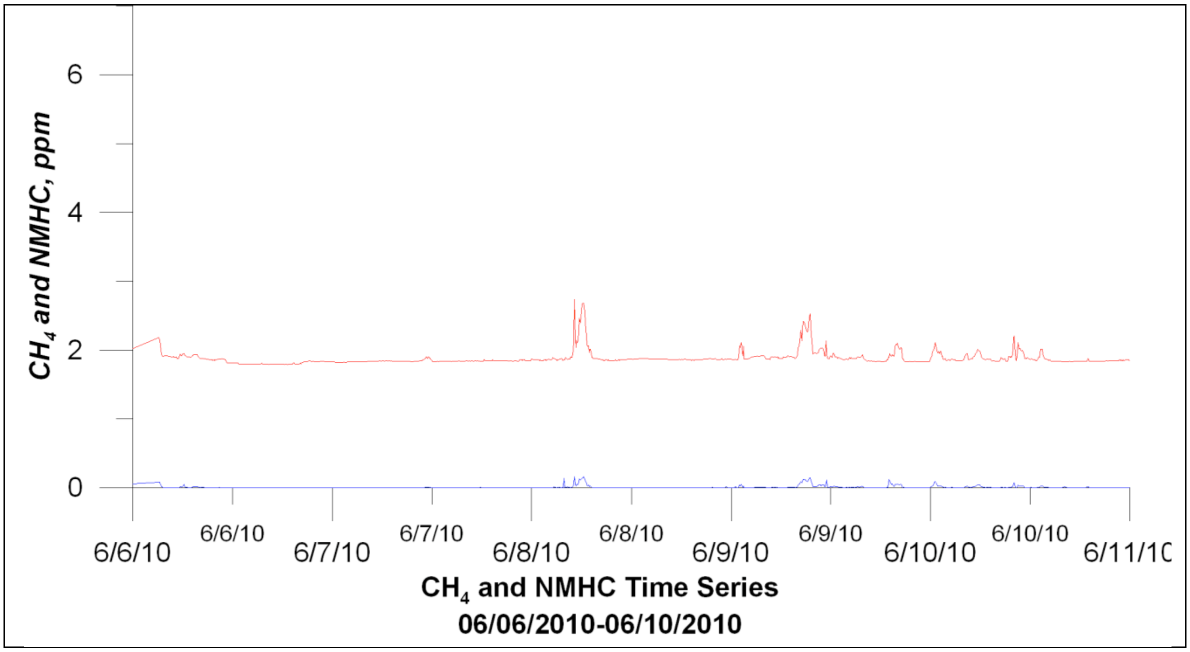


Figure 6-10. Time series for NO_x, NO, and NO_2 June 6 – 10, 2010.

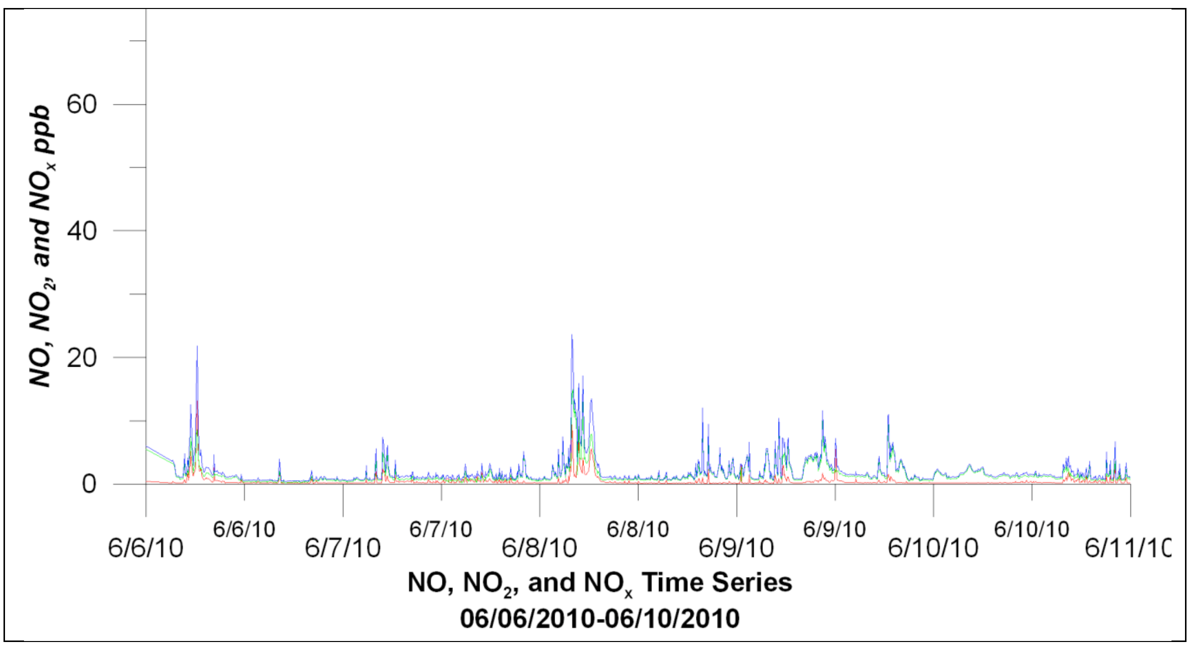


Figure 6-11. Time series for O_3 and NO_2 June 6 – 10, 2010.

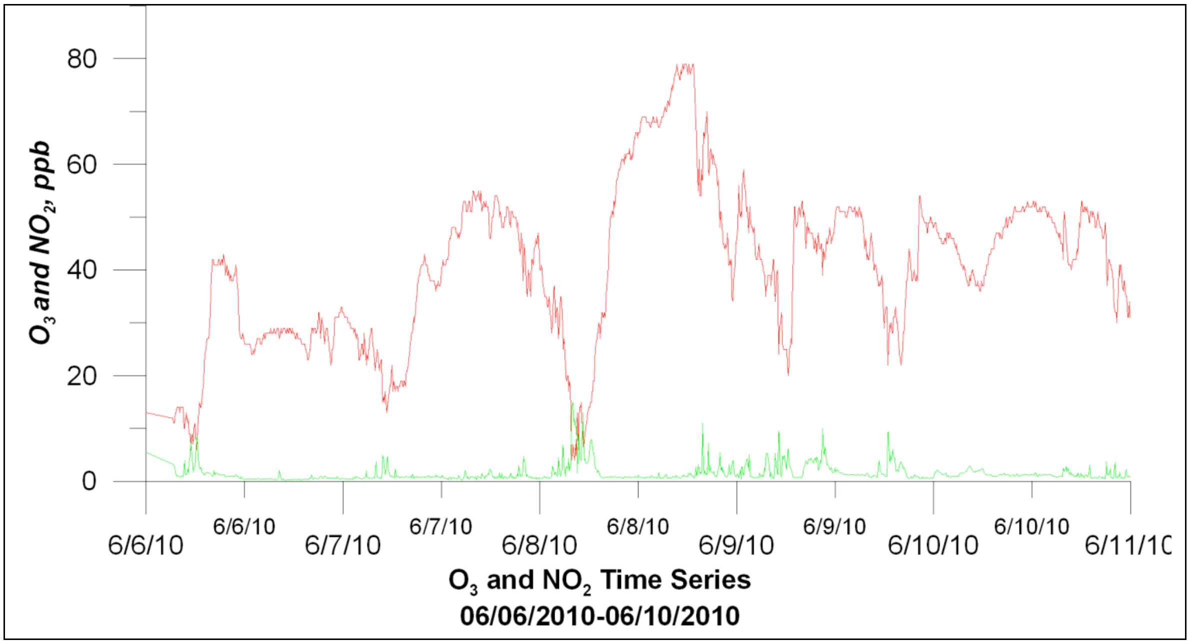
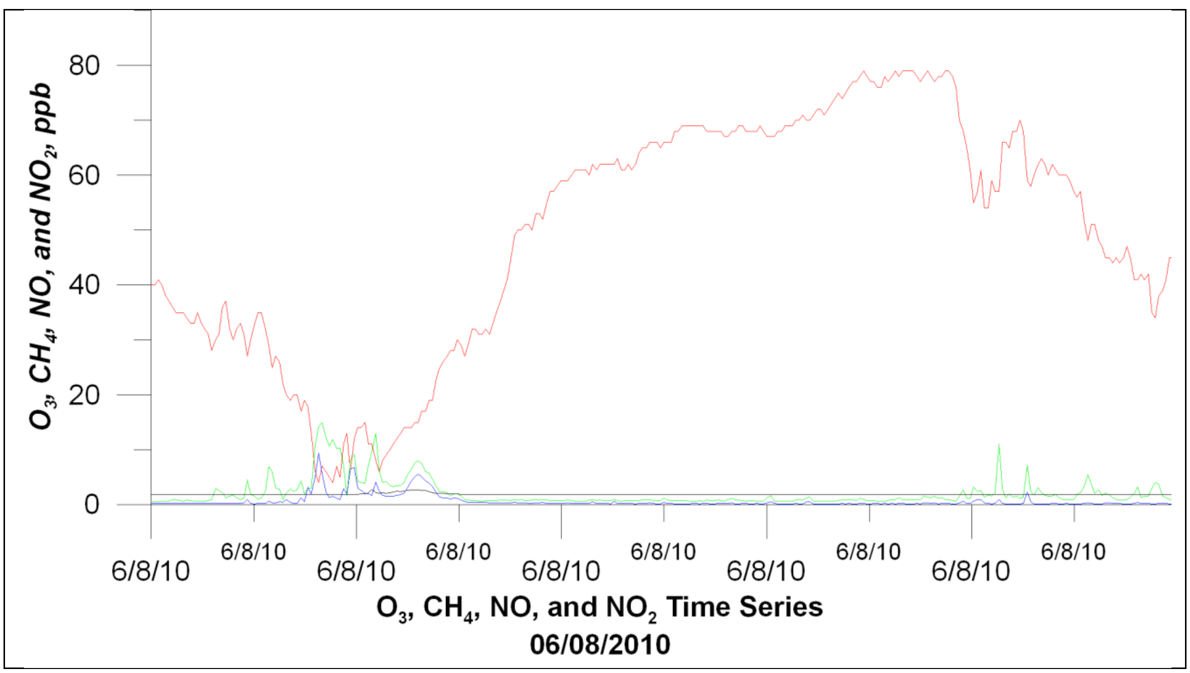


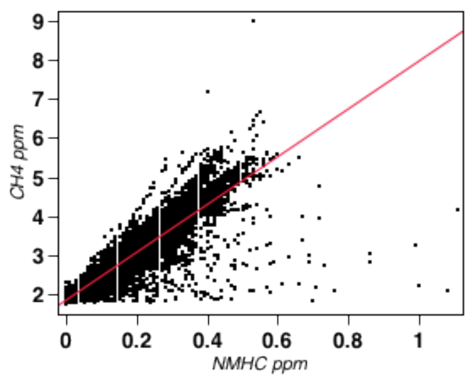
Figure 6-12. Time series for CH_4, NO, NO_2, and O_3 June 8, 2010.



Consideration of these three episodes and their context within the surrounding days for January reveals relatively high NO_x levels with O_3 reaching close to zero levels at night. During the April and June episodes elevated background levels are present leading up to the April episode and after the June episode days.

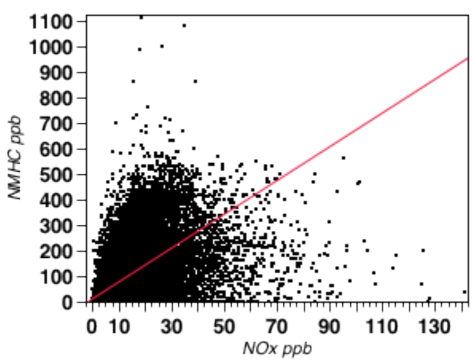
It has been postulated that ozone formation in Sublette County is NO_x saturated rather than NO_x limited. As such understanding the behaviour of hydocrabons and oxides of nitrogen is important. The use of hydrocarbon surrogate may be useful. This approach is based upon the relationship between CH_4 and NMHC given in Figure 6-13. This figure shows the clear relationship between CH_4 and NMHC during the monitoring period, a ratio of approximately 6 to 1 is calculated. This may have utility as monitoring of CH_4 is expanded in the WDEQ-AQD monitoring network. The intercept may be interpretetd as a CH_4 background of approximately 1.86 ppm. Note this value is close to the US background value of approximately 1.855 ppm. The value of 1.86 ppm is then subtracted from ambient CH_4 to indicate a robust hydrocarbon surrogate. This approach is reasonable given the non-detectable levels of NMHC during less polluted conditions. Figure 6-14 shows the relationship between NO_x and NHMC. This reveals a weak positive relationship with more occasions of additional NO_x than NMHC. A ratio of NMHC, as propane, to NO_x of approximately 7:1 is calculated. This ambient relationship may have utility for consideration of ozone production in particular when NMHC speciation as VOC components is either estimated or measured.

Figure 6-13. Bivariate fit of CH_4 by NMHC for monitoring period 10/14/2009 – 06/30/2010.



CH4 ppm = 1.8608231 + 6.0973174 × NMHC ppm; Intercept = 1.86.

Figure 6-14. Bivariate fit of NMHC by NO_x for monitoring period 10/14/2009 – 06/30/2010.



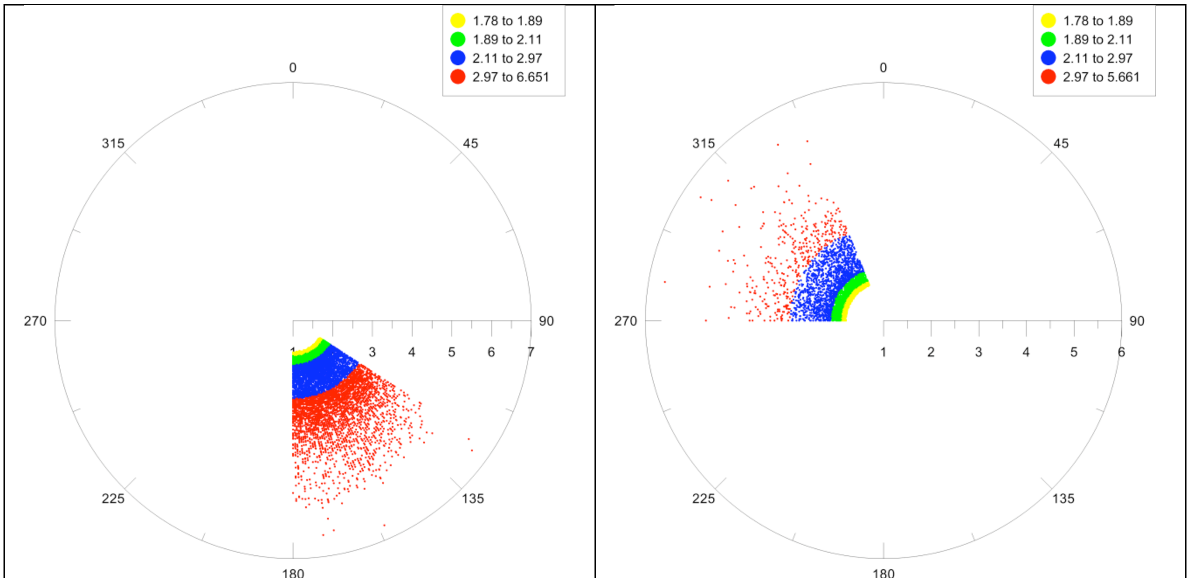
NMHC ppb = 9.52 + 6.62 × NOx ppb; Intercept = 9.52

6.1 Wind direction and speeds associated with CH_4 and NMHC measurements.

Figure 6-15 contrasts the wind directions associated with the greatest proportion of low concentrations, 270° to 338°, with that with the greatest proportion of higher concentrations, 123° to 180°. The former direction is associated with the Gros Ventre wind field. The latter direction is aligned with the Jonah Field development at a distance of approximately 12 miles. These two segments are selected for comparative purposes as a first indicative step. The Southwest wind direction is not included in this comparison. Figure 6-15 clearly shows that the populations of samples are different. A more detailed view of selected wind direction segments in Figure 6-16 shows that the selections show relatively uniform behavior. Table 6-1 reinforces the previous comments and shows that the two populations are different, in particular with respect to median and greater percentile values. Sublette County has a complex wind field that shows diurnal, daily and seasonal variations. As noted earlier, care must be taken with wind direction analysis as these are not back trajectory assessments and as such are indicative and the first step toward more detailed analysis. Such analysis could include all wind directions.

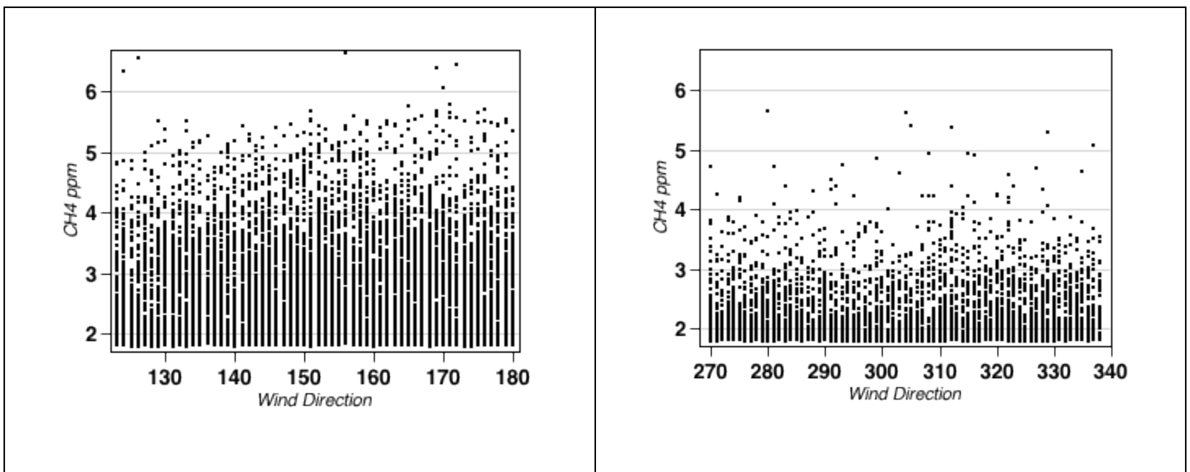
Figure 6-17 and Figure 6-18 replicate the previous figures for wind speeds greater than, and inclusive the median value for wind speed of 2.36 m/s (approximately 6 mph), as such, speeds are more likely to reflect direction at greater distances from the measurement site. This assessment reveals the same previously noted behavior. Again table 6-2 reveals that the two populations are different, in particular with respect to median and greater percentile values. For the latter data selection average wind speeds of 4 m/s would reflect a travel time of approximately 80 minutes. During periods of low wind speeds, winds in the Upper Green River Basin are often variable, so further analysis of these preliminary correlations is advised. Given the fact that the wind direction with highest concentrations appears to be from the south, development of back trajectory analysis is recommended.

Figure 6-15. Polar plots of CH_4 data points for the Southeast (123-180º) and Northwest (270-338°) quadrants.



A. Southeast (123-180º) quadrant. B. Northwest (270-338°) quadrant.

Figure 6-16. Bivariate fit of CH_4 by Wind Direction for the Southeast (123-180º) and Northwest (270-338°) quadrants.

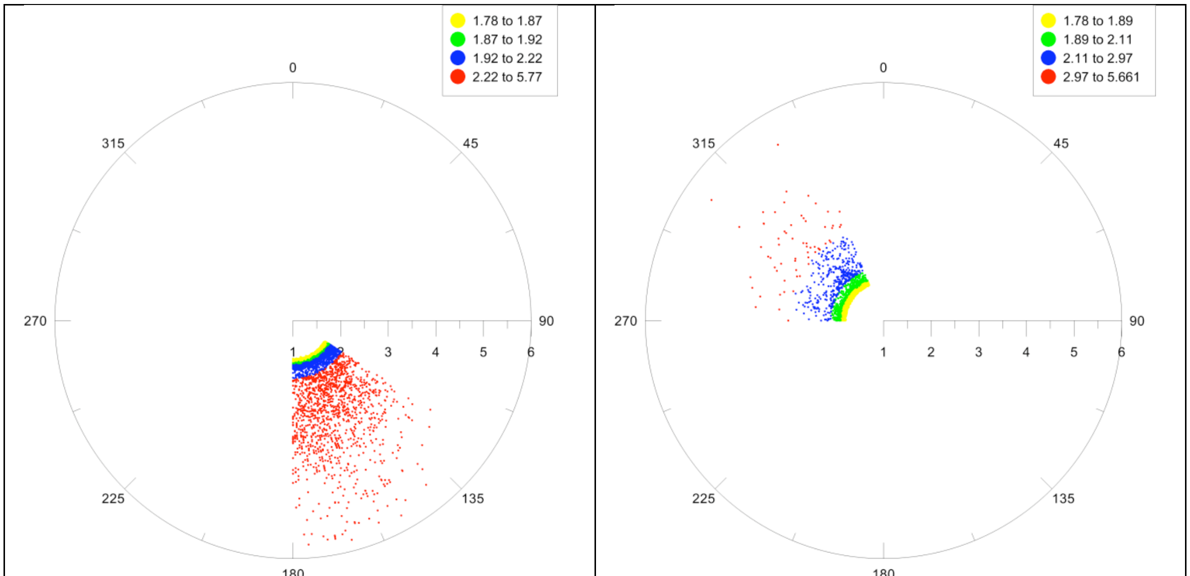


A. Southeast (123-180º) quadrant. B. Northwest (270-338°) quadrant.

Table 6-1. Distribution of CH_4 values by quadrant.

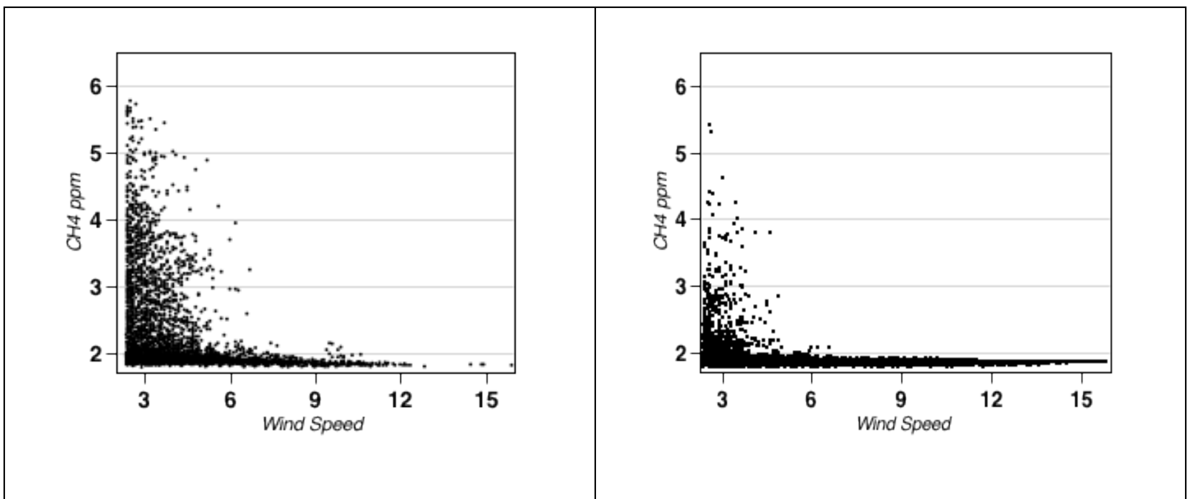
	N	0% Minimum	25% Quartile	50% Median	75% Quartile	100% Maximum	Mean	SD
SE Quadrant	12824	1.78	1.89	2.13	2.99	6.65	2.51	0.799
NW Quadrant	18426	1.78	1.84	1.85	1.88	5.66	1.94	0.293

Figure 6-17. Polar plots of CH_4 data points for wind speeds greater than median for the Southeast (123-180º) and Northwest (270-338°) quadrants.



A. Southeast (123-180º) quadrant.	B. Northwest (270-338°) quadrant.

Figure 6-18. Bivariate fit of CH_4 by wind speed greater than median for the Southeast (123-180º) and Northwest (270-338°) quadrants.



A. Southeast (123-180º) quadrant.	B. Northwest (270-338°) quadrant.

Table 6-2. Distribution of CH_4 values by quadrant for wind speed greater than median.

	N	0% Minimum	25% Quartile	50% Median	75% Quartile	100% Maximum	Mean	SD
SE Quadrant	5137	1.78	1.86	1.92	2.22	5.77	2.22	0.664
NW Quadrant	14520	1.78	1.84	1.85	1.86	5.41	1.87	0.152

7.0 CONCLUSIONS

For the nine-month duration of the study, we draw the following conclusions:

- The mobile laboratory operated above the required data capture criteria of 75%, with values data capture between 95% and 99% for measured parameters.
- Wind rose diagrams indicated two wind fields of importance to the normal conditions in study area namely; NW Gros-Ventre pattern and a southerly wind pattern. North-easterly wind directions were uncommon.
- The site location can defined as a upwind site for PAPA and either an upwind or a downwind site for Jonah Field, depending on the meteorological conditions.
- Three quarterly audits performed by an external contractor showed that each assessed parameter was properly measured with no measurements outside protocol ranges.
- The ozone NAAQS was not exceeded at any time during the monitoring period. However there were a number of episodes that exceeded 70 ppb for 8-hr averages.
- These ozone episodes revealed the possibility of wintertime ozone episodes as early in the year as January. The April and June episodes appear to have a photochemical component, with the presence of high background levels during the week surrounding the day with the highest concentrations.
- The importance of atmospheric mixing and air pollutant concentration was shown by the diurnal curves for methane, as afternoon mixing tended to show the closest approximation to tropospheric background levels.
- Diurnal curves for CH_4 and NMHC showed that local sources are most likely to influence measured concentration during times associated with the highest atmospheric stability.
- Data for CH_4 and NMHC indicate commonality of emission sources. This data revealed the incidence of concentrations above normal background levels in particular for southerly wind directions and low wind speeds.
- Pollution rose diagrams indicate wind flows from the South to South East with low wind speeds have elevated levels of CH_4 and NMHC but low levels of ozone.
- Behavior of measured nitrogen species indicates additional influence from local sources. Nitric Oxide concentrations from traffic sources are important, and for NO_2 concentrations the influence of daytime photochemical production is evident in late afternoon hours.
- NO_x and NO measurements are also often elevated at the same times as CH_4 and NMHC.
- Diurnal variation plots reveal the importance of traffic emissions for NO_x and NO measurements.
- Time series plots reveal the role of meteorology with the coldest season associated with higher pollution levels, most likely due primarily to the influence of temperature inversions upon mixing behavior.

APPENDIX A: FOURTH QUARTER 2009 AUDIT REPORT

5.9 UNIVERSITY OF WYOMING TRAILER

5.9.1 Site Location

At the time of the audit, the trailer was located 42° 35' 57.95" North Latitude and 109° 52' 11.70" West Longitude (GPS).

5.9.2 Station Equipment Summary, Audit Results and Recommendations

Table 1. Site Monitoring Equipment

Site: UW Trailer **Date:** 11/10/09

AMBIENT AIR QUALITY MONITORS

Parameter	Manufacturer	Model	Serial No.	Range	Last Cal
Ozone	Thermo	49i	CM08420038	1.000 ppm	10/15/09
Nitric Oxide	Thermo	42i	08305328314	0.5 ppm	10/15/09
Nitrogen Oxides	Thermo	42i	08305328314	0.5 ppm	10/15/09
Nitrogen Dioxide	Thermo	42i	08305328314	0.5 ppm	10/15/09
Total Hydrocarbons	Thermo	55i	0908635578	5 ppm	10/15/09

Table 5.9.1. Monitoring equipment at University of Wyoming Trailer.

Site: UW Mobile Lab (Olson Ranch)
Project: University of Wyoming
Operator: University of Wyoming

AMBIENT AIR QUALITY MONITORS

Audit Date	Parameter	Max Diff. (%)	DAS Slope	DAS Intercept	DAS Correlation
11/10/2009	Ozone	-3.4	0.966	0.001	1.0000
11/10/2009	Total Hydrocarbons	5.1	1.029	0.033	1.0000
11/10/2009	Nitric Oxide	13.6	1.116	0.001	1.0000
11/10/2009	Nitrogen Oxides	6.8	1.042	0.001	1.0000
11/10/2009	Nitrogen Dioxide	-5.0	0.984	-0.001	1.0000

Audit Criteria: Max Diff ±15%, Slope 1.000 ± 0.15: Intercept 0 ± 0.015 ppm (THC 0 ± 0.9 ppm); Correlation > 0.9950

Table 5.9.2. Audit results for University of Wyoming Trailer.

Key Audit Findings

A The measured NO_2 converter efficiency was just at the audit criteria of 96%. Furthermore, the relative responses of the three channels (NO, NO_2, and NOx), while meeting the audit criteria, were approximately 6% to 15% different from each other, which is unusual. It is recommended that the analyzer be recalibrated, with special attention paid to the converter efficiency.

5.9.3 Performance Audit Reports

The performance audit reports for the air quality and meteorological instrumentation follow.

TRB Systems
26074 Avenue Hall Unit 9
Valencia, CA 91355
(661) 294-1103

AUDIT RECORD

OZONE

Date:	**11/10/09**	Site name:	**UW Mobile Lab (Olson Ranch)**
Start:	**11:50 MST**	Operator:	**University of Wyoming**
Finish:	**12:45 MST**	Project:	**University of Wyoming**
Audited by:	**David Yoho**		
Witness:	**Jeff Soltice**		

Analyzer make:	**Thermo**	Model:	**49i**
Serial No.:	**CM08420038**	Filter:	**10/15/09**
Sample flow:	**0.650 / 0.650 lpm**	Ozone Measure:	**85808 Hz**
Span Set Point:	**1.001**	Ozone Ref:	**92422 Hz**
Zero Set Point:	**0.0**	Last cal.:	**10/15/09**
Range:	**1.000 ppm**		

O3 Audit Point	PPM Input (X)	PPM DAS (Y)	PPM DAS (Y)
1	0.000	0.000	NA
2	0.043	0.043	0.0
3	0.089	0.086	-3.4
4	0.190	0.184	-3.2

Linear Regression: (Y=PPM Corrected, X=PPM Input)

	DAS
Slope:	0.966
Intercept:	0.001
Correlation:	1.0000

Comments: No problems noted.

Audit Equipment	Make	Model	ID	Certification Date
Dilution System:	API	700	225	11/8/09
Ozone Standard:	API	700	225	09/11/09
Zero Air System:	API	701	2427	

Ozone Transfer Standard			
Sample Freq: NA	Cell Temperature:	NA	deg C
Control Freq: NA	Ambient Pressure:	NA	"Hg
Span Setting: NA	Certification Slope:	1.0063	
	Certification Intercept:	0.0080	ppm

AUDIT RECORD

NITRIC OXIDE

T&B Systems
26074 Avenue Hall Unit 9
Valencia, CA 91355
(661) 294-1103

Date:	**11/10/09**	Site Name:	**UW Mobile Lab (Olson Ranch)**
Start:	**9:00 MST**	Operator:	**University of Wyoming**
Finish:	**11:10 MST**	Project:	**University of Wyoming**
Audited by:	**David Yoho**		
Witness:	**Jeff Soltice**		

Analyzer make:	**Thermo**	Model:	**42i**
Serial No.:	**08305328314**	Filter:	**10/15/09**
Sample flow:	**.56 lpm**	Span setting:	**0.912**
Zero setting:	**0.0031**	Vacuum:	**N/A**
Range:	**0.500 PPM**	Mode:	**N/A**
		Last cal.:	**10/15/09**

NO Audit Point	PPM Input (X)	PPM DAS (Y)	PPM Dif (%)
1	0.000	0.000	NA
2	0.088	0.100	13.6
3	0.163	0.184	12.9
4	0.410	0.458	11.7

Linear Regression: (Y=PPM Corrected, X=PPM Input)

	DAS
Slope:	1.116
Intercept:	0.001
Correlation:	1.0000

Comments: No problems noted.

Audit Equipment	Make	Model	ID	Certification Date
Dilution System:	API	700	225	11/8/09
Zero Air System:	API	701	2427	NA
Calibration Gas:	SMI	Multi	JJ708A	12/28/08

AUDIT RECORD

OXIDES OF NITROGEN

T&B Systems

26074 Avenue Hall Unit 9
Valencia, CA 91355
(661) 294-1103

Date: **11/10/09**
Start: **9:00 MST**
Finish: **11:10 MST**
Audited by: **David Yoho**
Witness: **Jeff Soltice**

Site Name: **UW Mobile Lab (Olson Ranch)**
Organization: **University of Wyoming**
Project: **University of Wyoming**

Analyzer make: **Thermo**
Serial No.: **08305328314**
Sample flow: **N/A**
Zero setting: **.0028 lpm**
Range: **0.500 PPM**

Model: **42i**
Filter: **10/15/09**
Span setting: **1.000**
Vacuum: **N/A**
Last cal.: **10/15/09**

NOx Audit Point	PPM Input (X)	PPM DAS (Y)	PPM Dif (%)
1	0.000	0.000	NA
2	0.088	0.094	6.8
3	0.163	0.172	5.5
4	0.410	0.428	4.4

Linear Regression: (Y=PPM Corrected, X=PPM Input)

	DAS
Slope:	1.042
Intercept:	0.001
Correlation:	1.0000

Comments: No problems noted.

Audit Equipment	Make	Model	ID	Certification Date
Dilution System:	API	700	225	11/8/09
Zero Air System:	API	701	2427	NA
Calibration Gas:	SMI	Multi	JJ708A	12/28/08

AUDIT RECORD

NITROGEN DIOXIDE

T&B Systems
25074 Avenue Hall Unit 9
Valencia, CA 91355
(661) 294-1103

Date: **11/10/09**
Start: **9:00 MST**
Finish: **11:10 MST**
Audited by: **David Yoho**
Witness: **Jeff Soltice**

Site Name: **UW Mobile Lab (Olson Ranch)**
Organization: **University of Wyoming**
Project: **University of Wyoming**

Analyzer make: **Thermo**
Serial No.: **08305328314**
Ozone flow: **NA**
Range: **0.500 PPM**

Model: **42i**
Converter T.: **327 deg C**
Last cal.: **10/15/09**

NO2 Audit Point	PPM Input (X)	PPM DAS (Y)	PPM Dif (%)
1	0.000	0.000	NA
2	0.060	0.057	-5.0
3	0.141	0.138	-2.1
4	0.337	0.331	-1.8

Linear Regression: (Y=PPM Corrected, X=PPM Input)

	DAS
Slope:	0.984
Intercept:	-0.001
Correlation:	1.0000

Converter Efficiency
95.6%

Comments: No problems noted.

Audit Equipment	Make	Model	ID	Certification Date
Dilution System:	API	700	225	11/8/09
Zero Air System:	API	701	2427	NA
Calibration Gas:	SMI	Multi	JJ708A	12/28/08

AUDIT RECORD

TOTAL HYDROCARBONS

T&B Systems
26074 Avenue Hall Unit 9
Valencia, CA 91355
(661) 294-1103

Date: **11/10/09**
Start: **11:10 MST**
Finish: **11:50 MST**
Audited by: **David Yoho**
Witness: **Jeff Soltice**

Site name: **UW Mobile Lab (Olson Ranch)**
Operator: **University of Wyoming**
Project: **University of Wyoming**

Analyzer make: **Thermo**
Serial No.: **0908635578**
Sample flow: **NA**
Zero setting: **NA**
Range: **5 PPM**

Model: **55i**
Filter: **10/15/09**
Span setting: **NA**
Vacuum: **NA**
Last cal.: **10/15/09**

Methane Audit Point	PPM Input (X)	PPM DAS (Y)	PPM Dif (%)
1	0.00	0.02	NA
2	1.75	1.84	5.1
3	3.23	3.37	4.3
4	8.14	8.40	3.2

Linear Regression: (Y=PPM Corrected, X=PPM Input)

	DAS
Slope:	1.029
Intercept:	0.03
Correlation:	1.0000

Comments: No problems noted.

Audit Equipment	Make	Model	ID	Certification Date
Dilution System:	API	700	225	11/8/09
Zero Air System:	API	12/01/01	08/23/06	NA
Calibration Gas:	SMI	Multi	JJ708A	12/28/08

APPENDIX B: FIRST QUARTER 2010 AUDIT REPORT

5.8 UNIVERSITY OF WYOMING TRAILER

5.8.1 Site Location

At the time of the audit, the trailer was located 42° 35' 57.95" North Latitude and 109° 52' 11.70" West Longitude (GPS).

5.8.2 Station Equipment Summary, Audit Results and Recommendations

Table 1. Site Monitoring Equipment

Site: UW Trailer **Date:** 02/16/10

AMBIENT AIR QUALITY MONITORS

Parameter	Manufacturer	Model	Serial No.	Range	Last Cal
Ozone	Thermo	49i	CM08420038	1.000 ppm	2/11/10
Nitric Oxide	Thermo	42i	08305328314	0.5 ppm	10/15/09
Nitrogen Oxides	Thermo	42i	08305328314	0.5 ppm	10/15/09
Nitrogen Dioxide	Thermo	42i	08305328314	0.5 ppm	10/15/09
Total Hydrocarbons	Thermo	55i	0908635578	5 ppm	10/15/09

Table 5.8.1. Monitoring equipment at the U of WY trailer.

Site: UW Mobile Lab (Olson Ranch)
Project: University of Wyoming
Operator: University of Wyoming

AMBIENT AIR QUALITY MONITORS

Audit Date	Parameter	Max Diff. (%)	DAS Slope	DAS Intercept	DAS Correlation
2/16/2010	**Ozone**	-3.2	0.966	0.001	1.0000
2/16/2010	**Total Hydrocarbons**	-4.0	0.956	0.057	0.9999
2/16/2010	**Nitric Oxide**	-3.9	0.960	0.001	1.0000
2/16/2010	**Nitrogen Oxides**	-3.9	0.960	0.001	1.0000
2/16/2010	**Nitrogen Dioxide**	-9.8	0.901	0.001	1.0000

Audit Criteria: Max Diff ±15%, Slope 1.000 ± 0.15: Intercept 0 ± 0.015 ppm (THC 0 ± 0.9 ppm); Correlation > 0.9950

Table 5.8.2. Audit results for the U of WY trailer.

Key Audit Findings

A. The analyzer NO_2 coefficient had a setting of 1.05, which affects the NOx values during the GPT checks, resulting in a reported NO_2 converter efficiency of less than 96%. The coefficient was changed to 1.000 following the audit, with a notable improvement in converter efficiency (>99%).

AUDIT RECORD

NITRIC OXIDE

T&B Systems
26074 Avenue Hall Unit 9
Valencia, CA 91355
(661) 294-1103

Date: **02/16/10**
Start: **8:40 MST**
Finish: **10:55 MST**
Audited by: **David Yoho**
Witness: **Jeff Soltice**

Site Name: **UW Mobile Lab (Olson Ranch)**
Operator: **University of Wyoming**
Project: **University of Wyoming**

Analyzer make: **Thermo**
Serial No.: **08305328314**
Sample flow: **.56 lpm**
Zero setting: **0.0031**
Range: **0.500** **PPM**

Model: **42i**
Filter: **10/15/09**
Span setting: **0.912**
Vacuum: **N/A**
Mode: **N/A**
Last cal.: **10/15/09**

NO Audit Point	PPM Input (X)	PPM DAS (Y)	PPM Dif (%)
1	0.000	0.000	NA
2	0.088	0.086	-2.3
3	0.175	0.169	-3.4
4	0.435	0.418	-3.9

Linear Regression: (Y=PPM Corrected, X=PPM Input)

	DAS
Slope:	0.960
Intercept:	0.001
Correlation:	1.0000

Comments: No problems noted.

Audit Equipment	Make	Model	ID	Certification Date
Dilution System:	API	700	225	2/9/10
Zero Air System:	API	701	2427	NA
Calibration Gas:	SMI	Multi	JJ708A	12/28/08

AUDIT RECORD

OXIDES OF NITROGEN

T&B Systems
26074 Avenue Hall Unit 9
Valencia, CA 91355
(661) 294-1103

Date: **02/16/10**
Start: **8:40 MST**
Finish: **10:55 MST**
Audited by: **David Yoho**
Witness: **Jeff Soltice**

Site Name: **UW Mobile Lab (Olson Ranch)**
Organization: **University of Wyoming**
Project: **University of Wyoming**

Analyzer make: **Thermo**
Serial No.: **08305328314**
Sample flow: **N/A**
Zero setting: **.0028 lpm**
Range: **0.500 PPM**

Model: **42i**
Filter: **10/15/09**
Span setting: **1.000**
Vacuum: **N/A**
Last cal.: **10/15/09**

NOx Audit Point	PPM Input (X)	PPM DAS (Y)	PPM Dif (%)
1	0.000	0.000	NA
2	0.088	0.086	-2.3
3	0.175	0.169	-3.4
4	0.435	0.418	-3.9

Linear Regression: (Y=PPM Corrected, X=PPM Input)

	DAS
Slope:	0.960
Intercept:	0.001
Correlation:	1.0000

Comments: No problems noted.

Audit Equipment	Make	Model	ID	Certification Date
Dilution System:	API	700	225	2/9/10
Zero Air System:	API	701	2427	NA
Calibration Gas:	SMI	Multi	JJ708A	12/28/08

AUDIT RECORD

NITROGEN DIOXIDE

T&B Systems
26074 Avenue Hall Unit 9
Valencia, CA 91355
(661) 294-1103

Date: **02/16/10**
Start: **8:40 MST**
Finish: **10:55 MST**
Audited by: **David Yoho**
Witness: **Jeff Soltice**

Site Name: **UW Mobile Lab (Olson Ranch)**
Organization: **University of Wyoming**
Project: **University of Wyoming**

Analyzer make: **Thermo**
Serial No.: **08305328314**
Ozone flow: **NA**
Range: **0.500 PPM**

Model: **42i**
Converter T.: **327 deg C**
Last cal.: **10/15/09**

NO2 Audit Point	PPM Input (X)	PPM DAS (Y)	PPM Dif (%)
1	0.000	0.000	NA
2	0.073	0.067	-8.2
3	0.167	0.152	-9.0
4	0.378	0.341	-9.8

Linear Regression: (Y=PPM Corrected, X=PPM Input)

	DAS
Slope:	0.901
Intercept:	0.001
Correlation:	1.0000

Converter Efficiency
94.2%

Comments: The analyzer NO2 coefficient had a setting of 1.05, which affects the Nox values (converter efficiency) during the GPT checks. The coefficient was changed to 1.000 following the audit, with a notable improvement in converter efficiency (>99%).

Audit Equipment	Make	Model	ID	Certification Date
Dilution System:	API	700	225	2/9/10
Zero Air System:	API	701	2427	NA
Calibration Gas:	SMI	Multi	JJ708A	12/28/08

AUDIT RECORD

TOTAL HYDROCARBONS

T&B Systems
26074 Avenue Hall Unit 9
Valencia, CA 91355
(661) 294-1103

Date: **02/16/10**
Start: **10:25 MST**
Finish: **10:55 MST**
Audited by: **David Yoho**
Witness: **Jeff Soltice**

Site name: **UW Mobile Lab (Olson Ranch)**
Operator: **University of Wyoming**
Project: **University of Wyoming**

Analyzer make: **Thermo**
Serial No.: **0908635578**
Sample flow: **NA**
Zero setting: **NA**
Range: **5 PPM**

Model: **55i**
Filter: **10/15/09**
Span setting: **NA**
Vacuum: **NA**
Last cal.: **10/15/09**

Methane Audit Point	PPM Input (X)	PPM DAS (Y)	PPM Dif (%)
1	0.00	0.00	NA
2	1.75	1.76	0.6
3	3.47	3.43	-1.2
4	8.69	8.34	-4.0

Linear Regression: (Y=PPM Corrected, X=PPM Input)

	DAS
Slope:	0.956
Intercept:	0.06
Correlation:	0.9999

Comments: No problems noted.

Audit Equipment	Make	Model	ID	Certification Date
Dilution System:	API	700	225	2/9/10
Zero Air System:	API	12/01/01	08/23/06	NA
Calibration Gas:	SMI	Multi	JJ708A	12/28/08

AUDIT RECORD

OZONE

T&B Systems
26074 Avenue Hall Unit 9
Valencia, CA 91355
(661) 294-1103

Date: **02/16/10**
Start: **7:50 MST**
Finish: **8:40 MST**
Audited by: **David Yoho**
Witness: **Jeff Soltice**

Site name: **UW Mobile Lab (Olson Ranch)**
Operator: **University of Wyoming**
Project: **University of Wyoming**

Analyzer make: **Thermo**
Serial No.: **CM08420038**
Sample flow: **0.650 / 0.650 lpm**
Span Set Point: **0.998**
Zero Set Point: **0.0**
Range: **1.000 ppm**

Model: **49i**
Filter: **02/01/10**
Ozone Measure: **85808 Hz**
Ozone Ref: **92422 Hz**
Last cal.: **2/11/10**

O3 Audit Point	PPM Input (X)	PPM DAS (Y)	PPM DAS (Y)
1	0.000	0.000	
2	0.043	0.043	0.0
3	0.088	0.086	-2.3
4	0.190	0.184	-3.2

Linear Regression: (Y=PPM Corrected, X=PPM Input)

	DAS
Slope:	0.966
Intercept:	0.001
Correlation:	1.0000

Comments: No problems noted.

Audit Equipment	Make	Model	ID	Certification Date
Dilution System:	API	700	225	2/9/10
Ozone Standard:	API	700	225	2/1/10
Zero Air System:	API	701	2427	

Ozone Transfer Standard			
Sample Freq: NA		Cell Temperature:	NA deg C
Control Freq: NA		Ambient Pressure:	NA "Hg
Span Setting: NA		Certification Slope:	1.0063
		Certification Intercept:	0.0000 ppm

APPENDIX C: SECOND QUARTER 2010 AUDIT REPORT

5.10 UNIVERSITY OF WYOMING TRAILER (OLSON RANCH)

5.10.1 Site Location

At the time of the audit, the trailer was located 42° 35' 57.95” North Latitude and 109° 52' 11.70” West Longitude (GPS).

5.10.2 Station Equipment Summary, Audit Results and Recommendations

Table 1. Site Monitoring Equipment

Site: UW Trailer **Date:** 04/21/10

AMBIENT AIR QUALITY MONITORS

Parameter	Manufacturer	Model	Serial No.	Range	Last Cal
Ozone	Thermo	49i	CM08420038	1.000 ppm	3/20/10
Nitric Oxide	Thermo	42i	08305328314	0.5 ppm	3/20/10
Nitrogen Oxides	Thermo	42i	08305328314	0.5 ppm	3/20/10
Nitrogen Dioxide	Thermo	42i	08305328314	0.5 ppm	3/20/10
Total Hydrocarbons	Thermo	55i	0908635578	5 ppm	3/20/10

Table 5.10.1. Monitoring equipment at University of Wyoming Trailer.

Site: UW Mobile Lab (Olson Ranch)
Project: University of Wyoming
Operator: University of Wyoming

AMBIENT AIR QUALITY MONITORS

Audit Date	Parameter	Max Diff. (%)	DAS Slope	DAS Intercept	DAS Correlation
4/21/2010	Ozone	-2.6	0.974	0.000	1.0000
4/21/2010	Total Hydrocarbons	-2.6	0.973	0.017	1.0000
4/21/2010	Nitric Oxide	-3.5	0.967	0.000	1.0000
4/21/2010	Nitrogen Oxides	-5.2	0.953	0.000	1.0000
4/21/2010	Nitrogen Dioxide	-5.8	0.941	0.000	1.0000

Audit Criteria: Max Diff ±15%, Slope 1.000 ± 0.15: Intercept 0 ± 0.015 ppm (THC 0 ± 0.9 ppm); Correlation > 0.9950

Table 5.10.2. Audit results for University of Wyoming Trailer.

Key Audit Findings

No problems were noted.

5.10.3 Performance Audit Reports

The performance audit reports for the air quality instrumentation follow.

AUDIT RECORD

NITRIC OXIDE

T&B Systems
26074 Avenue Hall Unit 9
Valencia, CA 91355
(661) 294-1103

Date: **04/21/10**
Start: **6:30 MST**
Finish: **8:30 MST**
Audited by: **David Yoho**
Witness: **Jeff Soltice**

Site Name: **UW Mobile Lab (Olson Ranch)**
Operator: **University of Wyoming**
Project: **University of Wyoming**

Analyzer make: **Thermo**
Serial No.: **08305328314**
Sample flow: **0.54 lpm**
Zero setting: **0.0028**
Range: **0.500 PPM**

Model: **42i**
Filter: **03/20/10**
Span setting: **0.838**
Vacuum: **N/A**
Mode: **N/A**
Last cal.: **3/20/10**

NO Audit Point	PPM Input (X)	PPM DAS (Y)	PPM Dif (%)
1	0.000	0.000	NA
2	0.093	0.090	-3.2
3	0.173	0.167	-3.5
4	0.427	0.413	-3.3

Linear Regression: (Y=PPM Corrected, X=PPM Input)

	DAS
Slope:	0.967
Intercept:	0.000
Correlation:	1.0000

Comments: No problems noted.

Audit Equipment	Make	Model	ID	Certification Date
Dilution System:	API	700	225	4/15/10
Zero Air System:	API	701	2427	NA
Calibration Gas:	SMI	Multi	JJ708A	12/28/08

AUDIT RECORD

OXIDES OF NITROGEN

T&B Systems
26074 Avenue Hall Unit 9
Valencia, CA 91355
(661) 294-1103

Date: **04/21/10**
Start: **6:30 MST**
Finish: **8:30 MST**
Audited by: **David Yoho**
Witness: **Jeff Soltice**

Site Name: **UW Mobile Lab (Olson Ranch)**
Organization: **University of Wyoming**
Project: **University of Wyoming**

Analyzer make: **Thermo**
Serial No.: **08305328314**
Sample flow: **0.54 lpm**
Zero setting: **0.0038**
Range: **0.500** **PPM**

Model: **42i**
Filter: **03/20/10**
Span setting: **0.984**
Vacuum: **N/A**
Last cal.: **3/20/10**

NOx Audit Point	PPM Input (X)	PPM DAS (Y)	PPM Dif (%)
1	0.000	0.000	NA
2	0.093	0.089	-4.3
3	0.173	0.164	-5.2
4	0.427	0.407	-4.7

Linear Regression: (Y=PPM Corrected, X=PPM Input)

	DAS
Slope:	0.953
Intercept:	0.000
Correlation:	1.0000

Comments: No problems noted.

Audit Equipment	Make	Model	ID	Certification Date
Dilution System:	API	700	225	4/15/10
Zero Air System:	API	701	2427	NA
Calibration Gas:	SMI	Multi	JJ708A	12/28/08

AUDIT RECORD

NITROGEN DIOXIDE

T&B Systems
26074 Avenue Hall Unit 9
Valencia, CA 91355
(661) 294-1103

Date: **04/21/10**
Start: **6:30 MST**
Finish: **8:30 MST**
Audited by: **David Yoho**
Witness: **Jeff Soltice**

Site Name: **UW Mobile Lab (Olson Ranch)**
Organization: **University of Wyoming**
Project: **University of Wyoming**

Analyzer make: **Thermo**
Serial No.: **08305328314**
Ozone flow: **NA**
Range: **0.500 PPM**

Model: **42i**
Converter T.: **325 deg C**
Last cal.: **3/20/10**

NO2 Audit Point	PPM Input (X)	PPM DAS (Y)	PPM Dif (%)
1	0.000	0.000	NA
2	0.072	0.068	-5.6
3	0.172	0.162	-5.8
4	0.342	0.322	-5.8

Linear Regression: (Y=PPM Corrected, X=PPM Input)

	DAS
Slope:	0.941
Intercept:	0.000
Correlation:	1.0000

Converter Efficiency
98.7%

Comments: No problems noted.

Audit Equipment	Make	Model	ID	Certification Date
Dilution System:	API	700	225	4/15/10
Zero Air System:	API	701	2427	NA
Calibration Gas:	SMI	Multi	JJ708A	12/28/08

AUDIT RECORD

TOTAL HYDROCARBONS

T&B Systems
26074 Avenue Hall Unit 9
Valencia, CA 91355
(661) 294-1103

Date: **04/21/10**
Start: **6:30 MST**
Finish: **8:30 MST**
Audited by: **David Yoho**
Witness: **Jeff Soltice**

Site name: **UW Mobile Lab (Olson Ranch)**
Operator: **University of Wyoming**
Project: **University of Wyoming**

Analyzer make: **Thermo**
Serial No.: **0908635578**
Sample flow: **NA**
Zero setting: **NA**
Range: **5 PPM**

Model: **55i**
Filter: **03/20/10**
Span setting: **NA**
Vacuum: **NA**
Last cal.: **3/20/10**

Methane Audit Point	PPM Input (X)	PPM DAS (Y)	PPM Dif (%)
1	0.00	0.00	NA
2	1.86	1.83	-1.6
3	3.44	3.39	-1.5
4	8.47	8.25	-2.6

Linear Regression: (Y=PPM Corrected, X=PPM Input)

	DAS
Slope:	0.973
Intercept:	0.02
Correlation:	1.0000

Comments: No problems noted.

Audit Equipment	Make	Model	ID	Certification Date
Dilution System:	API	700	225	4/15/10
Zero Air System:	API	12/01/01	08/23/06	NA
Calibration Gas:	SMI	Multi	JJ708A	12/28/08

AUDIT RECORD

OZONE

T&B Systems
26074 Avenue Hall Unit 9
Valencia, CA 91355
(661) 294-1103

Date: **04/21/10**
Start: **8:30 MST**
Finish: **9:20 MST**
Audited by: **David Yoho**
Witness: **Jeff Soltice**

Site name: **UW Mobile Lab (Olson Ranch)**
Operator: **University of Wyoming**
Project: **University of Wyoming**

Analyzer make: **Thermo**
Serial No.: **CM08420038**
Sample flow: **0.630 / 0.630 lpm**
Span Set Point: **1.008**
Zero Set Point: **0.6**
Range: **1.000 ppm**

Model: **49i**
Filter: **03/20/10**
Ozone Measure: **78304 Hz**
Ozone Ref: **88423 Hz**
Last cal.: **March-10**

O3 Audit Point	PPM Input (X)	PPM DAS (Y)	PPM DAS (Y)
1	0.000	0.000	NA
2	0.045	0.044	-2.2
3	0.089	0.088	-1.1
4	0.191	0.186	-2.6

Linear Regression: (Y=PPM Corrected, X=PPM Input)

	DAS
Slope:	0.974
Intercept:	0.000
Correlation:	1.0000

Comments: No problems noted.

Audit Equipment	Make	Model	ID	Certification Date
Dilution System:	API	700	225	4/15/10
Ozone Standard:	API	700	225	02/01/10
Zero Air System:	API	701	2427	

Ozone Transfer Standard			
Sample Freq: NA	Cell Temperature:	NA	deg C
Control Freq: NA	Ambient Pressure:	NA	"Hg
Span Setting: NA	Certification Slope:	1.0063	
	Certification Intercept:	0.0000	ppm