GARFIELD COUNTY
2008 AIR QUALITY MONITORING SUMMARY

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EXECUTIVE SUMMARY

This report summarizes air quality monitoring data collected during 2008 in Garfield County, Colorado. The monitoring stations used for this analysis include the Parachute, Rifle, Brock, and Bell-Melton sites, which are all in close proximity to oil and gas development in the county. Monitoring at these sites included criteria pollutants, volatile organic compounds (VOCs), and meteorology.

Criteria pollutants are pollutants subject to the National Ambient Air Quality Standards (NAAQS). Criteria pollutants monitored in 2008 included particulate matter $\leq$ 10 micrometers in diameter (PM_{10}) at the Parachute and Rifle sites, and particulate matter $\leq$ 2.5 micrometers in diameter ($PM_{2.5}$) and ozone (O_3) at the Rifle site. At present, air quality measurements in Garfield County do not violate air quality standards for O_3, PM_{10}, or $PM_{2.5}$, but PM_{10} levels appear to be increasing and limited data are available for O_3 and $PM_{2.5}$.

Meteorological parameters and VOCs, including speciated non-methane hydrocarbons (SNMOC) and carbonyl compounds, were monitored at all four sites in 2008. SNMOC monitoring data indicated levels of light alkanes (subset of SNMOCs) two to five times higher than sites outside of Garfield County where measurements were available. These light alkanes are the primary components of natural gas. Some of the less abundant SNMOCs, such as the alkenes (including biogenic compounds) and aromatics (including the BTEX compounds benzene, toluene, ethylbenzene and x/p-xylenes), were shown to have significant potential for O_3 formation. The limited O_3 measurements indicate that levels were far below the O_3 formation potential of the VOCs, indicating that O_3 formation may be limited by nitric oxides (NO_X) availability. This might indicate that more NO_X in the area could increase O_3, and that the most effective way to reduce O_3 under current conditions is to reduce NO_X.

Hazardous air pollutants (HAPs) are a subset of VOC compounds, and include compounds that are known or believed to cause human health effects at low doses. Annual average concentrations measured for formaldehyde, acetaldehyde and 1,3-butatdiene were lower in Garfield County than in other areas outside the county where measurements were available for 2008, as reported by the Environmental Protection Agency (EPA) for sites in the national Urban Air Toxics Monitoring Program (UATMP) and National Air Toxics Trends Stations (NATTS) network. Annual average concentrations of benzene, toluene, ethylbenzene and m/p-xylenes at the Parachute site were higher than most averages reported across the United States. A detailed risk assessment for all measured HAPs will be made available in a separate report published by the Colorado Department of Public Health and Environment (CDPHE).

1.0 INTRODUCTION

Oil and gas exploration and production within the Piceance Basin in Colorado, and elsewhere in the Rocky Mountain region, has undergone rapid growth over the last decade. In response to this growth, concerns have grown regarding the impacts of oil and gas development in Garfield County.

The Garfield County Public Health Department (GCPHD) is committed to protecting the health and welfare of its citizens. In response to citizen concerns, in 2005, the GCPHD enhanced air quality monitoring efforts to evaluate levels of PM_{10} and VOCs in the area. In 2008, the monitoring network was modified to encompass SNMOCs and carbonyl compounds and the regulatory monitoring network expanded from PM_{10} to include $PM_{2.5}$ and O_3. These changes were designed to serve a wide range of purposes, including monitoring of criteria pollutant levels, ozone formation potential, toxics assessments, and source attribution.

The current monitoring network in Garfield County consists of four (4) stations. Characteristics of the monitoring sites are described below.

- Parachute (PACO): Parachute is a small urban center of approximately 1,300 people (US Census, 2008) within very close proximity to oil and development activities. The town is located along Interstate 70 and is the transportation hub for heavily traveled roads which service the surrounding canyons.

- Rifle (RICO): Rifle is a rapidly growing urban center on the Interstate 70 corridor with estimated population of about 9,200 people (US Census, 2008). Rifle is in close proximity to oil and gas development activities, and is also central to industrial support for the oil and gas industry.

- Brock (MOCO): The Brock site is a rural location about four (4) miles south of Rifle, amid oil and development activities.

- Bell-Melton (BRCO): The Bell-Melton site is a rural homestead approximately four (4) miles south of the town of Silt, in close proximity to moderate oil and gas development activities.

Figure 1-1 is a map of the monitoring sites in Garfield County, Figure 1-2 is a regional map showing the location of sites in proximity to major cities in Western Colorado, and Table 1-1 lists the parameters monitored. The Colorado Department of Public Health and Environment (CDPHE) operates the PM_{10} monitors in Rifle and Parachute. SNMOC and carbonyl compounds are sampled at all sites and analyzed by the Eastern Research Group, Inc. (ERG). The GCPHD monitors meteorology at all except the Rifle station. Air Resource Specialists, Inc. (ARS) monitors, collects and validates continuous PM_{10} and $PM_{2.5}$, O_3, and meteorology at the Rifle site. ARS also operates a digital Web camera at the Rifle site. Images are collected every 15-minutes and displayed on the Garfield County Air Quality Monitoring Website (http://www.garfieldcountyaq.net), along with associated data.

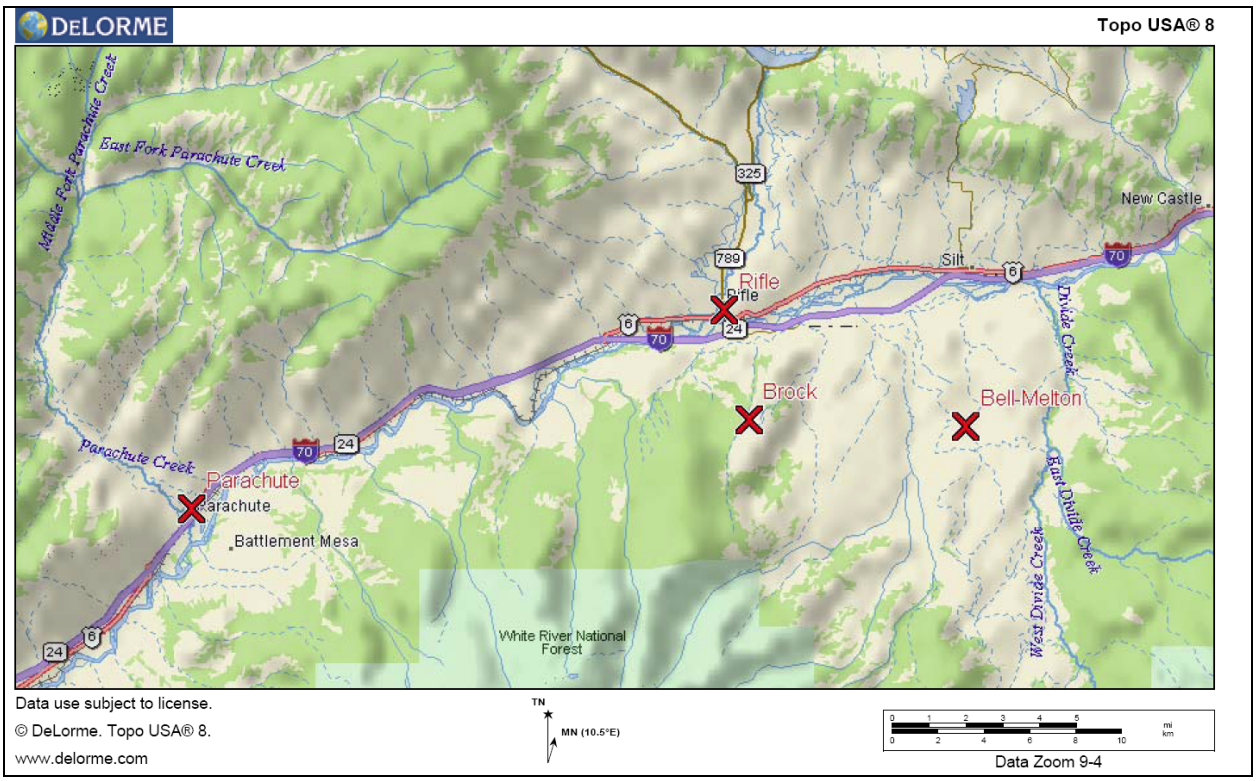

Figure 1-1. Map of Garfield County Monitoring Sites.

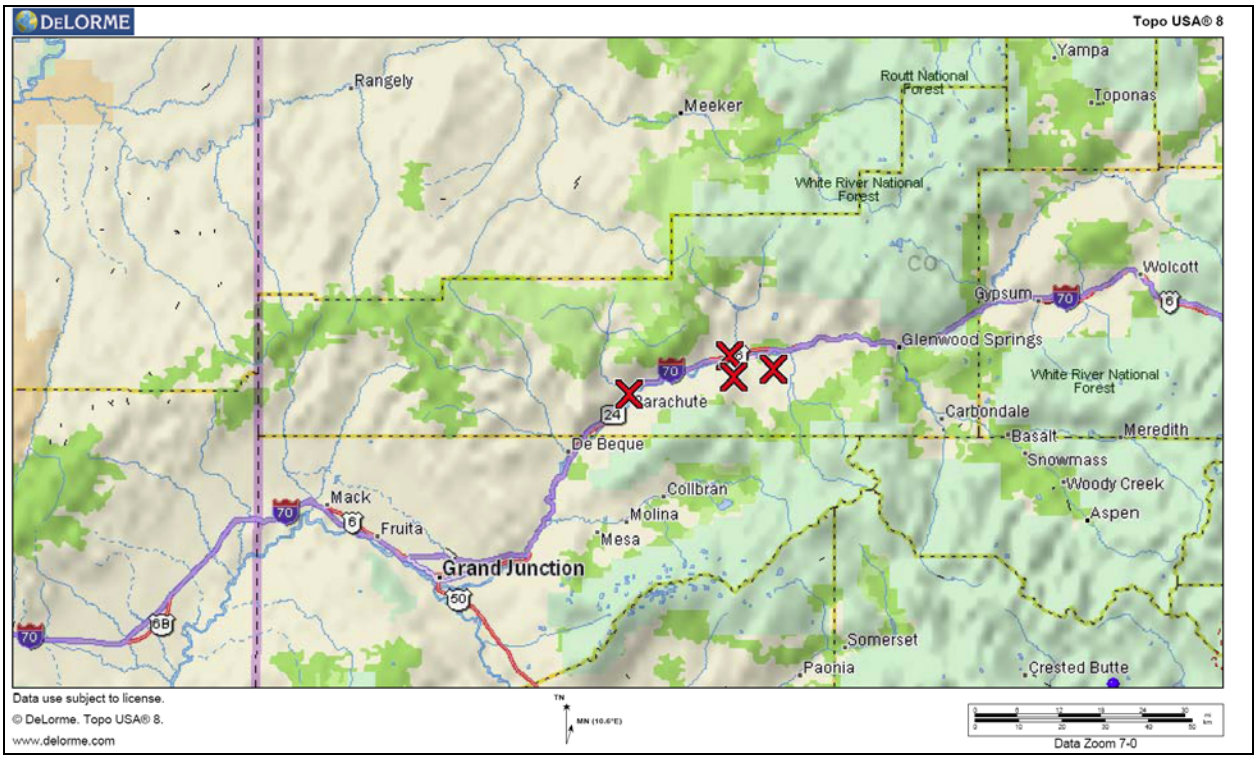

Figure 1-2. Map of Garfield County in Western Colorado.

Table 1-1

Garfield County
Parameters Monitored by Site

Component	Method	Sampling Frequency	Reporting Agency
Rifle, Colorado			
SNMOC	TO-12	24-hour (1/6 day)	ERG
Carbonyls	TO-11A	24-hour (1/12 day)	ERG
PM_{10}	FRM	24-hour (1/3 day)	CDPHE
PM_{10}	TEOM	Hourly	ARS
$PM_{2.5}$	TEOM	Hourly	ARS
Ozone	42C	Hourly	ARS
Meteorology	Various	Hourly	ARS
Visibility Web Camera	Digital	15-min	ARS
Parachute, Colorado			
SNMOC	TO-12	24-hour (1/6 day)	ERG
Carbonyls	TO-11A	24-hour (1/12 day)	ERG
PM_{10}	FRM	24-hour (1/3 day)	CDPHE
Meteorology	Various	Hourly	GCPHD
Brock, Colorado			
SNMOC	TO-12	24-hour (1/6 day)	ERG
Carbonyls	TO-11A	24-hour (1/12 day)	ERG
Meteorology	Various	Hourly	GCPHD
Bell-Melton, Colorado			
SNMOC	TO-12	24-hour (1/6 day)	ERG
Carbonyls	TO-11A	24-hour (1/12 day)	ERG
Meteorology	Various	Hourly	GCPHD

The following sections summarize data collected in 2008 at the Garfield County monitoring sites and presents analysis, including metrological characteristics, criteria pollutant levels, and levels of volatile organic compounds.

This air quality data summary report has been prepared by Air Resource Specialists, Inc. (ARS) for the Garfield County Public Health Department (GCPHD). Any questions regarding the contents of this report should be addressed to:

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2.0 METEOROLOGICAL SUMMARIES

Meteorological data collected along with air quality parameters are used to better understand the local conditions and transport of air pollutants. Meteorological data collected at these sites includes wind speed, wind direction, temperature, relative humidity, and precipitation. Quarterly time series plots for all parameters collected during 2008 are presented in Appendix A.

Figures 2-1 through 2-4 present annual wind roses for the monitoring sites. A wind rose shows the frequency of wind direction and uses different shading to represent wind speeds. For example, Figure 2-1 indicates that most winds (~15%) at the Parachute site came from the east-northeast, but wind speeds from that direction were never higher than 6.9 m/s. Higher speed winds tended to come from the west through north directions. Winds out of the south were rare at the Parachute site.

Generally, wind directions at the Parachute and Rifle sites were scattered, with up and down canyon flows apparent, and a high percentage of calm winds (21.46 and 24.52%, respectively). Winds from the south were most prevalent at the Brock site, and winds from the southeast were most prevalent at the Bell-Melton site.

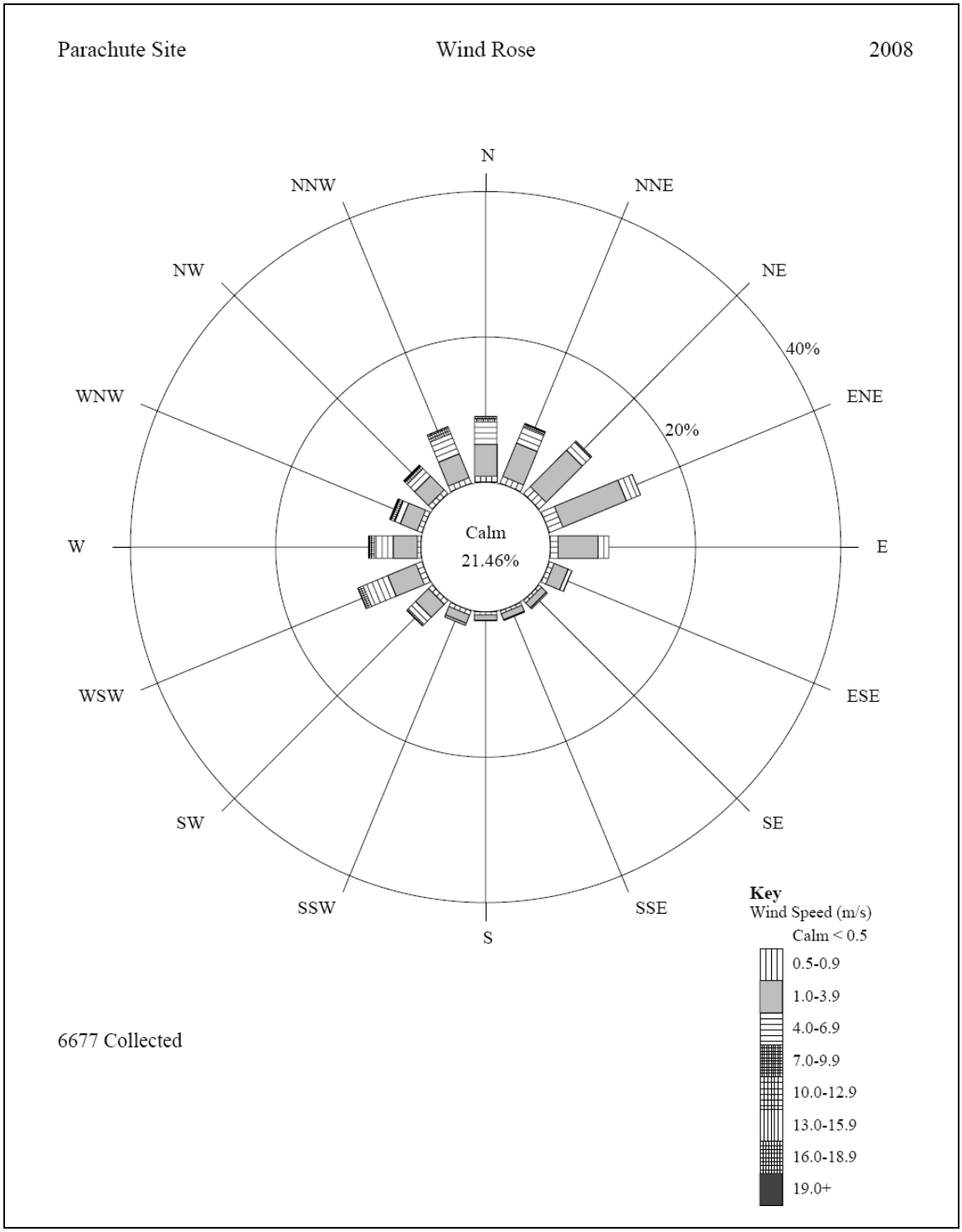


Figure 2-1. 2008 Wind Rose for the Parachute Monitoring Site.

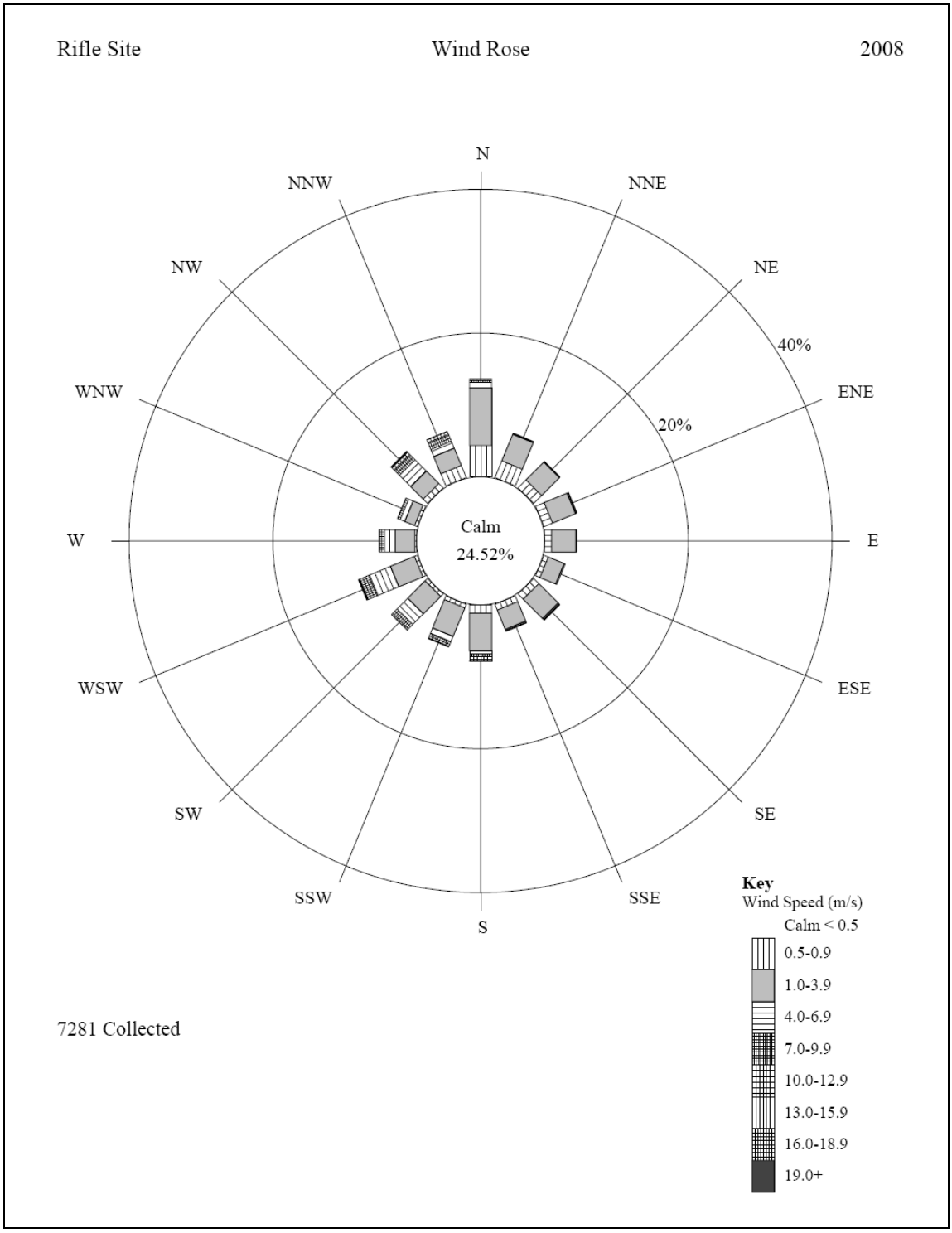


Figure 2-2. 2008 Wind Rose for the Rifle Monitoring Site.

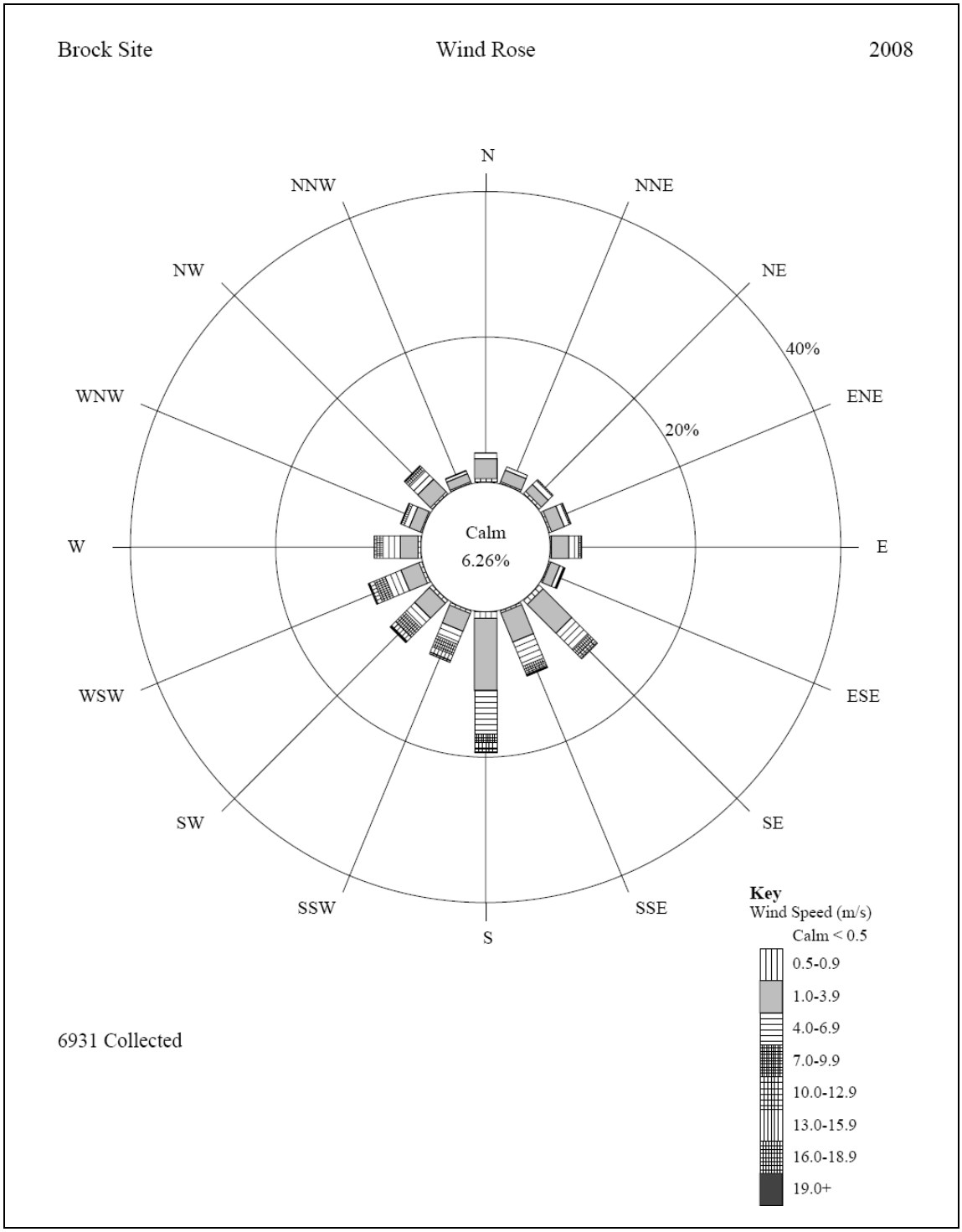


Figure 2-3. 2008 Wind Rose for the Brock Monitoring Site.

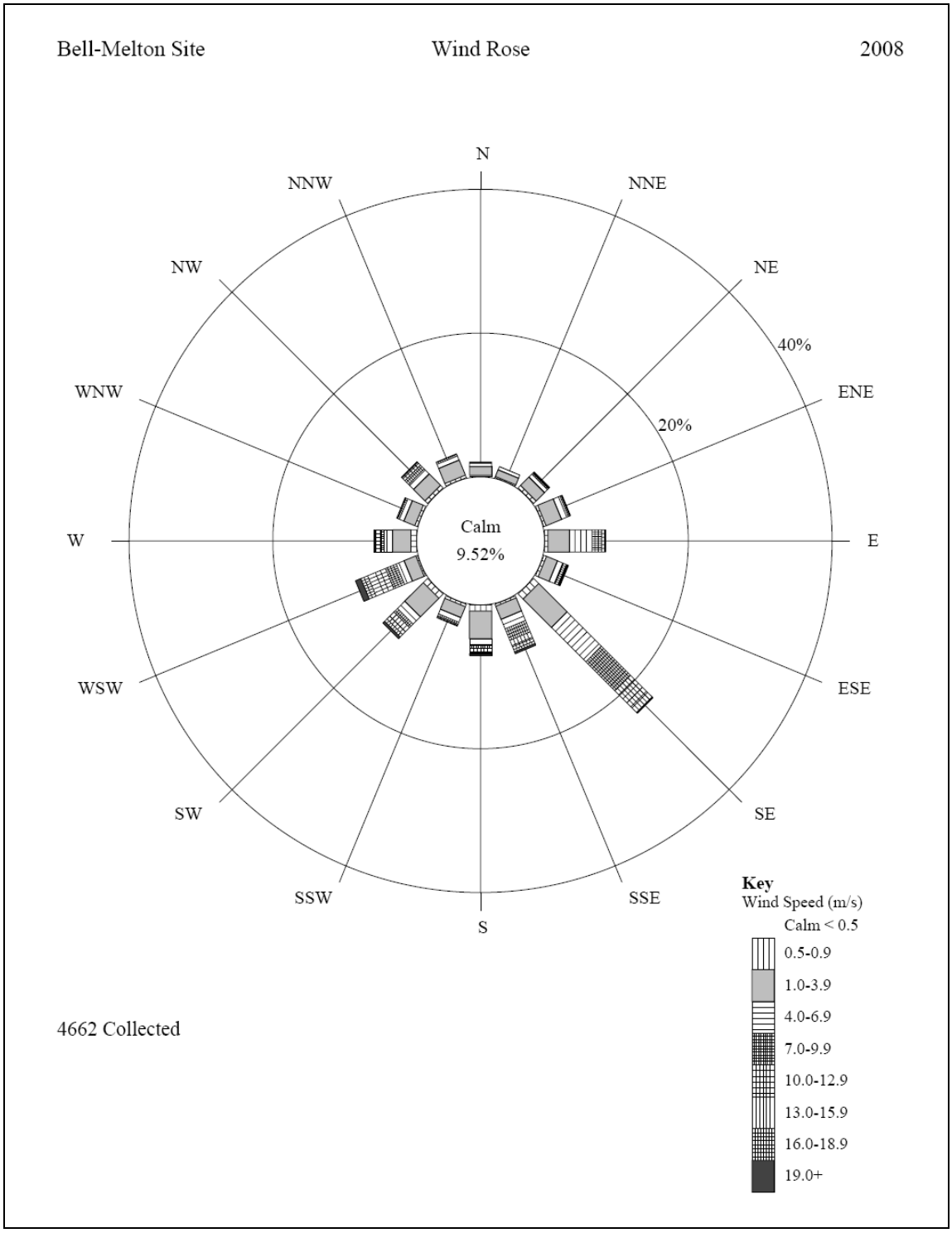


Figure 2-4. 2008 Wind Rose for the Bell-Melton Monitoring Site.

2.1 RESIDENCE TIME MAPS

Meteorological back trajectories centered at the Rifle site were generated to identify the geographic source areas of influence. Back trajectory analyses use interpolated measured or modeled meteorological fields to estimate the most likely central path over geographical areas that provided air to a receptor at a given time. The method essentially follows a parcel of air backward in hourly steps for a specified length of time. Back trajectories account for the impact of wind direction and wind speed on delivery of emissions to the receptor but do not account for chemical transformation, dispersion and deposition of emissions.

Trajectories were generated using the Hybrid-Single Particle Lagrangian Integrated Trajectory (HYSPLIT) Model developed by the National Oceanic and Atmospheric Administration's (NOAA) Air Resources Laboratory (ARL). Detailed information regarding the trajectory model and these data sets can be found on NOAA's Web site (http://www.arl.noaa.gov/ready/hysplit4.html).

Four (4) back trajectories were generated per day, with end times of 0000, 0600, 1200, and 1800 MST, with end heights of 500 meters. Each hourly point along 72-hour back trajectory paths were binned and summed into 1 degree horizontal grid cells of latitude and longitude, and plotted as a residence time where different colors indicate the percent of total back trajectories that traversed each longitude latitude grid cell.

Figure 2-5 presents a map of the 2008 residence time centered at the Rifle site in Garfield County. One general path of influence comes from the northwest, through Utah and Idaho. Another more pronounced path is from the south-southwest through Utah and Arizona. Figure 2-6 presents quarterly residence time maps, which follow the same general pattern as the annual map, with the first quarter (January through March) trajectories originating furthest west, and the third quarter (July through September) trajectories originating nearer to the site. This indicates that the site experienced, on average, faster moving air parcels in the first quarter than the third quarter. Very few back trajectories originate east of Rifle, with the largest eastern influence occurring during the third quarter.

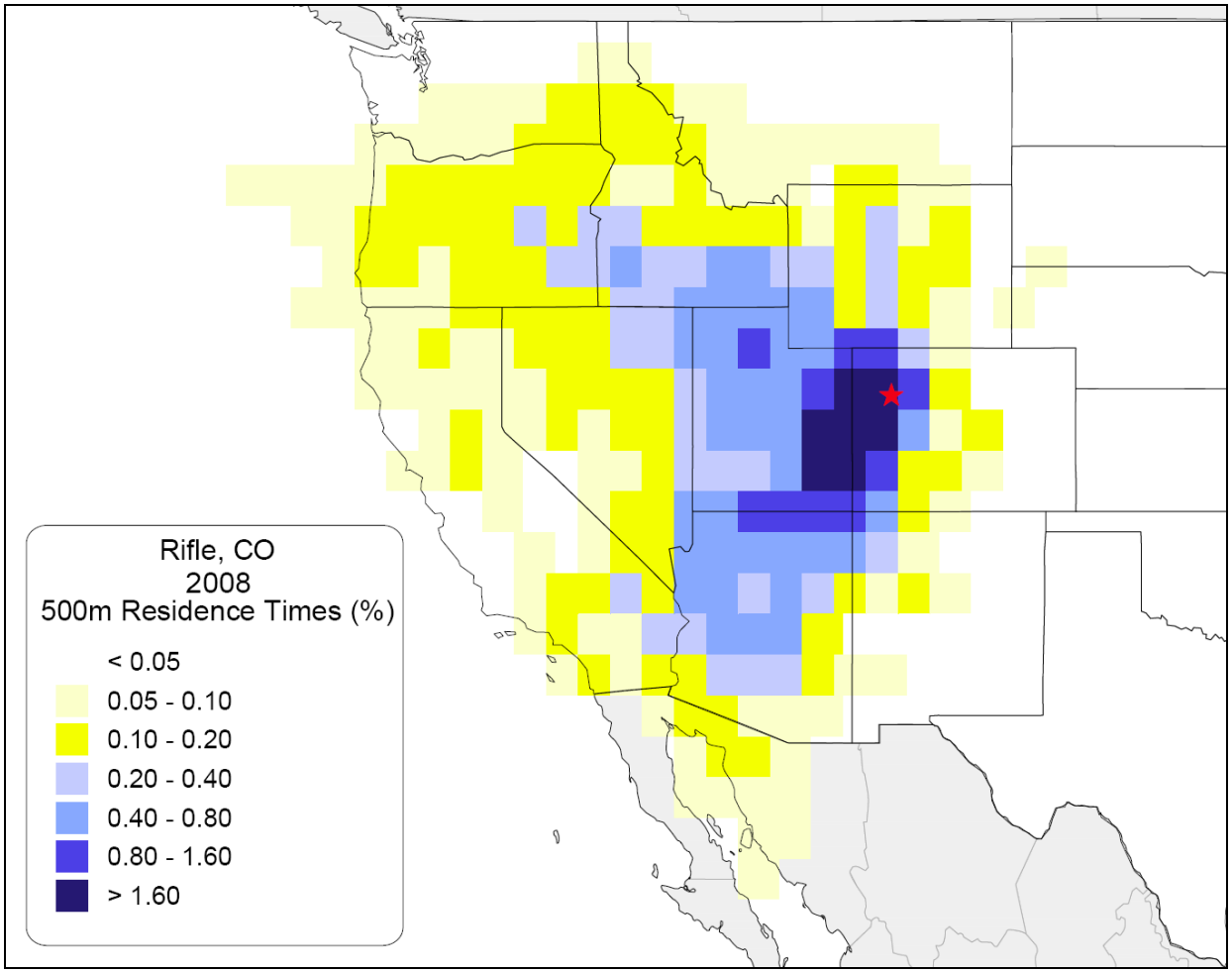


Figure 2-5. 2008 Residence Time Map for Rifle Monitoring Site in Garfield County.

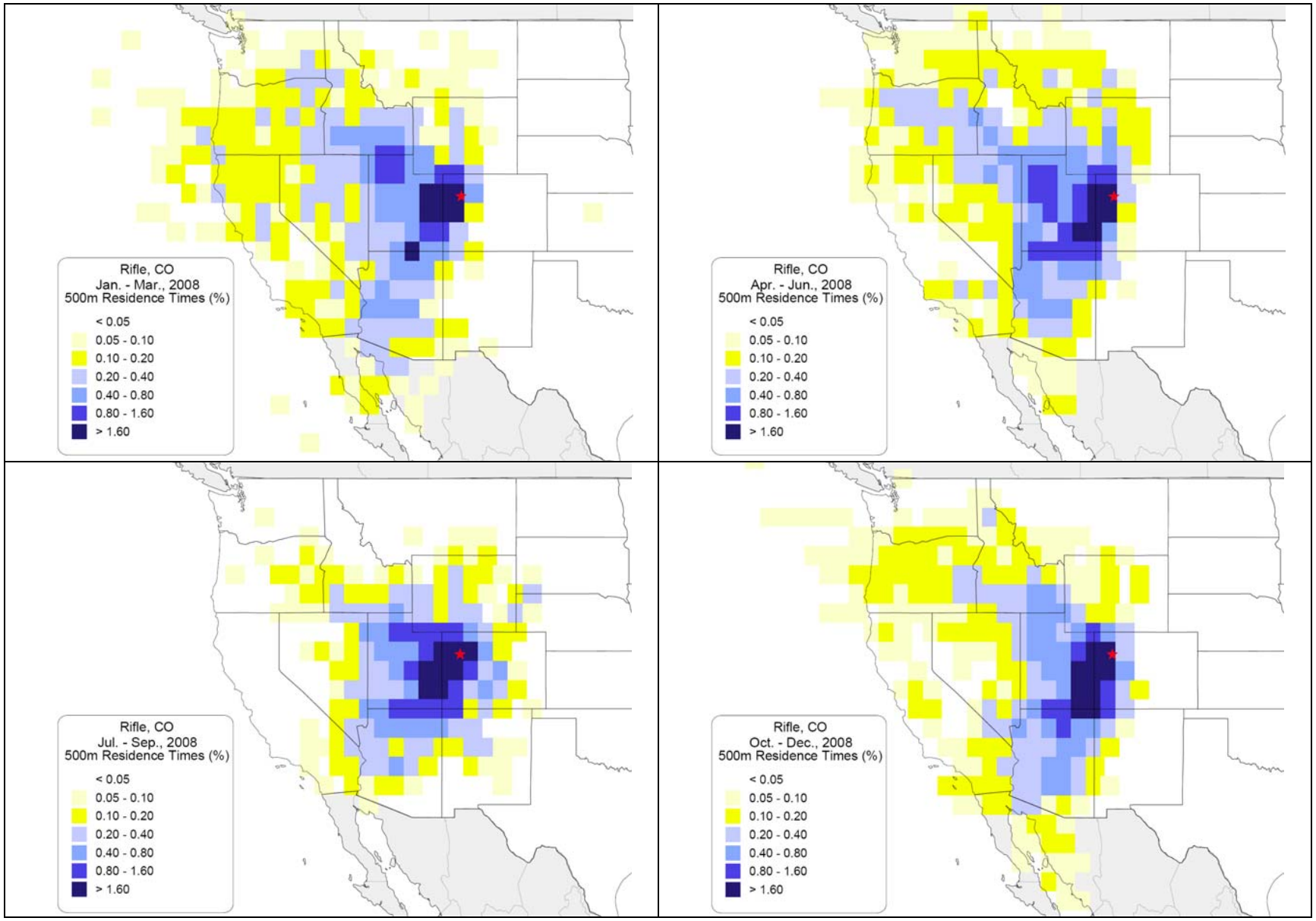


Figure 2-6. 2008 Quarterly Residence Time Maps for Rifle Monitoring Site in Garfield County.

3.0 CRITERIA POLLUTANT SUMMARIES

The Clean Air Act requires EPA to set two (2) types of NAAQS for ground-level O_3, particle pollution ($PM_{2.5}$ and PM_{10}), lead, nitrogen dioxide (NO_2), carbon monoxide (CO), and sulfur dioxide (SO_2). The types of standards are as follows:

- Primary Standards: These standards are designed to protect public health with an adequate margin of safety, including the health of sensitive populations such as asthmatics, children, and the elderly.

- Secondary Standards: These standards are designed to protect public welfare from adverse effects, including visibility impairment and effects on the environment (e.g., vegetation, soils, water, and wildlife).

PM_{10} has been monitored at the Parachute and Rifle sites for several years. Garfield County began monitoring continuous $PM_{2.5}$ and PM_{10} at the Rifle site in September 2008. The level of the national primary and secondary ambient air quality standards for PM_{10} is a 24-hour average concentration of 150 micrograms per cubic meter ($\mu g/m^3$). A violation of the standard occurs when the number of days with a 24-hour average concentration above 150 $\mu g/m^3$ over a three (3) year period is equal to or less than one. The standards for $PM_{2.5}$ are an annual arithmetic mean of 15 $\mu g/m^3$, and a 24-hour average of 35 $\mu g/m^3$. A violation of the $PM_{2.5}$ standard occurs when the three (3) year average of the weighted annual mean exceeds that annual standard, or the three (3) year average of the 98th percentile 24-hour average value exceeds the 24-hour standard.

O_3 monitoring began at the Rifle site in June 2008. The NAAQS for O_3 is 0.075 ppm (75 ppb) 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 76 ppb. A violation of the standard occurs when the three (3) year average of the fourth highest daily maximum 8-hour average ozone concentration equals or exceeds 76 ppb.

Values measured for O_3, $PM_{2.5}$, and PM_{10} in 2008 at the Rifle site are presented with corresponding NAAQS in Table 3-1. PM_{10} measured at the Parachute site is presented in Table 3-2. At present, air quality measurements in Garfield County do not violate air quality standards for these criteria pollutants.

Table 3-1

2008 Standards Summary for the Rifle Site

Parameter	NAAQS		Measured		
	Averaging Time	Standard	Measured Value		Date(s)
Ozone (O_3)	Rolling 8-hour	0.075 ppm/ 75 ppb	Highest Daily Max.:	76* ppb	7/9, 7/10
			4th Highest Daily Max.:	66* ppb	7/13
Particulate Matter ≤2.5µm ($PM_{2.5}$)	Annual	15 µg/m^3	Arithmetic Mean:	11.2* µg/m^3	9/1-12/31
	24-hour	35 µg/m^3	Highest Max:	40* µg/m^3	12/31
			98th percentile:	30* µg/m^3	12/30
Particulate Matter ≤10µm (PM_{10})	24-hour	150 µg/m^3	Highest Daily Max.:	114 µg/m^3	4/15
			2nd Highest Daily Max.:	88 µg/m^3	4/21

* Values for O_3 and $PM_{2.5}$ at the Rifle site do not represent complete years.

Table 3-2

2008 Standards Summary for the Parachute Site

Parameter	NAAQS		Measured		
	Averaging Time	Standard	Measured Value		Date(s)
Particulate Matter ≤10µm (PM_{10})	24-hour	150 µg/m^3	Highest Daily Max.:	210 µg/m^3	9/24
			2nd Highest Daily Max.:	136 µg/m^3	4/24

3.1 OZONE

Ozone measurements began in June 2008 at the Rifle site. Figure 3-1 presents daily maximum 8-hour averages of ozone monitored at the site along with the NAAQS. Table 3-3 presents the highest daily maximum O_3 measurements in 2008. The daily maximum 8-hour average O_3 exceeded the standard at 76 ppb on both July 9, 2008 and July 10, 2008, but the 4th highest daily 8-hour average was 66 ppb. A violation of the standard does not occur until the 3-year average of the 4th highest daily maximum values is greater than 75 ppb.

Figure 3-2 presents an O_3 pollutant rose for the Rifle site. A pollutant rose shows the frequency of wind direction and uses different shading to represent O_3 values. While the pollutant rose indicates that predominant winds were out of the north, the site measured the highest concentrations of O_3 when winds were out of the west-southwest through south.

Figure 3-3 presents the diurnal cycle of measured hourly O_3 at the Rifle station. The cycle shows lowest concentrations in the early morning hours and maximum concentrations in the late afternoon. This pattern results from daytime photochemical production from NO_X ($NO + NO_2$) and VOC precursors, and ozone loss by dry deposition and reaction with NO at night.

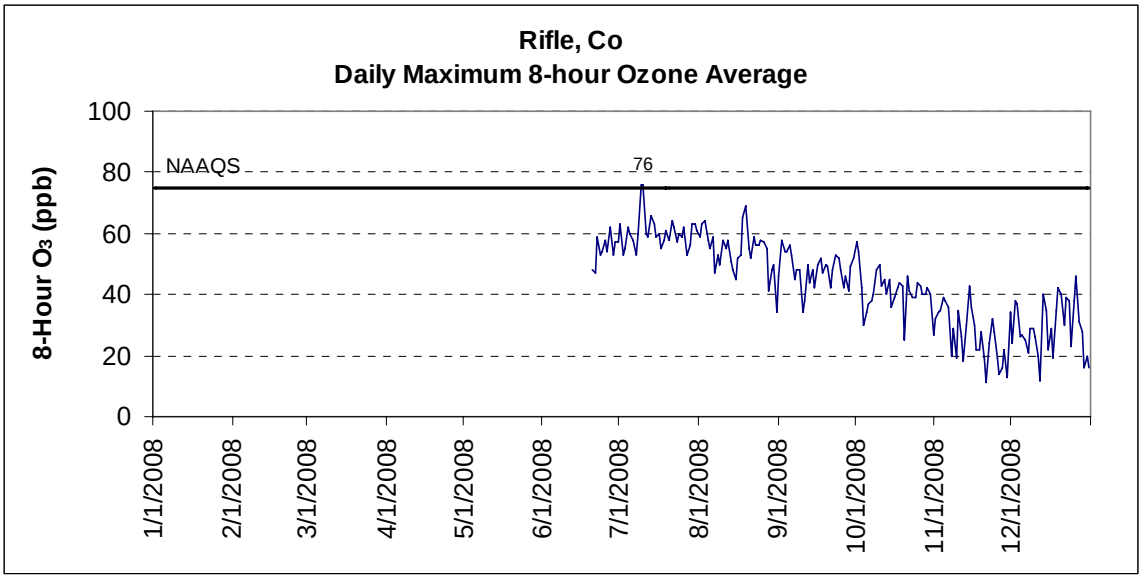


Figure 3-1. Daily Maximum 8-Hour Averages of Ozone Monitored at the Rifle Site.

Table 3-3

Rifle Site
Ten Highest Daily Maximum 8-Hour Ozone Averages in 2008

Level	Date	Daily Maximum 8-Hour Ozone (ppb)
1	7/09/2008	76
2	7/10/2008	76
3	8/19/2008	69
4*	**7/13/2008**	**66**
5	8/18/2008	65
6	8/03/2008	64
7	7/21/2008	64
8	8/02/2008	63
9	7/14/2008	63
10	7/29/2008	63

* The 3-year average of the 4th highest daily maximum is used to determine attainment status.

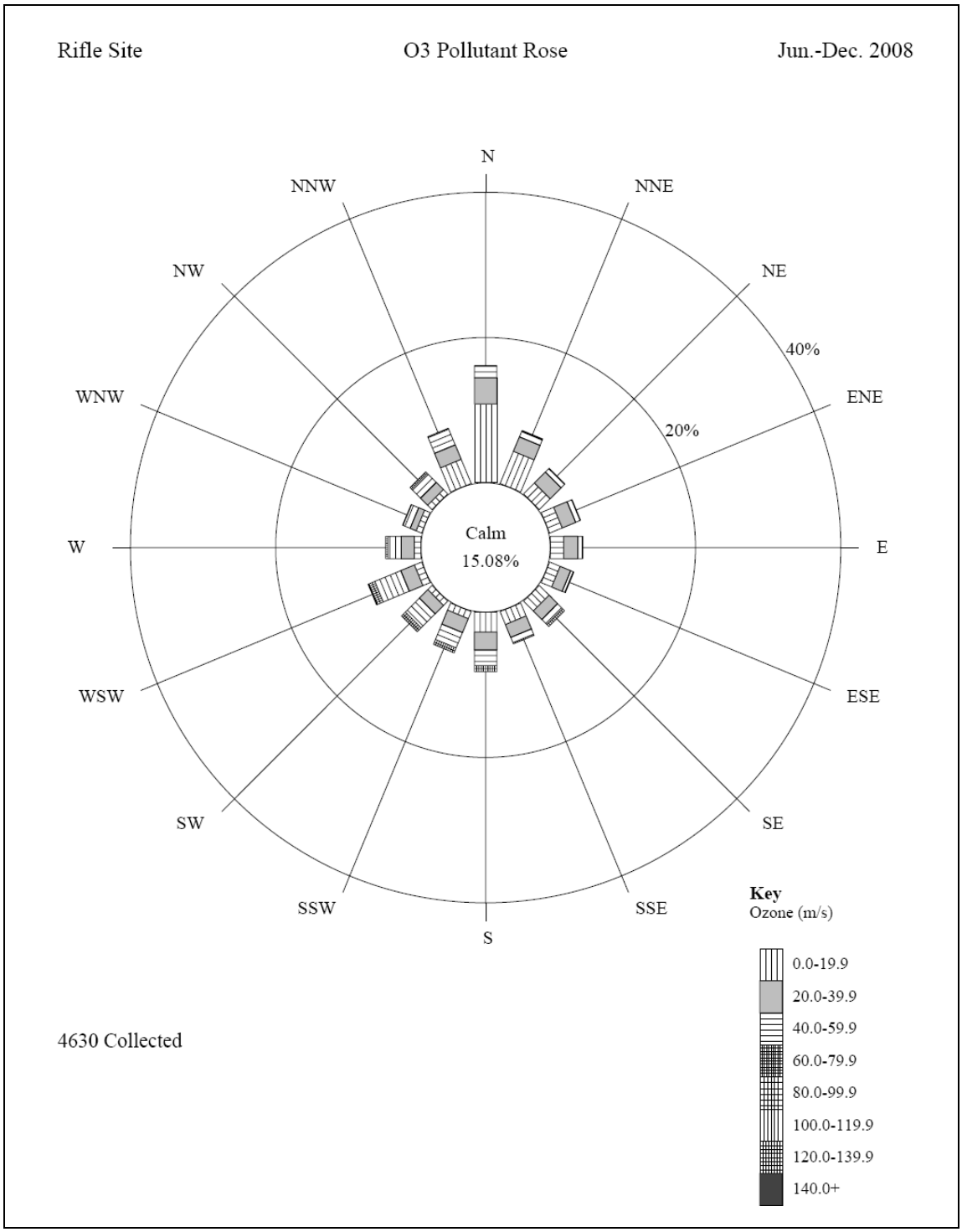


Figure 3-2. 2008 Ozone Pollutant Rose for the Rifle Monitoring Site.

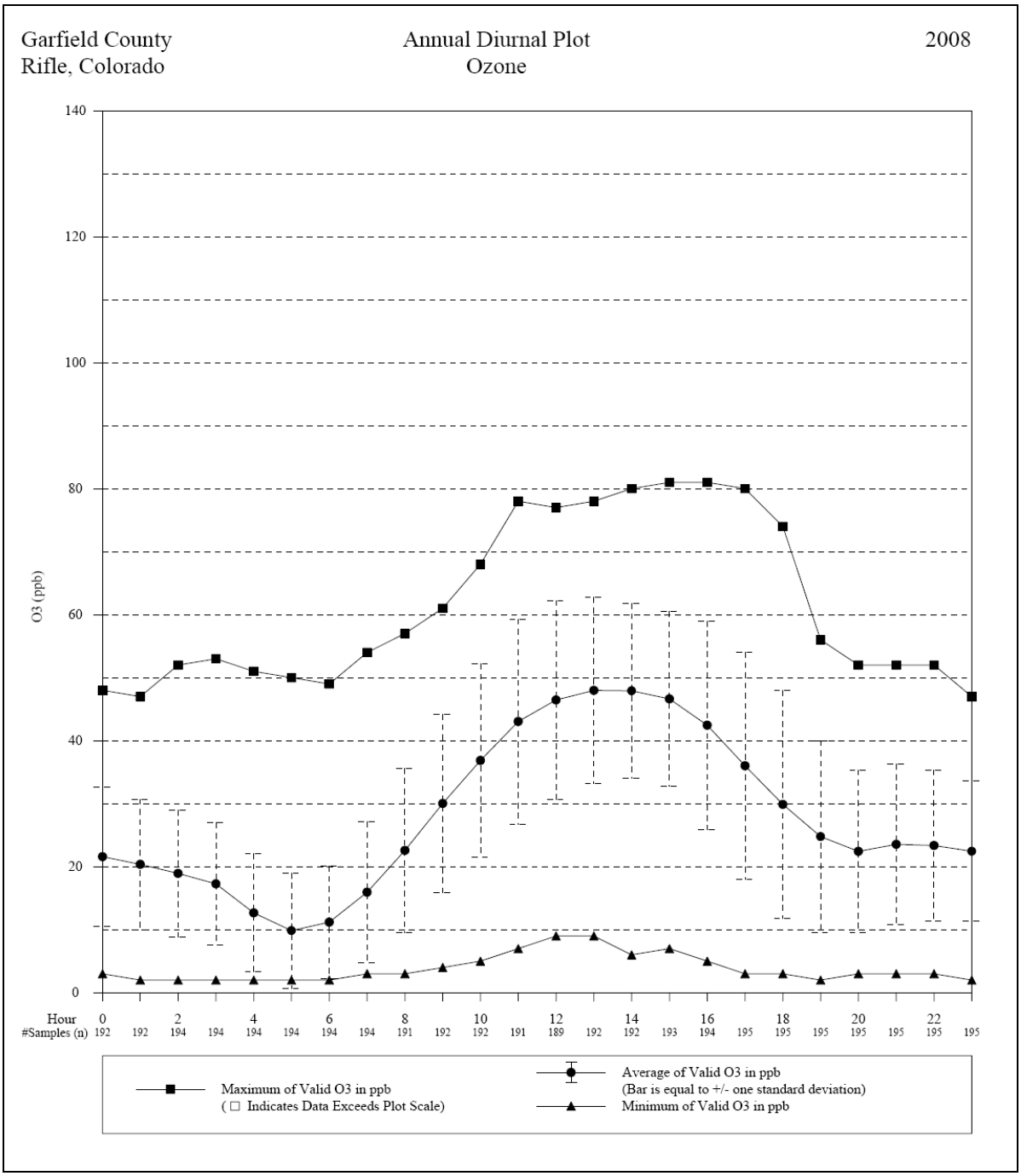


Figure 3-3. 2008 Diurnal Plot Showing Average Concentrations of O_3 at the Rifle Monitoring Site.

3.2 PARTICULATE MATTER (PM_{10} AND $PM_{2.5}$)

In 2008, 24-hour PM_{10} was monitored at the Parachute and Rifle sites. Continuous PM_{10} and $PM_{2.5}$ monitoring began at the Rifle site in September 2008.

Figure 3-4 presents the annual average PM_{10} measured at the Parachute site since 2000, and Figure 3-5 presents annual average PM_{10} measured at the Rifle site since 2005. PM_{10} at the Parachute site has been increasing since 2004, with average PM_{10} measured in 2008 about 55% higher than recorded in 2007. At the Rifle site, 2008 was the highest average recorded, but an increasing trend is not as apparent.

Figures 3-6 and 3-7 present the highest and second highest 24-hour average values measured at the Parachute and Rifle sites, respectively. The NAAQS for PM_{10} is a 24-hour average of 150 ppb (shown on chart), which was exceeded at the Parachute site in 2008. At the Rifle site, the standard has not been exceeded, but the highest and second highest averages are higher in 2008 than previous years. An exceedance of the standard does not constitute a violation until the average number of annual exceedances over a 3-year period is greater than or equal to 1.

Continuous PM_{10} overlapped with the filter based PM_{10} measurements at the Rifle site between September and December 2008. Figure 3-8 presents a correlation plot comparing 24-hour averages from both methods. Filter based PM_{10} is sampled on a 1-in-3 day schedule, so relatively few daily averages were available for comparison between September and December 2008. However, the comparison shows good correlation (R^2 = 0.97), with the continuous instrument averaging only slightly higher (~2 $\mu g/m^3$) than the filter based method.

Figures 3-9 and 3-10 present PM_{10} and $PM_{2.5}$ pollutant roses constructed from the continuous hourly data measured at the Rifle site. The pollutant roses show that the highest PM concentrations were associated with winds out of the north.

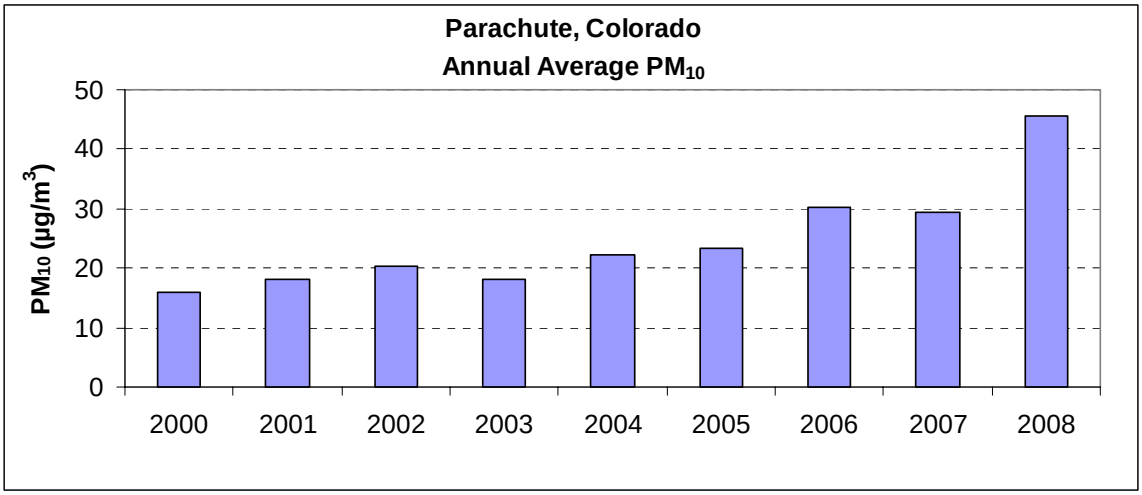


Figure 3-4. Annual Average PM_{10} Measured at the Parachute Site.

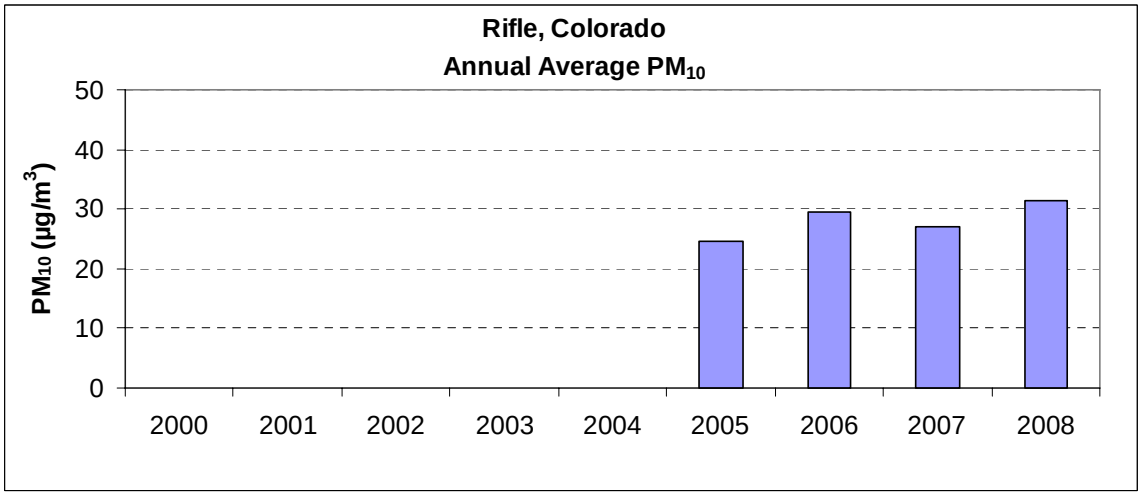


Figure 3-5. Annual Average PM_{10} Measured at the Rifle Site.

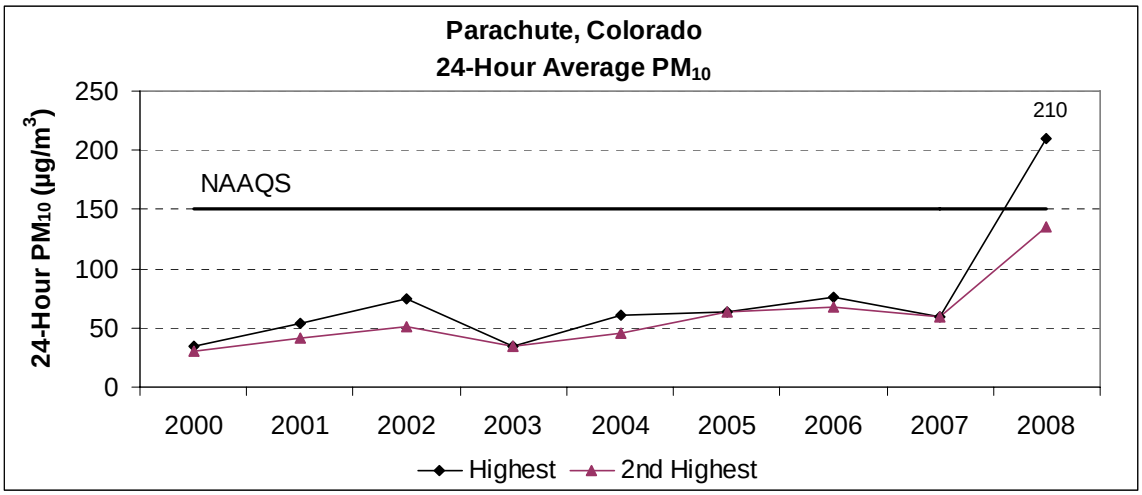


Figure 3-6. Highest and Second Highest 24-Hour Average PM_{10} Measured at the Parachute Site.

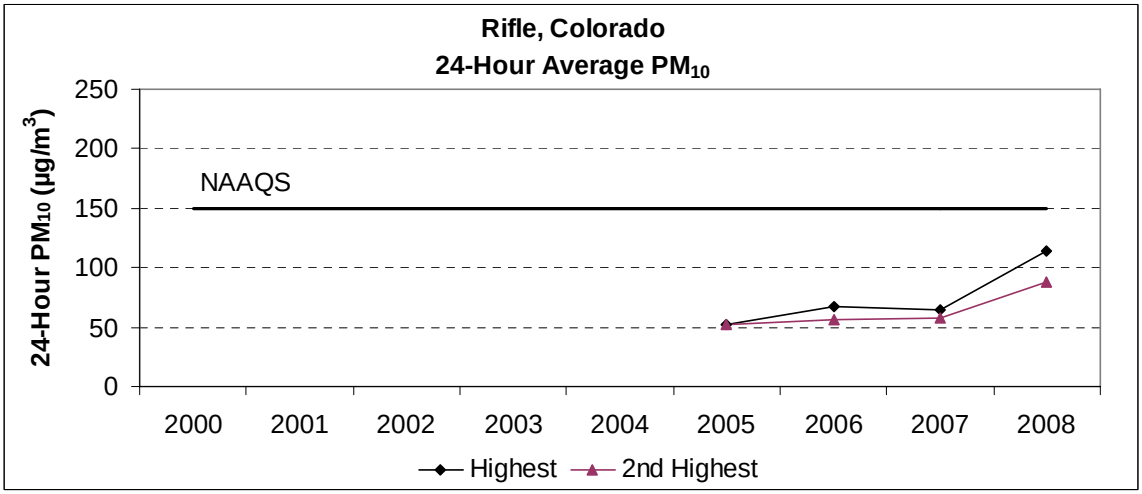


Figure 3-7. Highest and Second Highest 24-Hour Average PM_{10} Measured at the Rifle Site.

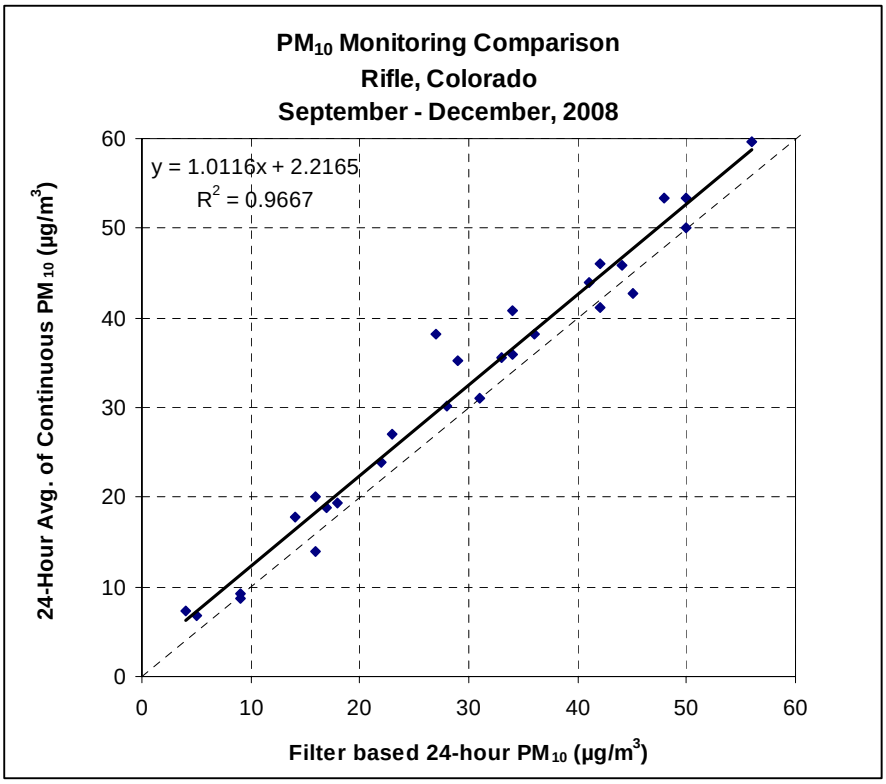


Figure 3-8. Correlation between Continuous and Filter Based Measurements at the Rifle Site in 2008.

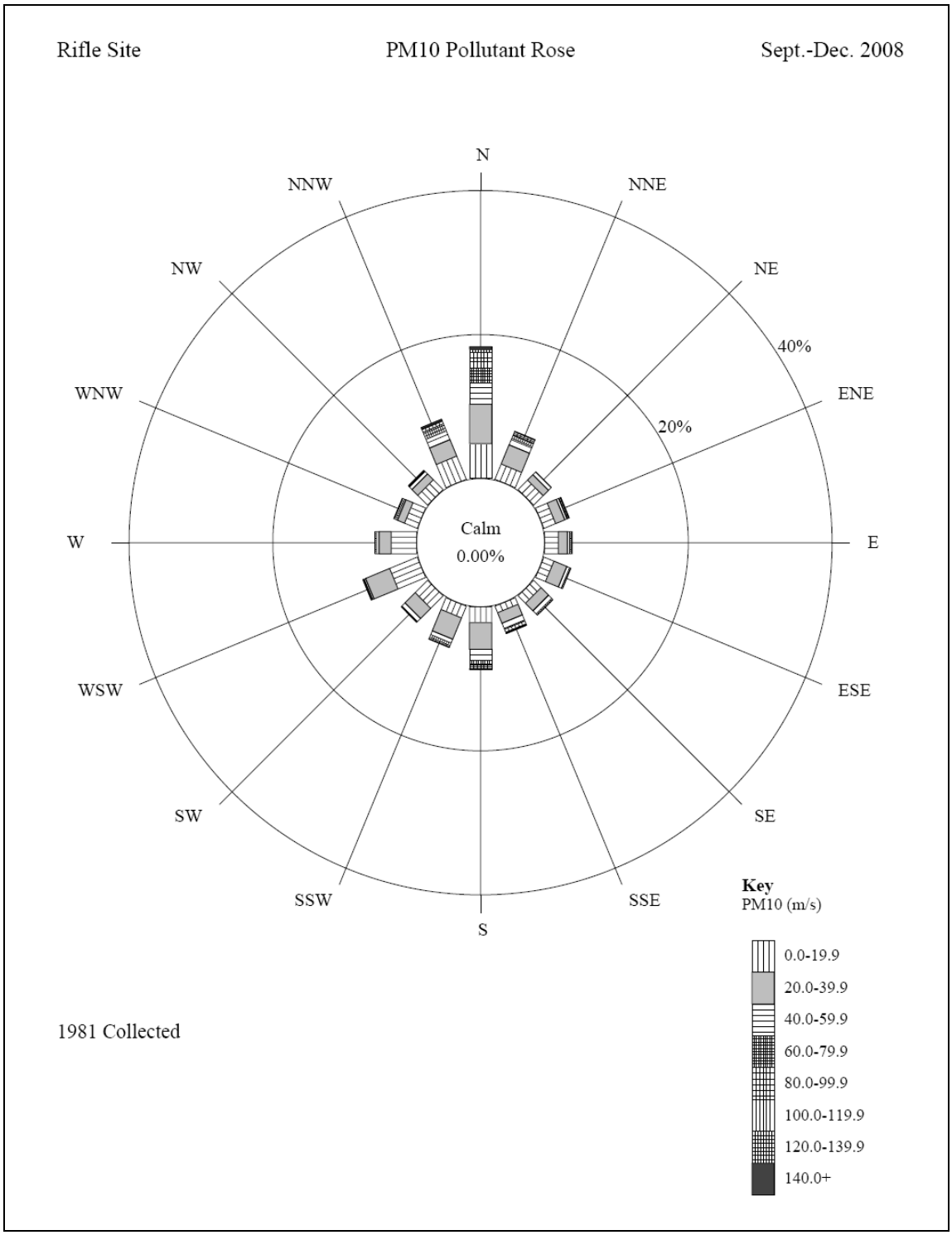


Figure 3-9. 2008 PM_{10} Pollutant Rose for the Rifle Monitoring Site.

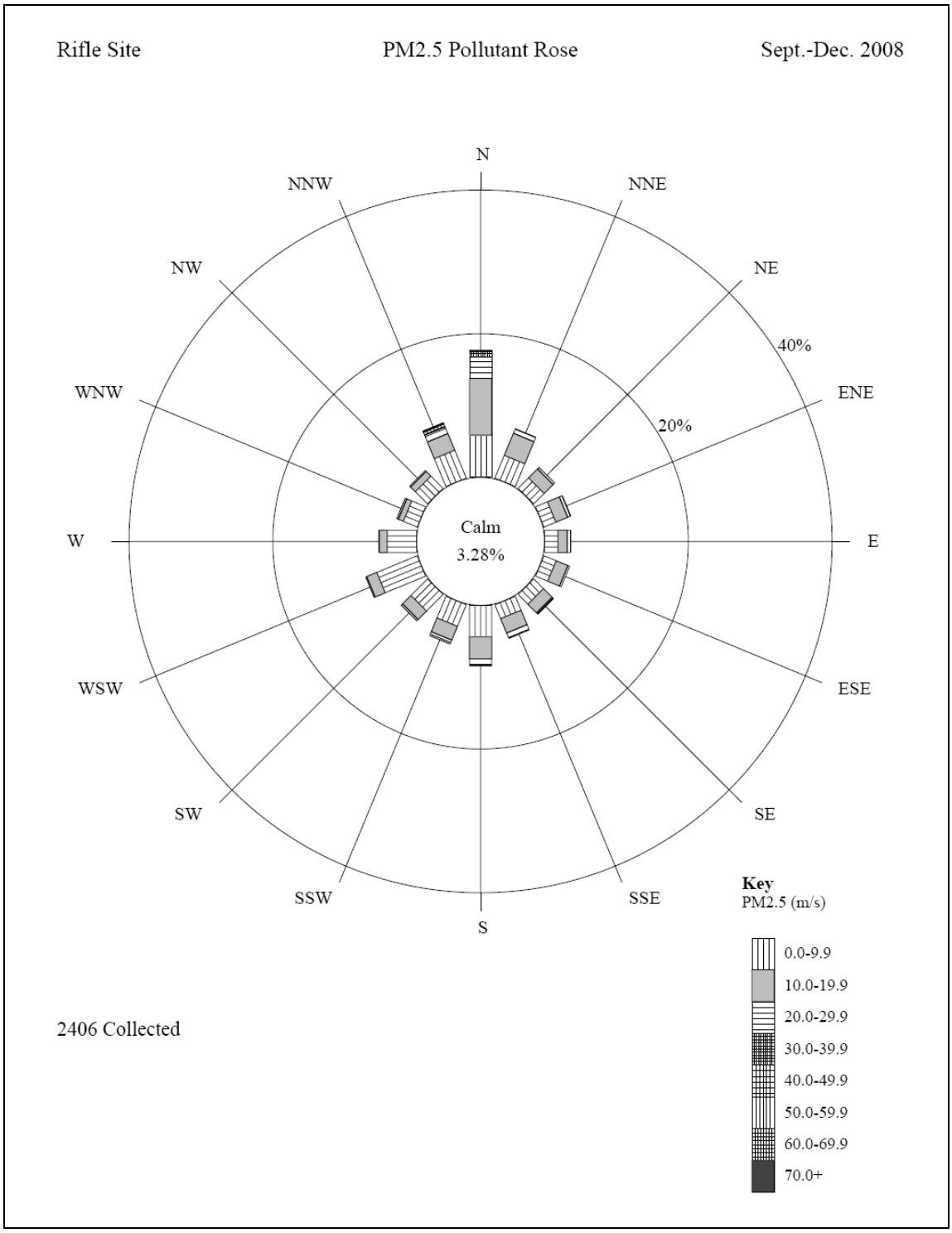


Figure 3-10. 2008 $PM_{2.5}$ Pollutant Rose for Rifle Monitoring Site.

4.0 SNMOC AND CARBONYL SUMMARIES

In 2008, SNMOCs and carbonyl compounds were monitored at all four (4) sites in Garfield County. SNMOCs and carbonyl compounds are subsets of VOCs. VOCs are generally carbon- and hydrogen-based chemicals that exist in the gas phase or can evaporate from liquids. VOCs can react in the atmosphere to form ozone and fine particulate matter. HAPs are a subset of VOC compounds, and include compounds that are known or believed to cause human health effects at low doses. Summaries of SNMOC and carbonyl monitoring in 2008 are presented in this section.

4.1 SNMOC

SNMOC compounds were collected and analyzed according to EPA Compendium Method TO-12, with 24-hour samples collected at all four (4) sites on a 1-in-6 day schedule. This method includes analyses for 81 different compounds. Appendix B lists minimum, maximum, and average concentrations of all detected SNMOC compounds by site.

SNMOC compounds can be grouped into classifications with similar characteristics. For these summaries, measured SNMOC compounds were grouped into the following categories:

- Light Alkanes: Alkanes are the simplest hydrocarbons, consisting of only carbon and hydrogen with single bonds. Light alkanes, which here include alkanes with up to five (5) carbon atoms (ethane, propane, iso/n-butane and iso/n-pentane) are the primary components of natural gas. Light hydrocarbons have also been shown to dominate the composition of gasoline vapor (Ying, 2008).

- Heavy Alkanes: The hydrocarbons in crude oil are mostly heavy alkanes, which here include alkanes with more than five (5) carbon atoms (C5). Crude oil products include gasoline, a refined mix of predominantly C6 to C10 hydrocarbons, and diesel, which is a refined mix ranging from approximately C10 to C15.

- Alkenes: Alkenes are more complex than alkanes, with at least one (1) carbon to carbon double bond. These compounds are not generally found in crude oil. Alkenes are much more reactive than alkanes, and will deplete quickly in the atmosphere. Alkenes are produced in refineries when larger alkane moledules are dissociated (or cracked) into smaller compounds. Some alkene compounds, including terpenes such as isoprene and a- and b-pinene, are naturally emitted from vegetation.

- Aromatics: Aromatic compounds are the most abundant compounds emitted from gas-fired engines. These compounds include the BTEX parameters (benzene, toluene, ethylbenzene and m/p-xylenes), which are commonly associated with motor vehicles.

Figure 4-1 presents categories of measured SNMOCs in units of ppbV (parts per billion by volume) measured in 2008 at each site. In general, compounds measured were dominated by light alkanes. On average, the six (6) compounds ethane, propane, n-butane, iso-butane,

n-pentatne and isopentane, accounted for more than 80 percent of the measured compounds at each site.

The general seasonal variation shows higher concentrations in winter and lower concentrations in summer. These trends can be influenced by the variations in temperature, as VOCs can deplete faster during the summer due to increased reactivity. Also, some emissions, including cold-start engine emissions and residential wood burning, are higher in the winter. Events with unseasonably heavy alkane and aromatic concentrations are noted at the Parachute site on July 17, 2008, and at the Bell-Melton site on July 29, 2008.

Figure 4-2 presents the daily measurements by category in units of ppbC, where ppbC is results in ppbV multiplied by the number of carbons in each compound. Carbon content in a molecule is related to the compound reactivity, which contributes to ozone formation potential (discussed in Section 4.1.1). The unknown category indicates the part of the total carbon measurements were individual species were not identified. Total carbon measurements are still higher in the wintertime, but the heavier alkanes and aromatics are more significant sources of carbon, especially at the more urban Parachute and Rifle sites.

Figure 4-3 shows emissions from the biogenic compounds a-pinene, b-pinene, and isoprene. Other terpenes are emitted by biogenic sources, but these compounds have been used as tracers for biogenic sources. These compounds are highly reactive and short lived in the atmosphere. Detected concentrations were low, with highest measurements in the summer.

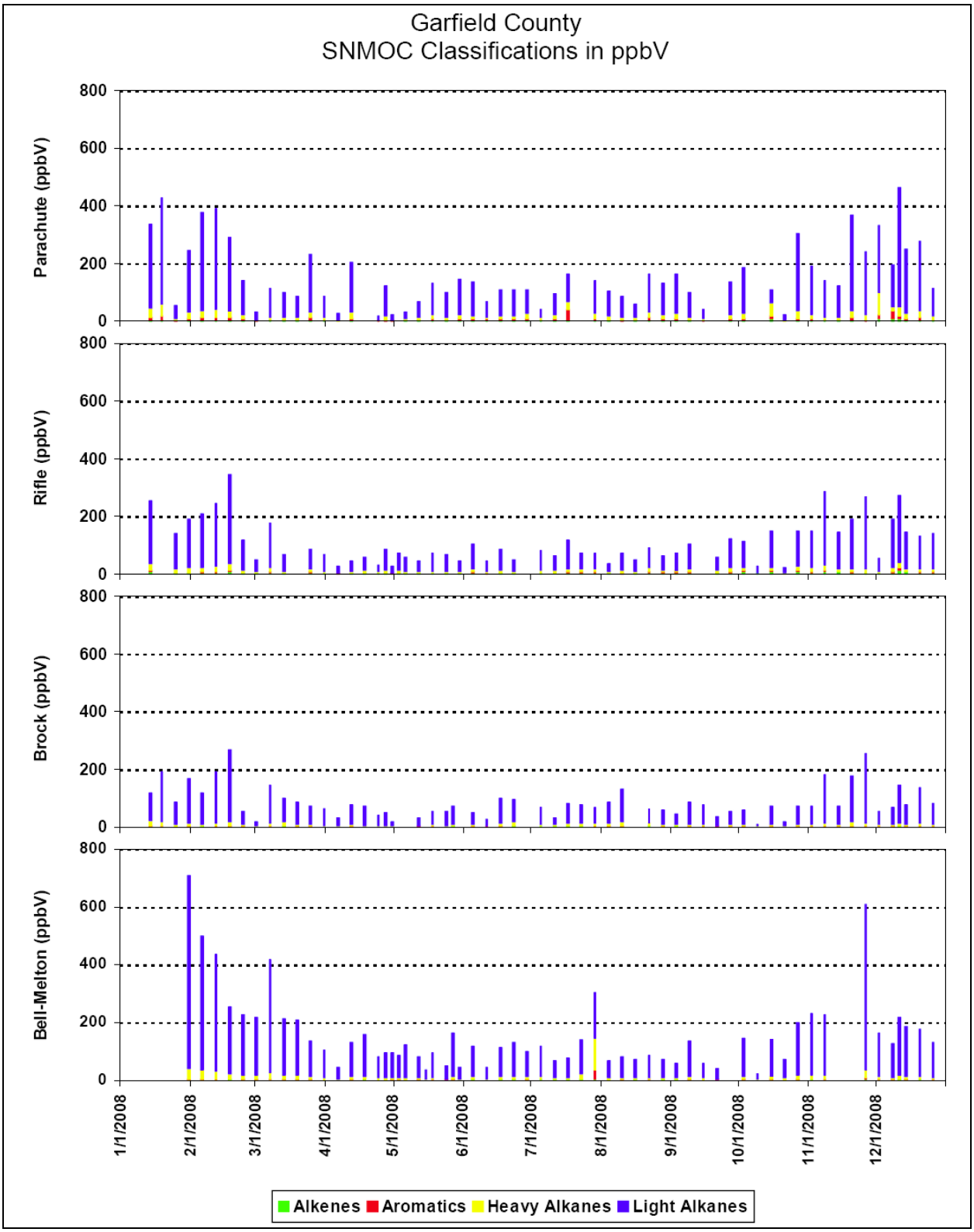


Figure 4-1. 2008 24-Hour SNMOC Measurements by Category in Units of ppbV.

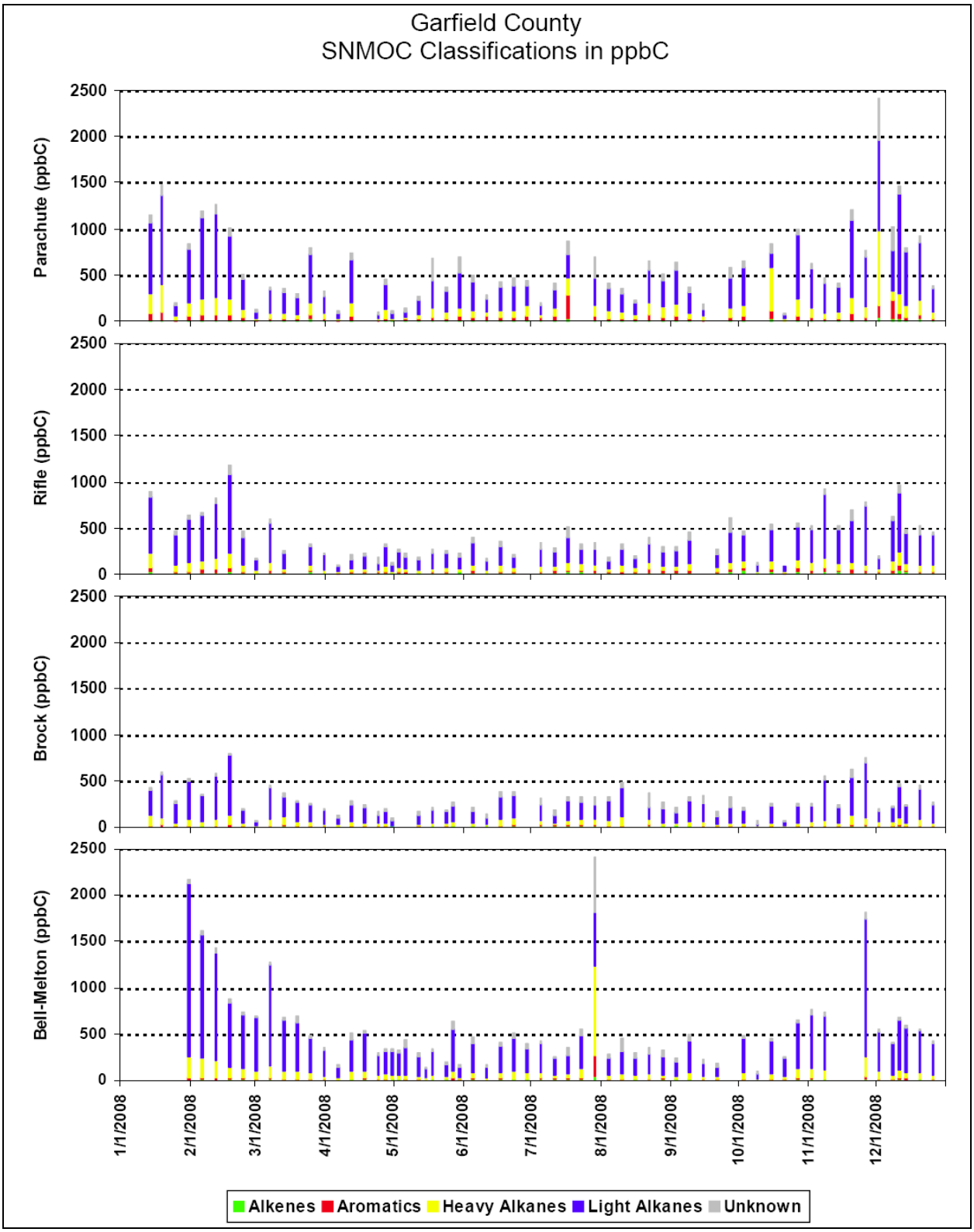


Figure 4-2. 2008 24-Hour SNMOC Measurements by Category in Units of ppbC.

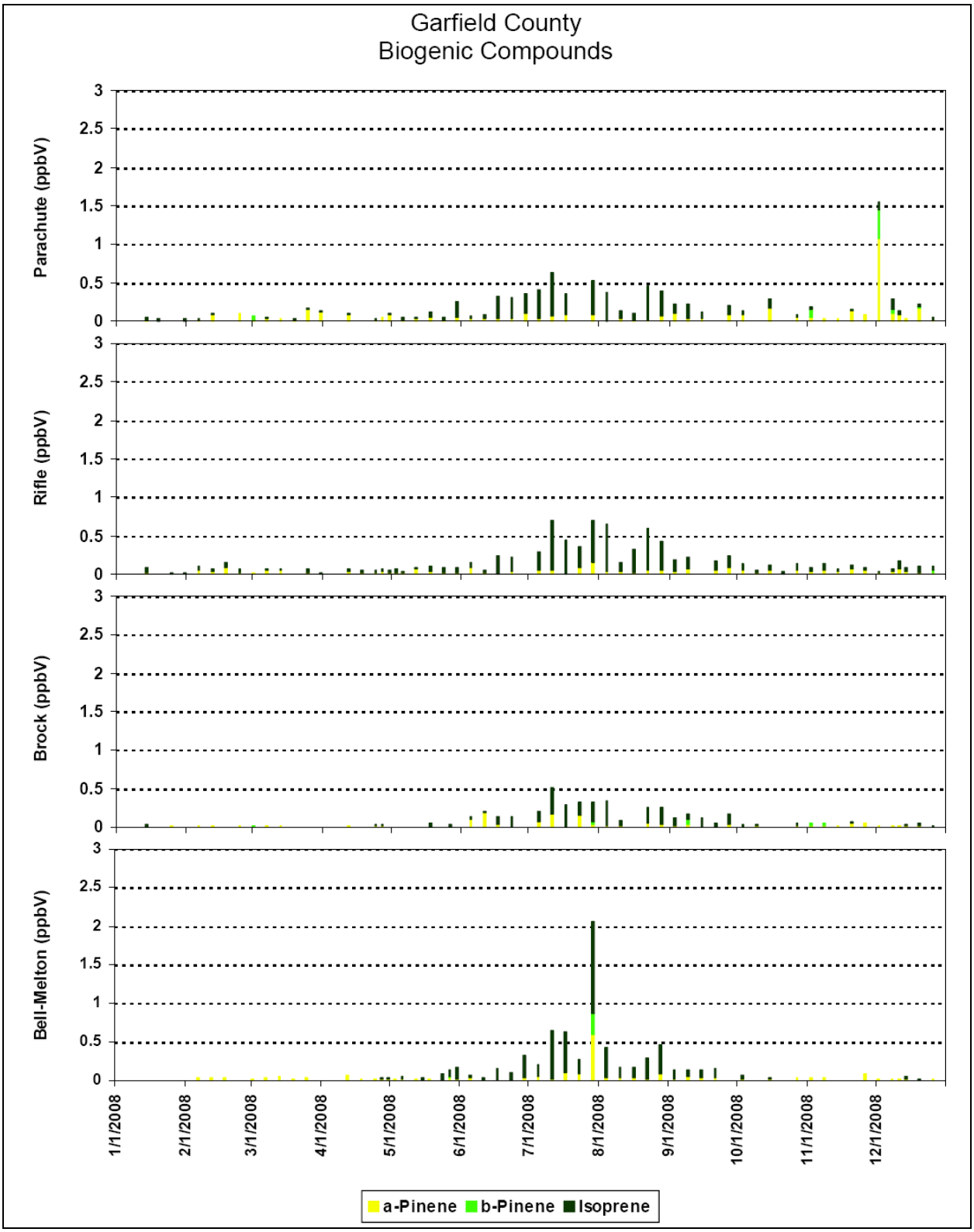


Figure 4-3. 2008 24-Hour Biogenic Tracer Measurements in Units of ppbV.

4.1.1 SNMOC Ozone Formation Potential

Ozone is a secondary pollutant, meaning it is not emitted directly from sources, but is formed from photochemical interactions of VOCs and oxides of nitrogen (NO_X) in the presence of sunlight. The basic formation and depletion equations for O_3 are presented below:

NO_2 + sunlight → NO + O

O + O_2 + M → O_3 + M (where M is a non-reactive molecule required for this process)

NO + O_3 → NO_2 + O_2

Without the presence of VOCs, the diurnal cycle is a balanced reaction, with equal production and depletion of O_3. When VOCs are present, they can react with NO to produce NO_2, as follows:

NO + RO → NO_2 + RO_2
(where R represents a reactive VOC)

This effectively creates competition for NO, allowing O_3 to build up instead of being depleted by NO. Also, when NO reacts with hydrocarbons, additional NO_2 is produced without consuming O_3. The produced NO_2 can further react to produce more O_3.

The potential of individual VOCs to contribute to O_3 formation depends on the reactivity of each compound. Ozone formation potential can be quantified using a Maximum Incremental Reactivity (MIR) scale developed using scenarios where ambient ozone is most sensitive to changes in VOC emissions (Carter, 1994). The California Air Resources Board (CARB) regularly updates and publishes these values. This report uses MIR values published by CARB as updated on March 17, 2009. While MIRs are actually calculated in terms of ozone impact per unit VOC emitted, doing a MIR analysis of measured atmospheric VOCs gives an idea of the relative potential for the measured VOCs to contribute to ozone formation.

Figure 4-4 presents the daily maximum 1-hour ozone average measured at the Rifle site, along with the cumulative reactivity in ppb O_3 for the SNMOCs measured at all sites. Potential O_3 formation is affected by both reactivity and availability. The light alkanes that dominate measurements by volume are the least reactive compounds. Other compounds that were much less abundant, are highly reactive and have much more potential to contribute to ozone formation. These included the alkenes (including some biogenic compounds) and aromatics (including the BTEX compounds benzene, toluene, ethylbenzene and x/p-xylenes). Other less abundant compounds, including small quantities of alkenes, are shown to have potential to significantly contribute to O_3 production.

The cumulative maximum O_3 potential for measured SNMOCs is much higher than the actual measured O_3. The magnitude of these potential values is not realistic because they represent the cumulative effect of all compounds under ideal conditions and assume that all compounds react completely in a 24-hour period. This representation does show that, if all other conditions were ideal for O_3 formation, the SNMOC levels are sufficient to produce more O_3 than observed. Available NO_X may be a limiting factor in O_3 formation. Levels of NO_X at the

site in 2008 are unknown. At high VOC to NO_X ratios, an area would be considered NO_X limited, and NO_X controls may be more effective than VOC controls to reduce O_3. At low VOC to NO_X ratios, VOC controls may be more effective for ozone control.

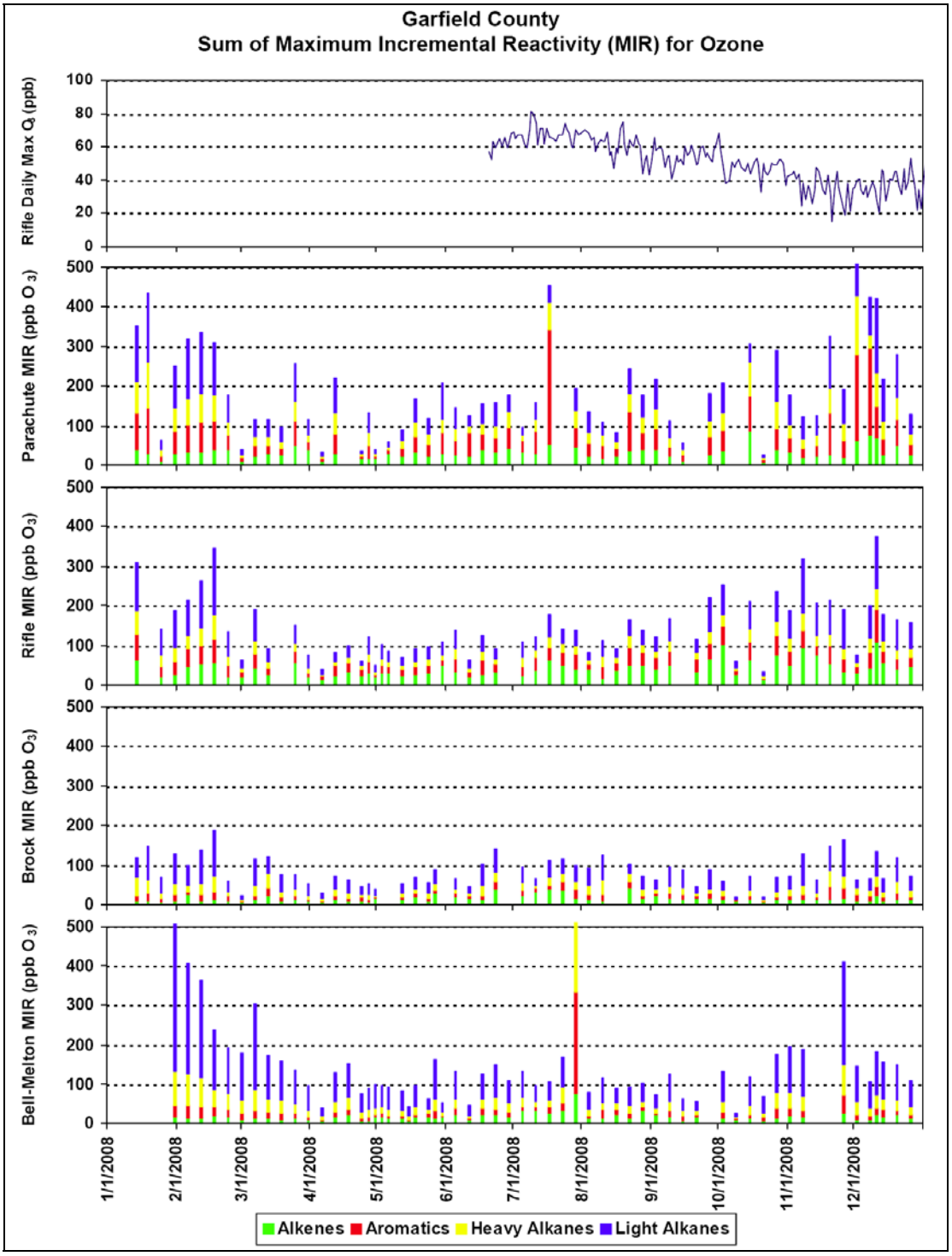


Figure 4-4. Highest Daily 1-Hour O_3 Measurement and Sum of MIR Potential, Based on SNMOC Measurements, at the Rifle Site in 2008.

4.1.2 Regional SNMOC Comparisons

The EPA publishes an annual report encompassing data collected from sites across the country as part of the Urban Air Toxics Monitoring Program (UATMP) and National Air Toxics Trends Stations (NATTS) National Monitoring Programs. Participating agencies have samples analyzed by the Eastern Research Group, Inc. (ERG) laboratory in Morrisville, North Carolina. In 2008, nine (9) sites, including the four (4) Garfield County sites, sampled for SNMOC concentrations. Annual average concentrations for data collected in 2008 were provided by the ERG laboratory.

Figure 4-5 shows, in descending order, the annual average concentrations measured at the SNMOC sites in 2008. There are additional sites monitoring pollutants in the EPA UATMP/NATTS networks, but only these nine (9) sites were analyzed using method TO-12 for the same suite of SNMOC compounds, making total concentration comparable. Notably, concentrations of SNMOCs are highest at the Garfield County sites, although the five (5) other sites shown here do not represent broad regional coverage. Alkanes, especially the light alkanes, showed the largest differences. The additional sites are also a mix of rural and urban sites with a variety of source influences. The highest average ppbV concentrations were measured at the Bell-Melton site. The lowest average ppbV concentrations in Garfield County were observed at the Brock site, but this was still more than twice as high as the next highest site, in Bountiful, Utah. In the 2007 EPA UATMP/NATTS monitoring report, it is noted that several emission sources involving petroleum and natural gas production and refining are located two to five miles from the Bountiful site (EPA, 2008).

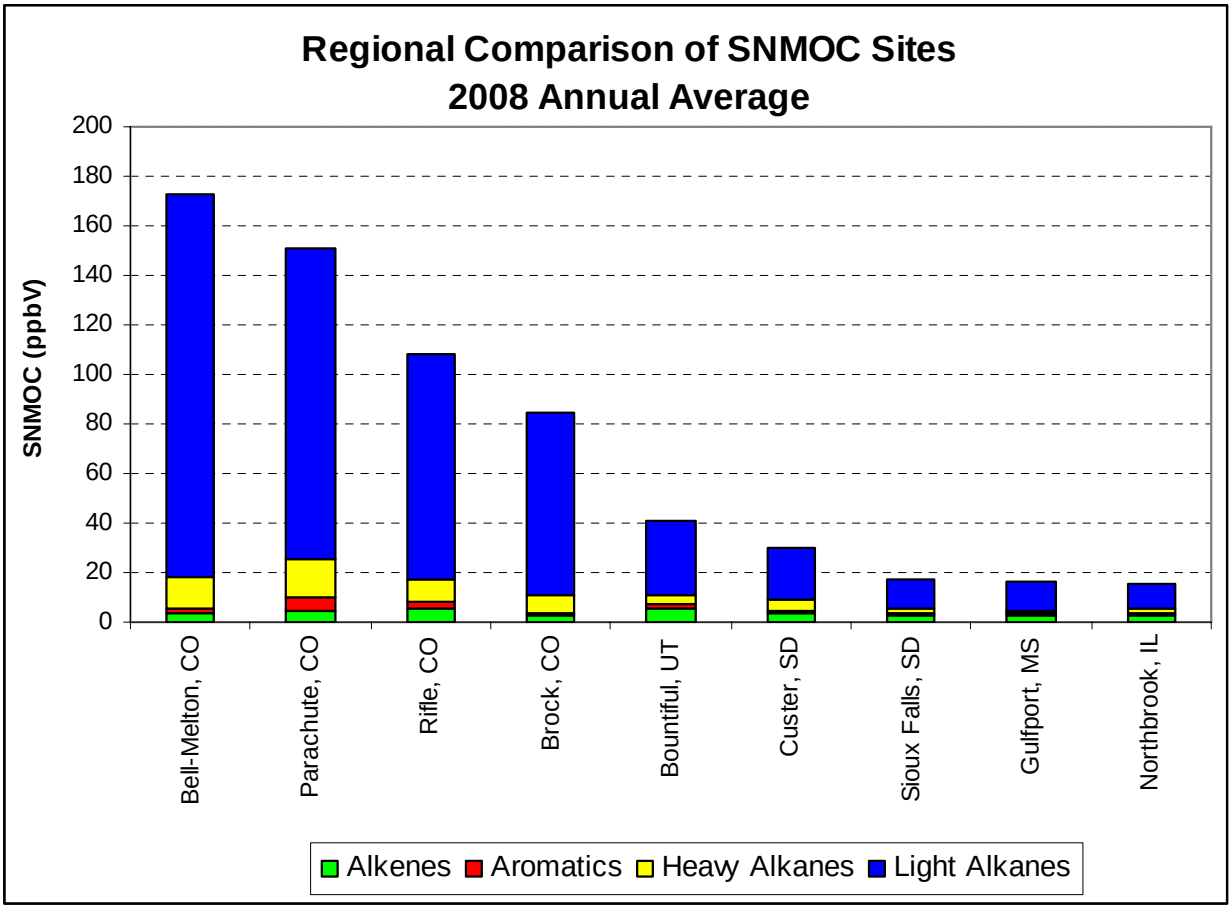


Figure 4-5 Average SNMOC Concentrations Measured by the EPA UATMP/NATTS National Monitoring Programs in 2008.

4.2 CARBONYLS

Carbonyl compounds were collected and analyzed according to EPA Compendium Method TO-11A, with 24-hour samples collected at all four sites on a 1-in-12 day schedule. This method includes analysis for twelve (12) different carbonyl compounds.

Carbonyls are highly reactive and play a critical role in the formation of ozone. Some carbonyls, including formaldehyde and acetaldehyde, also have adverse chronic and acute health effects. The major sources of directly emitted carbonyls are fuel combustion, mobile sources, and process emissions from oil refineries (CARB, 2009).

Appendix C lists minimum, maximum, and average concentrations of all detected carbonyl compounds. Major compounds included formaldehyde, acetaldehyde, and acetone. Other carbonyl compounds averaged less than 8% of the measured compounds by volume. Figure 4-6 presents a time series of the major compounds measured at each site in 2008. In general, carbonyl measurements were slightly higher in the summer at the Rifle, Brock, and Bell-Melton sites. Concentrations at the Parachute site were more consistent throughout the year.

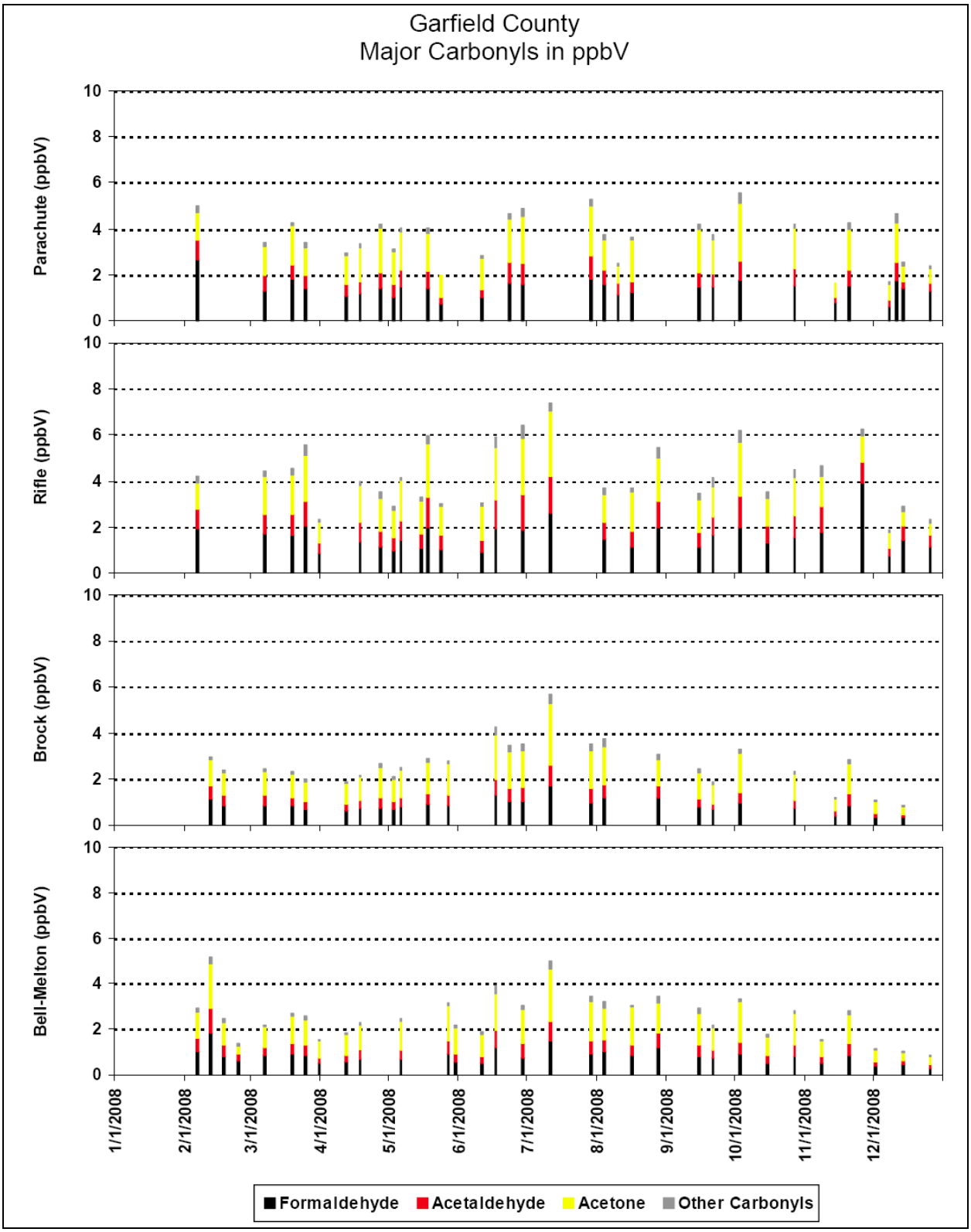


Figure 4-6. 2008 24-Hour Major Carbonyl Compound Concentrations in Units of ppbV.

4.2.1 Regional Carbonyl Comparisons

In 2008, 41 sites, including the four (4) Garfield County sites, sampled for carbonyl concentrations in cooperation with the EPA UATMP/NATTS National Monitoring Programs. Annual average concentrations for data collected in 2008 were provided by the ERG laboratories.

Figure 4-7 shows major carbonyl concentrations for all sites. Colorado sites, including Garfield County and the nearby Grand Junction site, are listed in descending order on the left, and other U.S. sites in descending order on the right. Measured carbonyls at the Garfield County sites are lower than the more urban Grand Junction site, and among the lower levels observed across the United States. Formaldehyde using the dominant carbonyl measured at most sites.

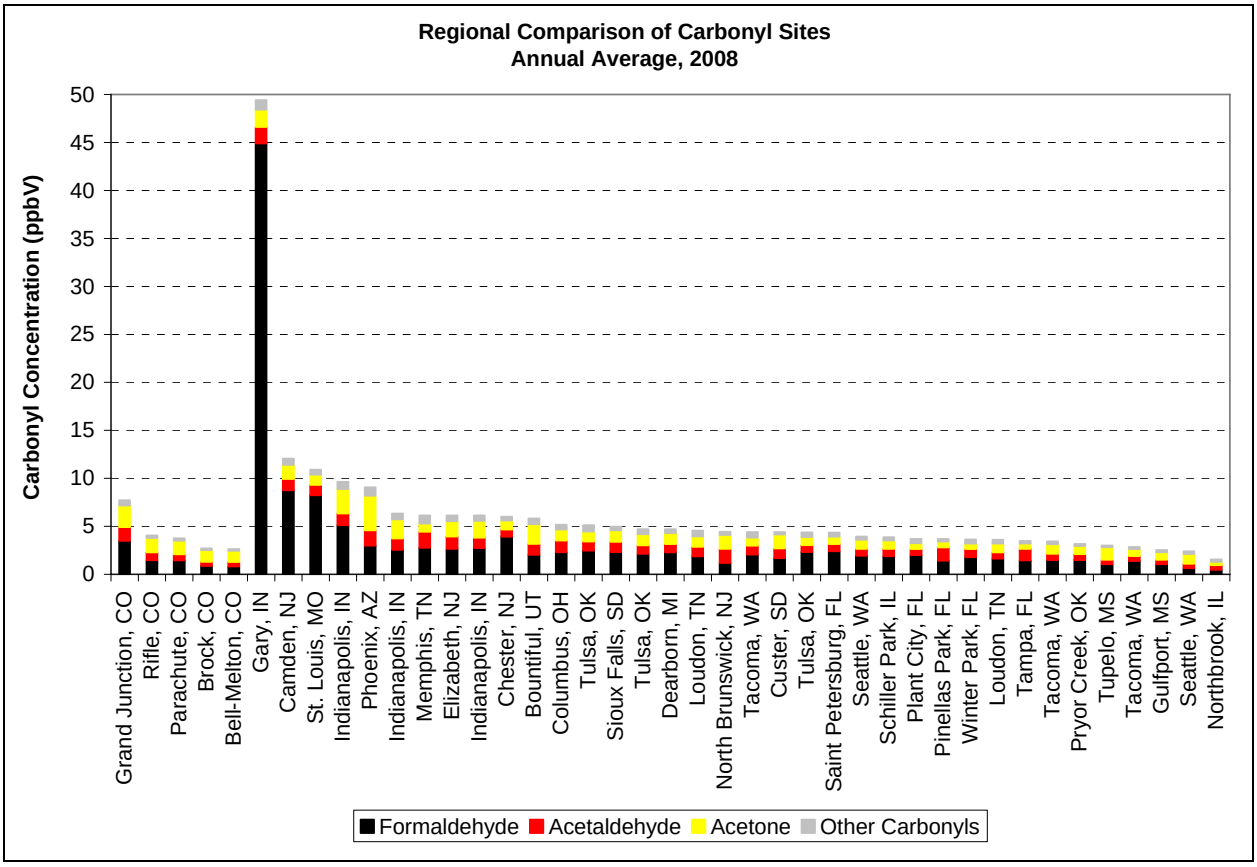


Figure 4-7. Average Carbonyl Concentrations Measured by the EPA UATMP/NATTS National Monitoring Program in 2008.

4.3 HAPS SUMMARIES

No NAAQS or any other ambient air standards exist for VOCs. Instead, emissions limits on industrial sources have been set. EPA has developed a set of risk factors for both acute and chronic exposures for HAPs. In addition, risk factors from the Agency for Toxic Substances and Disease Registry (ATSDR), the California Air Resources Board (CARB), the National Institute

for Occupational Safety and Health (NIOSH), and others can be used to determine potential risks from exposure to VOCs. Not all measured VOCs have associated risk factors, and those that do are also referred to as Hazardous Air Pollutants (HAPs).

Of the SNMOC and Carbonyl compounds measured in Garfield County, ten (10) compounds have been identified as HAPs. Tables 4-1 presents the HAPs compounds measured in 2008 for each site, and indicates the number of detections, and the minimum, maximum and average concentrations measured in units of $\mu g/m^3$. Detection of a HAP does not necessarily indicate a known health risk. Health risk analysis for measured concentrations will be presented in a separate report prepared by the CDPHE.

Table 4-1

Garfield County Measured HAPs in 2008

Pollutant	Parachute				Rifle				Brock				Bell-Melton			
	# Samples/ # Detections (%)	Min	Max	Avg, ± StDev*	# Samples/ # Detections (%)	Min	Max	Avg, ± StDev*	# Samples/ # Detections (%)	Min	Max	Avg, ± StDev*	# Samples/ # Detections (%)	Min	Max	Avg, ± StDev*
		(µg/m³)				(µg/m³)				(µg/m³)				(µg/m³)		
Acetaldehyde	28/28 (100%)	0.4	1.84	1.10 ± 0.38	29/29 (100%)	0.6	2.9	1.58 ± 0.59	27/27 (100%)	0.25	1.59	0.79 ± 0.31	31/31 (100%)	0.29	1.96	0.83 ± 0.37
Formaldehyde	28/28 (100%)	0.79	3.25	1.72 ± 0.49	29/29 (100%)	0.93	4.81	1.93 ± 0.78	27/27 (100%)	0.42	2.1	1.06 ± 0.36	31/31 (100%)	0.39	2.24	1.00 ± 0.39
1,3-Butadiene	30/57 (53%)	ND	0.33	0.08 ± 0.06	47/58 (81%)	ND	0.49	0.12 ± 0.1	1/58 (2%)	ND	0.05	0.05 ± 0	2/58 (3%)	ND	0.05	0.05 ± 0
Benzene	57/57 (100%)	0.35	11.1	2.33 ± 1.74	58/58 (100%)	0.38	4.08	1.68 ± 0.84	58/58 (100%)	0.18	2.4	0.94 ± 0.44	58/58 (100%)	0.18	13.6	1.32 ± 1.78
Ethylbenzene	57/57 (100%)	0.09	2.62	0.59 ± 0.51	58/58 (100%)	0.12	1.17	0.47 ± 0.22	58/56 (97%)	ND	0.48	0.16 ± 0.1	56/58 (97%)	ND	4.34	0.25 ± 0.56
Isopropyl-benzene	24/57 (42%)	ND	0.25	0.09 ± 0.02	30/58 (52%)	ND	0.12	0.09 ± 0	11/58 (19%)	ND	0.09	0.09 ± 0	13/58 (22%)	ND	0.3	0.09 ± 0.03
m-Xylene/ p-Xylene	57/57 (100%)	0.43	11.8	3.96 ± 2.53	58/58 (100%)	0.45	5.92	2.34 ± 1.22	58/58 (100%)	0.11	2.9	0.93 ± 0.54	58/58 (100%)	0.16	9.88	1.33 ± 1.38
n-Hexane	57/57 (100%)	0.77	18.8	5.87 ± 3.8	58/58 (100%)	0.76	15.9	4.56 ± 2.86	58/58 (100%)	0.35	24.3	3.95 ± 3.72	58/58 (100%)	1.02	22.1	6.31 ± 4.28
Styrene	9/57 (16%)	ND	1.92	0.12 ± 0.25	17/58 (29%)	ND	0.35	0.08 ± 0.05	9/58 (16%)	ND	0.43	0.08 ± 0.05	3/58 (5%)	ND	3.45	0.13 ± 0.44
Toluene	57/57 (100%)	0.71	118	10.07 ± 18.68	58/58 (100%)	0.76	15	4.32 ± 2.38	58/58 (100%)	0.29	4.88	1.97 ± 1.13	58/58 (100%)	0.37	79.1	3.59 ± 10.2

4.3.1 Regional HAPs Comparisons

Figures 4-8 through 4-12 present regional comparisons for the ten (10) HAPs measured in Garfield County. Sites are presented in descending order, where the Garfield County sites and the Grand Junction site are highlighted. These annual average values do not necessarily correspond to any known health risks. Regional observations include the following:

- For **acetaldehyde** and **formaldehyde**, Garfield County sites measured lower than the average of regional sites. The nearby, more urban Grand Junction site was among the top 85% of sites for acetaldehyde and formaldehyde.

- For **1,3-butadiene**, Garfield County sites measured near, or below average.

- For **benzene** and **ethylbenzene**, the Parachute site measured higher than average, and slightly higher than the nearby, more urban Grand Junction site.

- For **isopropylbenzene**, fewer regional values were available for comparison, but the Parachute measured the second highest average among the nine (9) sites where measurements were available.

- For **m/p-xylene**, the Parachute site and Rifle sites were among the higher regional sites, with the Parachute sites about 3 times higher than the average, and the Rifle site about 2 times higher.

- For **n-hexane**, fewer regional values were available for comparison, but the Garfield County sites measured four (4) of the five (5) highest averages among the nine (9) sites where measurements were available.

- For **styrene**, The Grand Junction site measured the highest regional average, followed by the rural Bell-Melton site in Garfield County.

- For **toluene**, three (3) of the four (4) Garfield County sites measured higher than the nearby, more urban Grand Junction site. Measurements at the Parachute site averaged about twice as high as the Rifle site.

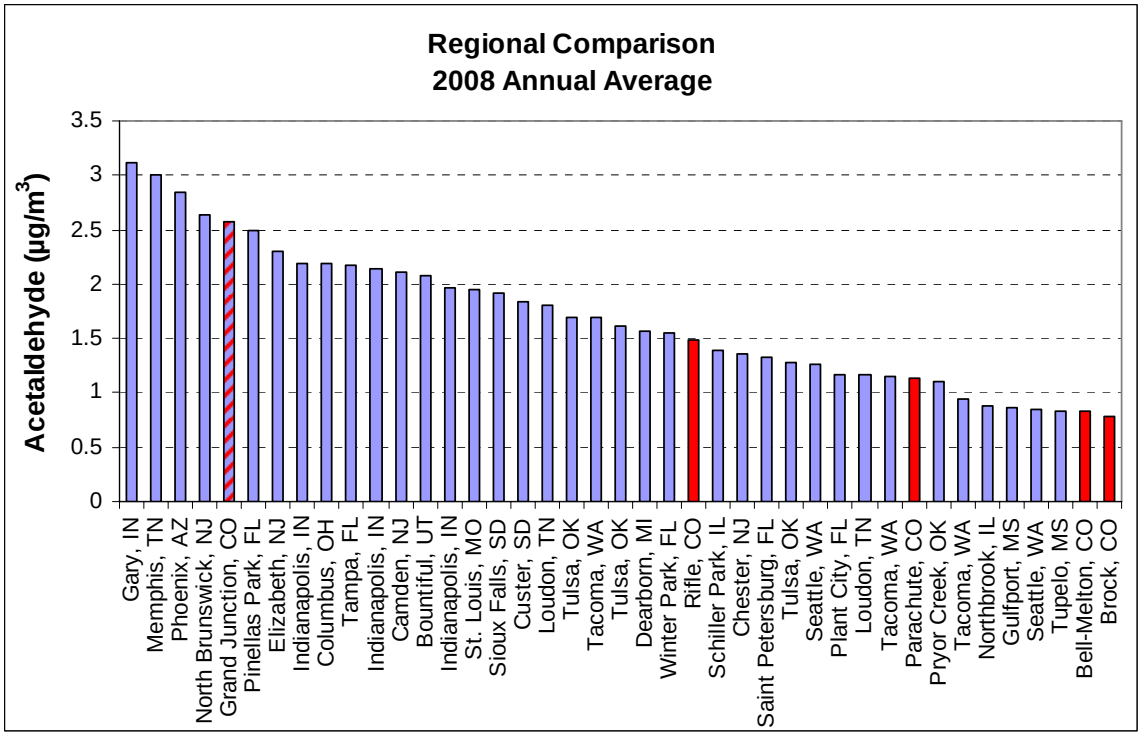


Figure 4-8. 2008 Annual Average Acetaldehyde Concentrations by Site, with Garfield County Sites Highlighted in Red, and Grand Junction with Cross Marks.

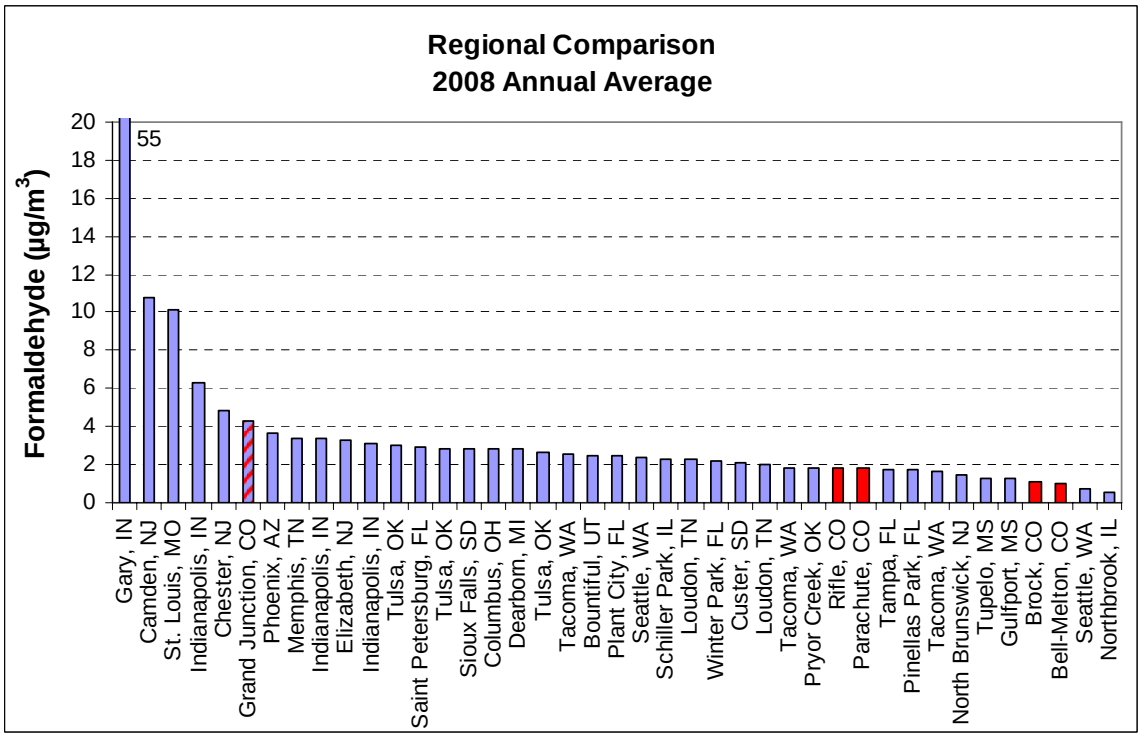


Figure 4-9. 2008 Annual Average Formaldehyde Concentrations by Site, with Garfield County Sites Highlighted in Red, and Grand Junction with Cross Marks.

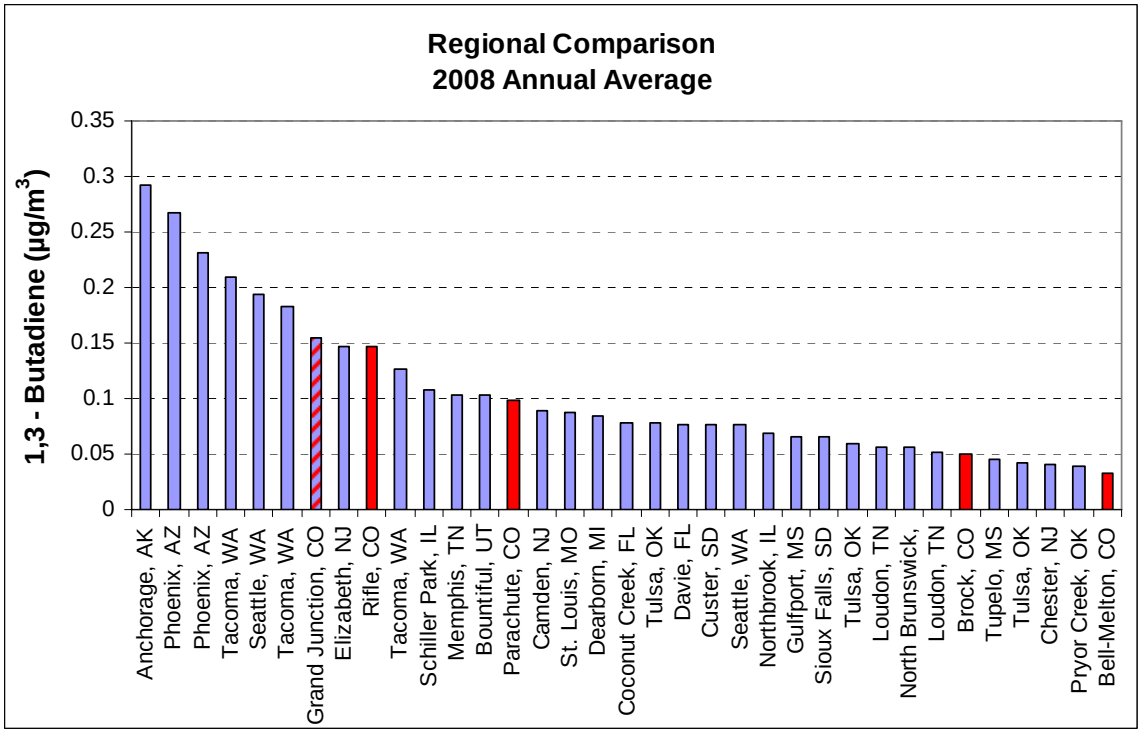


Figure 4-10. 2008 Annual Average 1,3-Butadiene Concentrations by Site, with Garfield County Sites Highlighted in Red, and Grand Junction with Cross Marks.

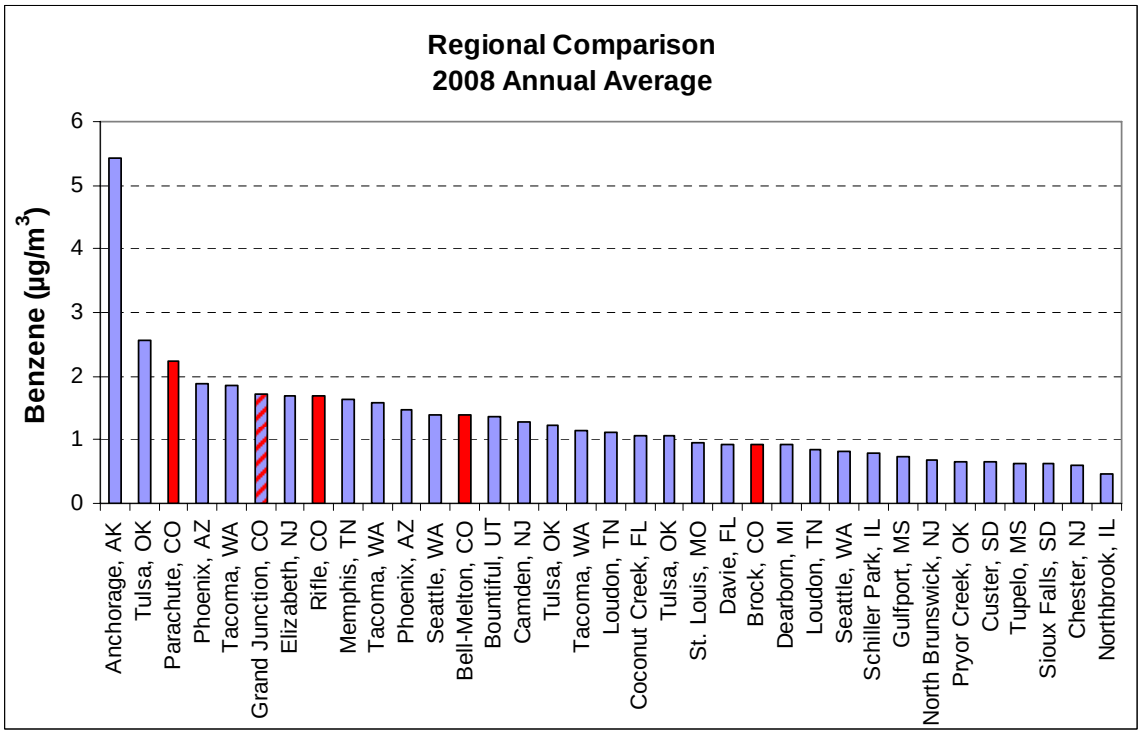


Figure 4-11. 2008 Annual Average Benzene Concentrations by Site, with Garfield County Sites Highlighted in Red, and Grand Junction with Cross Marks.

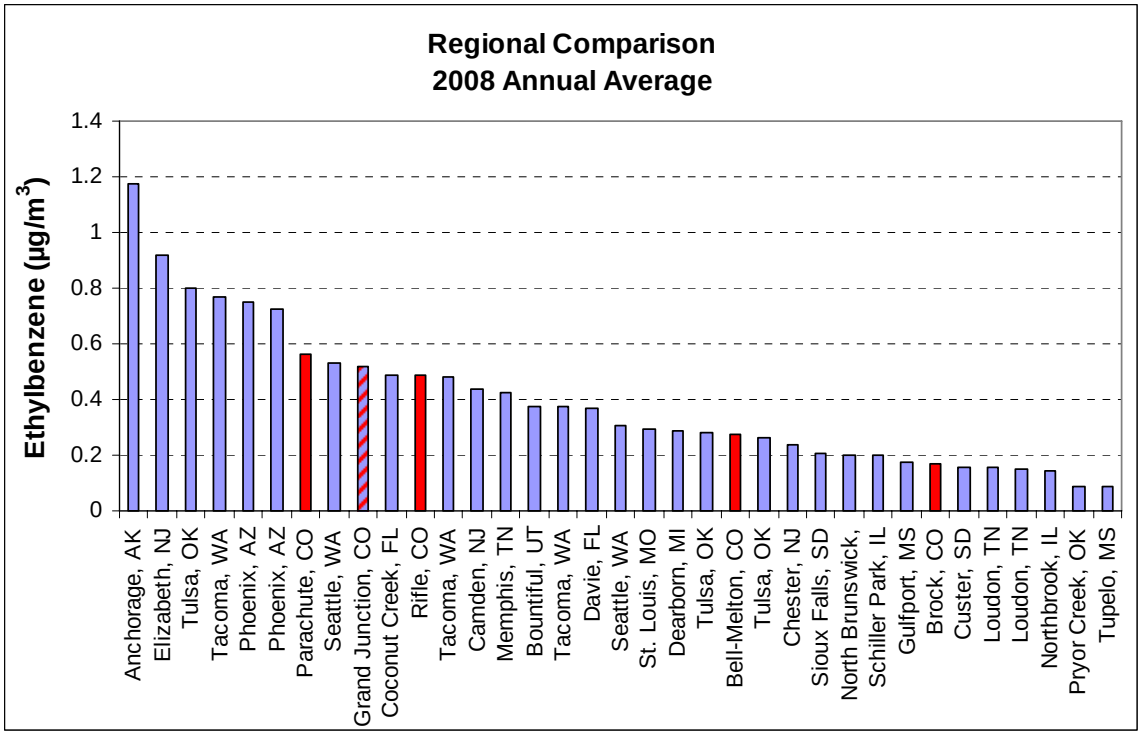


Figure 4-12. 2008 Annual Average Ethylbenzene Concentrations by Site, with Garfield County Sites Highlighted in Red, and Grand Junction with Cross Marks.

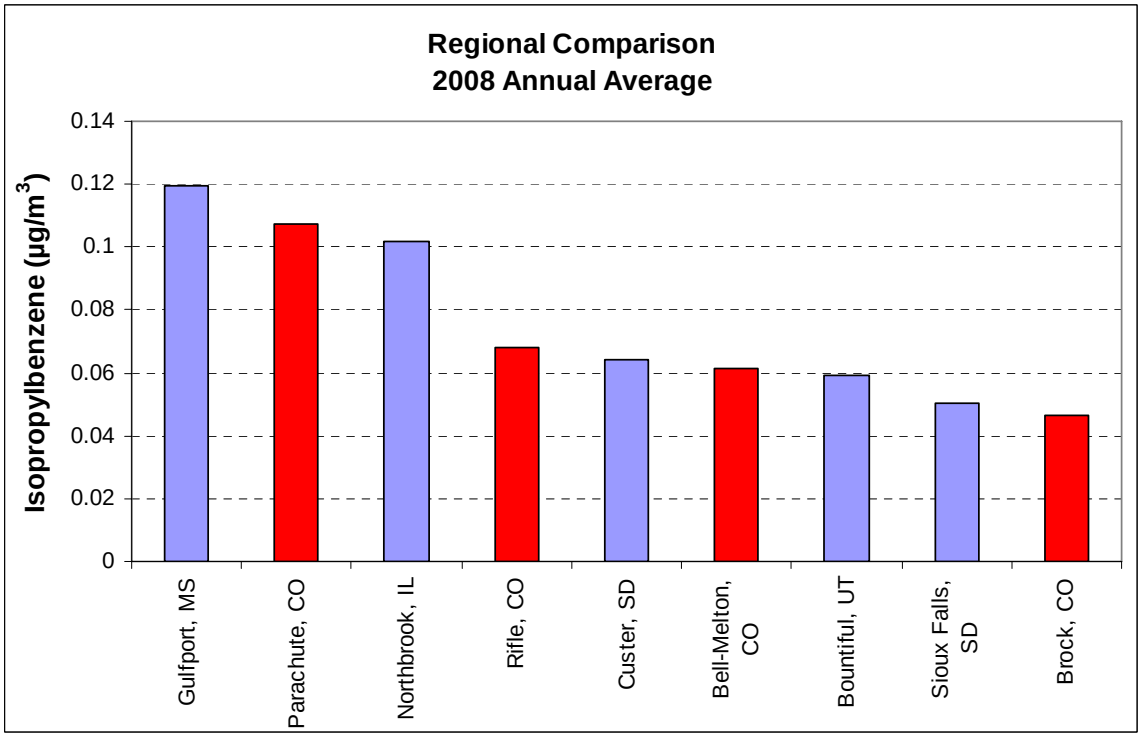


Figure 4-13. 2008 Annual Average Isopropylbenzene Concentrations by Site, with Garfield County Sites Highlighted in Red.

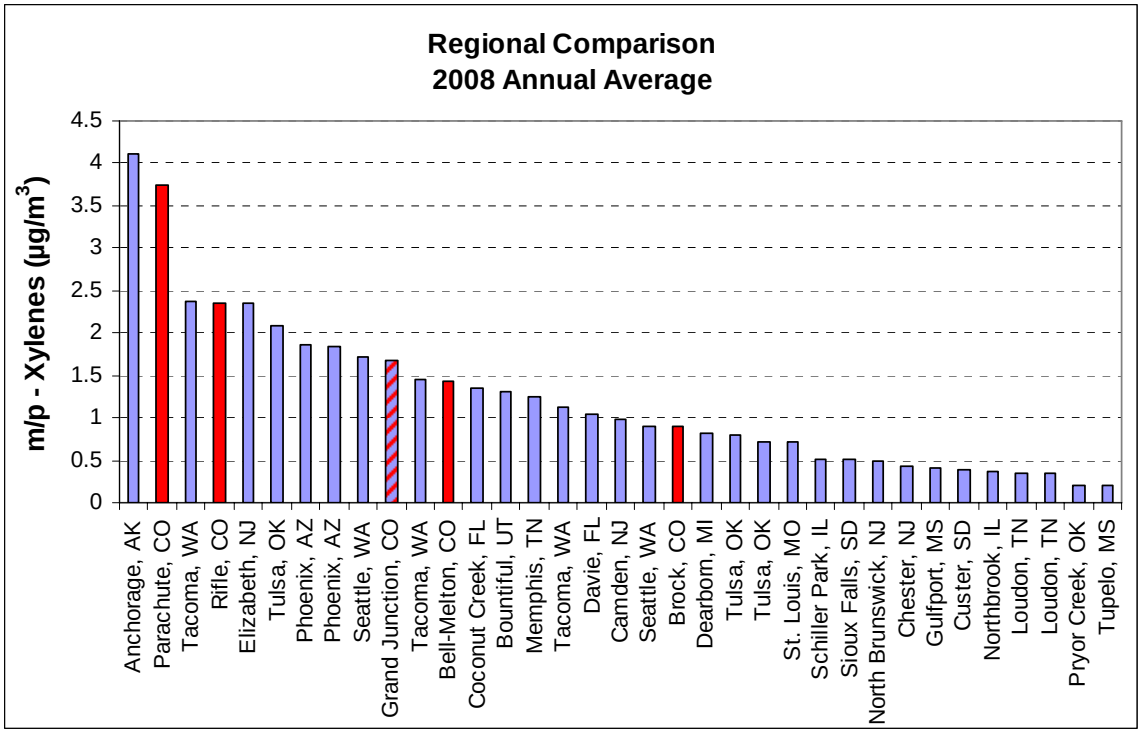


Figure 4-14. 2008 Annual Average m/p-Xylene Concentrations by Site, with Garfield County Sites Highlighted in Red, and Grand Junction with Cross Marks.

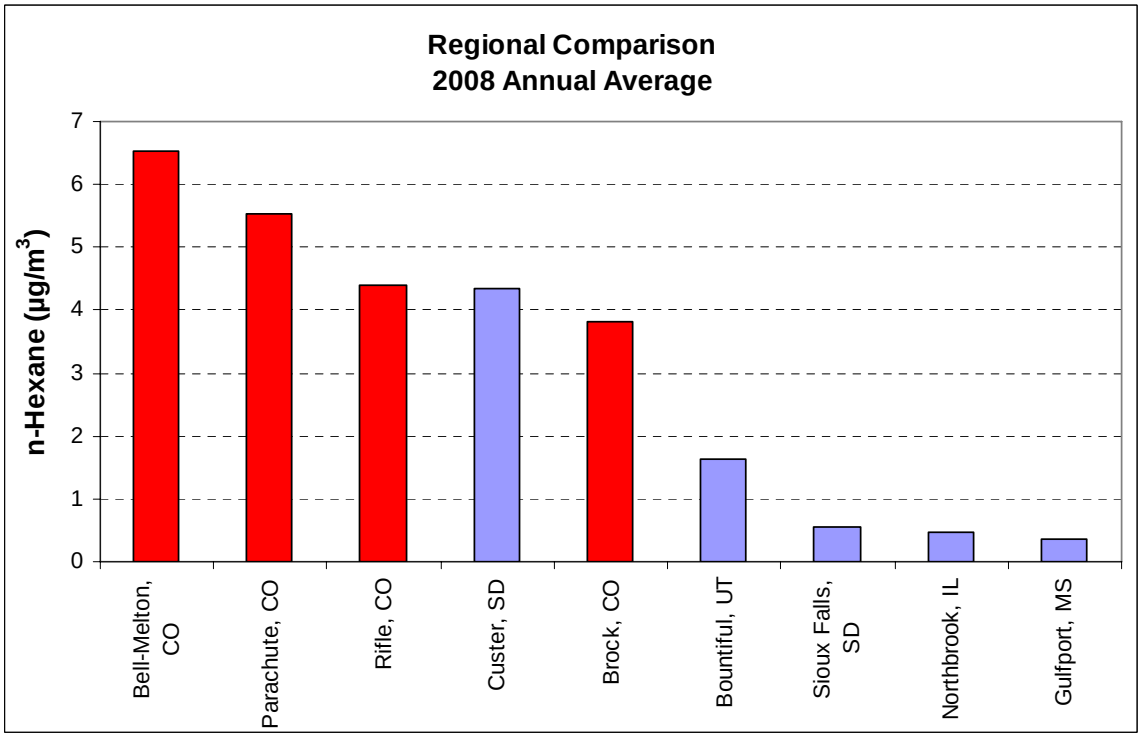


Figure 4-15. 2008 Annual Average n-Hexane Concentrations by Site, with Garfield County Sites Highlighted in Red.

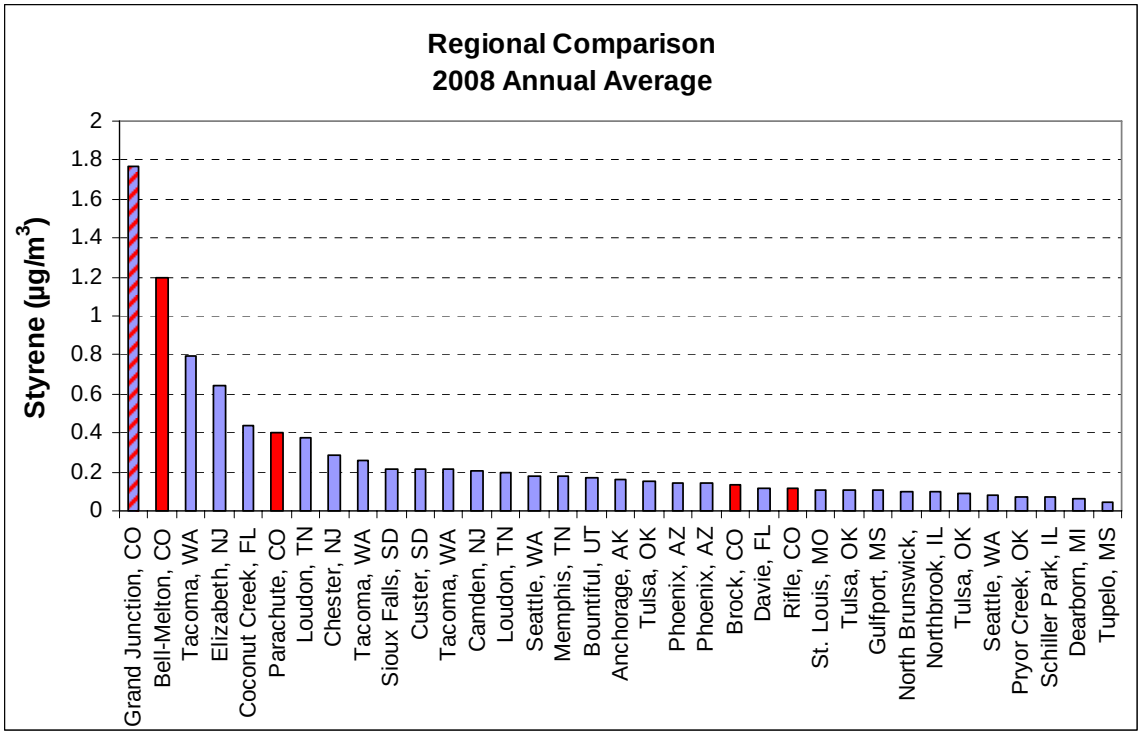


Figure 4-16. 2008 Annual Average Styrene Concentrations by Site, with Garfield County Sites Highlighted in Red, and Grand Junction with Cross Marks.

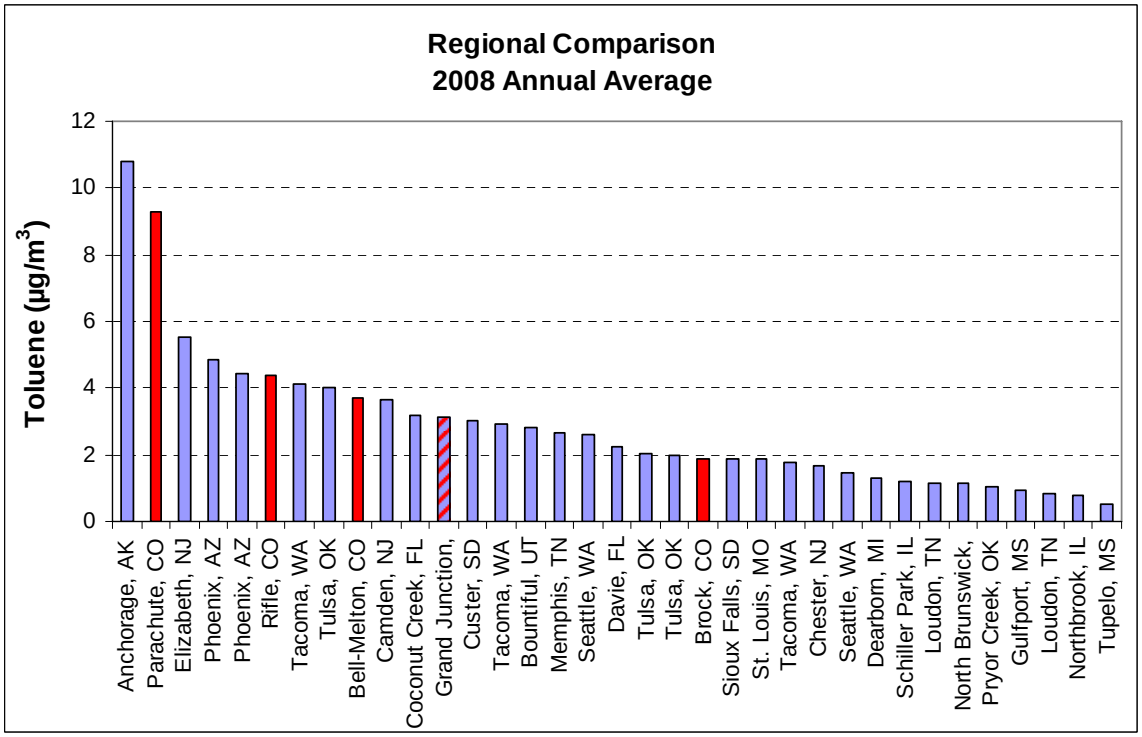


Figure 4-17. 2008 Annual Average Toluene Concentrations by Site, with Garfield County Sites Highlighted in Red, and Grand Junction with Cross Marks.

4.4 BTEX CONCENTRATION PROFILES

The BTEX parameters (benzene, toluene, ethylbenzene and m/p-xylenes), have been shown to be present both in motor vehicle exhaust and in ambient air near roadways. In particular, roadside studies have shown that ratios of the concentrations are fairly consistent, and these ratios have been used as tracers for vehicle activity (Carter, 1995).

Figure 4-18 shows the magnitude of BTEX parameters observed at the Garfield County sites. All parameters averaged highest at the Parachute site, followed by the Rifle, Bell-Melton, and Brock sites. Regional comparisons showed that the Parachute site averaged higher for all BTEX parameters than the nearby Grand Junction site. The Rifle site also averages higher than Grand Junction for toluene and the m/p-xylenes, and the Bell-Melton site also averaged higher toluene than nearby Grand Junction.

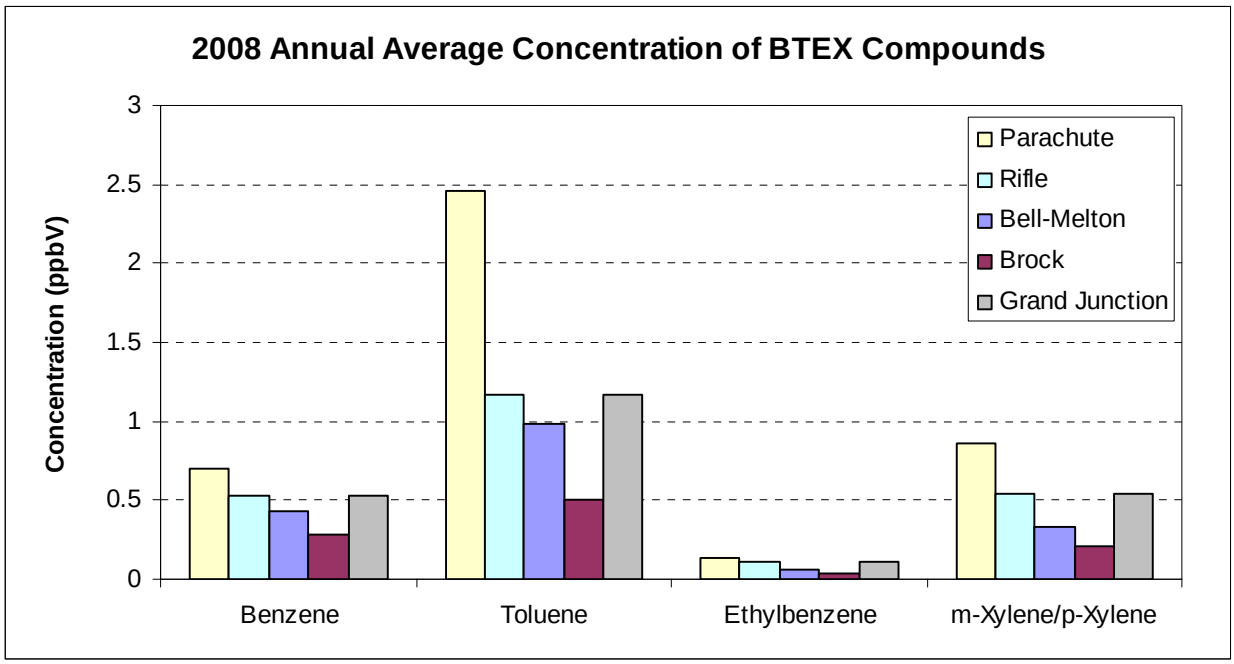


Figure 4-18. 2008 Annual Average Concentrations of BTEX Concentrations Measured at the Garfield County Sites, and the Grand Junction Site.

Following procedures outlined in the 2007 EPA UATMP/NATTS report (EPA, 2008), ratios of different pairs of the BTEX parameters were calculated and compared to the ratios reported in roadside studies. Table 4-5 compares ratios of concentrations measured at the Garfield County sites to the roadside study. The ratios at the Rifle site are the most similar to the roadside study profile. Other sites exhibit higher ratios and some variability, indicating that sources other than vehicle exhaust may contribute more significantly at these sites.

Table 4-2

Garfield County
2008 BTEX Mass Concentration Ratios

Site	Benzene-Ethylbenzene Ratio	Toluene-Ethylbenzene Ratio	Xylenes-Ethylbenzene Ratio
Roadside Study	**2.85**	**5.85**	**4.55**
Parachute	4.47	14.04	7.21
Rifle	3.56	8.99	4.84
Brock	5.90	11.58	5.44
Bell-Melton	6.19	12.60	6.19

5.0 CONCLUSIONS

General conclusions regarding data collected in 2008 at sampling sites in Garfield County are presented below.

Meteorological Data

Meteorological data were collected at all sites in 2008. Modeled meteorological data was also used to construct back trajectory residence time maps. Wind patterns exhibited the following traits:

- Based on collected data, winds at the Parachute and Rifle sites were variable and generally followed canyon flows patterns. The Parachute and Rifle sites also measured high percentages of calm winds.
- Winds at the Brock and Bell-Melton sites were predominantly from the south and southeast, respectively.
- Back trajectory residence time plots indicated that regional flow patterns into the area were from the northwest, through Utah and Idaho, and from the south-southwest through Utah and Arizona. There is very limited air flow from the east.

Criteria Pollutants

Monitoring of criteria pollutants included PM_{10} at the Parachute and Rifle sites, O_3 at the Rifle site (June - December, 2009), and continuous PM_{10} and $PM_{2.5}$ at the Rifle site (September - December, 2009). Findings include:

- Air quality measurements in Garfield County did not violate air quality standards for O_3, PM_{10}, or $PM_{2.5}$ in 2008.
- PM_{10} levels at the Parachute site appeared to increase over the last several years. Data from 2008 showed a highest 24-hour value of 210 $\mu g/m^3$, with a second highest value of 136 $\mu g/m^3$. The highest value exceeded the standard of 150 $\mu g/m^3$, but did not constitute a violation.
- PM_{10} levels at the Rifle site may also be increasing, but fewer years of data were available to reliably distinguish trends.
- Filter-based and continuous PM_{10} collocated at the Rifle site show a high degree of correlation.
- Limited O_3 and $PM_{2.5}$ data were available for 2008, and continued monitoring will be required to determine future compliance and trends.

SNMOC Compounds

SNMOC compounds were monitored at all four (4) sites on a 1-in-6 day schedule. Findings include:

- Light alkanes (alkanes with carbon content of 5 or less), which are associated with natural gas, were elevated at all sites in Garfield County, with values two to five times higher than the next highest averages measured at five other sites monitoring SNMOC compounds across the United States.

- Less abundant SNMOC compounds at the Garfield County site were shown to have more significant potential for O_3 formation than the light alkanes. These included the alkenes (including some biogenic compounds) and aromatics (including the BTEX compounds benzene, toluene, ethylbenzene, and x/p-xylenes).

- Analysis of O_3 formation potential show that, under ideal conditions, the potential contribution of VOCs to O_3 formation was higher than detected O_3 levels. This indicates that O_3 formation may be limited by NO_X availability. Local/regional increases in NO_X may adversely affect O_3 levels.

Carbonyl Compounds

Carbonyl compounds were monitored at all four sites on a 1-in-12 day schedule. Findings include:

- Carbonyl measurements were dominated by the compounds formaldehyde, acetaldehyde and acetone.

- Average Garfield County carbonyl concentrations were lower than most other sites across the United States, and lower than the nearby Grand Junction site.

HAPs

Results for monitored HAPs (including some SNMOC and carbonyl compounds) were compared to regional measurements reported for other sites across the United States. Findings include:

- Annual averages of formaldehyde, acetaldehyde and 1,3-butatdiene were lower than most regional sites.

- Concentrations of the BTEX parameters, including benzene, ethylbenzene, toluene, and m/p-xylenes were higher at the Parachute site than the nearby, more urban, Grand Junction site.

- Concentrations of styrene and n-hexane at the Bell-Melton site were higher than other Garfield County sites, and higher than most regional sites.

6.0 REFERENCES

California Air Resources Board (CARB), 2009, California Toxics Inventory, http://www.arb.ca.gov/toxics/cti/cti.htm. (July 17, 2009).

Carter, W.P.L., 1994, Development of ozone reactivity scales for volatile organic compounds. Journal of the Air & Waste Management Association, 44.

Conner, T.L., W. A. Lonneman, R. L. Seila, 1995, Transportation-Related Volatile Hydrocarbon Source Profiles Measured in Atlanta. Journal of the Air and Waste Management Association, 45: 383-394.

EPA, 2006. A Preliminary Risk-based Screening Approach for Air Toxics Monitoring Data Sets. Air, Pesticides, and Toxics Management Division. Atlanta, GA., February (EPA-904-B-06-001).

EPA, 2008, Final Report: 2007 National Monitoring Programs (UATMP and NATTS) Volume I: Main Content, Research Triangle Park, NC, December. (EPA-454/R-08-008a).

Ying L., M. Shao, L. Fu, S. Lu, L.Zeng and D.Tang, 2008, Source profiles of volatile organic compounds (VOCs) measured in China: Part I. Atmospheric Environment, 42:25, August.

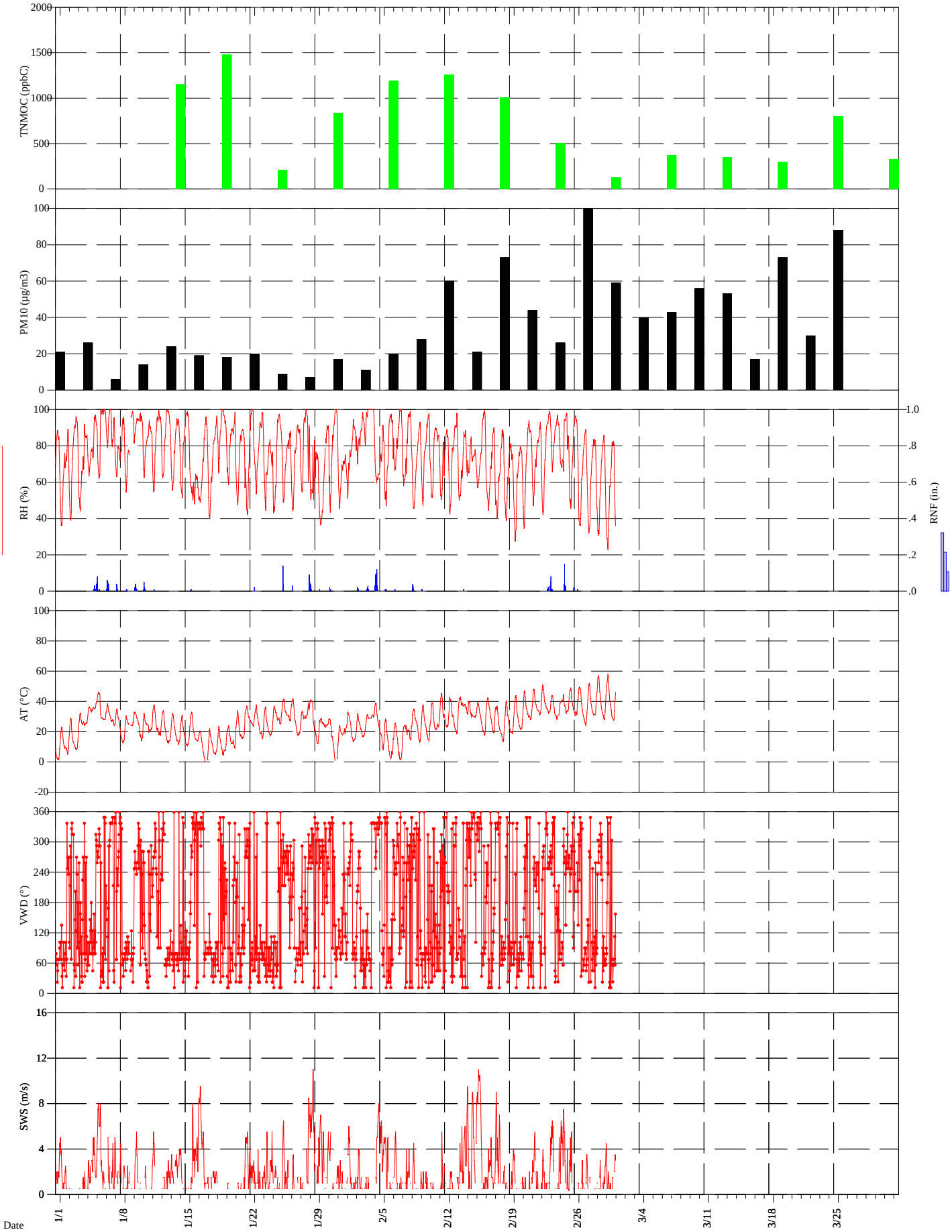
APPENDIX A

Garfield County

Stackplots
2008

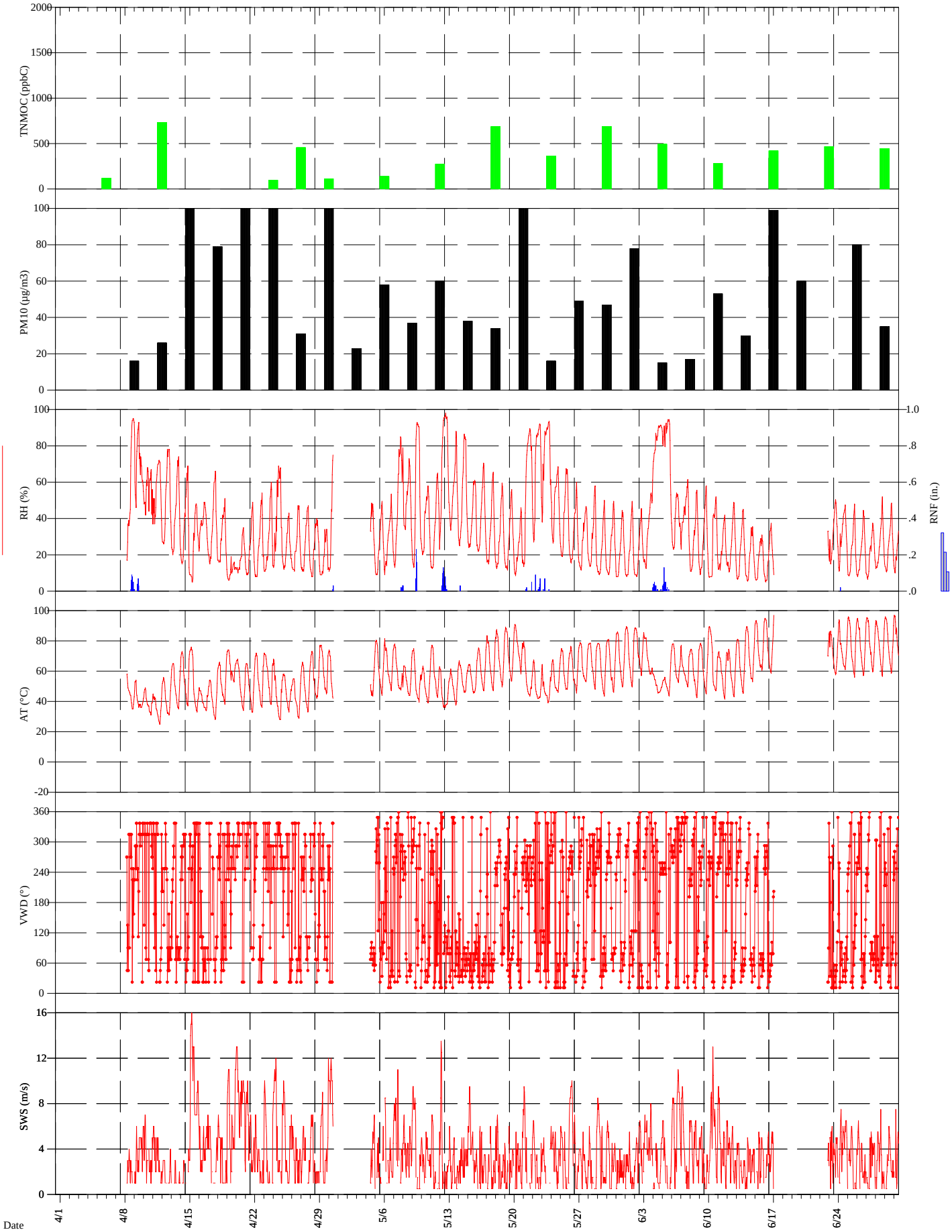
Garfield County, CO

Parachute Site



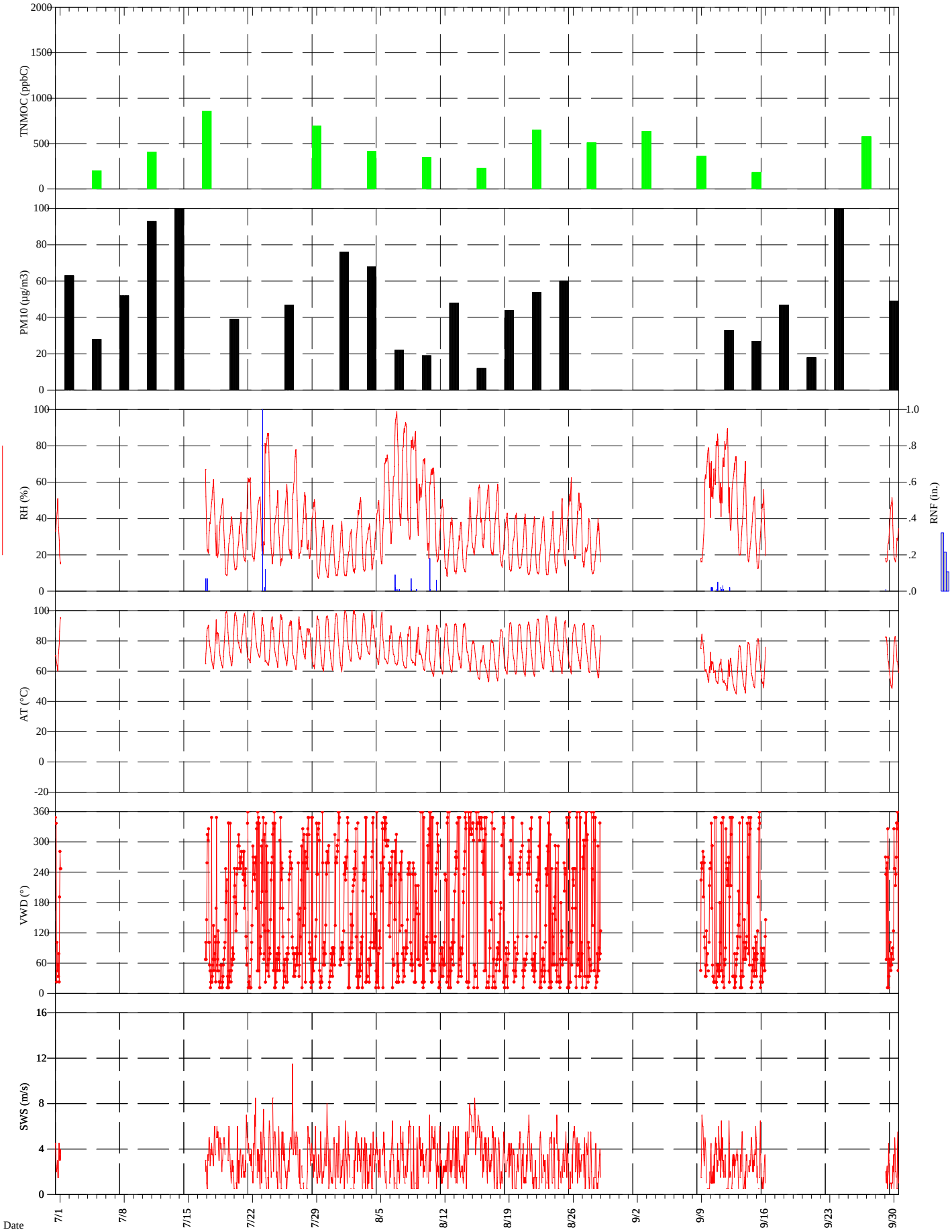
Garfield County, CO

Parachute Site



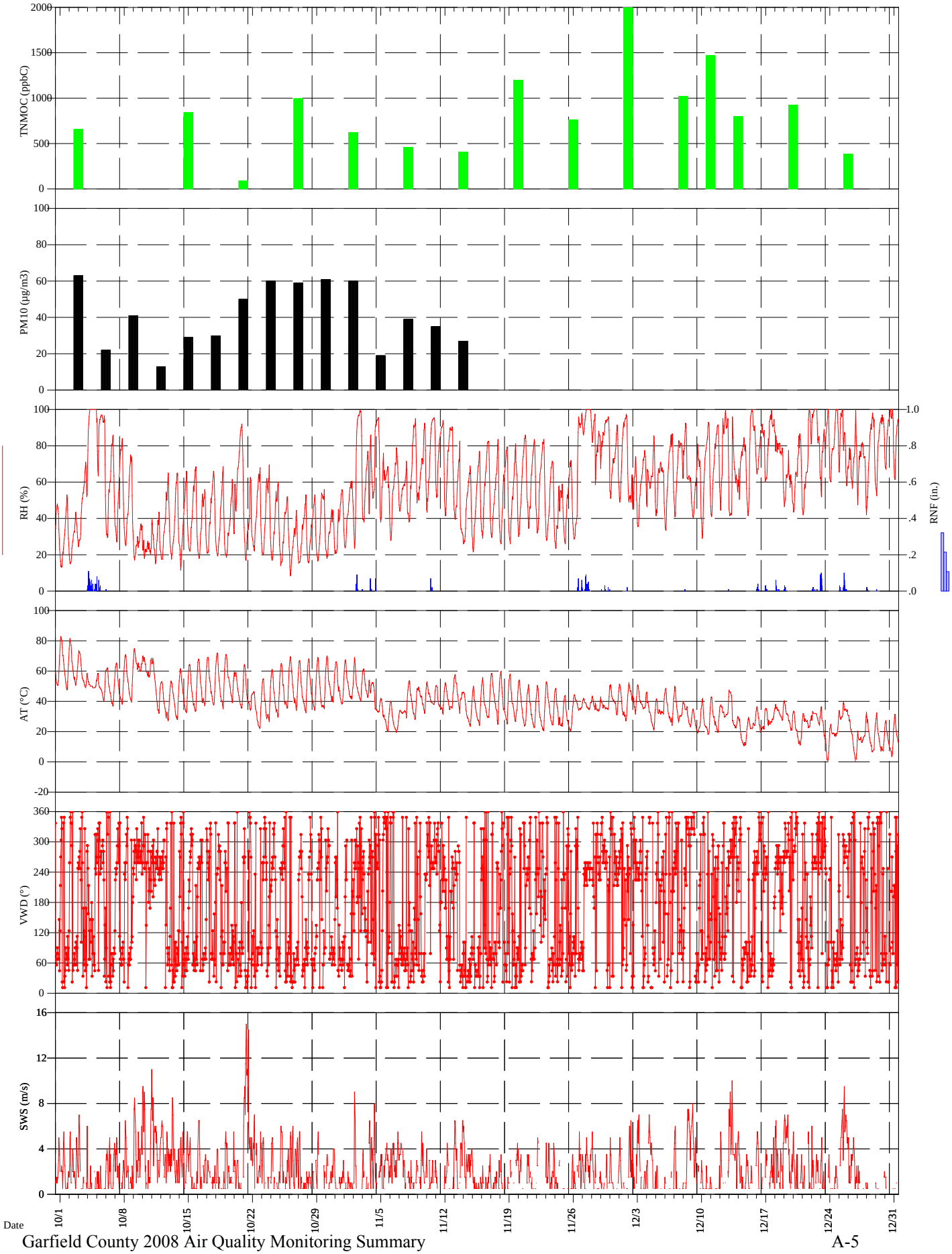
Garfield County, CO

Parachute Site



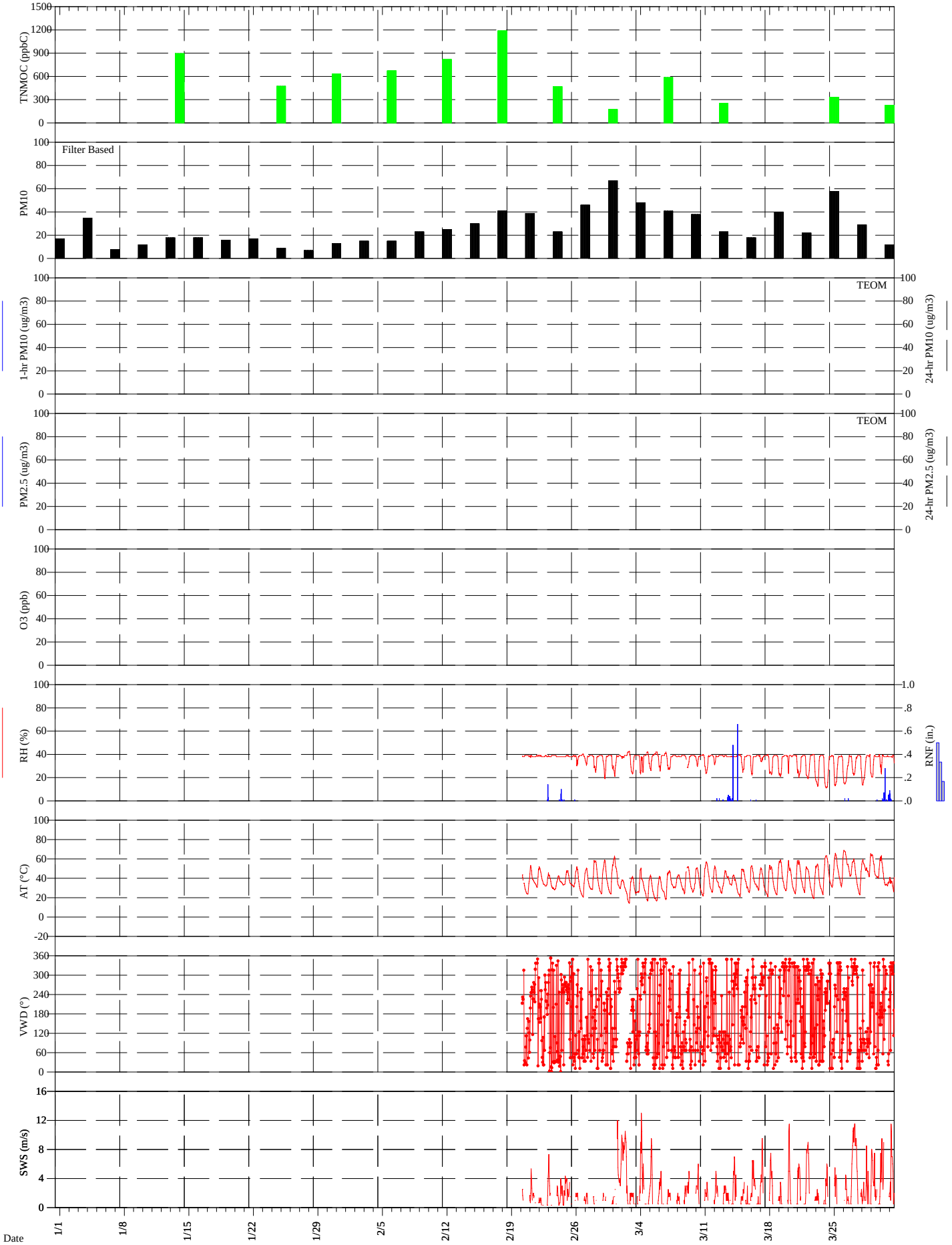
Garfield County, CO

Parachute Site



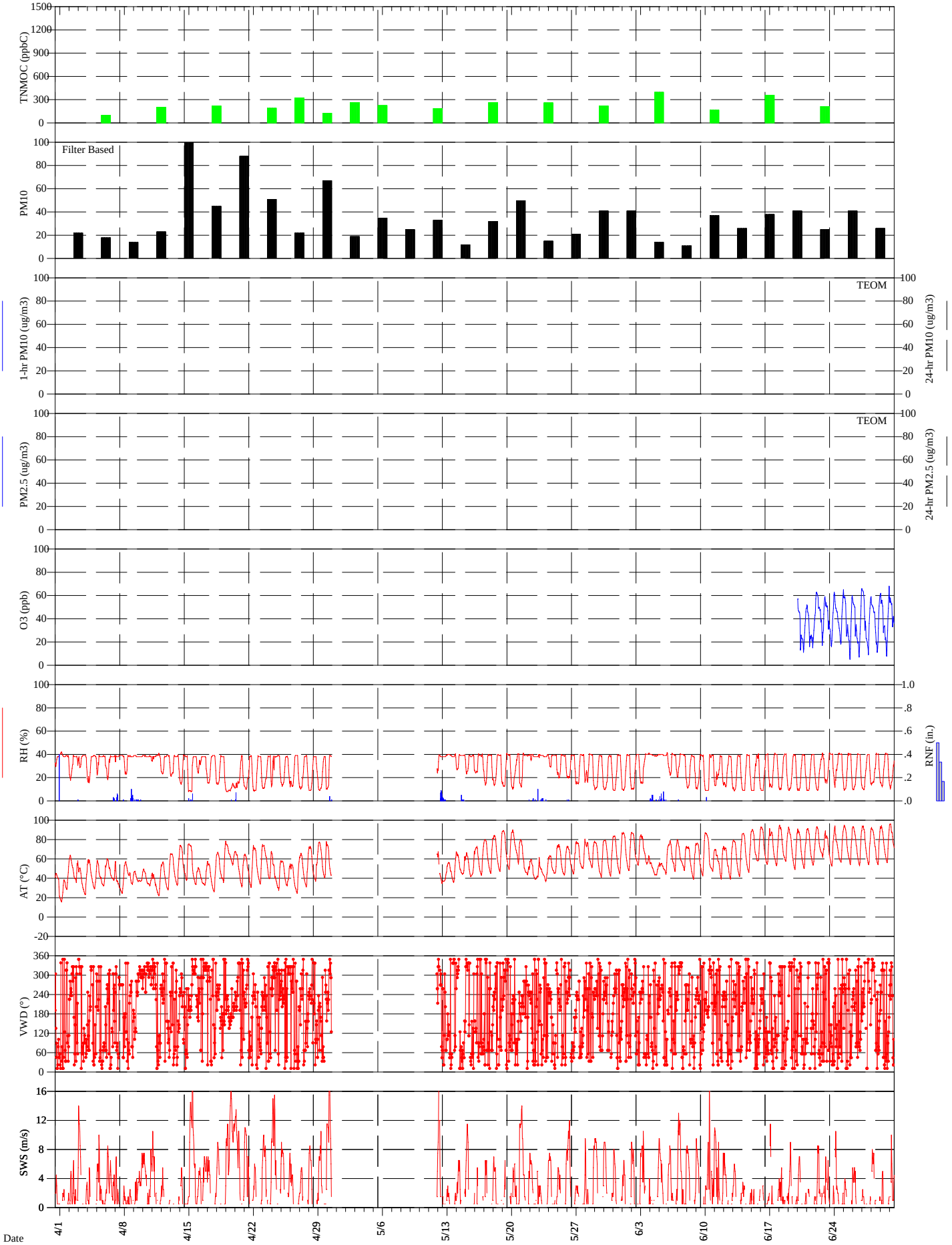
Garfield County, CO

Rifle Site



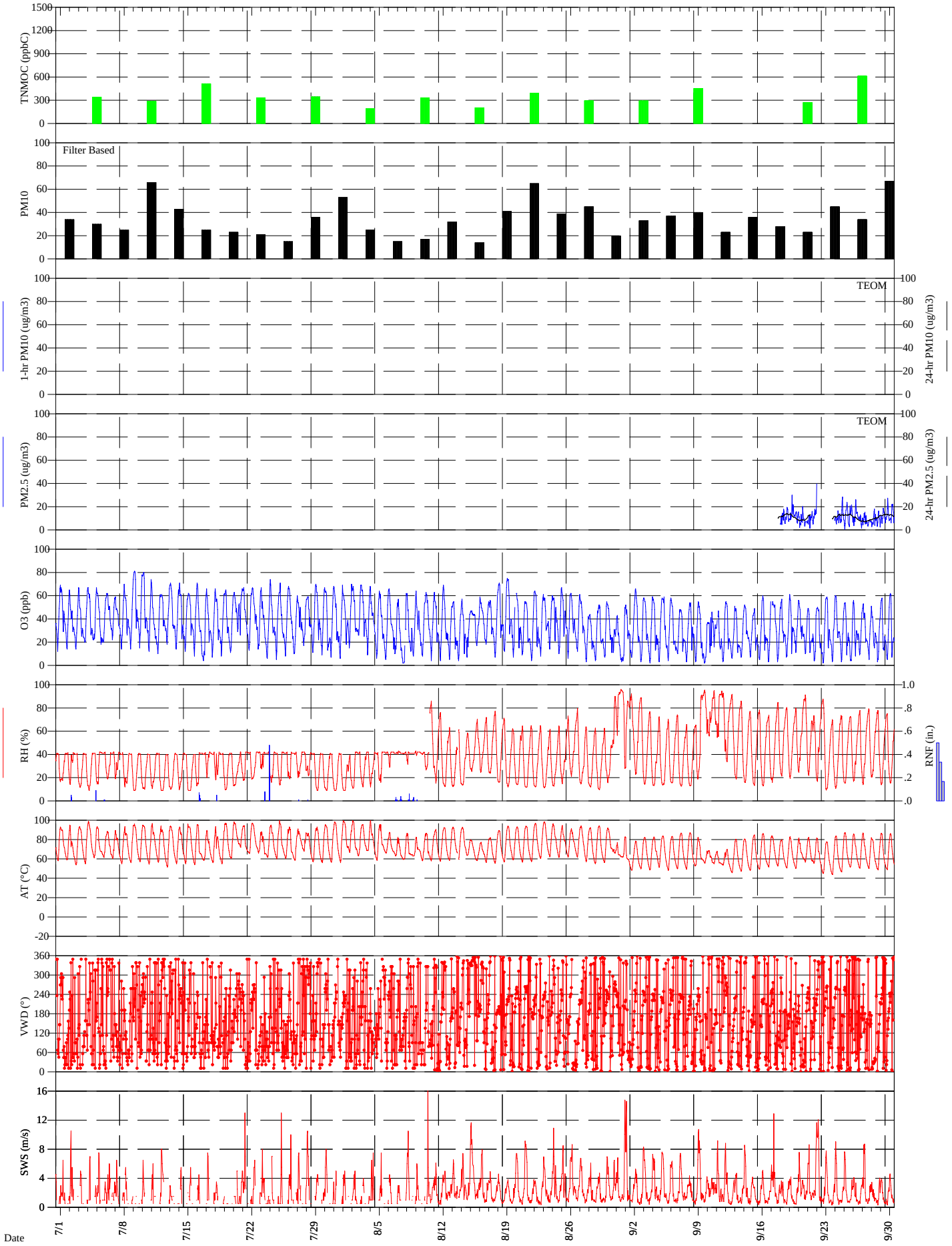
Garfield County, CO

Rifle Site



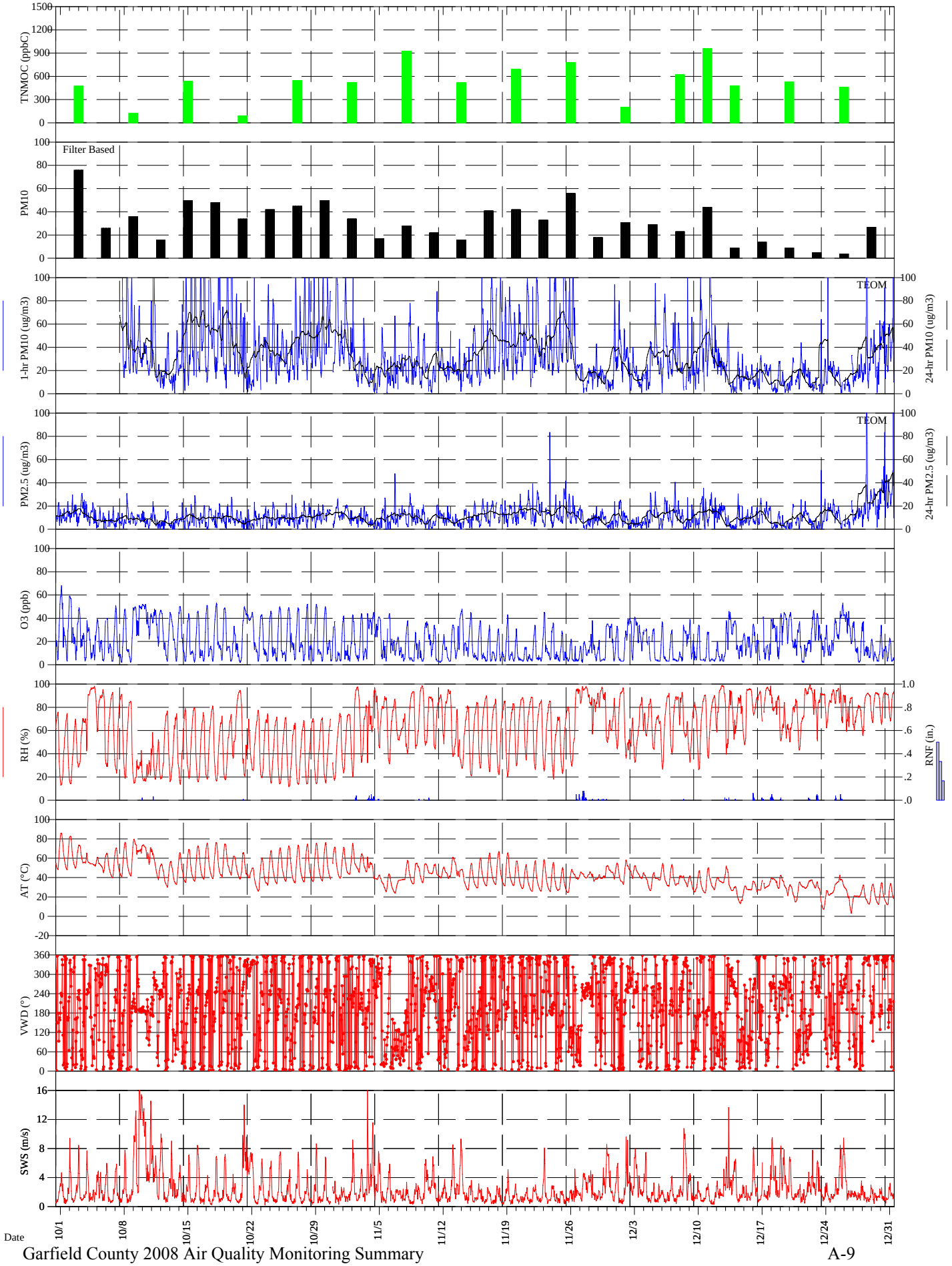
Garfield County, CO

Rifle Site



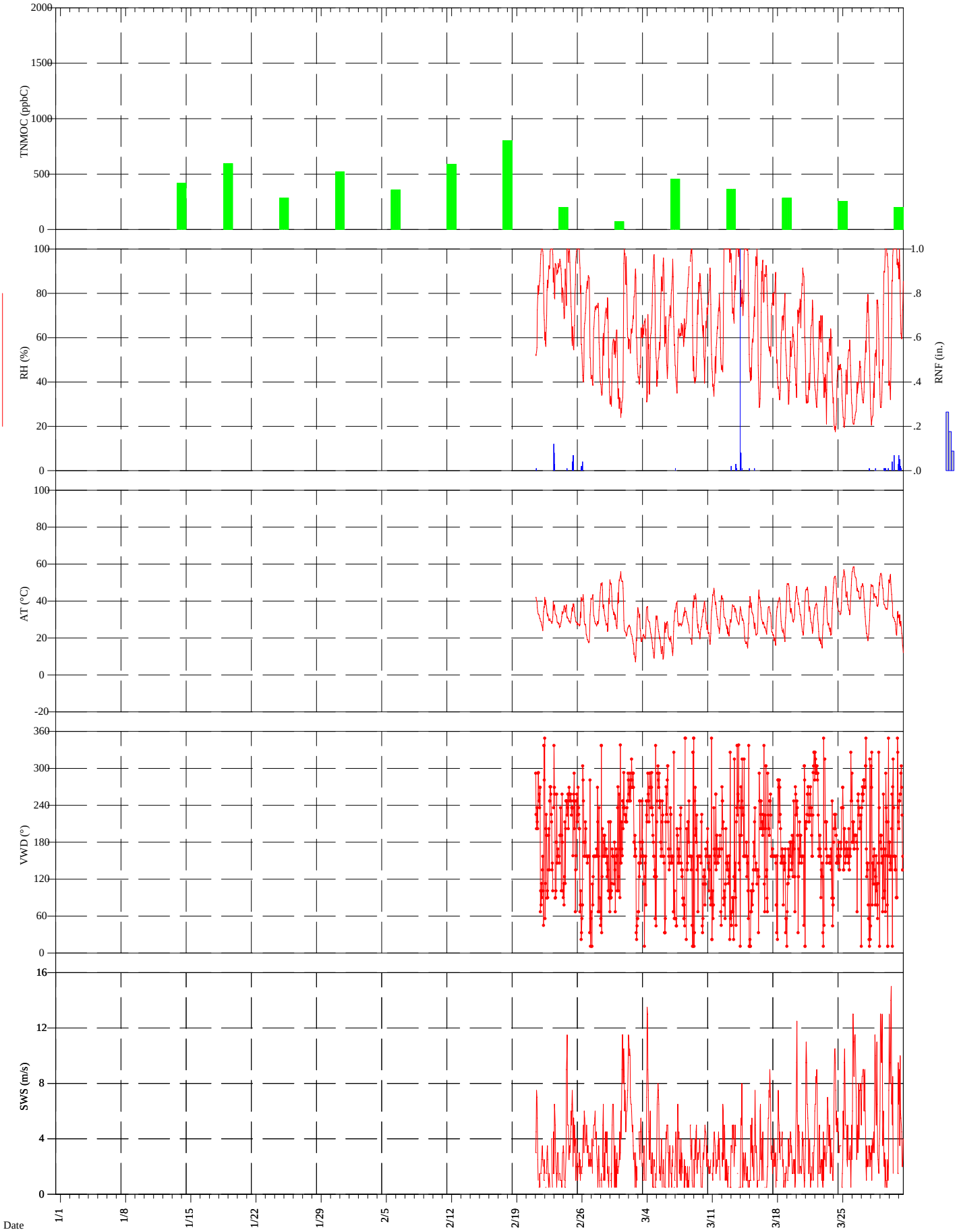
Garfield County, CO

Rifle Site



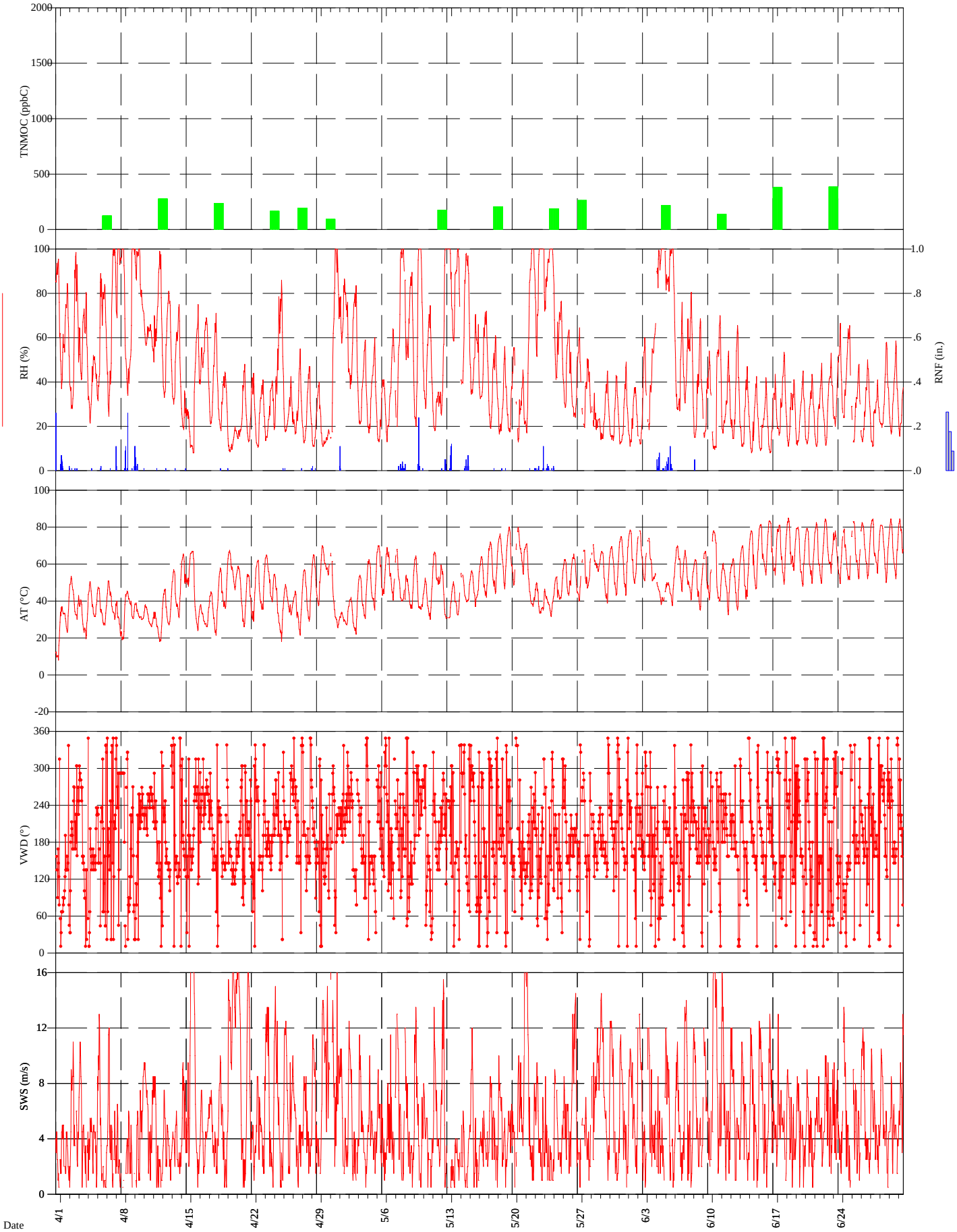
Garfield County, CO

Brock Site



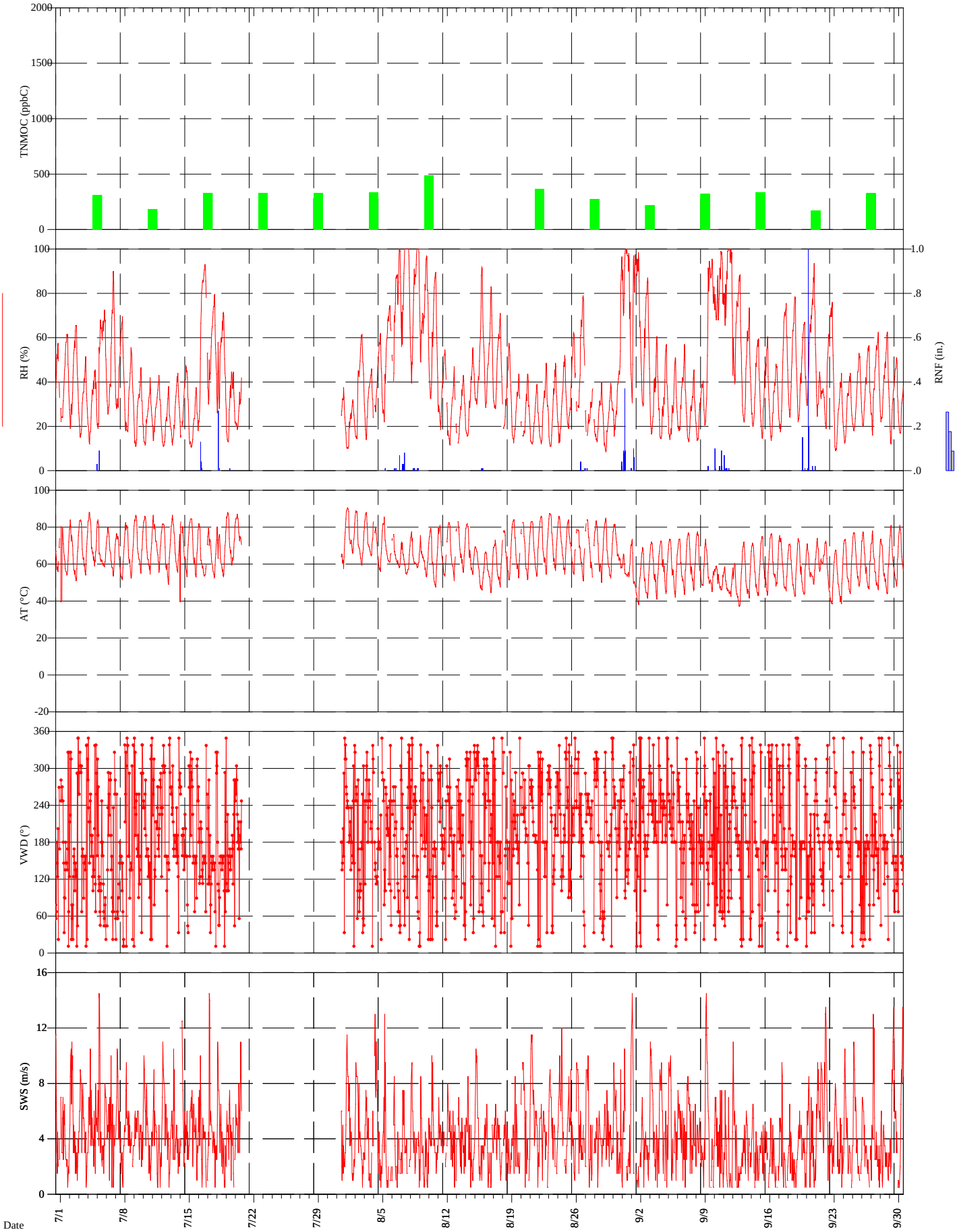
Garfield County, CO

Brock Site



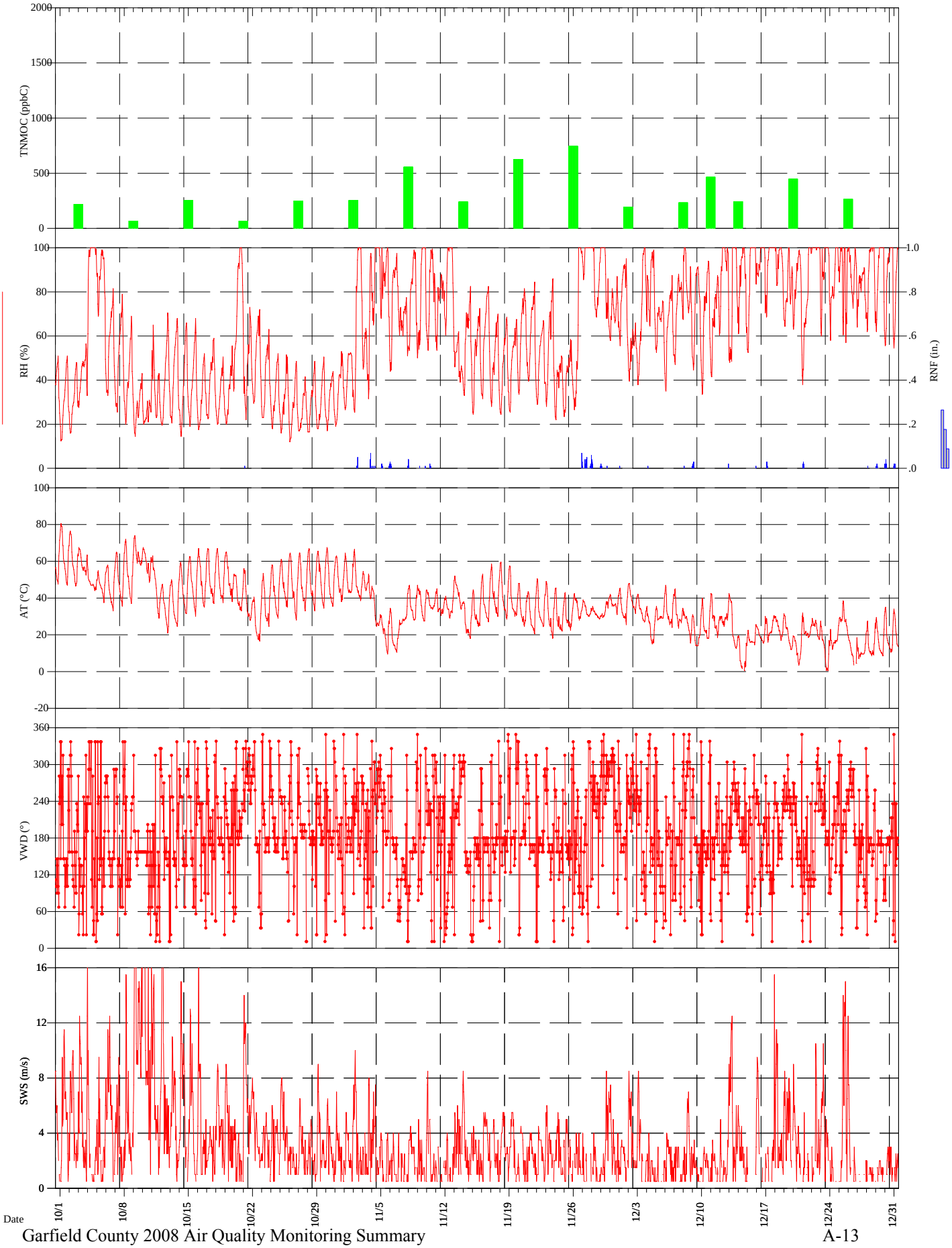
Garfield County, CO

Brock Site



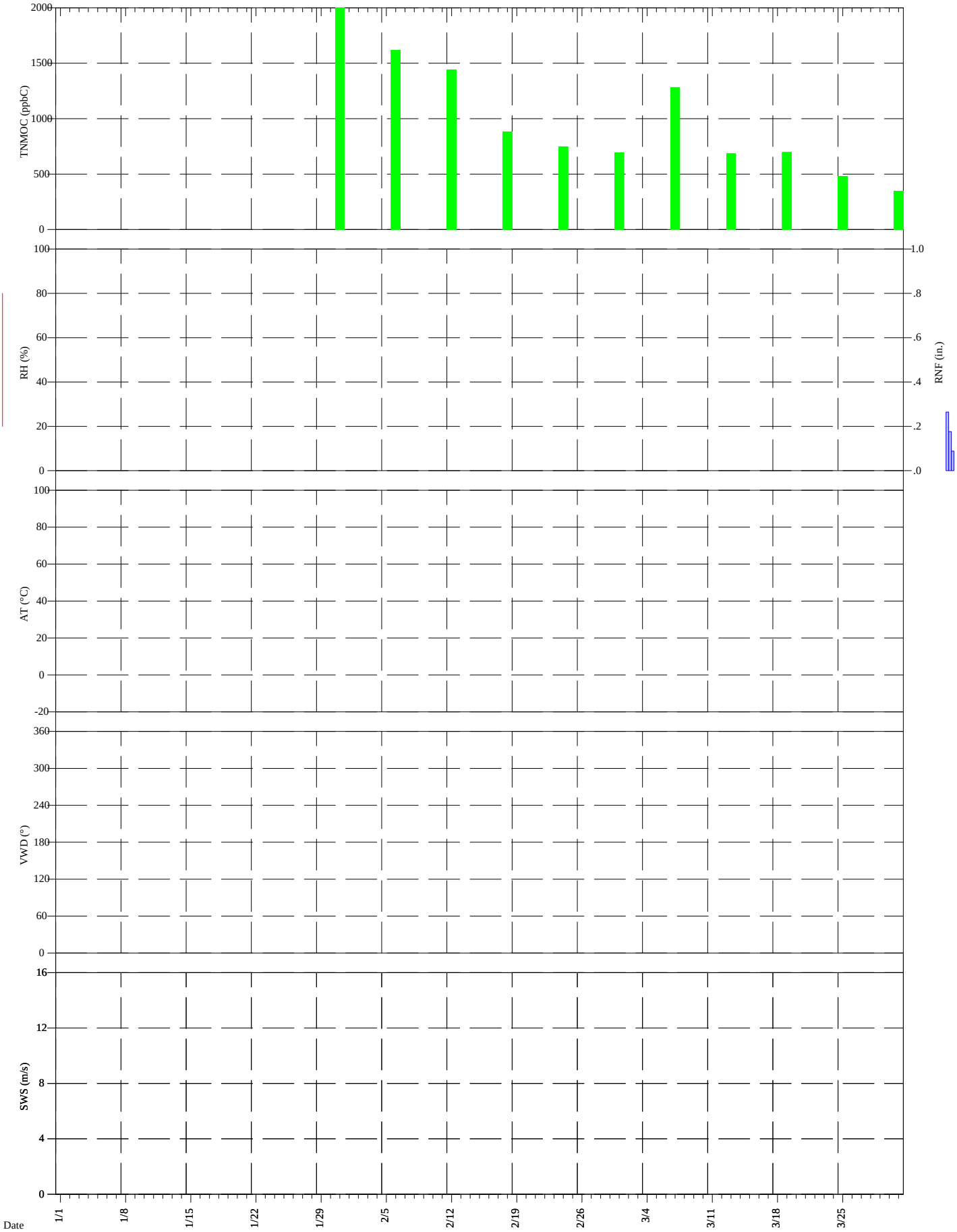
Garfield County, CO

Brock Site

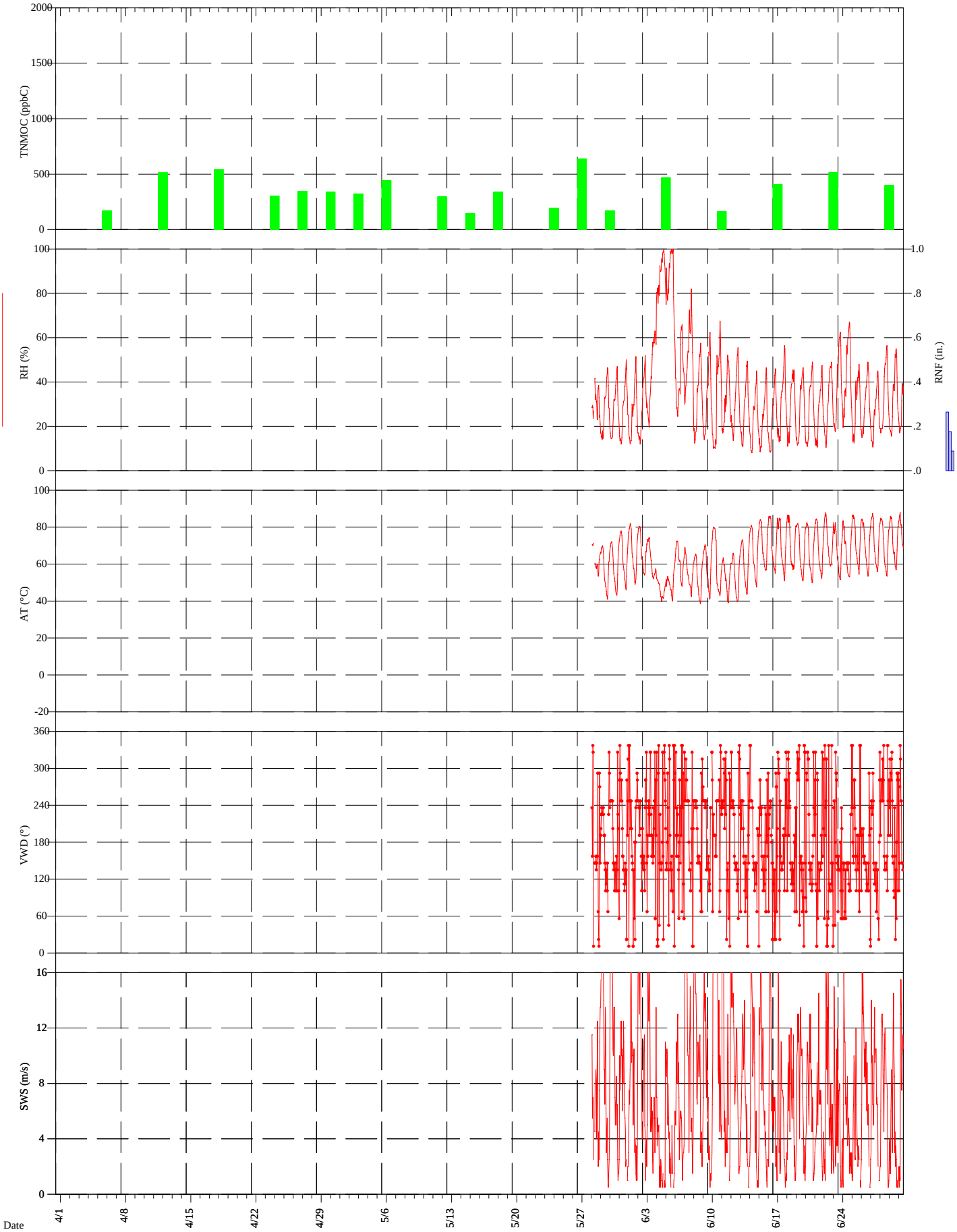


Garfield County, CO

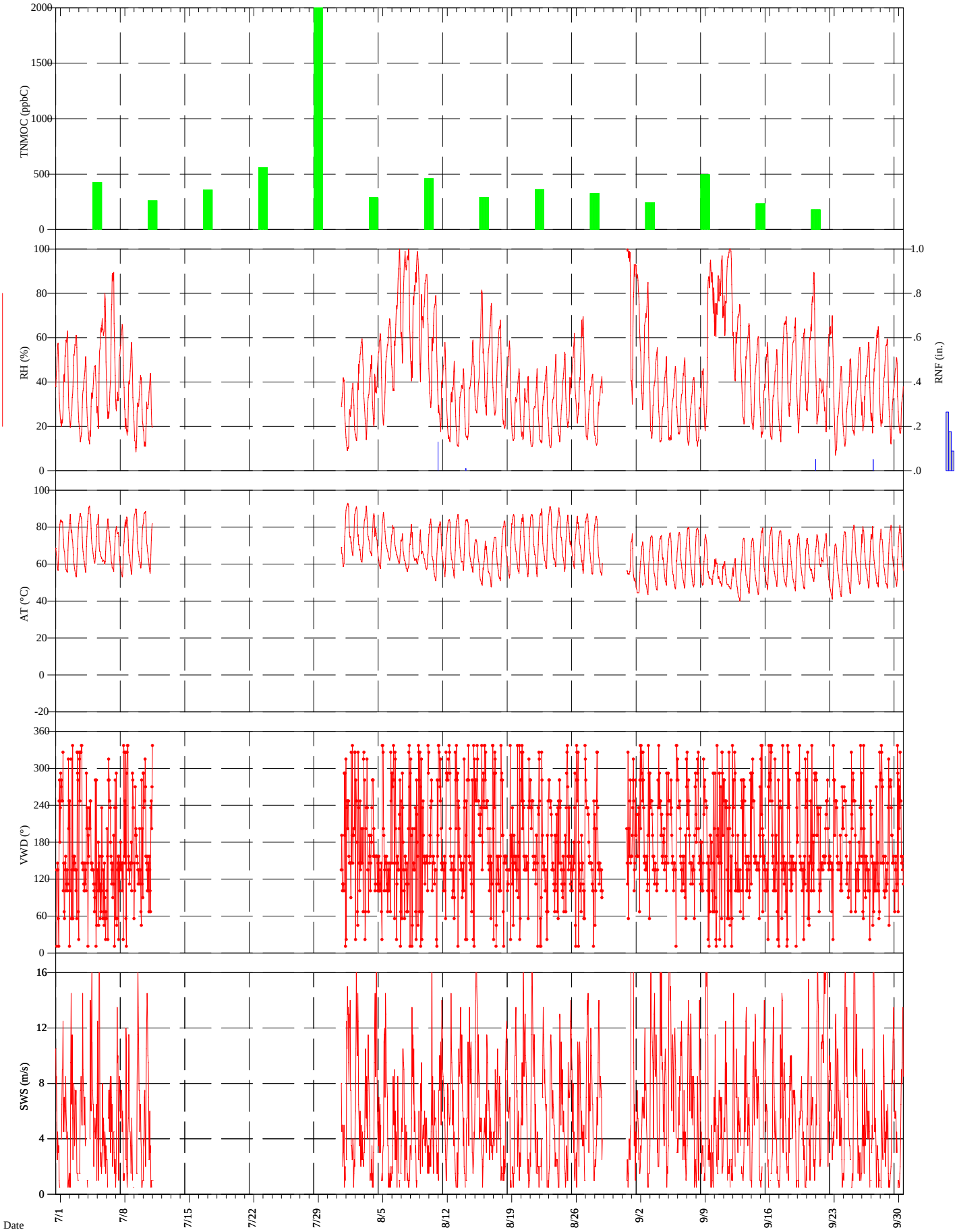
Bell Melton Site



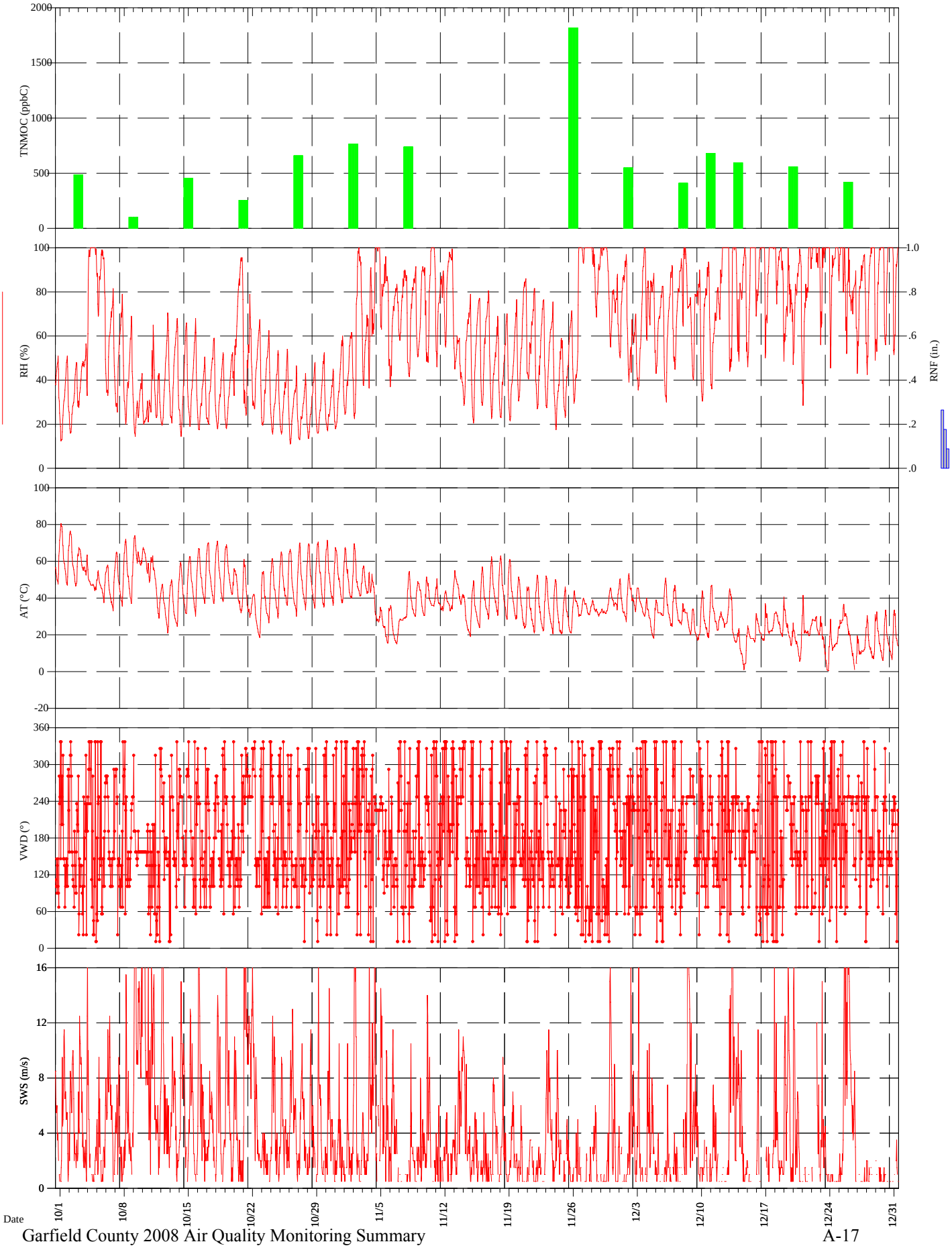
Garfield County, CO
Bell Melton Site



Garfield County, CO
Bell Melton Site



Garfield County, CO
Bell Melton Site



APPENDIX B

Garfield County

SNMOC Concentrations
2008

Garfield County SNMOC Monitoring
Parachute (PACO)
1/14/2008-12/26/2008 (every sixth day)

	Sample Count		Concentration (ppbV)		
Detected Compound (CAS Number)	**# Samples**	**# Detects**	**Minimum**	**Maximum**	**Average***
1,2,3-Trimethylbenzene (526-73-8)	57	52	ND	0.71	0.04
1,2,4-Trimethylbenzene (95-63-6)	57	57	0.02	1.50	0.17
1,3,5-Trimethylbenzene (108-67-8)	57	56	ND	1.09	0.13
1,3-Butadiene (106-99-0)	57	30	ND	0.15	0.03
1-Dodecene (112-41-4)	57	43	ND	0.37	0.06
1-Heptene (592-76-7)	57	53	ND	0.61	0.23
1-Hexene (592-41-6)	57	43	ND	0.05	0.04
1-Nonene (124-11-8)	57	48	ND	0.37	0.04
1-Octene (111-66-0)	57	18	ND	0.22	0.04
1-Pentene (109-67-1)	57	55	ND	0.23	0.05
1-Tridecene (2437-56-1)	57	2	ND	0.01	0.02
1-Undecene (821-95-4)	57	10	ND	0.19	0.02
2,2,3-Trimethylpentane (564-02-3)	57	51	ND	0.23	0.07
2,2,4-Trimethylpentane (540-84-1)	57	23	ND	0.78	0.05
2,2-Dimethylbutane (75-83-2)	57	57	0.03	0.55	0.21
2,3,4-Trimethylpentane (565-75-3)	57	45	ND	0.08	0.02
2,3-Dimethylbutane (79-29-8)	57	57	0.05	1.05	0.36
2,3-Dimethylpentane (565-59-3)	57	57	0.04	1.00	0.19
2,4-Dimethylpentane (108-08-7)	57	57	0.02	0.37	0.12
2-Methyl-1-butene (563-46-2)	57	44	ND	0.92	0.14
2-Methyl-1-pentene (763-29-1)	57	6	ND	0.05	0.04
2-Methyl-2-butene (513-35-9)	57	45	ND	0.47	0.06
2-Methylheptane (592-27-8)	57	57	0.04	1.05	0.30
2-Methylhexane (591-76-4)	57	56	ND	2.93	0.56
2-Methylpentane (107-83-5)	57	57	0.22	4.23	1.49
3-Methyl-1-butene (563-45-1)	57	2	ND	0.07	0.02
3-Methylheptane (589-81-1)	57	57	0.03	0.80	0.23
3-Methylhexane (589-34-4)	57	57	0.07	4.13	0.59
3-Methylpentane (96-14-0)	57	57	0.12	2.48	0.86
4-Methyl-1-pentene (691-37-2)	57	15	ND	0.07	0.04
Acetylene (74-86-2)	57	57	0.20	2.35	1.06
a-Pinene (80-56-8)	57	50	ND	1.08	0.07
Benzene (71-43-2)	57	57	0.11	3.47	0.73
b-Pinene (127-91-3)	57	5	ND	0.36	0.02
cis-2-Butene (590-18-1)	57	52	ND	0.21	0.05
cis-2-Hexene (7688-21-3)	57	11	ND	0.06	0.04
cis-2-Pentene (627-20-3)	57	37	ND	0.12	0.02
Cyclohexane (110-82-7)	57	57	0.11	3.80	1.16
Cyclopentane (287-92-3)	57	57	0.04	0.93	0.25
Cyclopentene (142-29-0)	57	44	ND	0.31	0.06
Ethane (74-84-0)	57	57	7.95	259.00	77.93
Ethylbenzene (100-41-4)	57	57	0.02	0.60	0.14

*Samples reported as non-detects (ND) were included in averages as 1/2 minimum detection limits.

Garfield County SNMOC Monitoring
Parachute (PACO)
1/14/2008-12/26/2008 (every sixth day)

	Sample Count		Concentration (ppbV)		
Detected Compound (CAS Number)	**# Samples**	**# Detects**	**Minimum**	**Maximum**	**Average***
Ethylene (74-85-1)	57	56	ND	3.67	1.48
Isobutane (75-28-5)	57	57	0.68	115.50	9.05
Isobutene/1-Butene (115-11-7 / 106-98-9)	57	44	ND	2.82	0.95
Isopentane (78-78-4)	57	55	ND	42.40	6.54
Isoprene (78-79-5)	57	46	ND	0.57	0.10
Isopropylbenzene (98-82-8)	57	24	ND	0.05	0.02
m-Diethylbenzene (141-93-5)	57	38	ND	0.41	0.03
Methylcyclohexane (108-87-2)	57	57	0.21	8.79	2.34
Methylcyclopentane (96-37-7)	57	57	0.13	2.92	0.95
m-Ethyltoluene (620-14-4)	57	57	0.01	0.50	0.10
m-Xylene/p-Xylene (108-38-3 / 106-42-3)	57	57	0.10	2.72	0.91
n-Butane (106-97-8)	57	57	0.83	22.85	7.56
n-Decane (124-18-5)	57	57	0.04	19.40	0.70
n-Dodecane (112-40-3)	57	57	0.02	11.83	0.54
n-Heptane (142-82-5)	57	57	0.10	4.74	1.07
n-Hexane (110-54-3)	57	57	0.22	5.33	1.67
n-Nonane (111-84-2)	57	57	0.04	2.54	0.43
n-Octane (111-65-9)	57	57	0.09	2.69	0.78
n-Pentane (109-66-0)	57	57	0.37	51.00	4.50
n-Propylbenzene (103-65-1)	57	55	ND	0.22	0.04
n-Tridecane (629-50-5)	57	32	ND	0.71	0.04
n-Undecane (1120-21-4)	57	57	0.03	35.27	1.22
o-Ethyltoluene (611-14-3)	57	55	ND	1.29	0.09
o-Xylene (95-47-6)	57	57	0.03	0.73	0.18
p-Diethylbenzene (105-05-5)	57	22	ND	0.32	0.02
p-Ethyltoluene (622-96-8)	57	57	0.01	0.70	0.07
Propane (74-98-6)	57	57	2.53	86.33	26.90
Propylene (115-07-1)	57	57	0.09	0.82	0.33
Styrene (100-42-5)	57	9	ND	0.45	0.03
Toluene (108-88-3)	57	57	0.19	31.43	2.67
trans-2-Butene (624-64-6)	57	54	ND	0.46	0.08
trans-2-Hexene (4050-45-7)	57	4	ND	0.06	0.04
trans-2-Pentene (646-04-8)	57	53	ND	0.32	0.04

*Samples reported as non-detects (ND) were included in averages as 1/2 minimum detection limits.

Garfield County SNMOC Monitoring
Rifle (RICO)
1/14/2008-12/26/2008 (every sixth day)

	Sample Count		Concentration (ppbV)		
Detected Compound (CAS Number)	**# Samples**	**# Detects**	**Minimum**	**Maximum**	**Average***
1,2,3-Trimethylbenzene (526-73-8)	58	53	ND	0.07	0.02
1,2,4-Trimethylbenzene (95-63-6)	58	58	0.03	0.32	0.13
1,3,5-Trimethylbenzene (108-67-8)	58	58	0.01	0.16	0.07
1,3-Butadiene (106-99-0)	58	47	ND	0.22	0.05
1-Dodecene (112-41-4)	58	21	ND	0.14	0.02
1-Heptene (592-76-7)	58	56	ND	0.42	0.14
1-Hexene (592-41-6)	58	49	ND	0.05	0.04
1-Nonene (124-11-8)	58	40	ND	0.08	0.02
1-Octene (111-66-0)	58	17	ND	0.11	0.02
1-Pentene (109-67-1)	58	57	ND	0.34	0.08
1-Tridecene (2437-56-1)	58	1	ND	0.01	0.02
1-Undecene (821-95-4)	58	9	ND	0.04	0.01
2,2,3-Trimethylpentane (564-02-3)	58	44	ND	0.10	0.04
2,2,4-Trimethylpentane (540-84-1)	58	58	0.01	0.20	0.04
2,2-Dimethylbutane (75-83-2)	58	58	0.03	0.41	0.15
2,3,4-Trimethylpentane (565-75-3)	58	52	ND	0.07	0.02
2,3-Dimethylbutane (79-29-8)	58	58	0.06	0.80	0.29
2,3-Dimethylpentane (565-59-3)	58	58	0.04	0.31	0.13
2,4-Dimethylpentane (108-08-7)	58	58	0.02	0.20	0.09
2-Methyl-1-butene (563-46-2)	58	52	ND	1.53	0.20
2-Methyl-1-pentene (763-29-1)	58	21	ND	0.05	0.04
2-Methyl-2-butene (513-35-9)	58	57	ND	0.63	0.12
2-Methylheptane (592-27-8)	58	58	0.02	0.42	0.15
2-Methylhexane (591-76-4)	58	58	0.08	0.84	0.35
2-Methylpentane (107-83-5)	58	58	0.28	3.35	1.28
3-Methyl-1-butene (563-45-1)	58	4	ND	0.10	0.02
3-Methylheptane (589-81-1)	58	58	0.02	0.28	0.11
3-Methylhexane (589-34-4)	58	58	0.04	0.84	0.34
3-Methylpentane (96-14-0)	58	58	0.13	2.03	0.71
4-Methyl-1-pentene (691-37-2)	58	14	ND	0.10	0.04
Acetylene (74-86-2)	58	58	0.38	4.66	1.48
a-Pinene (80-56-8)	58	51	ND	0.15	0.04
Benzene (71-43-2)	58	58	0.12	1.28	0.53
b-Pinene (127-91-3)	58	1	ND	0.03	0.01
cis-2-Butene (590-18-1)	58	58	0.02	0.82	0.13
cis-2-Hexene (7688-21-3)	58	12	ND	0.11	0.04
cis-2-Pentene (627-20-3)	58	53	ND	0.31	0.05
Cyclohexane (110-82-7)	58	58	0.13	2.15	0.72
Cyclopentane (287-92-3)	58	58	0.05	0.60	0.20
Cyclopentene (142-29-0)	58	53	ND	0.24	0.06
Ethane (74-84-0)	58	58	7.40	166.50	49.69
Ethylbenzene (100-41-4)	58	58	0.03	0.27	0.11

*Samples reported as non-detects (ND) were included in averages as 1/2 minimum detection limits.

Garfield County SNMOC Monitoring
Rifle (RICO)
1/14/2008-12/26/2008 (every sixth day)

	Sample Count		Concentration (ppbV)		
Detected Compound (CAS Number)	**# Samples**	**# Detects**	**Minimum**	**Maximum**	**Average***
Ethylene (74-85-1)	58	57	ND	6.80	1.80
Isobutane (75-28-5)	58	58	1.08	19.75	6.30
Isobutene/1-Butene (115-11-7 / 106-98-9)	58	49	ND	3.08	0.94
Isopentane (78-78-4)	58	55	ND	13.68	5.40
Isoprene (78-79-5)	58	56	ND	0.65	0.12
Isopropylbenzene (98-82-8)	58	30	ND	0.02	0.02
m-Diethylbenzene (141-93-5)	58	36	ND	0.13	0.01
Methylcyclohexane (108-87-2)	58	58	0.17	3.57	1.20
Methylcyclopentane (96-37-7)	58	58	0.13	1.77	0.65
m-Ethyltoluene (620-14-4)	58	58	0.02	0.20	0.09
m-Xylene/p-Xylene (108-38-3 / 106-42-3)	58	58	0.10	1.36	0.54
n-Butane (106-97-8)	58	58	1.30	22.45	7.20
n-Decane (124-18-5)	58	58	0.04	0.29	0.13
n-Dodecane (112-40-3)	58	58	0.01	0.51	0.10
n-Heptane (142-82-5)	58	58	0.09	1.71	0.58
n-Hexane (110-54-3)	58	58	0.22	4.52	1.29
n-Nonane (111-84-2)	58	58	0.03	0.44	0.16
n-Octane (111-65-9)	58	58	0.06	1.00	0.35
n-Pentane (109-66-0)	58	58	0.56	11.76	3.30
n-Propylbenzene (103-65-1)	58	55	ND	0.07	0.03
n-Tridecane (629-50-5)	58	31	ND	0.10	0.02
n-Undecane (1120-21-4)	58	58	0.02	0.61	0.14
o-Ethyltoluene (611-14-3)	58	57	ND	0.10	0.05
o-Xylene (95-47-6)	58	58	0.03	0.37	0.15
p-Diethylbenzene (105-05-5)	58	28	ND	0.03	0.01
p-Ethyltoluene (622-96-8)	58	58	0.01	0.11	0.05
Propane (74-98-6)	58	58	2.85	71.33	20.28
Propylene (115-07-1)	58	58	0.18	1.62	0.50
Styrene (100-42-5)	58	17	ND	0.08	0.02
Toluene (108-88-3)	58	58	0.20	3.99	1.15
trans-2-Butene (624-64-6)	58	58	0.03	0.84	0.16
trans-2-Hexene (4050-45-7)	58	20	ND	0.06	0.04
trans-2-Pentene (646-04-8)	58	58	0.02	0.62	0.11

*Samples reported as non-detects (ND) were included in averages as 1/2 minimum detection limits.

Garfield County SNMOC Monitoring
Brock (MOCO)
1/14/2008-12/26/2008 (every sixth day)

	Sample Count		Concentration (ppbV)		
Detected Compound (CAS Number)	**# Samples**	**# Detects**	**Minimum**	**Maximum**	**Average***
1,2,3-Trimethylbenzene (526-73-8)	58	25	ND	0.03	0.01
1,2,4-Trimethylbenzene (95-63-6)	58	58	0.01	0.13	0.04
1,3,5-Trimethylbenzene (108-67-8)	58	43	ND	0.08	0.02
1,3-Butadiene (106-99-0)	58	1	ND	0.02	0.02
1-Dodecene (112-41-4)	58	13	ND	0.22	0.03
1-Heptene (592-76-7)	58	53	ND	0.28	0.11
1-Hexene (592-41-6)	58	40	ND	0.06	0.04
1-Nonene (124-11-8)	58	26	ND	0.05	0.02
1-Octene (111-66-0)	58	13	ND	0.05	0.02
1-Pentene (109-67-1)	58	58	0.01	0.09	0.03
1-Tridecene (2437-56-1)	58	1	ND	0.01	0.02
1-Undecene (821-95-4)	58	9	ND	0.03	0.01
2,2,3-Trimethylpentane (564-02-3)	58	30	ND	0.06	0.02
2,2,4-Trimethylpentane (540-84-1)	58	31	ND	0.20	0.03
2,2-Dimethylbutane (75-83-2)	58	58	0.02	0.29	0.11
2,3,4-Trimethylpentane (565-75-3)	58	33	ND	0.06	0.01
2,3-Dimethylbutane (79-29-8)	58	58	0.03	0.52	0.20
2,3-Dimethylpentane (565-59-3)	58	57	ND	0.20	0.08
2,4-Dimethylpentane (108-08-7)	58	58	0.01	0.12	0.06
2-Methyl-1-butene (563-46-2)	58	27	ND	1.01	0.10
2-Methyl-1-pentene (763-29-1)	58	2	ND	0.01	0.04
2-Methyl-2-butene (513-35-9)	58	29	ND	0.09	0.03
2-Methylheptane (592-27-8)	58	57	ND	0.27	0.10
2-Methylhexane (591-76-4)	58	58	0.05	0.62	0.24
2-Methylpentane (107-83-5)	58	58	0.14	2.93	0.91
3-Methyl-1-butene (563-45-1)	58	4	ND	0.37	0.03
3-Methylheptane (589-81-1)	58	58	0.01	0.19	0.07
3-Methylhexane (589-34-4)	58	57	ND	0.53	0.22
3-Methylpentane (96-14-0)	58	58	0.06	2.87	0.53
4-Methyl-1-pentene (691-37-2)	58	6	ND	0.12	0.04
Acetylene (74-86-2)	58	58	0.12	1.04	0.48
a-Pinene (80-56-8)	58	35	ND	0.18	0.03
Benzene (71-43-2)	58	58	0.06	0.75	0.29
b-Pinene (127-91-3)	58	6	ND	0.07	0.01
cis-2-Butene (590-18-1)	58	31	ND	0.08	0.03
cis-2-Hexene (7688-21-3)	58	7	ND	0.03	0.04
cis-2-Pentene (627-20-3)	58	12	ND	0.03	0.02
Cyclohexane (110-82-7)	58	58	0.07	1.55	0.62
Cyclopentane (287-92-3)	58	58	0.02	0.36	0.14
Cyclopentene (142-29-0)	58	38	ND	0.30	0.05
Ethane (74-84-0)	58	58	5.35	157.50	42.72
Ethylbenzene (100-41-4)	58	56	ND	0.11	0.04

*Samples reported as non-detects (ND) were included in averages as 1/2 minimum detection limits.

Garfield County SNMOC Monitoring
Brock (MOCO)
1/14/2008-12/26/2008 (every sixth day)

	Sample Count		Concentration (ppbV)		
Detected Compound (CAS Number)	**# Samples**	**# Detects**	**Minimum**	**Maximum**	**Average***
Ethylene (74-85-1)	58	58	0.21	1.52	0.61
Isobutane (75-28-5)	58	58	0.44	13.72	4.53
Isobutene/1-Butene (115-11-7 / 106-98-9)	58	47	ND	2.33	0.59
Isopentane (78-78-4)	58	53	ND	11.04	3.73
Isoprene (78-79-5)	58	30	ND	0.35	0.06
Isopropylbenzene (98-82-8)	58	11	ND	0.02	0.02
m-Diethylbenzene (141-93-5)	58	16	ND	0.07	0.01
Methylcyclohexane (108-87-2)	58	58	0.08	2.44	0.98
Methylcyclopentane (96-37-7)	58	58	0.08	1.33	0.53
m-Ethyltoluene (620-14-4)	58	58	0.01	0.10	0.03
m-Xylene/p-Xylene (108-38-3 / 106-42-3)	58	58	0.03	0.67	0.21
n-Butane (106-97-8)	58	58	0.57	14.55	5.05
n-Decane (124-18-5)	58	58	0.02	0.20	0.07
n-Dodecane (112-40-3)	58	57	ND	0.29	0.07
n-Heptane (142-82-5)	58	58	0.04	1.15	0.44
n-Hexane (110-54-3)	58	58	0.10	6.88	1.12
n-Nonane (111-84-2)	58	58	0.01	0.28	0.08
n-Octane (111-65-9)	58	58	0.03	0.71	0.23
n-Pentane (109-66-0)	58	58	0.24	11.88	2.41
n-Propylbenzene (103-65-1)	58	45	ND	0.03	0.01
n-Tridecane (629-50-5)	58	19	ND	0.06	0.02
n-Undecane (1120-21-4)	58	58	0.01	0.29	0.09
o-Ethyltoluene (611-14-3)	58	35	ND	0.11	0.02
o-Xylene (95-47-6)	58	58	0.01	0.12	0.05
p-Diethylbenzene (105-05-5)	58	7	ND	0.13	0.01
p-Ethyltoluene (622-96-8)	58	51	ND	0.06	0.02
Propane (74-98-6)	58	58	1.96	54.67	17.14
Propylene (115-07-1)	58	58	0.08	0.44	0.16
Styrene (100-42-5)	58	9	ND	0.10	0.02
Toluene (108-88-3)	58	58	0.08	1.30	0.52
trans-2-Butene (624-64-6)	58	40	ND	0.11	0.04
trans-2-Pentene (646-04-8)	58	30	ND	0.06	0.02

*Samples reported as non-detects (ND) were included in averages as 1/2 minimum detection limits.

Garfield County SNMOC Monitoring
Bell-Melton (BRCO)
1/31/2008-12/26/2008 (every sixth day)

	Sample Count		Concentration (ppbV)		
Detected Compound (CAS Number)	**# Samples**	**# Detects**	**Minimum**	**Maximum**	**Average***
1,2,3-Trimethylbenzene (526-73-8)	58	22	ND	0.17	0.02
1,2,4-Trimethylbenzene (95-63-6)	58	58	0.01	0.63	0.06
1,3,5-Trimethylbenzene (108-67-8)	58	49	ND	0.17	0.03
1,3-Butadiene (106-99-0)	58	2	ND	0.02	0.02
1-Dodecene (112-41-4)	58	15	ND	0.14	0.02
1-Heptene (592-76-7)	58	56	ND	0.62	0.16
1-Hexene (592-41-6)	58	37	ND	0.06	0.04
1-Nonene (124-11-8)	58	32	ND	0.08	0.02
1-Octene (111-66-0)	58	11	ND	0.30	0.03
1-Pentene (109-67-1)	58	56	ND	0.11	0.03
1-Tridecene (2437-56-1)	58	2	ND	0.02	0.02
1-Undecene (821-95-4)	58	6	ND	0.03	0.01
2,2,3-Trimethylpentane (564-02-3)	58	28	ND	0.35	0.03
2,2,4-Trimethylpentane (540-84-1)	58	20	ND	0.46	0.04
2,2-Dimethylbutane (75-83-2)	58	58	0.03	0.66	0.19
2,3,4-Trimethylpentane (565-75-3)	58	33	ND	0.38	0.02
2,3-Dimethylbutane (79-29-8)	58	58	0.06	1.40	0.37
2,3-Dimethylpentane (565-59-3)	58	58	0.03	0.45	0.12
2,4-Dimethylpentane (108-08-7)	58	58	0.02	0.27	0.09
2-Methyl-1-butene (563-46-2)	58	27	ND	0.86	0.10
2-Methyl-1-pentene (763-29-1)	58	2	ND	0.04	0.04
2-Methyl-2-butene (513-35-9)	58	22	ND	0.15	0.03
2-Methylheptane (592-27-8)	58	58	0.02	0.63	0.15
2-Methylhexane (591-76-4)	58	58	0.09	1.18	0.34
2-Methylpentane (107-83-5)	58	58	0.29	5.83	1.66
3-Methyl-1-butene (563-45-1)	58	1	ND	0.07	0.02
3-Methylheptane (589-81-1)	58	58	0.02	0.76	0.10
3-Methylhexane (589-34-4)	58	58	0.05	1.07	0.32
3-Methylpentane (96-14-0)	58	58	0.13	3.00	0.86
4-Methyl-1-pentene (691-37-2)	58	12	ND	1.36	0.06
Acetylene (74-86-2)	58	58	0.12	1.70	0.49
a-Pinene (80-56-8)	58	46	ND	0.60	0.04
Benzene (71-43-2)	58	58	0.06	4.27	0.41
b-Pinene (127-91-3)	58	2	ND	0.26	0.01
cis-2-Butene (590-18-1)	58	23	ND	0.07	0.02
cis-2-Hexene (7688-21-3)	58	12	ND	0.20	0.04
cis-2-Pentene (627-20-3)	58	8	ND	0.05	0.02
Cyclohexane (110-82-7)	58	58	0.14	30.50	1.46
Cyclopentane (287-92-3)	58	58	0.06	1.02	0.28
Cyclopentene (142-29-0)	58	44	ND	0.24	0.05
Ethane (74-84-0)	58	58	8.75	334.50	69.05
Ethylbenzene (100-41-4)	58	56	ND	1.00	0.06

*Samples reported as non-detects (ND) were included in averages as 1/2 minimum detection limits.

Garfield County SNMOC Monitoring
Bell-Melton (BRCO)
1/31/2008-12/26/2008 (every sixth day)

	Sample Count		Concentration (ppbV)		
Detected Compound (CAS Number)	**# Samples**	**# Detects**	**Minimum**	**Maximum**	**Average***
Ethylene (74-85-1)	58	58	0.20	1.32	0.57
Isobutane (75-28-5)	58	58	1.23	49.75	11.31
Isobutene/1-Butene (115-11-7 / 106-98-9)	58	46	ND	2.06	0.62
Isopentane (78-78-4)	58	54	ND	41.80	7.71
Isoprene (78-79-5)	58	31	ND	1.20	0.10
Isopropylbenzene (98-82-8)	58	13	ND	0.06	0.02
m-Diethylbenzene (141-93-5)	58	17	ND	0.10	0.01
Methylcyclohexane (108-87-2)	58	58	0.21	5.47	1.42
Methylcyclopentane (96-37-7)	58	58	0.14	2.58	0.81
m-Ethyltoluene (620-14-4)	58	57	ND	0.33	0.04
m-Xylene/p-Xylene (108-38-3 / 106-42-3)	58	58	0.04	2.28	0.31
n-Butane (106-97-8)	58	58	1.55	57.50	12.63
n-Decane (124-18-5)	58	58	0.02	12.00	0.29
n-Dodecane (112-40-3)	58	58	0.01	10.25	0.25
n-Heptane (142-82-5)	58	58	0.09	2.33	0.66
n-Hexane (110-54-3)	58	58	0.29	6.27	1.79
n-Nonane (111-84-2)	58	58	0.02	0.48	0.13
n-Octane (111-65-9)	58	58	0.04	1.21	0.33
n-Pentane (109-66-0)	58	58	0.94	21.00	5.08
n-Propylbenzene (103-65-1)	58	47	ND	0.14	0.01
n-Tridecane (629-50-5)	58	19	ND	0.51	0.03
n-Undecane (1120-21-4)	58	58	0.03	39.82	0.78
o-Ethyltoluene (611-14-3)	58	41	ND	0.24	0.03
o-Xylene (95-47-6)	58	58	0.01	0.83	0.07
p-Diethylbenzene (105-05-5)	58	10	ND	0.08	0.01
p-Ethyltoluene (622-96-8)	58	56	ND	0.18	0.02
Propane (74-98-6)	58	58	4.47	175.00	36.99
Propylene (115-07-1)	58	58	0.07	0.35	0.15
Propyne (74-99-7)	58	1	ND	0.21	0.03
Styrene (100-42-5)	58	3	ND	0.81	0.03
Toluene (108-88-3)	58	58	0.10	21.00	0.95
trans-2-Butene (624-64-6)	58	41	ND	1.46	0.05
trans-2-Pentene (646-04-8)	58	28	ND	0.11	0.02

*Samples reported as non-detects (ND) were included in averages as 1/2 minimum detection limits.

APPENDIX C

Garfield County

Carbonyl Concentrations
2008

Garfield County Carbonyl Monitoring
Parachute (PACO)
2/6/2008-12/26/2008 (every twelfth day)

	Sample Count		Concentration (ppbV)		
Detected Compound (CAS Number)	**# Samples**	**# Detects**	**Minimum**	**Maximum**	**Average***
2,5-Dimethylbenzaldehyde (5779-94-2)	28	0	ND	ND	0.00
Acetaldehyde (75-07-0)	28	28	0.22	1.02	0.61
Acetone (67-64-1)	28	28	0.61	2.49	1.45
Benzaldehyde (100-52-7)	28	28	0.01	0.06	0.02
Butyraldehyde (123-72-8)	28	26	ND	0.24	0.04
Crotonaldehyde (123-73-9)	28	28	0.01	0.08	0.03
Formaldehyde (50-00-0)	28	28	0.64	2.65	1.40
Hexaldehyde (66-25-1)	28	24	ND	0.05	0.02
Isovaleraldehyde (590-86-3)	28	3	ND	0.04	0.00
Propionaldehyde (123-38-6)	28	26	ND	0.12	0.05
Tolualdehydes (NA)	28	27	ND	0.05	0.02
Valeraldehyde (110-62-3)	28	20	ND	0.03	0.01

*Samples reported as non-detects (ND) were included in averages as 1/2 minimum detection limits.

Garfield County Carbonyl Monitoring
Rifle (RICO)
2/6/2008-12/26/2008 (every twelfth day)

	Sample Count		Concentration (ppbV)		
Detected Compound (CAS Number)	**# Samples**	**# Detects**	**Minimum**	**Maximum**	**Average***
2,5-Dimethylbenzaldehyde (5779-94-2)	29	0	ND	ND	0.00
Acetaldehyde (75-07-0)	29	29	0.33	1.61	0.88
Acetone (67-64-1)	29	29	0.51	2.84	1.52
Benzaldehyde (100-52-7)	29	29	0.01	0.07	0.03
Butyraldehyde (123-72-8)	29	29	0.01	0.12	0.05
Crotonaldehyde (123-73-9)	29	29	0.01	0.15	0.05
Formaldehyde (50-00-0)	29	29	0.76	3.92	1.57
Hexaldehyde (66-25-1)	29	29	0.01	0.08	0.03
Isovaleraldehyde (590-86-3)	29	6	ND	0.04	0.01
Propionaldehyde (123-38-6)	29	27	ND	0.16	0.07
Tolualdehydes (NA)	29	29	0.02	0.05	0.03
Valeraldehyde (110-62-3)	29	24	ND	0.06	0.02

*Samples reported as non-detects (ND) were included in averages as 1/2 minimum detection limits.

Garfield County Carbonyl Monitoring
Brock (MOCO)
2/12/2008-12/14/2008 (every twelfth day)

	Sample Count		Concentration (ppbV)		
Detected Compound (CAS Number)	**# Samples**	**# Detects**	**Minimum**	**Maximum**	**Average***
2,5-Dimethylbenzaldehyde (5779-94-2)	27	0	ND	ND	0.00
Acetaldehyde (75-07-0)	27	27	0.14	0.88	0.44
Acetone (67-64-1)	27	27	0.32	2.68	1.22
Benzaldehyde (100-52-7)	27	25	ND	0.05	0.02
Butyraldehyde (123-72-8)	27	25	ND	0.06	0.02
Crotonaldehyde (123-73-9)	27	27	0.01	0.18	0.05
Formaldehyde (50-00-0)	27	27	0.34	1.71	0.86
Hexaldehyde (66-25-1)	27	22	ND	0.04	0.01
Isovaleraldehyde (590-86-3)	27	1	ND	0.02	0.00
Propionaldehyde (123-38-6)	27	27	0.01	0.08	0.03
Tolualdehydes (NA)	27	27	0.00	0.05	0.02
Valeraldehyde (110-62-3)	27	15	ND	0.02	0.01

*Samples reported as non-detects (ND) were included in averages as 1/2 minimum detection limits.

Garfield County Carbonyl Monitoring
Bell-Melton (BRCO)
2/6/2008-12/26/2008 (every twelfth day)

	Sample Count		Concentration (ppbV)		
Detected Compound (CAS Number)	**# Samples**	**# Detects**	**Minimum**	**Maximum**	**Average***
2,5-Dimethylbenzaldehyde (5779-94-2)	31	0	ND	ND	0.00
Acetaldehyde (75-07-0)	31	31	0.16	1.09	0.46
Acetone (67-64-1)	31	31	0.32	2.27	1.17
Benzaldehyde (100-52-7)	31	30	ND	0.04	0.02
Butyraldehyde (123-72-8)	31	29	ND	0.07	0.03
Crotonaldehyde (123-73-9)	31	29	ND	0.16	0.04
Formaldehyde (50-00-0)	31	31	0.32	1.82	0.82
Hexaldehyde (66-25-1)	31	23	ND	0.02	0.01
Isovaleraldehyde (590-86-3)	31	3	ND	0.03	0.00
Propionaldehyde (123-38-6)	31	30	ND	0.09	0.03
Tolualdehydes (NA)	31	29	ND	0.05	0.02
Valeraldehyde (110-62-3)	31	15	ND	0.02	0.01

*Samples reported as non-detects (ND) were included in averages as 1/2 minimum detection limits.

APPENDIX D

EPA UATMP/NATTS National Monitoring Program

Site List
2008

2008 Site List
EPA UATMP/NATTS National Monitoring Network

EPA Code	AQS ID	City/Site, State	Lat	Long	Method		
					VOC	SNMOC	Carbonyls
ANAK	02-020-0018	Anchorage, AK	61.21	-149.82			X
SPAZ	04-013-4003	Phoenix, AZ	33.40	-112.08			X
PXSS	04-013-9997	Phoenix, AZ	33.50	-112.10	X		X
MOCO	08-045-0000	Brock, CO	39.49	-107.77	X	X	
PACO	08-045-0005	Parachute, CO	39.45	-108.05	X	X	
RICO	08-045-0007	Rifle, CO	39.53	-107.78	X	X	
BRCO	08-045-0009	Bell-Melton, CO	39.49	-107.66	X	X	
GPCO	08-077-0018	Grand Junction, CO	39.06	-108.56	X		X
FLFL	12-011-1002	Davie, FL	26.08	-80.24			X
CCFL	12-011-5005	Coconut Creek, FL	26.30	-80.18			X
GAFL	12-057-1065	Tampa, FL	27.89	-82.54	X		
SYFL	12-057-3002	Plant City, FL	27.97	-82.23	X		
ORFL	12-095-2002	Winter Park, FL	28.60	-81.36	X		
AZFL	12-103-0018	Saint Petersburg, FL	27.79	-82.74	X		
SKFL	12-103-0026	Pinellas Park, FL	27.85	-82.71	X		
SPIL	17-031-3103	Schiller Park, IL	41.97	-87.88	X		X
NBIL	17-031-4201	Northbrook, IL	42.14	-87.80	X	X	X
INDEM	18-089-0022	Gary, IN	41.61	-87.30	X		
ININ	18-097-0057	Indianapolis, IN	39.75	-86.19	X		
WPIN	18-097-0078	Indianapolis, IN	39.81	-86.11	X		
IDIN	18-097-0085	Indianapolis, IN	39.74	-86.23	X		
DEMI	26-163-0033	Dearborn, MI	42.31	-83.15	X		X
GPMS	28-047-0008	Gulfport, MS	30.39	-89.05	X	X	X
TUMS	28-081-0005	Tupelo, MS	34.26	-88.77	X		X
S4MO	29-510-0085	St. Louis, MO	38.66	-90.20	X		X
CANJ	34-007-0003	Camden, NJ	39.92	-75.10	X		X
NBNJ	34-023-0006	North Brunswick, NJ	40.47	-74.42	X		X
CHNJ	34-027-3001	Chester, NJ	40.79	-74.68	X		X
ELNJ	34-039-0004	Elizabeth, NJ	40.64	-74.21	X		X
COOH	39-049-0034	Columbus, OH	40.00	-82.99	X		
PROK	40-097-0187	Pryor Creek, OK	36.29	-95.30	X		X
TSOK	40-143-0172	Tulsa, OK	36.16	-95.99	X		X
TUOK	40-143-0191	Tulsa, OK	36.14	-95.98	X		X
TOOK	40-143-0235	Tulsa, OK	36.13	-96.00	X		X
CUSD	46-033-0003	Custer, SD	43.77	-103.58	X	X	X
SSSD	46-099-0008	Sioux Falls, SD	43.55	-96.70	X	X	X
LDTN	47-105-0108	Loudon, TN	35.74	-84.32	X		X
MSTN	47-105-0109	Loudon, TN	35.72	-84.34	X		X
METN	47-157-0010	Memphis, TN	35.10	-90.07	X		X
BTUT	49-011-0004	Bountiful, UT	40.90	-111.88	X	X	X
CEWA	53-033-0057	Seattle, WA	47.56	-122.34	X		X
SEWA	53-033-0080	Seattle, WA	47.57	-122.31	X		X
ESWA	53-053-0029	Tacoma, WA	47.19	-122.45	X		X
EQWA	53-053-0031	Tacoma, WA	47.27	-122.39	X		X
EYWA	53-053-0034	Tacoma, WA	47.23	-122.41	X		X