MONITORING AND QUALITY ASSURANCE PLAN

for the

UPPER GREEN RIVER WINTER OZONE STUDY - 2009

Prepared for

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January 15, 2009

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SECTION 1

INTRODUCTION AND PROJECT OVERVIEW

This monitoring and quality assurance plan provides the basis for the collection of air quality and meteorological data for the Upper Green River Winter Ozone Study (UGWOS), sponsored by the Wyoming Department of Environmental Quality (WDEQ). While research in nature, the monitoring methods and objectives described in this plan are consistent whenever possible with EPA quality assurance guidance for the collection of air quality and meteorological data (US EPA 2008a and 2008b) and the most recent guidance for the collection of meteorological data for regulatory modeling applications (US EPA, 2000).

Recent high ozone events observed in this area have raised concerns regarding potential adverse health and ecological effects associated with monitored concentrations greater than the U.S. Environmental Protection Agency's ozone standard (set at an 8-hour average concentration of 0.075 ppm). Ozone formation in the Upper Green River Basin is unusual in that the highest concentrations have been recorded during the late winter and early spring (February to April) when sun angles are relatively low and temperatures are generally below freezing. This is in stark contrast to ozone exceedances in other areas, which occur during the warm summer months when abundant solar radiation and high temperatures act to increase precursor emissions and enhance the atmospheric reactions that result in ozone formation near the earth's surface (i.e., within the planetary boundary layer). Due to the pressing need to manage ozone air quality in the Upper Green River Basin and the limited amount of information currently available about the nature and causes of these unusual events, the WDEQ funded a comprehensive field study during the late winter – early spring season of 2007 and 2008. While meteorological conditions during the 2007 study period resulted in only limited monitoring, more favorable meteorological conditions during 2008 resulted in several days of high ozone concentrations, including a large number of days when the Federal ozone standard was exceeded. Additional measurements have been planned for the winter of 2009. This QA plan addresses the 2009 monitoring effort.

Data from these studies will be used to refine a conceptual model developed during the prior years studies of ozone formation. The conceptual model will be used along with the field data to develop accurate meteorological and air quality numerical simulations of the ozone events. Both the conceptual and numerical models will in turn be used to develop effective air quality management strategies needed to adequately protect public health and the environment in accordance with applicable State and Federal laws.

SECTION 2

SAMPLING PROGRAM DESCRIPTION

There are two levels or modes of field measurements in UGWOS: *continuous* and i*ntensive*. Continuous measurements will be ongoing from the start of the field study January 15, 2009 and continue until the scheduled end date, anticipated March 30, 2009. More extensive measurements will be conducted when the meteorological conditions are conducive to producing high ozone levels. These periods are hereafter referred to as Intensive Operational Periods (IOPs). IOPs will be initiated on a forecast basis and, as such, the field crew is committed to the project for its duration. Each IOP can last up to five days, and three such IOPs will be conducted over the study period. In contrast to the previous 2007 and 2008 studies, where IOP measurements measuring comprised the main core of the study, most of the 2009 study measurements will be continuous in nature, though additional efforts will occur during the IOPs.

2.1 Operational Forecasts and Readiness Protocol

The current conceptual model of the meteorological conditions conducive to the formation of high ozone levels in the Pinedale-Jonah fields during the winter and early spring is characterized by clear skies, light winds, extensive snow cover and a stable atmosphere. These conditions occur during periods when the synoptic weather is dominated by high pressure over the western Rockies, Intermountain area and the northern Great Basin. The primary broad scale characteristics dominating the Green River basin during the high probability events are weak pressure gradients within the context of a subsidence-dominated air mass.

In an effort to formulate the conceptual model, the synoptic scale weather patterns prior to occurrences of escalated ozone values in the study area during the winters of 2005 and 2006 were examined. Practical experience from the 2007 and 2008 studies has provided further understanding of conditions leading to higher ozone concentrations. Although many different nuances of the general pattern were encountered, the basic characteristics of the conceptual model did emerge. Figures 2-1 through 2-4 present composite views of the 700 mb and 500 mb configurations for all of the days with surface 8-hour averaged ozone concentrations greater than 60 ppb. Figure 2-1 shows the ridging pattern of the 500 mb height contours; Figure 2-2 presents the wind speed isotachs at 500 mb; Figure 2-3 shows the ridging pattern of the 700 mb height contours; and Figure 2-4 demonstrates that there was warmer air aloft just above the surface, indicating air mass subsidence.

National Weather Service numerical synoptic-scale models such as the North American Mesoscale model (NAM) and the Global Forecast System model (GFS), coupled with regional NWS Forecast Discussion guidance, will provide the experienced MSI and T&B Systems weather forecasters with the basis for daily long and medium range operation forecasts. An additional factor that appears to prove critical in operational forecasting is the presence of sufficient snow cover to provide the UV radiation component needed for ozone chemistry. Local observations will provide this information on a day-to-day basis.

We will also be evaluating the usefulness of the Rapid Update Cycle model (RUC), the Weather Research and Forecasting model (WRF) and the RAMS model from CSU in our short-term operational forecasting mode and possibly incorporate them into our daily forecasts.

An operational forecast will be issued by 10 MST each day that will include both a short-term and long-term forecast. All project participants will be required to provide any changes in their operational readiness daily to the Field Project Manager and that information will be included as well. This forecast will be posted on a project web site accessible to all participants. If conditions are developing that are conducive to the development of high ozone, an alert will be issued.

A “GO” alert will be issued at the 10 MST forecast at least 48 hrs before an IOP is to begin. Field crews will begin making preparations to debark to the field the following morning. A final GO or NO GO will be issued by 17 MST that afternoon. If the forecast remains a GO, the crews will deploy as scheduled.

We do not anticipate having to deploy the field crew when inclement weather hampers travel to and from the project area. It should be noted that the major characteristics of the meteorology that can lead to high ozone levels in the Pinedale-Jonah area are a stable atmosphere, clear skies, and light low-level winds. These conditions take some time (at least 48 hours after a storm frontal passage) to develop. Moreover, we expect operational conditions to occur during periods when the synoptic weather pattern in the western states is relatively stationary as opposed to short-waves of high and low pressure patterns, so it will not be necessary to start operations on the heels of a storm system.

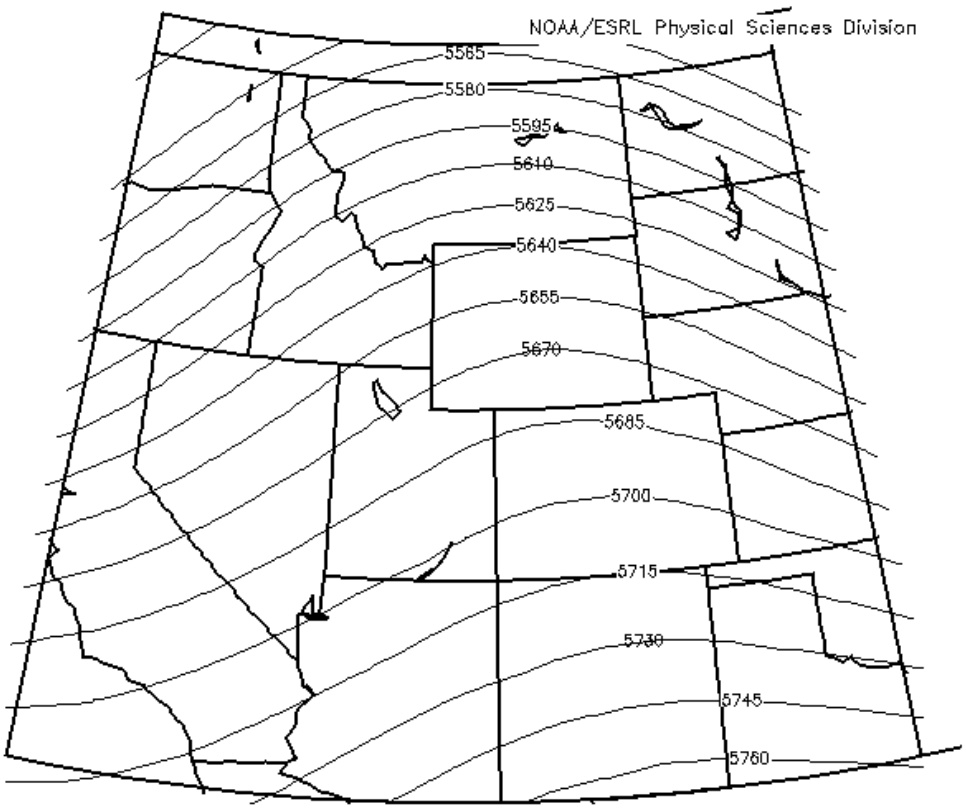

Figure 2-1 Composite 500 mb Heights During High Ozone Periods

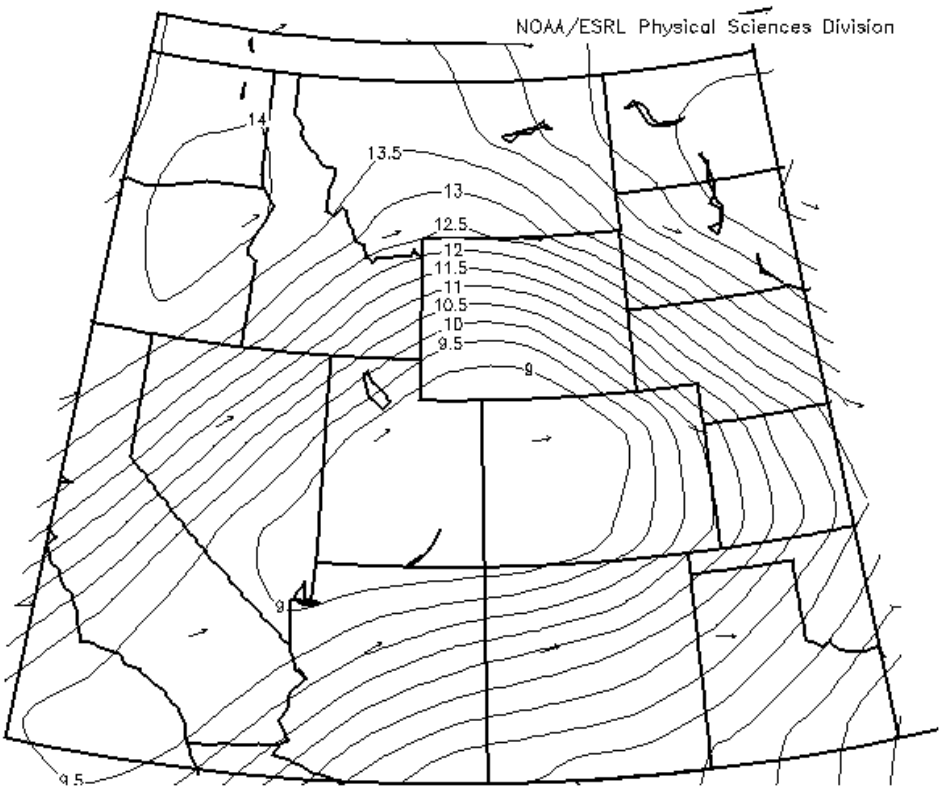

Figure 2-2 Composite 500 mb Winds During High Ozone Periods

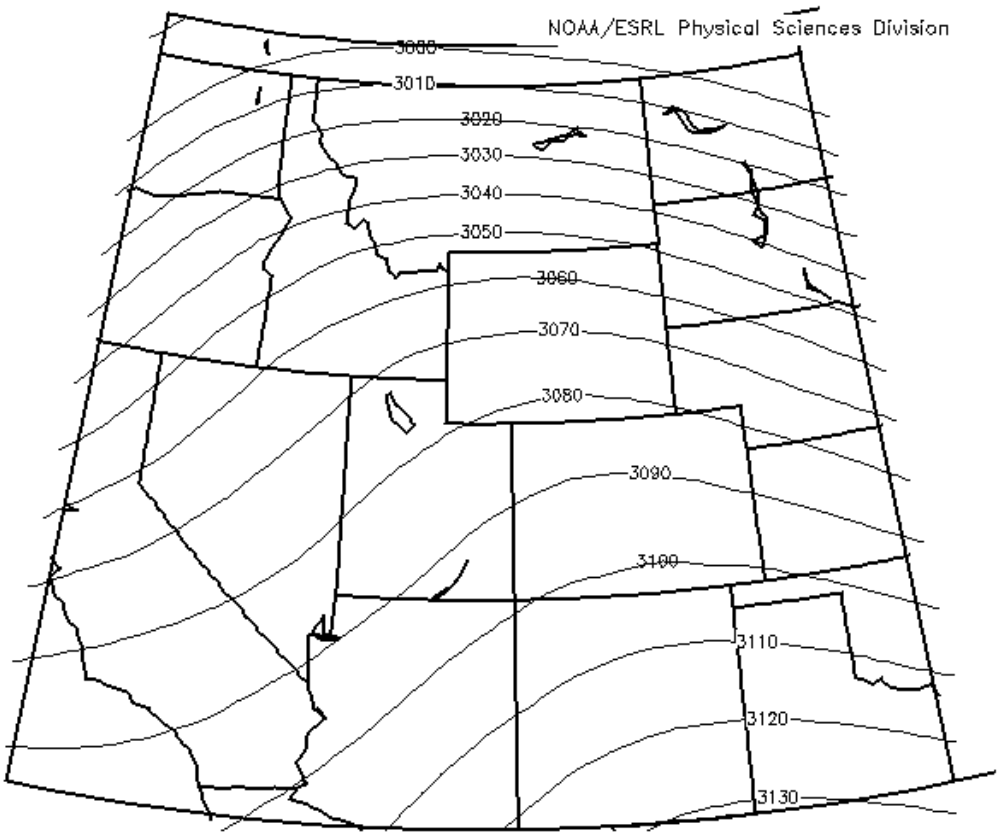

Figure 2-3 Composite 700 mb Heights During High Ozone Periods

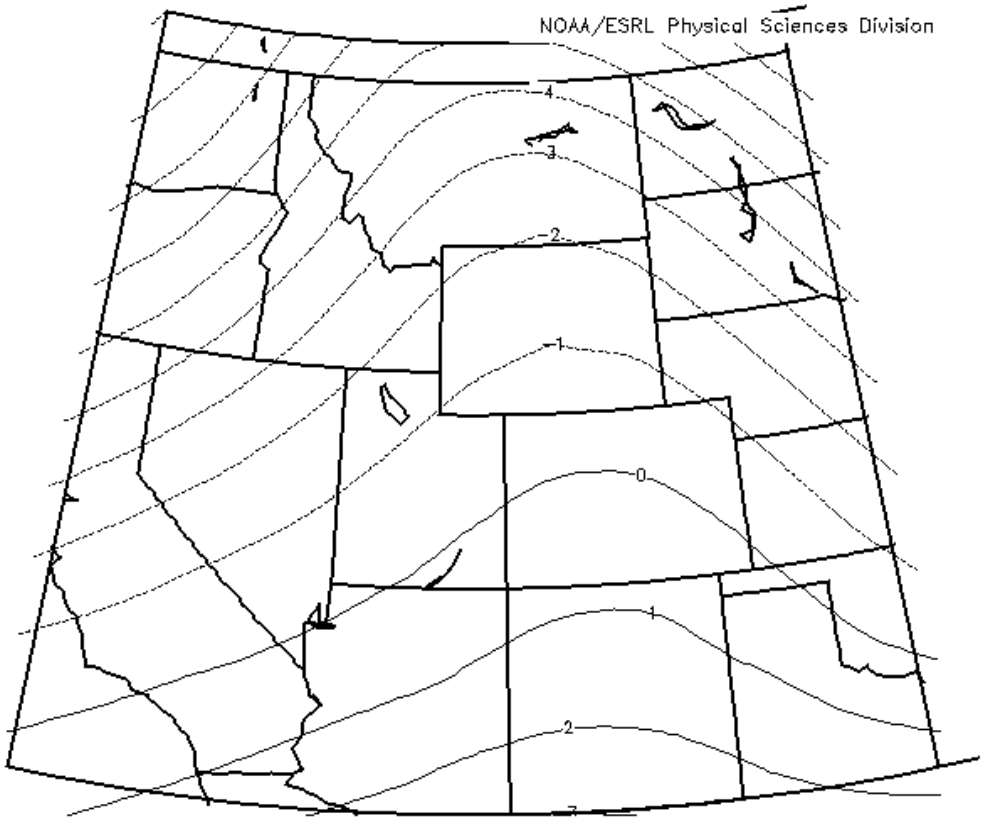

Figure 2-4 Composite 700 mb Temperature During High Ozone Periods

2.2 Continuous Measurements

Project-specific measurements to be continuously obtained over the complete field program period include surface and winds aloft, supplemental surface ozone and meteorology, and nitrogen species.

2.2.1 Mesonet Measurements

Surface ozone, wind, and temperature measurements will be taken from an 8-site mesonetwork (mesonet) and from Wenz Field (Pinedale airport). All sites will be equipped with cellular telemetry, allowing remote polling and real-time review of data.

2.2.2 SODAR Upper Level Winds

At a site on the south mesa, both surface and aloft winds will be measured continuously employing a MiniSodar (sodar) and surface meteorological station. Ozone will also be measured at the sodar site. The site is equipped with a battery bank, solar panels and a backup generator, providing continuous measurements without the need of AC power. However, the chosen site for operations does include available AC power. Remote communications is made possible with a cellular modem. All data will be posted near real-time on a web page as well as archived data posted automatically on a FTP server. These sodar data can be reviewed remotely, as necessary.

The WDEQ will service the sodar as necessary. T&B Systems will review the data on a daily basis.

2.2.3 Nitrogen Species, Additional Gaseous Measurements

The existing WDEQ Boulder site will be expanded to included measurements of NO/NO_y, true NO_2, and PAN.

CE-CERT will provide equipment and setup for the measurements. Routine checks of the equipment will for the most part be conducted remotely by CE-CERT, though MSI will be conducting regular visits to the Boulder site.

MSI will operate trace level carbon monoxide and sulfur dioxide analyzers as well as a chemiluminescent ozone analyzer at the Boulder site continuously during the field program. Calibration of these monitors will be verified with automated daily zero/span/precision checks.

NO/NO_x measurements will also be added at the sodar site beginning early February 2009.

2.3 Intensive Measurements

During periods when high ozone levels are forecast, additional intensive measurements will be initiated. The key components of the intensive monitoring periods (IOPs) are:

- VOC and carbonyl measurements
- Ozone/rawinsonde operations

2.3.1 Mesonet Ozone Measurements (including the MiniSodar site)

The mesonet ozone analyzers will operate continuously over the course of the study and routine performance checks of the analyzers will be conducted approximately once per week and/or before and after the IOPs. An MSI air quality technician will be assigned to the project area for the duration of the 2009 measurement period. An additional MSI technician will deploy to the field from the office in Salt Lake City immediately following issuance of the final GO. The ozone monitors will be span-checked prior to the first day of the IOP, if at all

possible. Their operation on-site will be checked using the 2-B ozone generator and zero-scrubber, and any zero and span deviations noted.

During the IOPs the sites will be visited every two to three days to and ensure appropriate operations. At these visits, batteries will be checked and the solar panels cleaned, as necessary. At the completion of each IOP, the ozone analyzers will be span and zero checked. All on-site operations will be conducted, documented and logged by the MSI technicians.

2.3.2 VOC and Carbonyl Measurements

VOC and carbonyl measurements will be conducted at two of the four existing WDEQ monitoring sites within the study area – Jonah and Boulder. The VOC and carbonyl measurements will be collocated and sampled simultaneously as four-hour integrated samples. On intensive study period days, samples will be taken from 0600-1000 and from1300-1700 hours.

VOC measurements will be made using 6-liter SUMMA canisters connected to combination canister/carbonyl samplers. Ambient air will be pumped to the canisters for a four-hour period. Carbonyl measurements will be made by pulling ambient air at approximately 2-4 LPM through DNPH cartridges with an ozone scrubber inserted upstream of the cartridge. The samplers are outfitted with data loggers that enable automatic start/stop operation. Samplers will be loaded with sampling media on the evening preceding a sampling event. Ambient air feeding the samplers will be obtained from separate Teflon sample tubes, one for VOC canisters and one for carbonyl cartridges, with the inlets positioned approximately one meter above the top of the monitoring shelter.

Research team technicians will be responsible for loading canister/cartridge media into the samplers, confirming sample run times, removing samples and filling out the affiliated documentation. Exposed sample media will be collected at the end of each intensive study day and brought to the project field office at the Pinedale Airport for packaging and shipment to EAS laboratory for analysis. Field sample sheets will accompany samples and the required chain-of-custody documentation will accompany each shipment.

Samplers will be cleaned prior to the start of the measurement program and tested for contamination. For the 2009 measurement program, 66 sample pairs are funded including 2 duplicates, 4 field blanks and sampler contamination checks.

MSI will conduct the VOC/Carbonyl sampling.

2.3.3 NO_2 Photolysis Rate

CE-CERT will measure the NO_2 photolysis rate using an actinometer. Measurements will be conducted at the Boulder site, in conjunction with the other continuous study-specific nitrogen species measurements. However, the method involves using large amounts of NO gas from certified gas cylinders.

Consequently, measurement of the NO_2 photolysis rate will be limited to IOP days.

2.3.4 Ozone/Rawinsondes

Free ascending balloon-borne measurements of ozone, temperature, relative humidity, and winds will be made from Wenz Field (Pinedale Airport) during IOPs. Four soundings are scheduled: two will be standard high resolution rawinsondes measuring temperature, humidity and winds every one second, and two will measure ozone as well. Scheduled rawinsonde sounding times are around 0700 MST and 1000 MST. The early morning sounding will document the vertical structure of the atmosphere during the most stable period over the diurnal cycle when the surface version is strongest. This sounding will closely correspond to the 12 GMT world-wide sounding schedule and data set. The mid-morning sounding will document evolution of the inversion and the boundary layer. Ozonesondes will then be released around 1300 MST and 1600 MST. The midday sounding will document the timing of the growth of the boundary layer, as well as the development of ozone. The late afternoon sounding will characterize conditions when the atmosphere is generally most unstable and the mixed layer has fully developed. Highest ozone concentrations have typically been observed during this late afternoon period. Soundings will extend to at least 500 mb or ~18,000 ft. Optimally, data will be gathered to 300 mb which is approximately 30,000 ft.

T&B Systems will be responsible for the ozone/rawinsondes.

2.4 Supplemental Monitoring and Data Collection

<u>UV Radiation</u>

Direct and reflected UV radiation sensors (radiometers) initially installed during the 2007 effort at the WDEQ Boulder site will be an important part of the UGWOS data set. The sensors will be checked and the data downloaded at the beginning and end of each IOP. Sensor checks will consist of a zero reading and comparison of the sensors output while orientated the same. The radiometer will be operational but unattended between IOPs.

<u>Archiving of NOAA Products</u>

Archiving of data that is not already archived on the web and readily available will occur on a daily basis. The items that will be archived for the period from January 15 through March 31, 2009 are listed below:

- MSI routinely archives 00Z and 12Z surface and upper air maps for 700 mb, 500 mb and 850 mb. (Also readily available on-line)
- MSI routinely archives data from all rawinsonde sites in the United States for both 00Z and 12Z time periods. (Also readily available on-line)
- MSI routinely archives Visual and IR, US east and west satellite images every 15 minutes. (Also readily available on-line)

In addition to the above, the following data are currently archived on the web and available for analysis:

- Snowpack - available at NOAA's National Operational Hydrologic Remote Sensing Center
- Total Column Ozone - A web site from NASA provides historical ozone global charts, and Dobson Unit measurements for any lat/long on any particular day.
- Local Camera Images - The current local camera images from Daniel, Jonah, Boulder and Pinedale can be viewed on line at the WDEQ or UGWOS web sites, and there is also a 2 week image archive on the WDEQ site which consists of an image at 9:00 12:00 and 15:00 MST each day. Archived images can also be requested from Air Resource Specialists, Inc. or InterMountain Labs.

SECTION 3

MONITORING SITE DESCRIPTIONS

Figure 3-1 presents a map of the UGWOS site locations. Tables 3-1 and 3-2 present coordinates and site selection rational (monitoring objectives), respectively, for each of the sites. Photographs of the sites can be found in Appendix A.

Also included in Figure 3-1 and Table 3-1 are the locations of additional ozone monitoring sites in the study region. While not part of UGWOS study, data from these sites are anticipated to play a substantial role during the analyses of the UGWOS data.

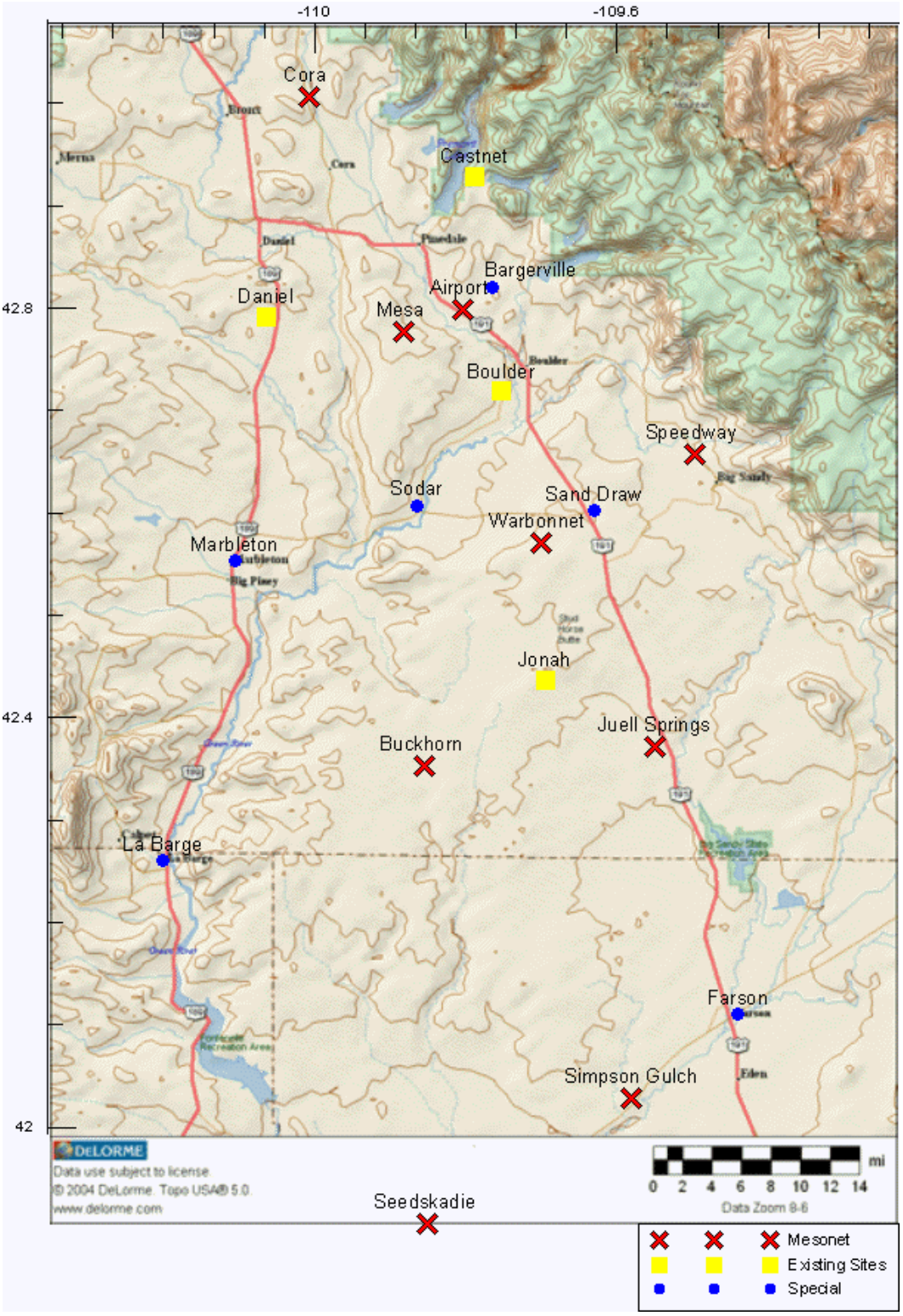

Figure 3-1. Map of UGWOS Site Locations

Table 3-1. Network Locations and Identifiers

		Latitude	Longitude	Elev.
MESONET SITES				
Site 1	Cora	43.0067	-110.0091	7558’
Site 2	Mesa	42.7775	-109.8826	7543’
Site 3	Warbonnet	42.5702	-109.7023	7425’
Site 4	Juell Springs	42.3716	-109.5504	6950’
Site 5	Simpson Gulch	42.0280	-109.5819	6691’
Site 6	Speedway Pit (Big Sandy)	42.6573	-109.4990	7206’
Site 7	Buckhorn	42.3524	-109.8542	7108’
Site 8	Seedskadie NWR	41.9050	-109.8499	6317’
Site 9	Airport (Weinz Field)	42.7982	-109.8049	7110’
WIND PROFILER SITE				
Sodar:	M&N Yard	42.6070	-109.8646	6910’
SURFACE VOC/CARBONYL SITES				
	Boulder	42.7190	-109.7540	7078’
	Jonah	42.4360	-109.6960	6848’
ADDITIONAL OZONE MONITORING SITES OF INTEREST				
	Daniel	42.7910	-110.0650	7084’
	Bargerville	42.8201	-109.7653	7345’
	Sand Draw	42.6020	-109.6299	7235’
	Marbleton	42.5526	-110.1051	6915’
	La Barge	42.26	-110.20	6600’
	Farson	42.11	-109.44	6595’
	Castnet	42.9284	-109.7880	7853’

Table 3-2. Major Objectives of Mesonet Sites

Site 1	Cora	Northern boundary site upwind from prevailing winds
Site 2	Mesa	Representative of northern Pinedale Anticline
Site 3	Warbonnet	Representative of middle and southern Pinedale Anticline
Site 4	Juell Springs	Representative of area SE of Jonah emissions
Site 5	Simpson Gulch	Southern boundary site
Site 6	Speedway Pit	Impact on Wind River Range foothills
Site 7	Buckhorn	Representative of area SW of Jonah emissions
Site 8	Seedskadie	Southeastern boundary site
Site 9	Airport	Surface measurements for ozonesonde
Site 10	Sodar	Drainage along New Fork River from Mesa emission sources

SECTION 4

MONITORING EQUIPMENT DESCRIPTION

The following section describes the monitoring equipment that will be used for UGWOS. Monitoring quality objectives (MQOs) are presented for each of the monitoring methods.

4.1 MESONET OZONE MONITORING

All equipment used at the mesonet ozone monitoring sites will be housed in a 70 to 100 quart insolated containers. A 110 amp-hour deep cycle 12-Volt battery will power all equipment. Each site will be equipped with solar panels, allowing continuous monitoring and an Airlink Raven digital cellular modem for remote telecommunications.

The following equipment will be at each of the mesonet sites:

<u>2B Model 202 Ozone Analyzer</u>

The 2B Ozone Monitor will be used for the mesonet Monitoring. This monitor has a low power consumption (12v DC, 0.33 amp, 4.0 Watt) relative to conventional instruments allowing operation with deep cycle batteries. Additionally, it does not require a temperature-controlled environment. The 2B Technologies Model 202 Ozone Monitor™ is designed to enable accurate and precise measurements of ozone ranging from low ppb (precision of ~1 ppbv) up to 100,000 ppb (0-100 ppm) based on the well established technique of absorption of light at 254 nm. "Absorption spectroscopy" is a chemical analysis technique made possible by the phenomenon that a given molecule absorbs light at selected wavelengths. The wavelengths absorbed are characteristic of each molecule's atomic features. The amount of light radiation absorbed by a substance depends on two factors: the number of molecules in the path of the light, and the characteristics of the molecule (e.g., absorption cross-section). Measurement of changes in the light intensity as it passes through the molecules, and the use of calibration and reference data, enable the determination of the number of molecules encountered.

Accuracy (performance checks)	±5%
Precision (performance checks)	±5%
Resolution	0.001 ppm
Lower Quantifiable Limit	0.002 ppm

RM Young Model 05305 Wind Monitor AQ

For surface monitoring of wind speed and wind direction at the mesonet sites, we will employ an RM Young 05305 Wind Monitor AQ wind speed and direction sensors. These sensors employ a propeller anemometer. The sensors will be mounted on 3-meter tripods (Figure 4-1), resulting in a measurement height of 3 meters. All sensors will be oriented to true north using either the GPS walk-off method or solar alignment method for orienting wind speed sensors.

Figure 4-1. Tripod mounting of wind sensors.

Monitoring quality objectives for the supplemental surface wind measurements are presented below.

Accuracy (instrument specifications)	
Horizontal Wind Speed	±(0.2 m/s + 5% of observed)
Horizontal Wind Direction	±5 degrees
Precision (performance checks)	
Horizontal Wind Speed	±0.1 m/s
Horizontal Wind Direction	±2 degrees
Output Resolution	
Horizontal Wind Speed	0.1 m/s
Horizontal Wind Direction	1.0 deg.
Starting Threshold	0.5 m/s

Campbell Scientific 109-L Temperature Probe

Ambient temperature will be monitored using a Campbell Scientific 109 temperature probe. The 109-L Temperature Probe is a thermistor designed for use specifically with the CR200-series data loggers and has a measurement temperature range of -50° to +70°C.

Accuracy (performance checks)	±0.5°C
Precision (performance checks)	±0.2°C
Resolution	0.01°C

Campbell Scientific CR206 Data Logger

All data will be stored using a Campbell Scientific CR206 data logger. Both 5-minute and 60-minute averages will be stored, though the 5-minute data will be used primarily for QC purposes. Based on the number of measurements an statistics being record, the CR206 can operate for a period of up to approximately two weeks before it is necessary to download data. The CR206 data logger is equipped with a 915 MHz radio, allowing remote accessing and downloading of data. Additionally, CDMA cellular modems will be used to retrieve the data via a real-time data connection.

Dasibi Model 1000 Series Ozone Analyzer

Though the site at the Pinedale airport (Weinz Field) is considered part of the mesonet, ozone at this will be measured with either Dasibi Model 1003 or Model 1008 UV photometric ozone analyzers (EPA equivalent numbers EQOA-0577-019 and EQOA-0383-056, respectively), due to the availability of AC power at this location. Sampling will be made through Teflon lines, which will be of sufficiently short length to meet EPA requirements for sample residence time. Interior temperature will also be monitored.

Accuracy (performance checks)	±5%
Precision (performance checks)	±5%
Resolution	0.001 ppm
Lower Quantifiable Limit	0.002 ppm

RM Young Model 05103 Wind Monitor

For surface monitoring of wind speed and wind direction at the Pinedale airport site, we will employ an RM Young 05103 Wind Monitor wind speed and direction sensors. MQOs for this sensor are similar to those for the model 05305 sensor presented above with the exception of the starting threshold, which is 1.0 m/s.

4.2 OZONE/RAWINSONDES

To profile ozone concentrations from the surface to the tropopause, we will use balloon-borne ozonesondes, with measurements placed at the Pinedale airport. The ozonesonde system has three primary components, described below:

Sippican W-9000

The Sippican W-9000 system consists of a SIPPICAN ZEEMET W-9000 GPS based navaid receiver/data system for measuring winds and the SIPPICAN Mark II Microsondes radiosonde packages.

The SIPPICAN ZEEMET W-9000 receiving station interfaces with a personal computer and printer. This is a state-of-the-art wind finding system employing GPS technology. The UHF receiver operates in the 400 MHZ range. SIPPICAN software enables the interface with the SIPPICAN W-9000 receiver and reduces the thermodynamic pressure, temperature and humidity (PTU) and navaid/wind data. During each flight, the technician is able to monitor both raw and reduced data in near real time. The software also includes graphics and plotting capabilities that allow the technician to review results during and at the end of each flight. Both raw and reduced data are stored on the hard disk in subdirectories identified by the flight name. All data files are copied to both primary and backup diskettes immediately after each flight.

SIPPICAN Mark IIa Microsondes

The SIPPICAN Mark IIa Microsondes are 10 x 19 x 15 cm and weigh 250 grams with a water-activated 18V battery. The radiosonde UHF transmitter sends its modulated signals in the 400 MHZ range. The Microsondes are calibrated at the factory in a computer-controlled environmental chamber. Calibration coefficients are stored in read-only-memory (ROM) within each sonde and are automatically transmitted to the receiver in 1.5 sec intervals. Temperature is measured using a bead thermistor and relative humidity using a carbon hygristor. The SIPPICAN W-9000 is an automatic wind finding system that is based on tracking the sonde using the GPS satellite network. The Microsonde incorporates a low-noise integrated circuit GPS receiver. Winds aloft are calculated from the change in balloon position (determined from navaid) with time. Height is obtained directly from GPS positioning and, unlike older systems, pressure is now a derived parameter, calculated from the hydrostatic equation, using measured height, temperature, and humidity.

Accuracy (instrument specifications)	
Horizontal Wind Speed	± 0.5 ms^{-1}
Horizontal Wind Direction	Unknown
Temperature	± 0.2° C
Relative Humidity	± 2.0%
Output Resolution	
Horizontal Wind Speed	0.1 m/s
Horizontal Wind Direction	1.0°
Temperature	0.1° C
Relative Humidity	1.0%

EN-SCI Corporation KZ-ECC Ozonesondes

EN-SCI Corporation KZ-ECC ozonesonde system will be used in conjunction with the SIPPICAN W-9000 Mark IIa Microsonde radiosonde package. Ozone is measured with an electrochemical concentration cell (ECC) ozonesonde coupled through an electronic interface to the Mark IIa radiosonde described above.

The ECC ozonesonde is of a simple design consisting of a rigid mainframe on which is mounted a motor-driven Teflon air sampling pump, a thermistor for measuring pump temperature, an ozone sensing ECC, and an electronics box containing interface circuitry which couple the ozone sensor to the radiosonde. The mainframe is mounted in a lightweight weatherproof polystyrene flight box that is taped and wired to the radiosonde during flight.

The ozone-sensing cell is made of two bright platinum electrodes immersed in potassium iodide (KI) solutions of different concentrations contained in separate cathode and anode chambers. The chambers are linked with an ion bridge that, in addition to providing an ion pathway, retards mixing of the cathode and anode electrolytes thereby preserving their concentrations. The electrolytes also contain potassium bromide (KBr) and a buffer whose concentrations in each half-cell are the same. The driving electromotive force for the cell, of approximately 0.13 V, is provided by the difference in potassium iodide concentrations in the two half cells. Sample air is forced through the ECC sensor by means of a non-reactive pump fabricated from TFE Teflon impregnated with glass fibers. The pump is designed to operate without ozone-destroying lubricants. Pumping efficiency for each pump varies from pump to pump and is also dependent on ambient air pressure. The sampling flow rate is calibrated at the factory and checked in the field before launch. The ECC ozone concentration calibration is also determined prior to launch.

When ozone in air enters the sensor, iodine is formed in the cathode half cell according to the relation

$$2KI + O_3 + H_2O \rightarrow 2KOH + I_2 + O_2. \qquad (1)$$

The cell converts the iodine to iodide according to

$$I_2 + 2e \rightarrow 2I^- \qquad (2)$$

during which time two electrons flow in the cell's external circuit. Measurement of the electron flow (i.e., the cell current), together with the rate at which ozone enters the cell per unit time, enables ozone concentrations in the sampled air to be derived from

$$p_3 = 4.307 \times 10^{-3}(i_m - i_b)T_p t \qquad (3)$$

where p_3 is the ozone partial pressure in nanobars, i_m is the measured sensor output current in microamperes, i_b is the sensor background current (i.e., the residual current emanating from the cell in the absence of ozone in the air) in microamperes, T_p is the pump temperature in Kelvin, and t is the time in seconds taken by the sonde gas sampling pump to force 100 ml of air through the sensor.

Sensitivity	2-3 ppb by volume ozone in air
Response Time	15 seconds for 67% of change; 60 seconds for 85% of change
Noise	less than 1% of full scale
Estimated Measurement Uncertainty	less than ± 10% of indicated value

As an integral part of the ozonesonde operations, a Dasibi EPA designated equivalent ozone analyzer and meteorological instrumentation will be installed at the ozonesonde launching site, within the hanger office building at the Pinedale Airport. The analyzer will provide ground-truth data. This equipment has been described previously.

4.3 VOC SAMPLING

VOC samples will be collected using SUMMA canisters connected to automated pumped canister samplers set up for 4-hour integrated samples. Carbonyl samples will be collected using DNPH-coated cartridges outfitted with ozone scrubbers and connected to constant flow pump systems over the same time period as the canisters. VOC samples will be analyzed using Method TO-14 with an expanded PAMS list of compounds (see Table 4-1). Carbonyl samples will be analyzed using Method TO-11 for the compounds listed in Table 4-2. Analyses will be performed by Environmental Analytical Services, Inc., Santa Barbara, CA.

Table 4-1. Target compound list for EPA Method TO-14 Toxics in Air (Expanded for PAMS).

Ethene	Cyclohexane	Total Petroleum Hydrocarbons:
Acetylene	2-Methylhexane	Total Non-Methane Hydrocarbons
Ethane	2,3-Dimethylpentane	Total Gas Non-Methane Organics
Propene	3-Methylhexane	Total Volatile Organic Compounds
Propane	2-Methyl-1hexene	TPH (gasoline)
i-Butane	Tert amyl methyl ether	TPH (diesel)
Methanol	2,2,4-Trimethylpentane	TPH (hexane)
1-Butene	n-Heptane	TPH (toluene)
1,3-Butadiene	Methylcyclohexane	TPH (methane)
n-Butane	2,5-Dimethylhexane	TPH (Jet A Fuel)
t-2-Butene	2,4-Dimethylhexane	TPH (Mineral Spirits)
c-2-Butene	2,3,4-Trimethylpentane	c6+ (hexane)
Ethanol	Toluene	Sample: Composition
3-Methyl-1-butene	2,3-Dimethylhexane	Total Identified
Acetone	2-Methylheptane	Paraffins
i-Pentane	4-Methylheptane	Isoparaffins
1-Pentene	3-Ethyl-3-methylpentane	Aromatics
Isopropanol	3-Methylheptane	Napthlenes
2-Methyl-1-butene	2-Methyl-1-heptene	Olefins
n-Pentane	n-Octane	Oxygenates
Isoprene	Ethylbenzene	Carbon Ranges:
t-2-Pentene	m,p-xylene	C2 (ethane)
c-2-Pentene	Styrene	C3 (propane)
Tert butyl alcohol	o-xylene	C4 (Butane)
2-Methyl-2-butene	1-Nonene	C5 (Pentane)
2,2-Dimethylbutane	n-Nonane	C6 (Hexane)
Cyclopentene	i-Propylbenzene	C7 (Heptane)
n-Propanol	n-propylbenzene	C8 (Octane)
Cyclopentane	a-Pinene	C9 (Nonane)
Methyl tert butyl ether	3-Ethyltoluene	C10 (Decane)
2,3-Dimethylbutane	4-Ethyltoluene	C11+ (Undecane)
2-Methylpentane	1,3,5-Trimethylbenzene	
3-Methylpentane	2-Ethyltoluene	
1-Hexene	b-Pinene	
n-Hexane	1,2,4-Trimethylbenzene	
Diisopropyl ether	n-Decane	
3-Methylcyclopentene	1,2,3-Trimethylbenzene	
Ethyl tert butyl ether	Indan	
Methylcyclopentane	d-Limonene	
2,4-Dimethylpentane	1,3-Diethylbenzene	
Benzene	1,4-Diethylbenzene	
	n-Butylbenzene	
	1,4-Dimethyl-2-ethylbenzene	
	1,3-Dimethyl-4-ethylbenzene	
	1,2-Dimethyl-4-ethylbenzene	
	Undecane	
	1,2,4,5-Tetramethylbenzene	
	1,2,3,5-Tetramethylbenzene	
	Napthalene	
	Dodecane	

Table 4-2. Target compound list for EPA Method TO-11 volatile organic compounds.

Compound
Formaldehyde
Acetaldehyde
Acrolein
Acetone
Propionaldehyde
Butyraldehyde
Methylethylketone
Benzaldehyde
Valeraldehyde
Cyclohexanone
Hexaldehyde

4.4 CONTINUOUS MEASUREMENTS

NO_x and NO_y

The basic principle for measuring NO_x and NO_y is chemiluminescent detection (CLD) of NO. Sample air is reacted with ozone in a low-pressure reaction chamber. NO in the sample combines with ozone to form NO_2 and produces light (chemiluminescence) that is detected by a photo multiplier tube.

Ambient sample is first drawn through a very short Teflon sample line and split into two parallel flow channels using a ½ inch PFA Teflon tee. Channel 1 passes through a Teflon filter and then directly to the detector, Channel 2 first passes through a catalytic converter before going through a Teflon filter to the detector. The catalytic converters reduce NO_2 and (in the case of NO_y) nitrate containing species in the sample to NO. Flow from each channel is alternately fed to the CLD to detect the NO. For NO_x the converter is located within the analyzer. For NO_y, the converter is operated outside of the analyzer, very close to the ambient sampling point, which allows for a very short flow path upstream of the converter and minimizes the loss of species such as HNO_3.

For the NO_y analyzer, in addition to alternating flows to the NO_y and NO channels to the reactor, the analyzer also alternates a flow of internal zero air, produced by pre-reacting the sample flow with a high concentration of ozone <u>before</u> reaching the CLD. The signal from this zero air stream is used to correct for analyzer drift, and allows the analyzer to achieve very low detection limits (0.05 ppb) compared with standard NO_x analyzers.

Accuracy (performance checks)	±10%
Precision (performance checks)	±15%
Noise	0.0005 ppm
Lower Quantifiable Limit	0.001 ppm
Converter efficiency	>96%

NO_2/PAN

NO_2 and PAN will be measured using a gas chromatographic method. A room temperature (25 ± 5°C, controlled to within ± 2°C) chromatographic column is operated on a carrier stream of zero air at a flow rate of about 40 ml/min. The column effluent passes through a Luminol detector. Ambient air is drawn through a sampling loop connected to a six-port GC injection valve. The ambient sample is injected at 1-minute intervals (i.e. the sample switched briefly into the carrier stream). PAN elutes from the column several seconds after NO_2. Excess Luminol in the detector reacts quantitatively with NO_2 and with PAN, generating light that is detected by a photo multiplier tube. The intensity of the light is proportional to the amount of NO_2 or PAN reactant present in the detector. The output of the PMT is amplified and fed to the NO_2/PAN GC computer data acquisition and analysis system, which stores and analyzes one complete chromatogram every minute. The NO_2 and PAN peaks in the chromatogram are processed to generate peak areas, a calibration factor is applied, and the resulting ambient NO_2 and PAN concentrations in ppb are stored on the NO_2/PAN GC computer along with the original chromatogram. The NO_2 and PAN concentrations are also sent to the monitoring station data logger, along with sample mode information.

The instrument includes an automatic calibration system that includes three modes of operation: ambient sample, zero air, and span gas. This system is set to provide 10 minutes of zero air, and 10 minutes of NO_2 span gas every two hours. These zero and span responses may be used to detect and compensate for calibration drift.

Accuracy (performance checks)	±10%
Precision (performance checks)	±15%
Noise	0.001 ppm
Lower Quantifiable Limit	0.002 ppm

NO_2 Photolysis Rate Measurements

An actinometer will be used to measure the NO_2 photolysis rate. A stream of nitrogen dioxide (O_2 free at approximately 1 ppm) in nitrogen is flowed through a quartz tube. The amount of NO_2 photolyzed is measured witha chemiluminescent oxides of nitrogen analyzer sampling at the outlet. The photolysis rate is calculated from the inlet/outlet concentrations, the tube geometry, the flow rate, and the effective quantum yield (Zafonte et al., 1977). It will be operated only during intensive operating days. On these days the site operator will, prior to dawn, activate a valve to initiate the flow of NO_2. Valve operation will be controlled through the site DAS. The DAS will always close the valve at a time chosen near dusk.

Low Level SO2 Measurements

Ambient SO2 will be monitored at the Boulder 2 site using a Teledyne API Model 100EU low level SO2 analyzer using the UV fluourescence principle. Stability is achieved with the use of an optical shutter to compensate for PMT drift and a reference detector to correct for changes in UV lamp intensity. A hydrocarbon "kicker" and advanced optical design combine to prevent inaccuracies due to interferents.

Trace Level CO Measurements

Ambient CO will be monitored at the Boulder 2 site using a Teledyne API Model 300 EU Gas Filter Correlation trace level CO analyzer. Using a gas filter correlation wheel, a high energy IR source alternately passes through a CO filled chamber and a chamber with no CO present. The light path then travels through the sample cell which has a folded measurement path of 14 meters. The energy loss through the sample cell is compared with the zero reference provided by the gas filter to produce a signal proportional to concentration.

In order to optimize trace level CO measurement, the objective and field mirrors in the sample cell are gold plated to maximize the signal to noise performance. The optical bench is enclosed in a temperature-controlled convection heated oven which dramatically reduces instrument noise and temperature related drift. A Nafion dryer significantly reduces interferences from humidity changes in the sample gas. Additionally, the analyzer periodically monitors and corrects its baseline by routing the sample stream through a heated, platinum CO scrubber. This Auto Reference function helps to correct instrument drift and eliminate any CO2 interferences.

Chemiluminescent Ozone Measurements

The Teledyne API Model 265A analyzer is designed to measure the concentration of ozone using the chemiluminescent reaction producing light emitted by the gas phase reaction of nitric oxide and ozone. The reaction of ozone with NO results in electronically excited NO2 molecules which release their excess energy by emitting a photon and dropping to a lower energy level. It has been shown that the number of emitted photons is directly proportional to the

ozone concentration in the reaction cell. This method of ozone measurement is not subject to the potential interferences that the UV photometric method may have and provide an independent measure of ambient ozone..

4.5 REMOTE SENSING UPPER AIR METEOROLOGY

An ASC Model 4000 miniSodar will be used to collect the upper air meteorology data, providing vertically and temporally resolved boundary layer winds and boundary layer depth (i.e., mixing height) data. The system also includes a surface-based meteorological system. The Sodar provides continuous (hourly and 10-minute) wind data with a vertical resolution of 10 m at heights from about 20 m up to about 250 m agl. The exact height coverage at any given time depends on atmospheric conditions. Continuous (hourly or sub-hourly) boundary layer depth can be derived from the Sodar reflectivity data. An example of this is shown in Figures 4-4. The sodar will be operated under a configuration that produce the highest quality data for the typical atmospheric conditions found in the Upper Green River Basin.

Accuracy (instrument specifications)	
Horizontal Wind Speed	0.5 m/s
Horizontal Wind Direction	±5°
Maximum Altitude	250 meters
Sampling Height Increment	5 meters and greater
Minimum Sampling Height	15 meters
Transmit Frequency	4500 Hz.
Averaging and Reporting Interval	1 to 60 minutes

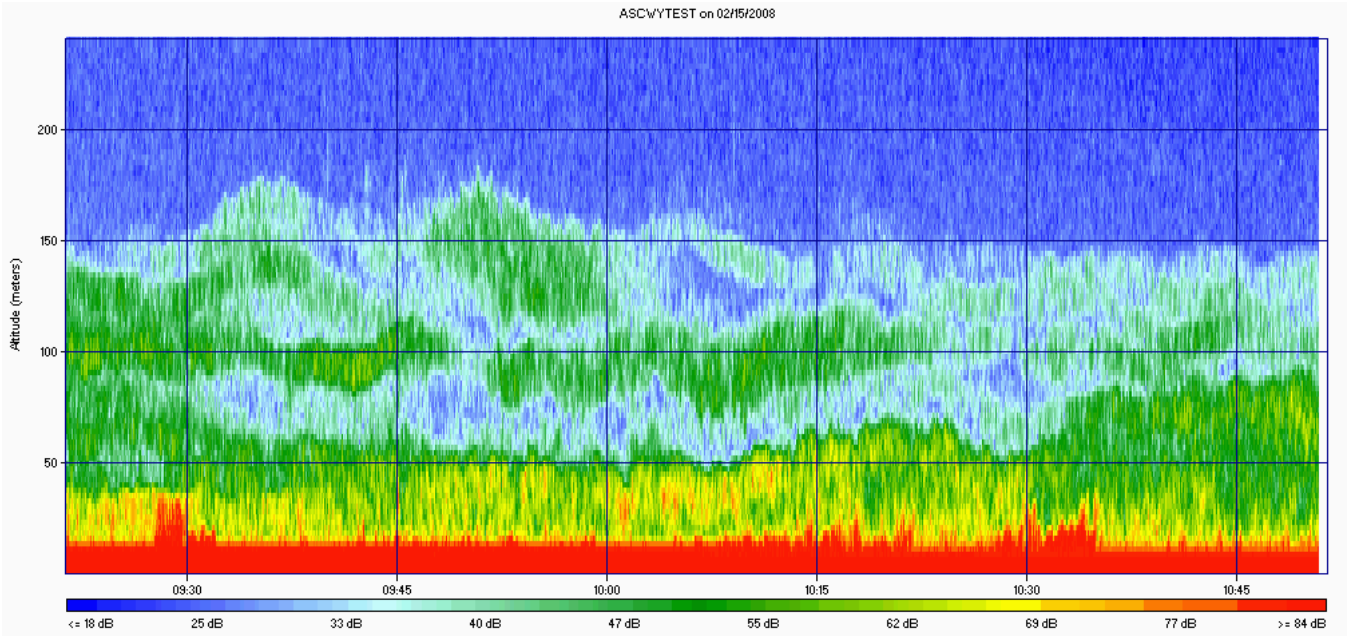

Figure 4-4. Example of sodar backscatter data capturing the daytime mixing height layers under cold wintertime conditions.

4.6 ADDITIONAL MEASUREMENTS

Total UV Radiation

UV radiation will be measured using two Eppley Total UV Radiation (TUVR) sensors – one facing upward to the sky and one facing downward to the ground. The Eppley Ultraviolet Radiometer consists essentially of a selenium barrier-layer photoelectric cell with a sealed-in quartz window, a bandpass filter to restrict the wavelength response of the photocell to the designed range, generally 295-385 nm (i.e. adhering closely to the generally accepted limits for solar ultraviolet radiation reaching the earth's surface, even at altitudes as high as l5,000 feet) and virgin Teflon diffusing disk. The purpose of this disk is twofold, - to reduce the light intensity at the filtered photocell (and thus to increase its stability with exposure time) and also to improve the adherence of the instrument to the Lambert cosine law (and is shaped with this object in view).

These sensors were installed at the Boulder site during the initial 2007 study and are currently being operated by Air Resource Specialist Inc.

SECTION 5

DATA REPORTING

5.1 DATA MANAGEMENT PLAN

A primary study objective is to produce an adequately validated data set from the field measurements that is well defined and documented, and available to researchers in a timely manner. The overall goal of the data management effort is to create a system that is straightforward and easy for users to obtain data and provide updates.

Each data provider will be responsible for reviewing and validating their collected data. The raw data will be validated to Level 1 as described in "The Measurement Process: Precision, Accuracy, and Validity" (Watson, 2001) before being submitted to the database. This includes flagging values for instrument downtime and performance tests, applying any adjustments for calibration deviation, investigating extreme values and applying appropriate flags. Flags used for UGWOS are presented in Table 5-1. Each data provider will be responsible for documenting the validation process so that it could be provided to the data manager and other analysts if needed.

In addition, each data provider will be responsible for furnishing information regarding the monitoring equipment used in the field study and any additional site information to the data manager as requested to enhance the overall documentation of the study. In particular, participants will provide the Monitoring Quality Objective (MQOs) defining the quality of all data submitted as "valid." These MQOs contain the following:

- Accuracy
- Precision
- Lower quantifiable limit
- Resolution
- Completeness

If cases exist where data do not meet the primary MQOs but is still deemed useable and can be defined with a secondary set of MQOs, these additional MQOs and the dates to which they apply will also be submitted.

Flag	Description
V	Valid. Data meets primary MQOs.
S	Valid, but does not meet primary MQOs. Secondary MQOs in effect.
I	Data invalid.
M	Missing. Measurement not taken.

Table 5-1. Data Flags.

Once the data have been validated to Level 1, the data will be prepared for submittal to the database in a form that clearly define the time reference, averaging period, parameter names and units. The time reference for the database is **local standard time (Mountain Standard Time)** and the averaging period reference will be standardized to **hour beginning (0 – 23)**. The data will be submitted as ASCII comma delimited text files or excel spreadsheet files, with data columns well defined to clarify site identification, parameters, instrumentation, units, and time reference.

Data will be submitted in a format similar to that of the final database structure, as outlined below. This basically has a second column for each measured value for an accompanying QC code. Data flagged as invalid or missing will be given a value of -9999. In the event that data for a given measurable is either all valid (meeting primary MQOs) or all missing, participants need not supply the flag column, though this must be specifically stated.

Database Management Design

T&B Systems will be responsible for assimilating the submitted data into an integrated relational Microsoft ACCESS database and is managing the data for subsequent distribution and analysis. The database will consist of both information and data files. The goal is to make the database very usable by data analysts and all participants.

The following describes the design for the database that was also implemented during the 2007 and 2008 field studies. The database includes an inventory spreadsheet file to help users track and ensure that all of the data were submitted and processed in a timely and consistent manner. All data files submitted will be examined to verify unique names for all sites, instruments, and parameters so that no orphan or duplicate records exist in any of the tables. A system is in place for identifying the version and or modification date of all data files.

The data have the following flat format:

Surface Hourly Meteorological Data

SITE, DATE, HOUR, WS, WS_QC, WD, WD_QC, TP, TP_QC, and any additional met parameters and QC codes, if collected.

Ozone 8-hour averaged:

SITE, DATE, HOUR, O3_8HR, O38HR_QC

Hourly Surface Air Quality:

SITE, DATE, HOUR, OZONE, O3_QC, NO, NO_QC, NOx, NOx_QC, NOy, NOy_QC, PAN, PAN_QC and any additional air quality parameters if collected and QC codes.

NMHC VOC:

SITE, DATE, HOUR, START_TIME, END_TIME, CANNISTER_ID, QC_CODE, PARAMETER1, PARAMETER2, PARAMETER3,..PARAMETERn, notes

Upper level meteorological and air quality data

The episodic rawinsonde and ozonesonde data will be stored together in a file with the following format:

SITE, DATE, TIME, HEIGHT, PRESSURE, PRESSURE_QC,

O3, O3_QC, WS, WS_QC, WD, WD_QC, TP, TP_QC, RH, RH_QC

SODAR data will be stored in both a flat file format and a CDF (common data format) or similar tabular format. CDF files are used for plotting the data. Participants should include both flat files and CDF files with their data submissions. The final flat format will be as follows:

SITE, DATE, HOUR, TIME, HEIGHT, WS, WS_QC, WD, WD_QC

The data will be formatted into the final database with the following unit configurations and naming conventions:

- Parts per million for O3
- Meters per second for wind speed (as a general rule, metric units will be used)
- Degrees Celsius for ambient temperature
- Percent for relative humidity

- Parts per billion carbon (ppb_c) for non-methanated hydrocarbon species
- Watts/m^2 for radiation

- SITE = Alpha-numeric site code identifier
- DATE = (MM/DD/YY)
- HOUR= Nearest whole begin hour (HH) (MST)
- TIME, START_TIME or END_TIME = Time stamp of data (HH:MM:SS) (MST)
- HEIGHT = Elevation in meters above MSL
- QC_CODE, WS_QC, WD_QC, O3_QC, etc =
  "V" (valid), "M" (missing), "I" (invalid), "S" (secondary MQOs)
- NOTES = any additional information

The Level 1 data files along with the documentation files will be available for download on an FTP server.

5.2 DATA REPORTING

Data files of all data collected during the study will be transmitted to WDEQ by June 15, 2009.

The team will review the validated data collected during the field study and prepare descriptive summaries in a report format for delivery to WDEQ. We will prepare summaries of air quality and meteorological conditions during the study period. In addition, we will prepare more detailed descriptive analyses of the air quality and meteorology measured during each high ozone event captured by the intensive operating periods. As part of our Level 1 data validation procedures, we will carefully examine all of the measurements. This process typically provides insight into the critical processes that determine the extent of pollution loading such as atmospheric stability, wind shears (low-level jets, etc), layers aloft, and boundary layer development (growth rate, peak mixing heights), including the nocturnal boundary, convective boundary, and residual layer. The meteorology leading up to and during periods with high ozone levels and the diurnal behavior of ozone aloft during these periods will be characterized.

Supporting the analyses discussion, products that will be produced in this phase of the study include but are not limited to:

1. Time-series plots of continuous measurements such as ozone, ambient temperature, radiation;
2. Vertical profiles of ozone, temperature, and winds;
3. Horizontal mapping of ozone, precursors, ambient temperature, and winds—both at the surface and aloft;
4. Time-height cross sections of ozone, potential temperature, winds, and mixing heights;
5. Time-height cross sections of transport statistics including scalar transport distance, vector transport distance, and recirculation factors;

6. Wind roses at the surface;
7. Pollution roses at the surface; and
8. Summary tables of 1-hour and 8-hour averaged ozone as well as statistical summaries showing hourly averages and maximums.

A final report will be prepared presenting:

- The above-mentioned information and associated analyses in an easy to digest format.
- A summary of field operations via tables showing the times of balloon-borne soundings, the times of ground and airplane sampling, VOC samples, and supplemental measurements. A measure of the associated data capture rates will be included. Problems encountered during the field operations will be discussed.
- Details of the database design including descriptions of the metafiles; field descriptors; and the accuracy, precision, lower limits, resolution, and completeness of each measurement.

A draft version of the report will be presented to WDEQ by August 31, 2009. Voluminous tables and figures will be incorporated into electronic appendices as appropriate. All report materials will be made available via a project web site with access restricted in accordance with WDEQ policies and procedures.

SECTION 6

QUALITY ASSURANCE PROGRAM

6.1 PROJECT MANAGEMENT

Mr. Till Stoeckenius will serve as overall project manager and co-principal investigator. Dr. Greg Yarwood will serve as ENVIRON's Principal in Charge for the proposed project, insuring that any and all ENVIRON resources needed for the timely and on-budget completion of the project are made available.

Study personnel responsibilities and contact information is presented in Table 6-1.

A UGWOS study web site has been developed to assist in communications between study participants and to display real-time data. This web site can be found at http://www.metsolution.com/ugwos09/index.htm.

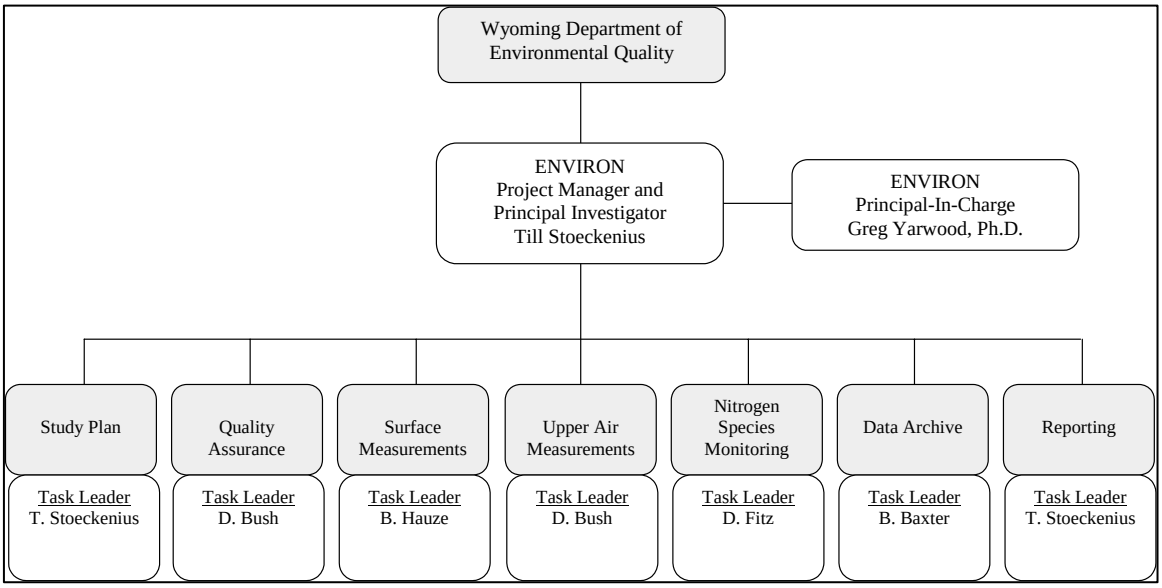

Figure 6-1. Project organization.

Table 6-2. Project Responsibilities and Contacts

Name	Organization	Key Responsibilities	Phone Numbers
Cara Keslar	Wyoming DEQ	Contract Manager	(307) 777-8684 (307) 421-9953 (cell)
Jennifer Frazier	Wyoming DEQ	Pinedale Support Daniel Site Operations	(307) 231-2387 (cell)
Till Stoeckenius	Environ	Project Manager Principal Investigator	(415) 899-0709 (415) 717-0039 (cell)
Greg Yarwood	Environ	Principal Investigator	(415) 899-0704
Don Lehrman	T&B Systems	Ozonesonde support Principal Investigator	(707) 526-2775 (707) 975-4412 (cell)
David Bush	T&B Systems	Quality Assurance	(530) 647-1169 (530) 903-6831 (cell)
Bob Baxter	T&B Systems	Measurements Support Sodar Operations	(661) 294-1103 (661) 645-0526 (cell)
Bill Knuth	T&B Systems	Study Setup and Teardown Ozonesondes Forecasting	(707) 279-1661 (707) 975-4413 (cell)
David Yoho	T&B Systems	QA support	(661) 294-1103 (661) 212-3008 (cell)
Bill Hauze	MSI	Mesonet and VOC Field Manager	(801) 474-3826 (801) 450-3776 (cell)
Dan Risch	MSI	Forecasting	(801) 474-3826
Tyler Ward	MSI	Mesonet Site Checks, VOC Sampling	(801) 450-8706 (cell) (928) 814-3926 (cell)
Dennis Fitz	CeCert	NOx Precursor Measurements - Manager	(951) 781-5781
Kurt Bumiller	CeCert	NOx Precursor Measurements - Installation	(951) 781-5796
Lincoln Sherman	ARS	Boulder Site Operations	(970) 222-5362

6.2 DATA QUALITY OBJECTIVES

Specific monitoring quality objects have been presented for each measurement in Section 4 of this document. The overall objectives for the collection of valid data will be as follows:

Air quality data: 80% of the possible data

Meteorological data: 90% of the possible data

For the above calculation, data lost during calibrations, maintenance or audits are considered invalid.

6.3 ASSESSMENT AND OVERSIGHT

QUALITY CONTROL PROCEDURES

As part of the quality assurance program, detailed quality control procedures have been implemented to assess and maintain control of the quality of the data collected. All equipment will undergo complete checkout and acceptance prior to the start of monitoring on January 15, 2009. This checkout will occur during the week prior to the start of monitoring, as well as during setup and installation of the equipment. Standard operating procedures (SOPs) for measurements will be completed prior to the start of monitoring. SOPs can be found in Appendix B.

A summary of key elements of the QC program for each measurement is presented below:

<u>Ozone Analyzers and Samplers</u>

All ozone analyzers and samplers will be routinely checked using a certified transfer standard, following operating procedures consistent with EPA guidelines. This will consist of zero and span checks conducted at the beginning and end of each IOP. For FEM ozone analyzer, these checks will be conducted using a transfer standard certified against a primary standard maintained following EPA's guidelines at MSI's office in Salt Lake City, UT. For the mesonet equipment, a 2B model 306 (S/N 2) portable ozone calibrator will be used. This portable ozone calibrator will also be compared regularly against MSI's primary standard. Zero/span checks of the mesonet samplers will be conducted at least twice per week during the IOPS, providing precision data. A pass/fail criterion of +/-10% will be used when evaluating the span and calibration data. A zero check and ground truth comparison will be performed on all ozonesonde equipment prior to each flight.

As an additional quality control effort, a mesonet ozone measurement system, consisting of a 2B ozone monitor sited outdoors in a portable cooler, will be collocated with the FEM ozone analyzer at the Boulder site. This system will be subjected to the same operating conditions and procedures as the mesonet sites, and will demonstrate comparability between the mesonet ozone measurements and the conventional FEM ozone measurements. The collocated equipment will be operated throughout the study period.

MiniSodar

The status of the instruments will be checked daily via remote access of the data. If any problems are encountered that could affect data recovery, repairs will be made promptly. The data will be transferred hourly to T&B's server, using a cellular modem. Data can also be accessed in real time via a web site so that team members can use the data to assist in special monitoring and forecasting. The link to the web site is: http://tbsys.serveftp.net/ugwossodar/

VOC Sampling

Four field blanks (approximately 5-10% of the up to 60 collected samples) will be collected and analyzed. In addition, the two samplers will be collocated during the study to collect two duplicate samples.

Nitrogen Species, Trace SO2 and CO, Chemiluminecent Ozone

Automatic zero/span checks of the analyzers will be conducted daily using a certified standard.

CALIBRATIONS

The purpose of a calibration is to establish a relationship between the ambient conditions and an instrument's response by challenging the instrument with known values and adjusting the instrument to respond properly to those values. The calibration method for each of the air quality and meteorological variables is summarized in Table 6-3.

Calibrations of the ozone instruments will be performed upon initial installation and at the end of the study period. Additional calibrations will be performed on an as-needed basis in the event of equipment repair or replacement. All calibrations will be performed in accordance with manufacturers recommendations and consistent with USEPA guidance (USEPA, 1994, 1995, 2000).

Calibrations and zero/span checks of all ozone monitoring equipment will be conducted using a transfer standard (2B Model 306, S/N 002) certified against a local ozone standard. This local standard in turn has been certified against MSI's primary standard maintained following EPA's guidelines at their office in Salt Lake City, UT, as well as against the US EPA Region 8 primary standard maintained at Boulder, CO.

Ozone data will be adjusted if the calibration slope is off by more than ±5% or if the zero is off by more than ±5 ppb.

The nitrogen species and trace level SO2 and CO analyzers will be calibrated using a certified dilution calibrator and a certified gas standard. Standard gas phase titration (GPT) methodologies will be used for calibration of NO_2 channels.

All meteorological sensors will be calibrated at the beginning and end of the study. Wind speed sensors will be calibrated using an RM Young constant rpm motor simulating wind speeds at several points across the sensor's operating

range. Wind direction sensors will be calibrated by checking responses in 30° or 45° increments. Calibration of the UV radiometers is provided by the manufacturer.

Table 6-3. Calibration methods for the monitored variables.

Measurement Variable	Calibration Method
Ozone (O_3)	Multipoint comparison of ozone concentrations with ozone transfer standard
Nitrogen Species Trace Level SO2 and CO	Multipoint comparison of concentrations against a dilution of a certified gas standard
Wind Speed	Rotational rate using a selectable speed anemometer drive
Wind Direction	Alignment using true north and linearity with a directional protractor
Temperature	Water bath comparisons to a certified transfer standard

INDEPENDENT AUDITS

As part of the quality assurance program, an independent audit program will be implemented that will use an independent entity to verify the site operations and data accuracy. These audits will be performed using personnel independent of the measurement program. This will establish confidence in the data collected and allow the measurement processes to be supported through independent verification. Audits will be performed in accordance with the principles of the US EPA.

System audits will be conducted of all data collection operations. System audits will address the following:

- Siting
- Adherence to SOPs
- QA/QC procedures
- Documentation
- Data collection and chain of custody

In addition to the system audits, performance audits will be conducted at the mesonet sites and of the nitrogen oxide measurements at the Boulder site. Performance audits will be conducted using equipment and standards independent of those used in the field.

At the mesonet sites, wind speed sensors will be audited using an RM Young constant rpm motor simulating wind speeds at several points across the sensor's operating range. Wind direction sensors will be audited by checking responses in 30° or 45° increments. Temperature sensors will be audit using a water bath and a certified audit sensor. The ozone monitors will be audited using an ozone

transfer standard that is certified against T&B's primary standard maintained following EPA's guidelines at their office in Valencia, CA.

The nitrogen species measurements at Boulder will be audited using a certified dilution system and a certified cylinder of NO.

Mr. David Bush will conduct the audits of all measurement platforms. These audits will be conducted near the beginning of the study, after the continuous measurements have been implemented. Comments and recommendations resulting from the audits will be discussed with measurement personnel at the time of the audit, with a written memo report provided to study management within 48 hours of the audit.

6.4 DATA VALIDATION

All data collected for UGWOS will be validated to Level 1 validation (see Section 5). As part of the validation effort, participant's data will be evaluated to verify that they meet the stated MQOs. If data clearly do not meet MQOs, they will be removed from the database as invalid data. If, however, data miss meeting the primary MQOs in a definable way to the point where the data are still considered useful, secondary MQOs will be assigned to the data in question. This use of secondary MQOs will be specifically documented in metafiles associated with the data.

SECTION 7

REFERENCES

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APPENDIX A

SITE PHOTOS

View to North

View to East

View to South

View to West

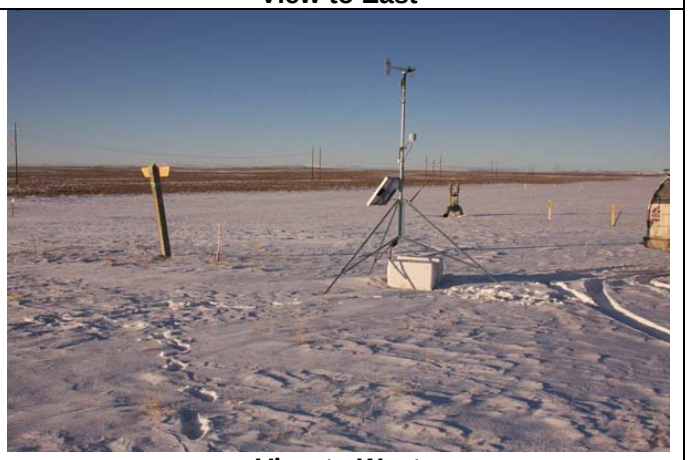
View of Site

Airport

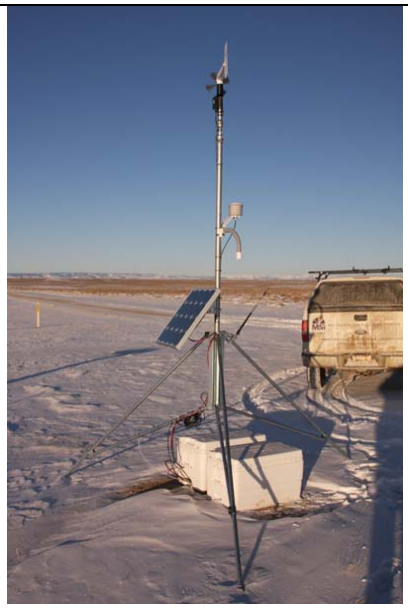
View to North

View to East

View to South

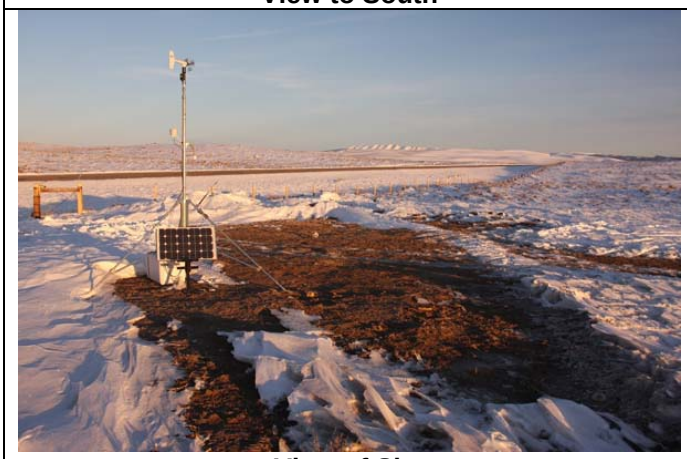


View to West

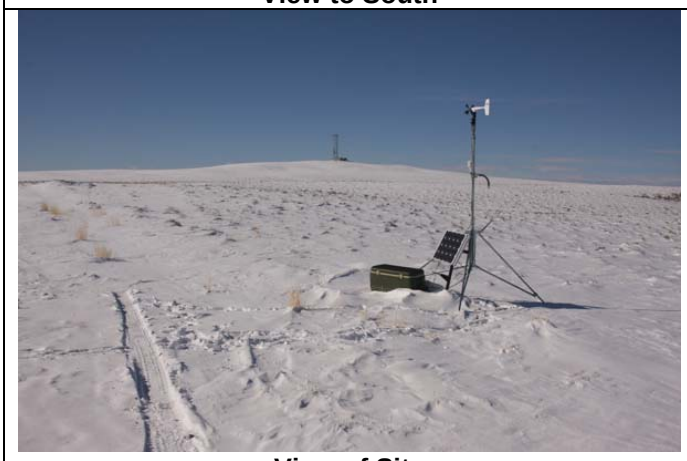


View of Site

Buckhorn

View to North	View to East
View to South	View to West
 View of Site	

Cora

View to North	View to East
View to South	View to West
 View of Site	

Juell

View to North

View to East

View to South

View to West

View of Site

Mesa

View to North

View to East

View to South

View to West

View of Site

Seedskadie

View to North

View to East

View to South

View to West

View of Site

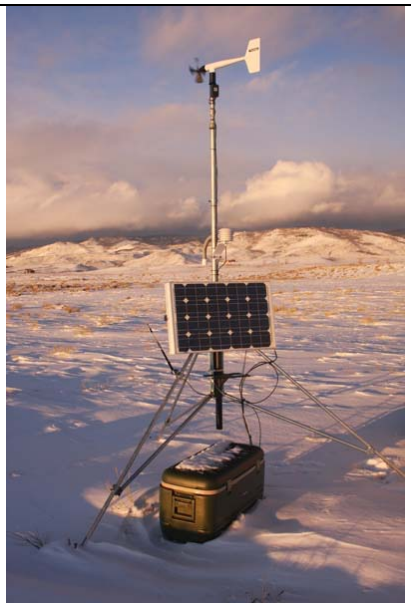
Simpson

View to North

View to East

View to South

View to West

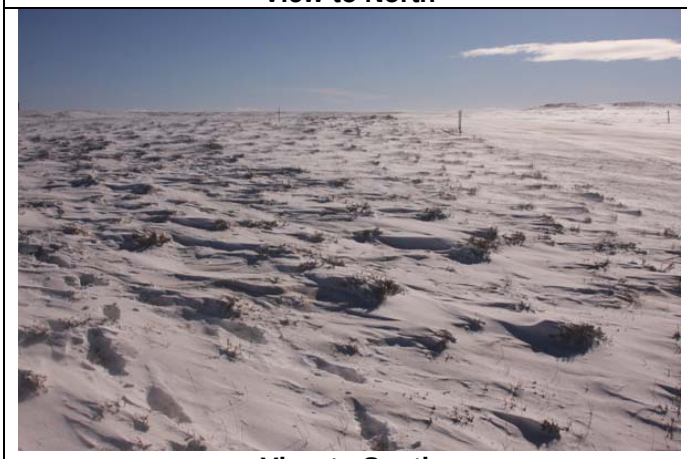


View of Site

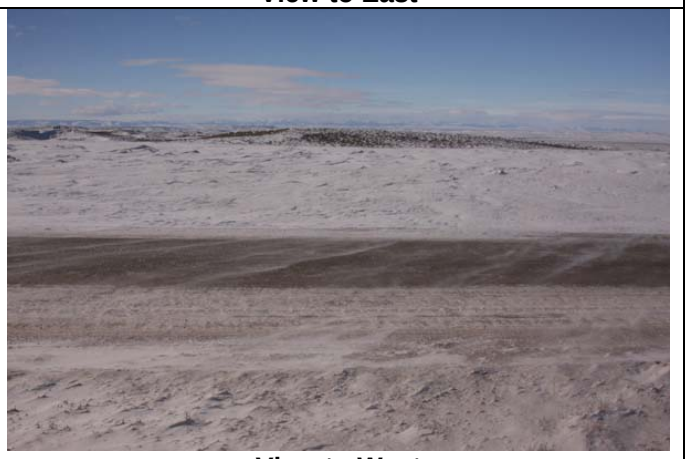
Speedway

View to North

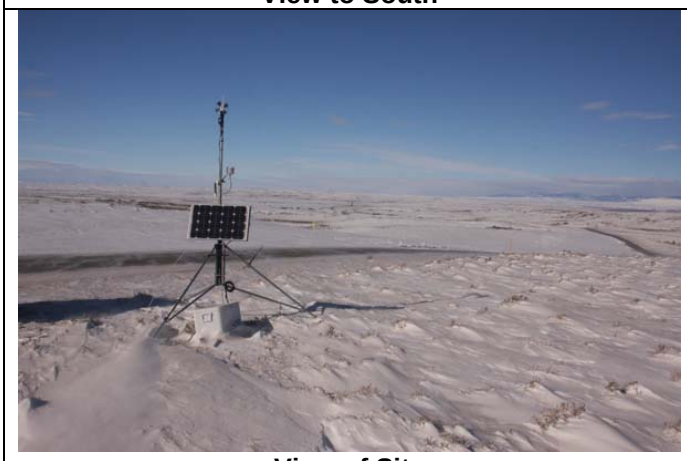
View to East



View to South



View to West



View of Site

Warbonnet

View to North (Approximate U Beam)

View to East

View to South

View to West (Approximate V Beam)

MiniSodar/Ozone Site

APPENDIX B

STANDARD OPERATING PROCEDURES