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Project 57 Air Monitoring Report: October 1, 2013, through December 31, 2014

Prepared by

Steve A. Mizell, George Nikolich, Greg McCurdy,
Craig Shadel, and Julianne J. Miller

Submitted to

Nevada Field Office
National Nuclear Security Administration
U.S. Department of Energy
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Nevada System of Higher Education

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ABSTRACT

On April 24, 1957, the Atomic Energy Commission (AEC, now the Department of Energy [DOE]) conducted the Project 57 safety experiment in western Emigrant Valley north east of the Nevada National Security Site (NNSS, formerly the Nevada Test Site) on lands withdrawn by the Department of Defense (DoD) for the Nevada Test and Training Range (NTTR). The test was undertaken to develop (1) a means of estimating plutonium distribution resulting from a nonnuclear detonation; (2) biomedical evaluation techniques for use in plutonium-laden environments; (3) methods of surface decontamination; and (4) instruments and field procedures for prompt estimation of alpha contamination (Shreve, 1958). Although the test did not result in the fission of nuclear materials, it did disseminate plutonium across the land surface. Following the experiment, the AEC fenced the contaminated area and returned control of the surrounding land to the DoD. Various radiological surveys have been performed in the area and in 2007, the DOE expanded the demarked contamination area by posting signs 200 to 400 feet (60 to 120 meters) outside of the original fence.

Plutonium in soil is thought to attach preferentially to smaller particles. Therefore, redistribution of soil particulates by wind (dust) is the mechanism most likely to transport plutonium beyond the boundary of the Project 57 contamination area. In 2011, DRI installed two instrumentation towers to measure radiological, meteorological, and dust conditions. The monitoring activity was implemented to determine if radionuclide contamination was detectable in samples of airborne dust and characterize meteorological and environmental parameters that influence dust transport. Collected data also permits comparison of radiological conditions at the Project 57 monitoring stations to conditions observed at Community Environmental Monitoring Program (CEMP) stations around the NTTR.

Biweekly samples of airborne particulates are submitted for laboratory assessment of gross alpha and gross beta radioactivity and for determination of gamma-emitting radionuclides. Annual average gross alpha values at the Project 57 monitoring stations are in the same range as the highest two values reported for the CEMP stations surrounding the NTTR. Annual average gross beta values at the Project 57 monitoring stations are slightly higher than the lowest value reported for the CEMP stations surrounding the NTTR. Gamma spectroscopy analyses on samples collected from the Project 57 stations identified only naturally occurring radionuclides. No manmade radionuclides were detected. Thermoluminescent dosimeters (TLDs) indicated that the average annual radioactivity dose at the monitoring stations is higher than the dose determined at surrounding CEMP stations but approximately half of the estimated national average dose received by the general public as a result of exposure to natural sources. The TLDs at the Project 57 monitoring stations are exposed to both natural sources (terrestrial and cosmic) and radioactive releases from the Project 57 contamination area. These comparisons show that the gross alpha, gross beta, and gamma spectroscopy levels at the Project 57 monitoring stations are similar to levels observed at the CEMP stations but that the average annual dose rate is higher than at the CEMP stations.

Winds in excess of approximately 15 mph begin to generate dust movement by saltation (migration of sand at the ground surface) or direct suspension in the air. Saltated sand, PM_{10} (inhalable) dust, and $PM_{2.5}$ (fine particulate dust) exhibit an approximately exponential increase with increasing wind speed. The greatest concentrations of dust occur

for winds exceeding 20 mph. During the reporting period, winds in excess of 20 mph occurred approximately 1.6 percent of the time. Preliminary assessment of individual wind events suggests that dust generation is highly variable likely because of the influence of other meteorological and environmental parameters. Although winds sufficient to generate significant amounts of dust occur at the Project 57 site, they are infrequent and of short duration. Additionally, the potential for wind transport of dust is dependent on other parameters whose influence have not yet been assessed.

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LIST OF ACRONYMS

AEC	Atomic Energy Commission
Am-241	americium-241
BSNE	Big Spring Number Eight
Bq/m^3	Becquerel per cubic meter
CAS	corrective action site
CAU	corrective action unit
CEMP	Community Environmental Monitoring Program
cfm	cubic feet per minute
cps	counts per second
CY	calendar year
DoD	U.S. Department of Defense
DOE	U.S. Department of Energy
DRI	Desert Research Institute
FY	fiscal year
mR	millirem
NAFR	Nellis Air Force Range
NFO	Nevada Field Office
NNSA	National Nuclear Security Administration
NNSS	Nevada National Security Site
NTTR	Nevada Test and Training Range
$PM_{2.5}$	particulate matter less than 2.5 µm
PM_{10}	particulate matter less than 10 µm
Pu-241	plutonium-241
RCT	radiological control technician
RMA	radiological material area
TLD	thermoluminescent dosimeter
µCi/ml	microcurie per milliliter
$\mu g/m^3$	microgram per cubic meter
µm	micrometers

INTRODUCTION

During the late 1950s, the Atomic Energy Commission (AEC) (now the Department of Energy [DOE]) conducted a series of safety experiments to determine if a nuclear device subjected to a large conventional explosives detonation would result in a thermonuclear explosion. The AEC obtained temporary use of a large portion of western Emigrant Valley from the U.S. Department of Defense (DoD) for the Project 57 safety experiment. Following the safety experiment, the AEC fenced the contaminated area and returned control of the surrounding land to the DoD. The area was part of the Nevada Test and Training Range (NTTR, formerly the Nellis Air Force Range). For safety and security reasons, access to the NTTR is controlled through the use of both physical (i.e., fences) and administrative (e.g., signs and postings) controls. Therefore, the public cannot access the Project 57 site and there are no known human receptors with routine access to the site.

Project 57 was detonated on April 24, 1957, in Emigrant Valley approximately 13 miles (21 kilometers) northeast of the north end of Yucca Flat (Figure 1). This test was undertaken to develop (1) a means of estimating immediate distribution and long-term redistribution of plutonium dispersed during a nonnuclear detonation; (2) biomedical evaluation techniques for use in likely plutonium-laden environments; (3) methods of decontamination of ground areas, pavements, and building materials; and (4) alpha survey instruments and field monitoring procedures to promptly estimate contaminant deposition (Shreve, 1958). Data collection stations were distributed on a variable-scale rectangular grid pattern that extended approximately 9.5 miles (15.3 kilometers) north of the ground zero detonation point and encompassed a total of approximately 64.5 square miles (167 square kilometers). Although the test did not result in the fission of nuclear materials, it did disseminate plutonium across the ground surface.

Various radiological surveys have been performed in the area since Project 57 was conducted. The original fence constructed by the AEC to control access to Project 57 delineated the initial contamination area and was located based on radioactivity surveys performed shortly after the Project 57 test was conducted (Figure 2). The distribution of americium-241 (Am-241) in the area was determined in a 1997 flyover (written communication from Navarro to DRI, 2010) and showed Am-241 concentrations ranging from as much as 70,000 counts per second (cps) at ground zero to background values. This survey documented Am-241 concentrations on the ground surface beyond the east side contamination area fence at levels of up to 150 cps. In 2007, the DOE expanded the contamination area by posting “Contamination Area” signs 200 to 400 feet (60 to 120 meters) outside of the original fence, which formed a new, concentric contamination area boundary. However, Am-241 concentrations in the range of 70 to 150 cps are observed in the 1997 airborne survey data to extend beyond the east side of the new contamination area boundary (Figure 2).

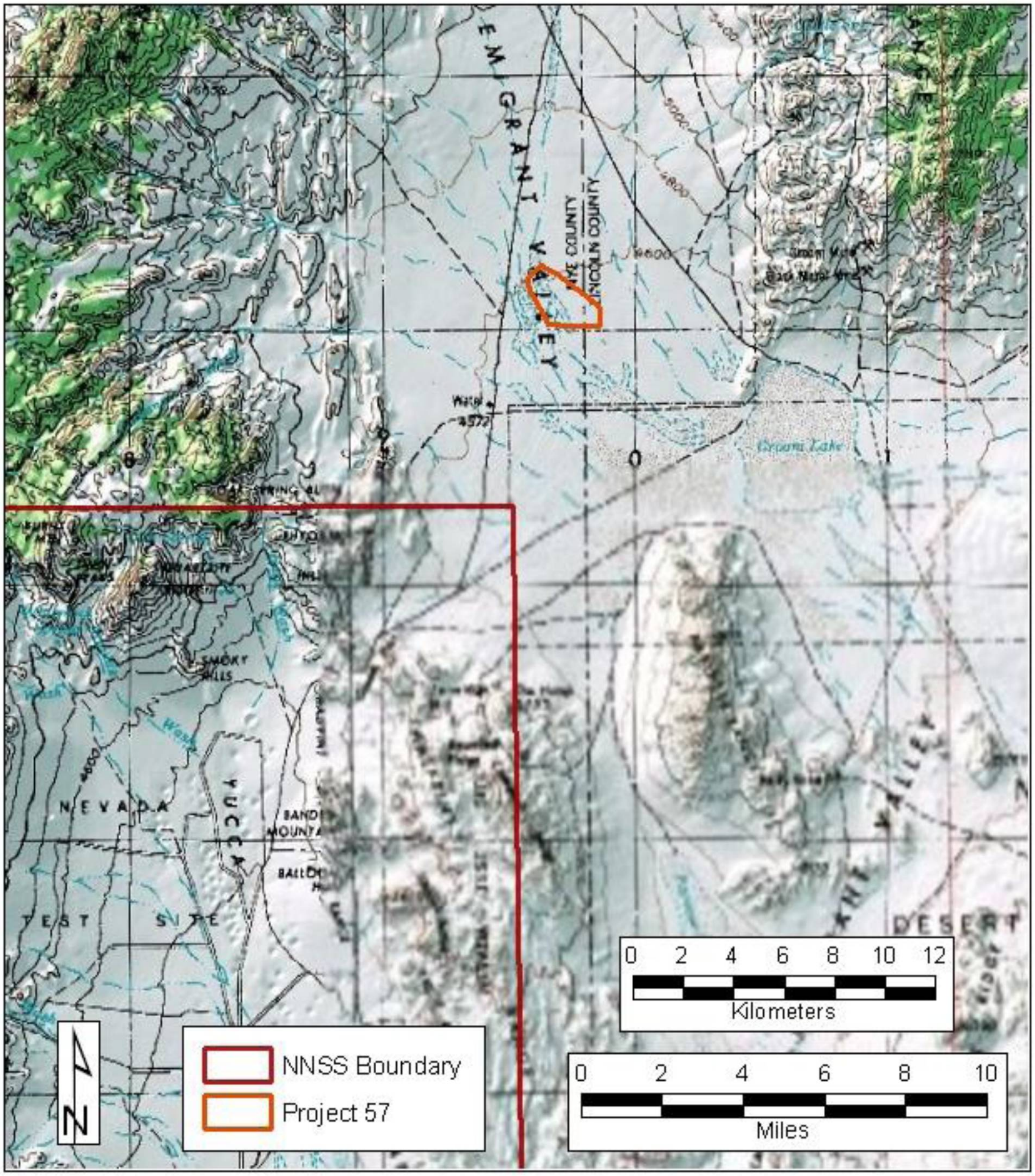


Figure 1. Project 57, outlined in orange, is off of the northeast corner of the Nevada National Security Site on the Nevada Test and Training Range at the Lincoln/Nye County border in western Emigrant Valley.

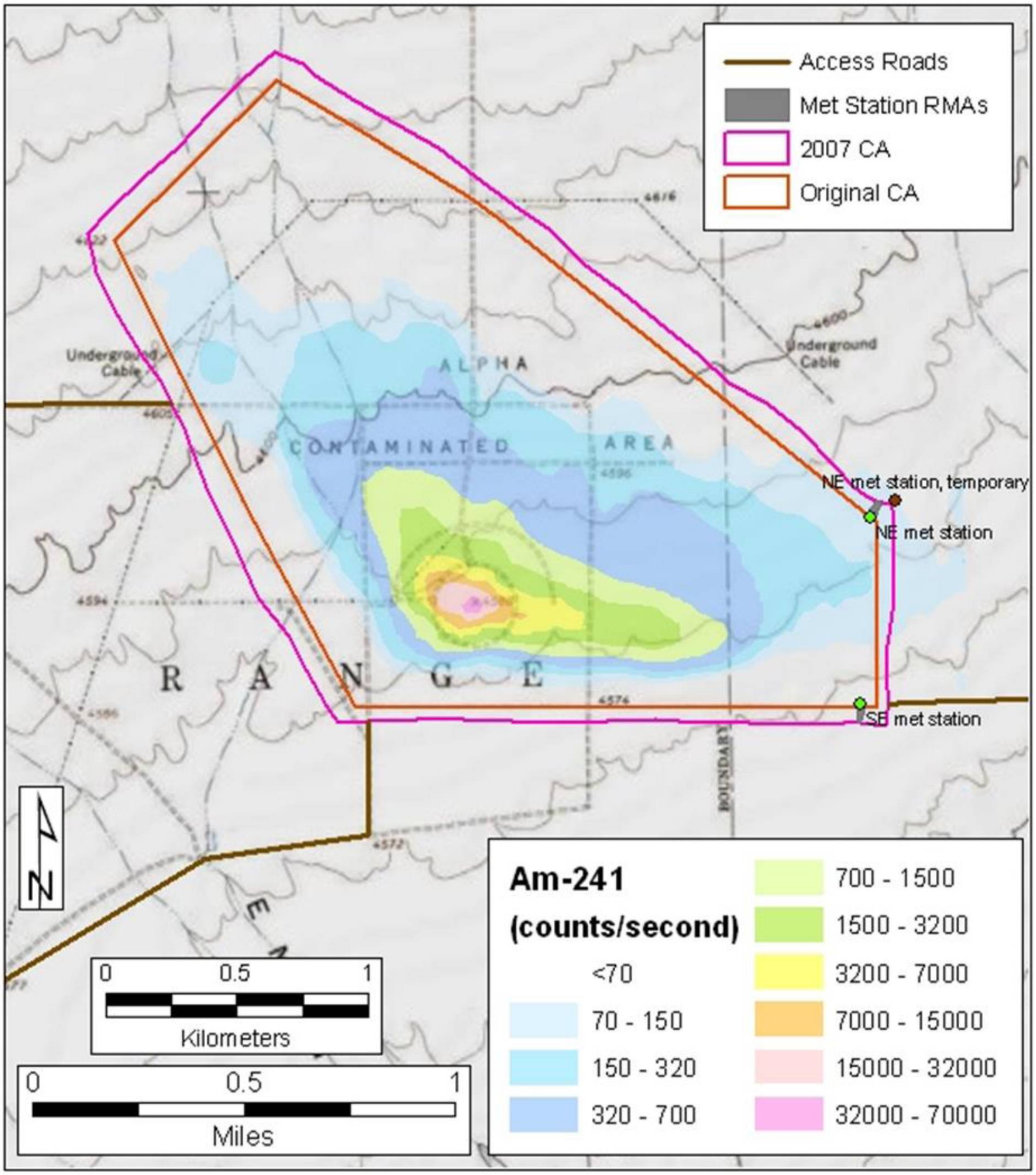


Figure 2. Americium-241 concentrations measured during the 1997 flyover survey (from Navarro, 2010) and the original and 2007 contamination area boundaries are shown. The green diamonds and red dot indicate the locations of the air monitoring/meteorological stations.

The U.S. Department of Energy (DOE), National Nuclear Security Administration, Nevada Field Office (NNSA/NFO) is currently working to achieve regulatory closure of radionuclide-contaminated soil sites under its purview. With respect to closure efforts, the Project 57 contamination area is designated Corrective Action Unit (CAU) 415, Project 57 No. 1 Plutonium Dispersion Site, which consists of one Corrective Action Site (CAS): NAFR-23-02, Pu Contaminated Soil. This CAS includes several facilities associated with Project 57 as well as the plutonium contaminated soil.

In 2011, at the request of the NNSA/NFO, the Desert Research Institute (DRI) constructed and deployed two environmental monitoring stations at Project 57. Data collected at these monitoring stations is used to conduct field assessments of potential wind transport of radionuclide-contaminated soil from the Project 57 site. The assessment is intended to provide site-specific information on meteorological conditions that result in airborne soil particle redistribution, as well as determine which, if any, radiological contaminants may be entrained with the soil particles and estimate their concentrations. Determining the potential for transport of radionuclide-contaminated soils will facilitate an appropriate closure design and postclosure monitoring program.

MONITORING STATION LOCATIONS AND CAPABILITIES

The Project 57 site is located near the center of the western subbasin of Emigrant Valley. Soils in the area are dominated by fine particles that are subject to transport under moderate to strong winds. Tamura (1985), Friesen (1992), Murarik *et al.* (1992), and Misra *et al.* (1993) indicate that plutonium has a tendency to bind with fine soil particles. Therefore, the particles most likely to be transported by wind are also the particles most likely to be contaminated by radionuclides. Because plutonium is likely to reside in the upper few inches (or centimeters) of soil, soil erosion by wind can potentially lead to the mobilization and redistribution of radionuclide-contaminated soil. Additionally, inhaling airborne dust raised from an area of contaminated soil is the primary risk to humans.

There were no historical site-specific data describing wind direction, speed, or other climate parameters at the Project 57 site when the monitoring stations were deployed. Regional wind data from the Community Environmental Monitoring Program (http://www.wrcc.dri.edu/) and the NNSS (NSTec, 2011) indicated that southwest and northwest winds are predominant. The monitoring stations were located north and south of the Project 57 contamination area to maximize the fetch across the contamination area.

Currently, DRI is performing a field-scale assessment of meteorological conditions that could potentially affect the transport of contaminated soil at the site. Data are being collected by air monitoring/meteorological stations at two locations (Figure 2). The northeast location was selected to obtain downwind data along the predominant spring through fall southwest wind direction and the southeast location was selected to obtain downwind information for the northwest winds that are common during the winter.

The northeast monitoring station (P-57-1) was installed on April 20, 2011, at a temporary location outside of the northeast corner of the current contamination area boundary (Figure 2). National Security Technologies (NSTec) Radiological Control Technicians (RCTs) surveyed two corridors from the current contamination area boundary to the former contamination area boundary at the fence and determined the corridors could be downgraded to radioactive material areas (RMAs). RMAs can be accessed by Radiological Worker II–trained personnel without RCT support. On August 11, 2011, P-57-1 was reinstalled at the fence line on the northeast side of the contamination area (it was removed from the temporary location on July 27). The southeast monitoring station (P-57-2) was installed in the southern RMA corridor at the fence boundary during early November 2011. Table 1 lists the coordinates and elevations of both monitoring stations. Figures 3 and 4 show the P-57-1 and P-57-2 monitoring stations, respectively, as deployed at the fence boundary. These locations were selected in an effort maximize the fetch over the contamination area as winds approached the monitoring stations.

Wind direction data collected from the P-57-1 and P-57-2 stations provided site-specific information. These data indicated that the dominant winds passing over the monitoring stations were not traversing the Project 57 ground zero. The site specific data was used to select new monitoring stations, that are directly downwind of the Project 57 ground zero during the predominant southwest and northwest winds. Stations P-57-1 and P-57-2 were decommissioned and the equipment was relocated to establish new monitoring stations, P-57-3 and P-57-4, at these new locations on January 7, 2015. This report reviews and analyzes data collected from the P-57-1 and P-57-2 stations for fiscal year (FY) 2014 and the first quarter of FY2015 (October 1, 2013 through January 7, 2015) when these stations were decommissioned.

Table 1. Project 57 meteorological stations are located in Emigrant Valley, Nevada, at the coordinates and elevations given.

Meteorological Station	Latitude	Longitude	Elevation
P-57-1	37° 19’ 19”	115° 53’ 20”	4,590 ft
P-57-2	37° 18’ 53”	115° 53’ 21”	4,575 ft

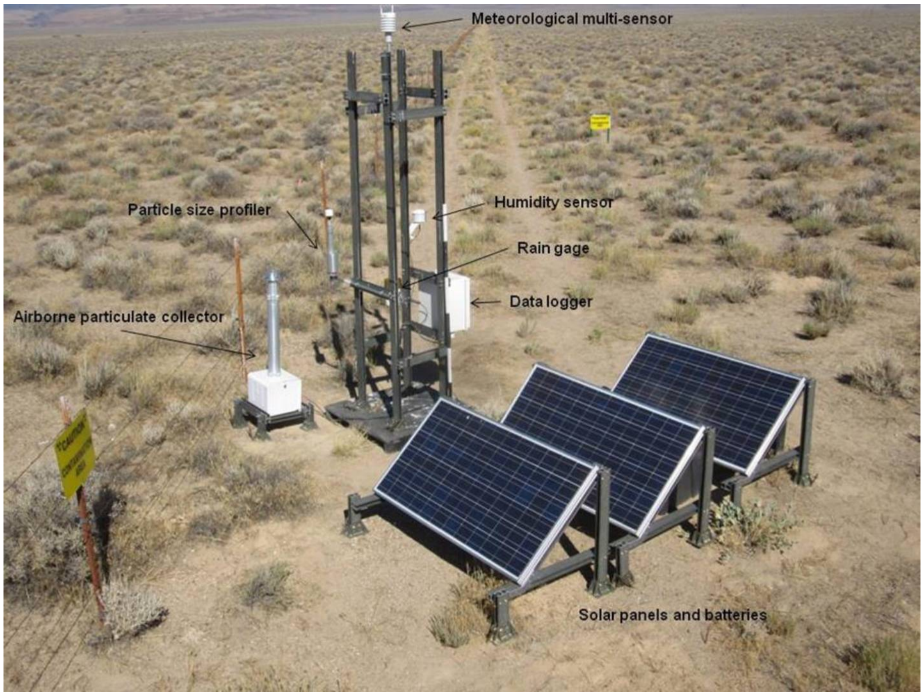


Figure 3. Project 57 monitoring station #1 (P-57-1) was installed at the northeast corner of the Project 57 fenced boundary in August 2011. The associated saltation sensor (not pictured) was installed in January 2012.

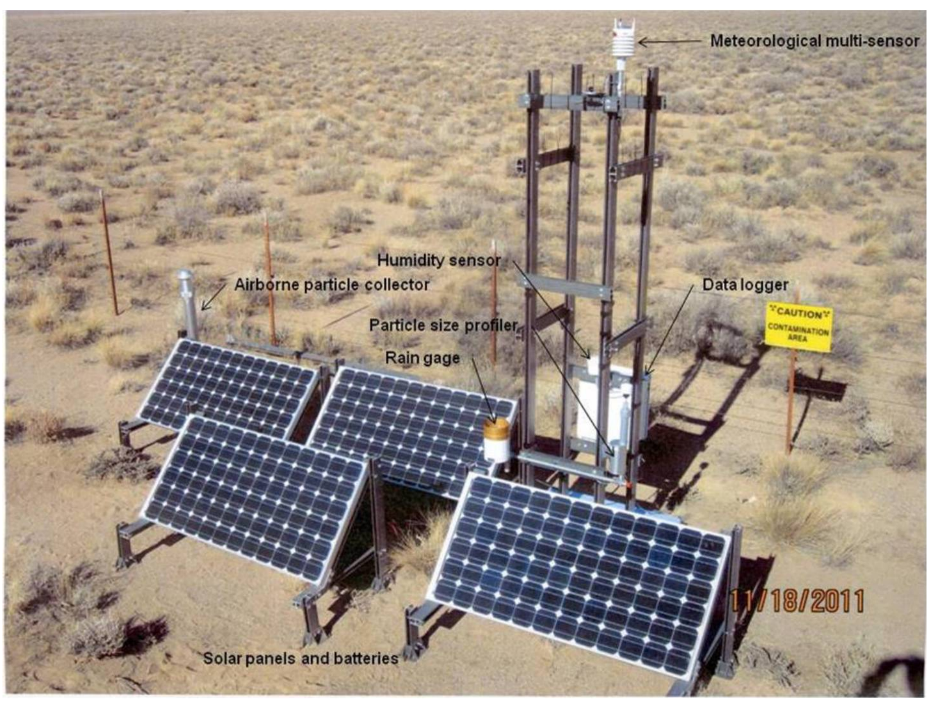


Figure 4. Project 57 monitoring station #2 (P-57-2) was installed at the southeast corner of the Project 57 fence boundary in November 2011. The associated saltation sensor was installed in December 2011.

The fundamental design of these stations is similar to that used in the Community Environmental Monitoring Program (CEMP) (NSTec, 2013). The equipment deployed provides data on radiological, meteorological, and environmental conditions. Table 2 lists the parameters measured. The Quality Assurance Program is also patterned after that used by CEMP (Appendix C).

Plutonium was the principal radionuclide released into the environment during the Project 57 experiment. It attaches to small soil particles and may be suspended in the air and transported from the site along with windblown dust. Continuous flow, low-volume air samplers (flow rate is approximately 2 ft^3 [0.05663 m^3] per minute) are used to collect airborne particulates at each station. The air is drawn through filters that are retrieved every two weeks and delivered to the Radioanalytical Services Laboratory (RSL) at the University of Nevada, Las Vegas, for analyses. Gross alpha, gross beta, and gamma spectroscopy analyses are performed in an effort to assess the magnitude of radionuclides associated with the suspended dust. Gamma spectroscopy is performed to determine if Am-241, the daughter product of plutonium-241 (Pu-241), is present. If Am-241 is detected, then alpha spectroscopy is performed to determine the quantity of Pu-241 present.

Table 2. Radiological, meteorological, and environmental sensors deployed at the Project 57 air monitoring stations. Dates refer to the first occurrence of data collection for the specified parameter at the P-57-1 and P-57-2 stations.

Instrument/Measurement	P-57-1	P-57-2	Data Collection Interval
Wind speed	8/11/2011	11/18/2011	3 seconds
Wind direction	8/11/2011	11/18/2011	3 seconds
Precipitation	8/11/2011	11/18/2011	3 seconds
Temperature	8/11/2011	11/18/2011	3 seconds
Relative humidity	8/11/2011	11/18/2011	3 seconds
Solar radiation	not installed	11/18/2011	3 seconds
Barometric pressure	8/11/2011	11/18/2011	3 seconds
Soil temperature	8/11/2011	11/18/2011	3 seconds
Soil moisture content	8/11/2011	11/18/2011	3 seconds
Airborne particle size profiler	8/11/2011	11/18/2011	1 minute
Saltation sensor	1/09/2012	1/09/2012	3 seconds
Data logger	8/11/2011	11/18/2011	Monthly
Airborne particle collector	8/11/2011	11/18/2011	Biweekly
Thermoluminescent dosimeters	1/09/2012	1/09/2012	Quarterly
BSNE Sand Traps	4/14/2014	4/14/2014	TBD[1]

[1] The data collection interval for the BSNE saltation collectors has not been determined.

Suspension and transport of dust is controlled by local meteorological and other environmental conditions, such as wind speed and soil moisture content. Electronic sensors measure these parameters at the stations every three seconds. The three-second measurements are averaged or totaled as appropriate and stored in the on-site data logger every 10 minutes. The maximum and minimum values of each parameter observed during the 10 minute interval are also saved so they can be used to evaluate data quality or for future analysis. The data loggers are downloaded during site visits once each month. The retrieved data are quality checked and archived by the Western Regional Climate Center for later interpretation.

Thermoluminescent dosimeters (TLDs) were installed at both stations in November 2011 and are collected on a quarterly basis for laboratory analysis. Saltation sensors, which are used to measure the occurrence and frequency of soil particle transport by saltation, were installed at the P-57-2 and P-57-1 stations in December 2011 and early January 2012, respectively

On April 14, 2014, DRI installed Big Spring Number Eight (BSNE) dust samplers to collect dust and soil transported by saltation at the Project 57 monitoring stations. The BSNE traps are isokinetic wind aspirated samplers (Figure 5) that collect all of the airborne sand and a large portion of the airborne dust that enters the opening regardless of wind speed. Three replicate BSNE samplers, each with two collectors, were installed along the fence line at both Project 57 monitoring stations. The inlet height is set at 6 in (15 cm) to collect the maximum amount of erodible soil material. The two collectors at each mounting rod are installed so that one is pointed toward the contamination area to collect material moving across the contaminated ground. The other collector is pointed in the opposite direction to collect material moving across the uncontaminated soil. The BSNE samplers will permit radiological assessment of soil material transported near the ground surface, estimation of net movement of soil material to and from the contaminated area, and perhaps assessment of spatial variability in soil transport. The BSNE collectors were collected in January 2015 when the P-57-1 and P-57-2 stations were decommissioned. Collected samples have not been analyzed. No data from this collection effort is included in this report.

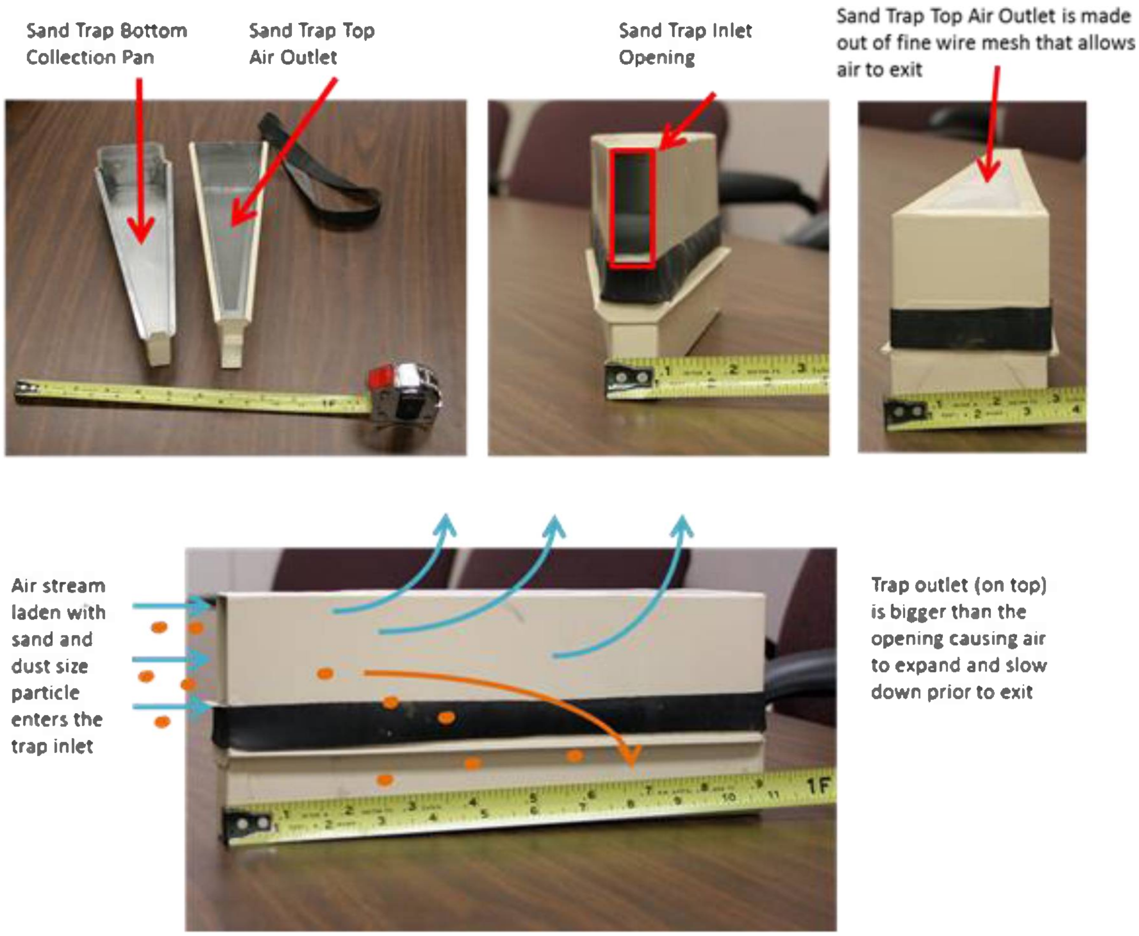


Figure 5. Sand and dust particles are carried into the BSNE Sand Trap by fast moving air. As the air slows down, momentum is lost and the particles settle on the bottom of the collection pan.

OBSERVED WEATHER AND ENVIRONMENTAL CONDITIONS

Meteorological equipment (Table 2) operated continuously and a complete record of observations was collected at P-57-1 for the reporting period: October 1, 2013, to January 7, 2015. However, no data were collected at P-57-2 from March 5 to 17, 2014, when the data logger power cable was inadvertently disconnected during a routine service visit. The P-57-2 wind-speed sensor was also damaged by birds in mid-October, and then failed completely on November 21, 2013. A replacement sensor was installed on November 25, 2013. The subsequent data quality review determined that all wind-speed data at P-57-2 between October 16, 2013, at 9:40 a.m. and November 21, 2013, was likely erroneous and they were removed from the data record and further analysis. Charts displaying daily observations of the meteorological and other environmental parameters are displayed in Appendices A, B, and C. Summaries and highlights of observations collected during the reporting period are discussed in the following paragraphs.

Total precipitation for the reporting period was 5.67 in (144.02 mm) and 6.07 in (154.18 mm) at P-57-1 and P-57-2, respectively. No precipitation was observed during June and October 2014 (Figure 6) and maximum rainfall for various time intervals occurred during August 2014 (Table 3). The majority (53 percent) of the precipitation received during the reporting period occurred during four storms, each of which produced daily precipitation totals in excess of 0.5 in (12.70 mm) (Figures 6 and 7). The first storm on February 28, 2014, was a typical springtime storm that lasted approximately 10 hours with consistent light to moderate rainfall (< 0.1 in/10 min) and produced a total of approximately 0.70 in (17.78 mm) at both stations. A storm on August 4, 2014, lasted 12 hours and was characterized by several brief, moderate (~0.1 in/10 min.) showers that lasted 30 to 60 minutes each with little to no rainfall between the showers. This event produced a total of approximately 1.12 in (28.45 mm) rain at P-57-1 and 1.35 in (34.29 mm) at P-57-2. On August 19, 2014, a brief but very intense rainfall event that lasted barely one hour produced peak rainfall rates greater than 0.30 in/10 min and totaled almost 0.65 in (16.51 mm). A storm on September 8, 2014, manifested as a series of brief showers that occurred over a 12 hour period. Individual showers occasionally peaked at more than 0.20 in/10 min and lasted less than 30 minutes. Total precipitation from this September storm was just over 0.5 in (12.70 mm) at both stations.

Table 3. Extremes in observed precipitation at both Project 57 monitoring stations occurred on the same dates and had similar magnitude.

Station	**Minimum Monthly (in)**	**Maximum Monthly (in)**	**Maximum Daily (in)**	**Maximum Hourly (in)**	**Maximum 10 min (in)**
P-57-1	0	2.10	1.12	0.64	0.34
P-57-2	0	2.37	1.35	0.65	0.30
Date	June and Oct 2014	Aug 2014	Aug 4, 2014	Aug 19, 2014	Aug 19, 2014

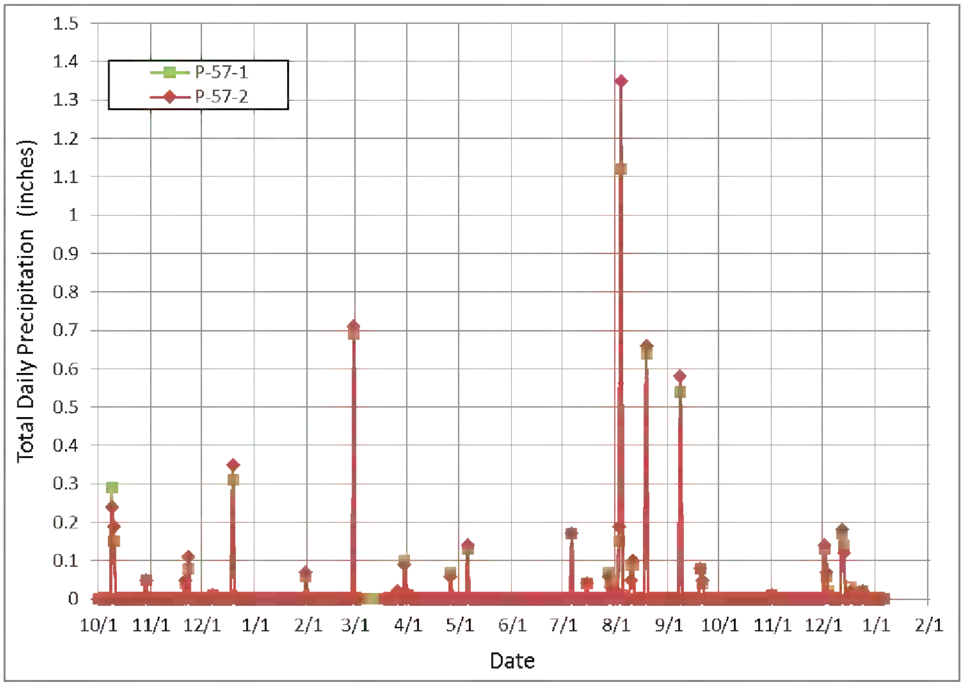


Figure 6. Daily precipitation during the period October 1, 2013, through January 6, 2015, shows slight differences in precipitation received at the Project 57 monitoring stations.

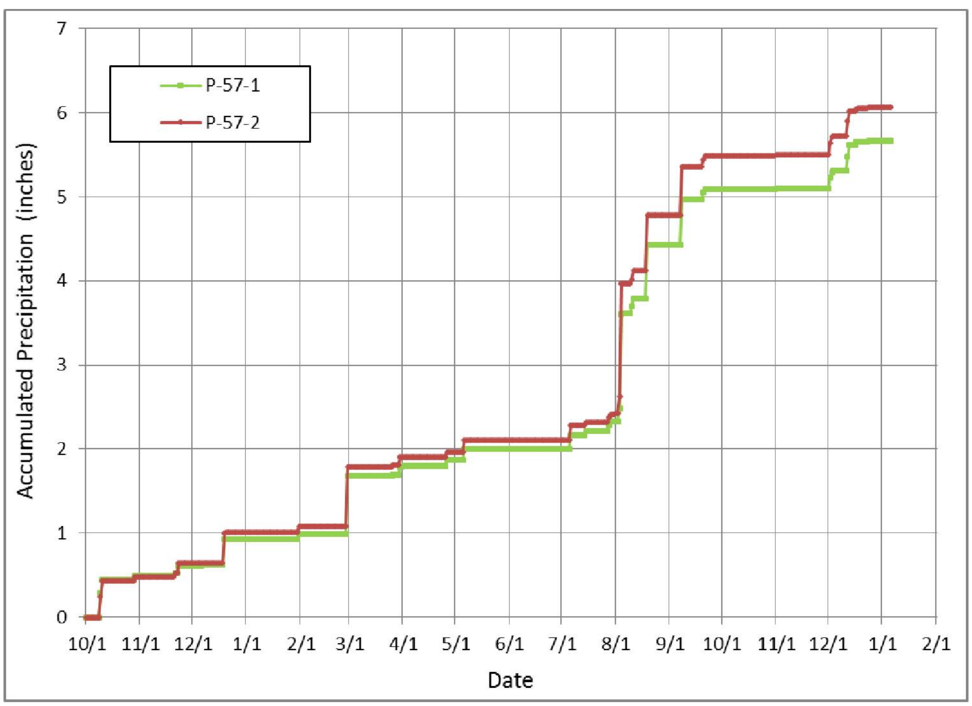


Figure 7. Cumulative precipitation at the Project 57 monitoring stations for the period October 1, 2013, through January 6, 2015.

Daily average air temperature follows the expected annual cycle (Figure 8). Over the reporting period, the seasonal variations in the daily average temperature ranged from 17.0 °F to 86.8 °F at P-57-1 and 17.1 °F to 86.9 °F at P-57-2. The observed extreme temperatures, based on the three-second observations, ranged from -1.3 °F to 104.1 °F at P-57-1 and from -1.3 °F to 104.3 °F at P-57-2 (Appendix Figures A-1 and A-6). The -1.3 °F minimum temperature, which occurred on December 6, 2013, is a new record low temperature for the Project 57 stations for the four winter seasons that have been observed. The new low temperature is more than six degrees below the previous record low temperature of +5 °F, which was observed in January 2013. The summer maximum temperatures at both monitoring stations were recorded on July 13, 2014.

The average daily soil temperature also exhibits an annual seasonal pattern (Figure 9) and is typically warmer at P-57-2. Figure 10 shows a very strong correlation between the daily average air and soil temperature with coefficients of determination (R^2) greater than 95 percent. The regression equation at P-57-2 has a slightly steeper slope and lower intercept than the equation for P-57-1, which indicates that the soil warms more quickly at P-57-2. Air and soil temperatures in the low end of observed values plot above the linear regression line. This illustrates the ability of the soil to retain heat through the short periods of sharp air temperature decline. Soil at P-57-2 is typically a bit wetter than the soil at station P-57-1 (Figure 11).

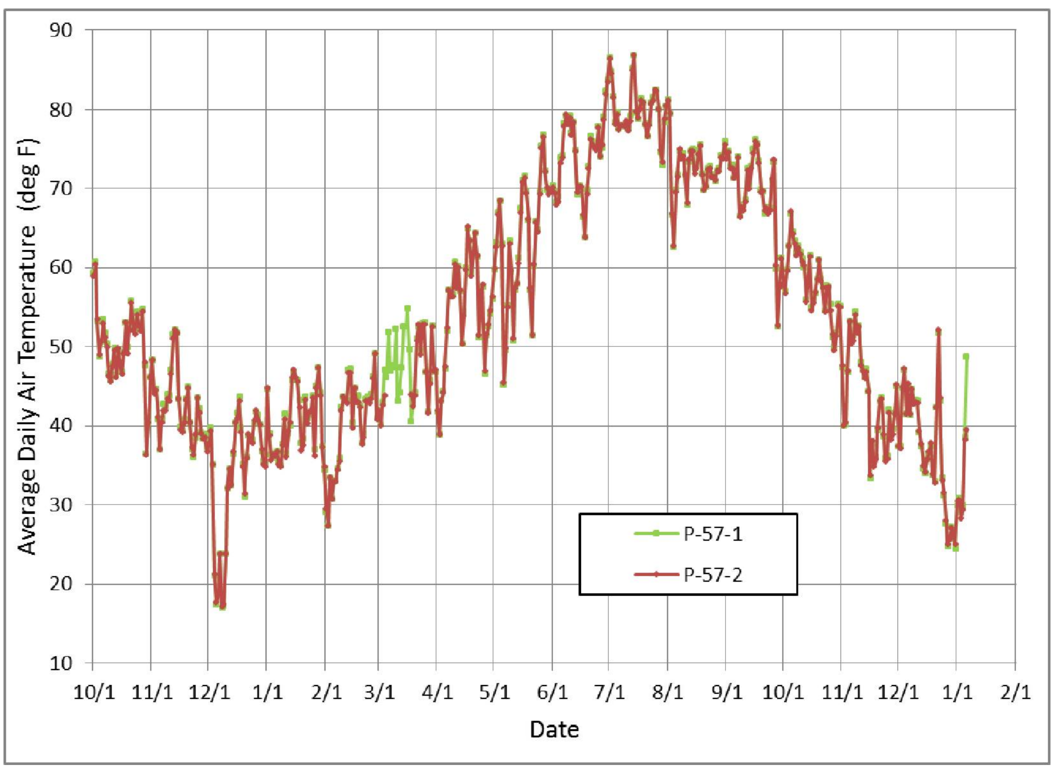


Figure 8. Daily average air temperature during the period October 1, 2013, through January 6, 2015, shows the anticipated annual trends.

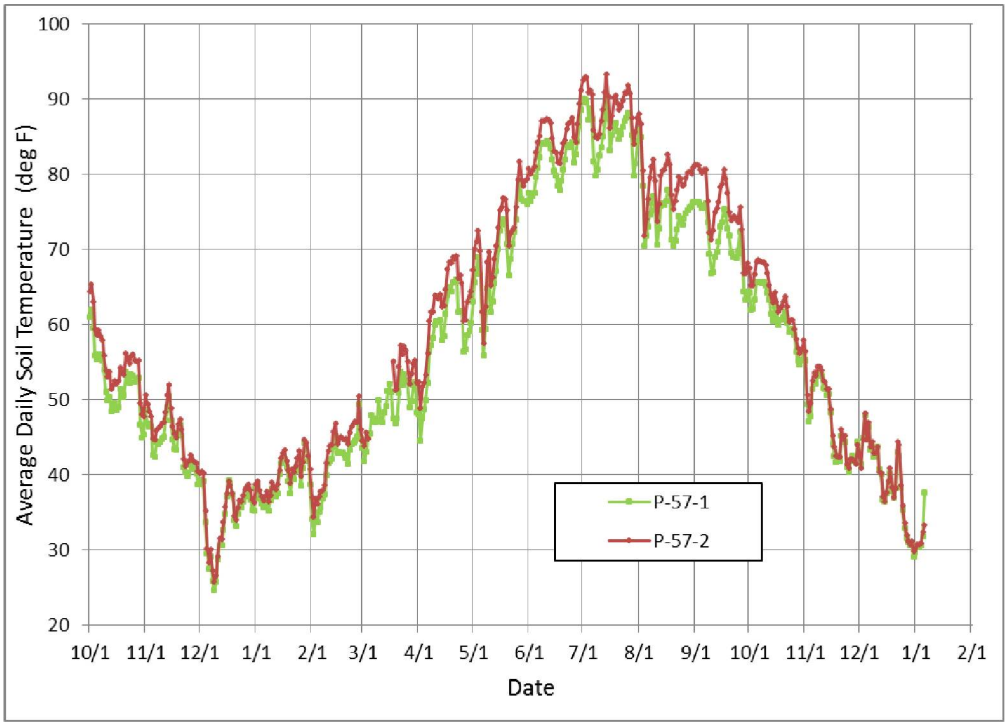


Figure 9. The average daily soil temperature at P-57-2 is typically slightly warmer than at P-57-1 throughout the reporting period.

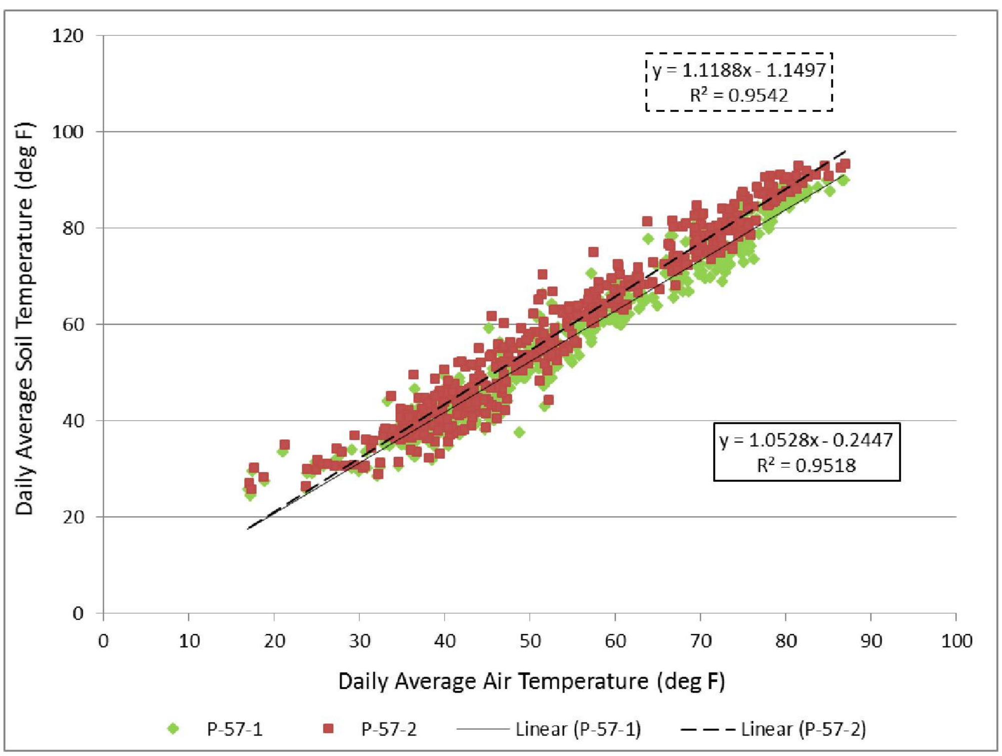


Figure 10. As expected there is strong correlation between average daily air temperature and average daily soil temperature at the Project 57 monitoring stations.

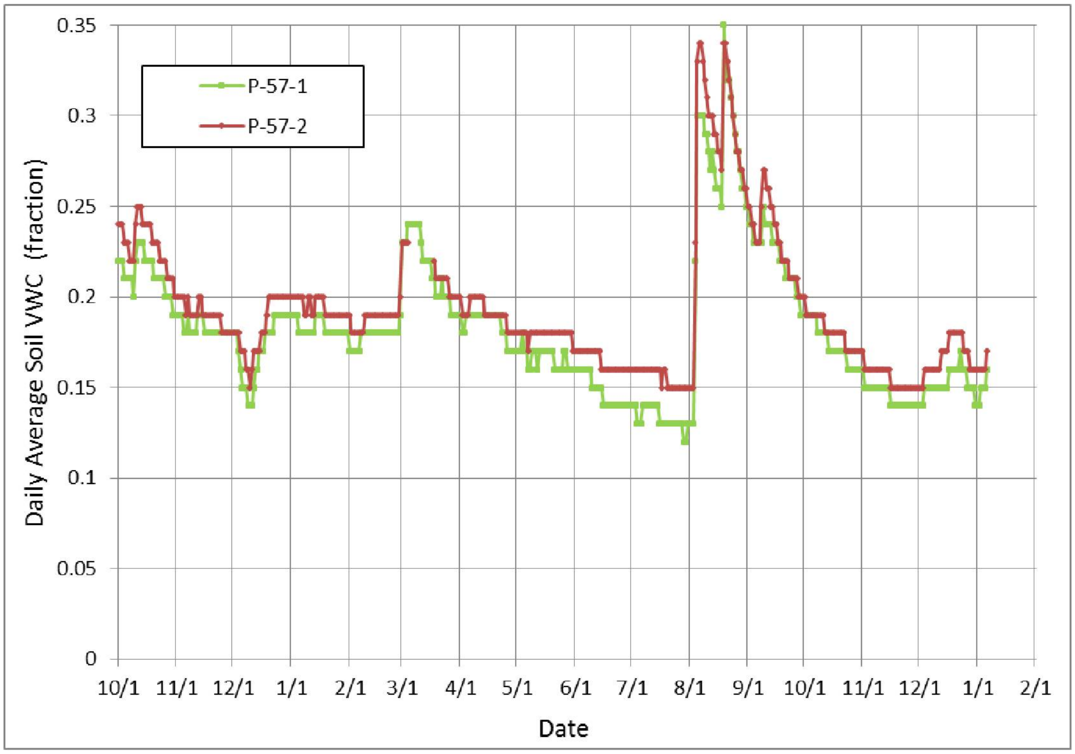
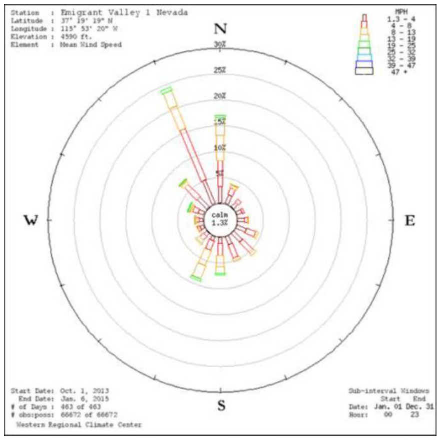


Figure 11. Volumetric soil moisture content is slightly greater at station P-57-2 throughout the reporting period.

For the reporting period, winds were predominantly from either the north-to-northwest or the south-to-southwest quadrants at both Project 57 monitoring stations. Winds from the north to northwest were the most common and occurred 45 percent of the time at P-57-2 and 48 percent of the time at P-57-1 (Figure 12 and Appendix Figures A-12 and A-15). Winds from the south to southwest were the second most common and occurred approximately 20 percent of the time at both stations. To characterize seasonal variations in wind conditions, the collected wind data were segregated into a summer season (March 1 to August 31) and winter season (September 1 to February 28). Seasonally segregated winds came from the same predominant directions as the reporting period winds (Figure 12). However, summer winds from the south to southwest occurred approximately 30 percent of the time at both monitoring stations much more frequently than for the all-seasons assessment. Winter winds were significantly more common from the north to northwest. During the winter, the north to northwest winds occurred 54 percent of the time at P-57-1 and 51 percent of the time at P-57-2, whereas winds from the south to southwest occurred less than 15 percent of the time at both monitoring stations.

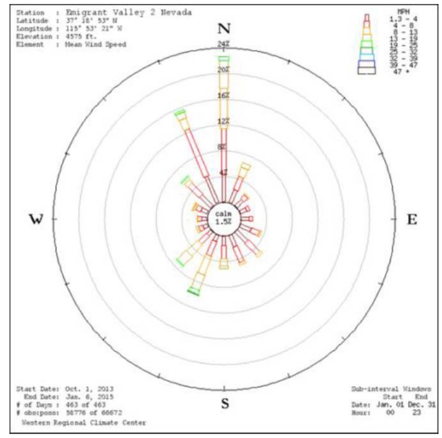
Generally, wind speeds must exceed 15 mph to produce dust by saltation or suspension. At the Project 57 stations, wind speed exceeds 15 mph approximately nine percent of the time during the reporting period. Wind roses for winds in excess of 15 mph (Figure 13) show the same dominant directions seen in the analysis of all winds. However, these stronger winds occur almost as frequently from the south and southwest as they do from the north and northwest.

P-57-1

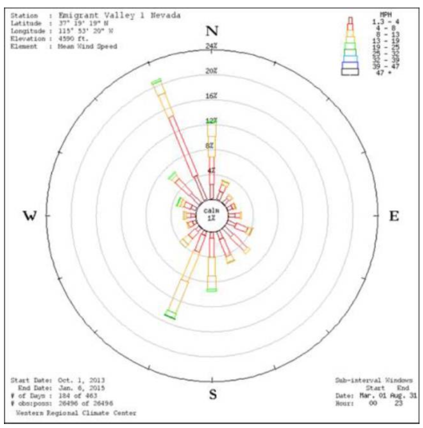


Reporting Period

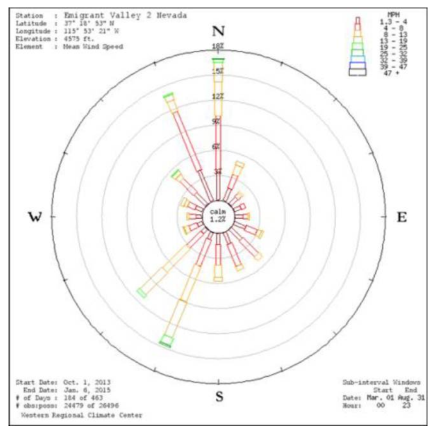
P-57-2



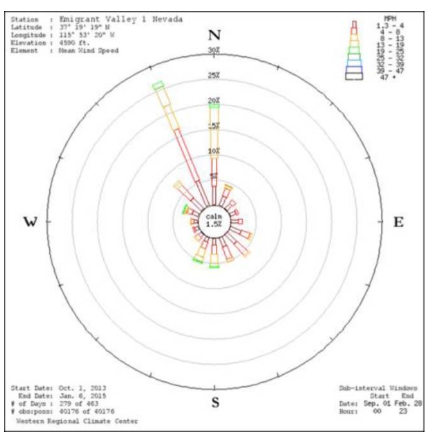
Reporting Period



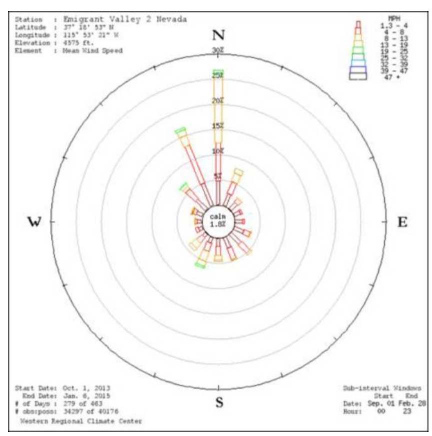
Summer Season



Summer Season



Winter Season



Winter Season

Figure 12. Wind roses generated from the 10-minute average wind speed and direction for the reporting period indicated minor differences between the P-57-1 and P-57-2 monitoring station locations.

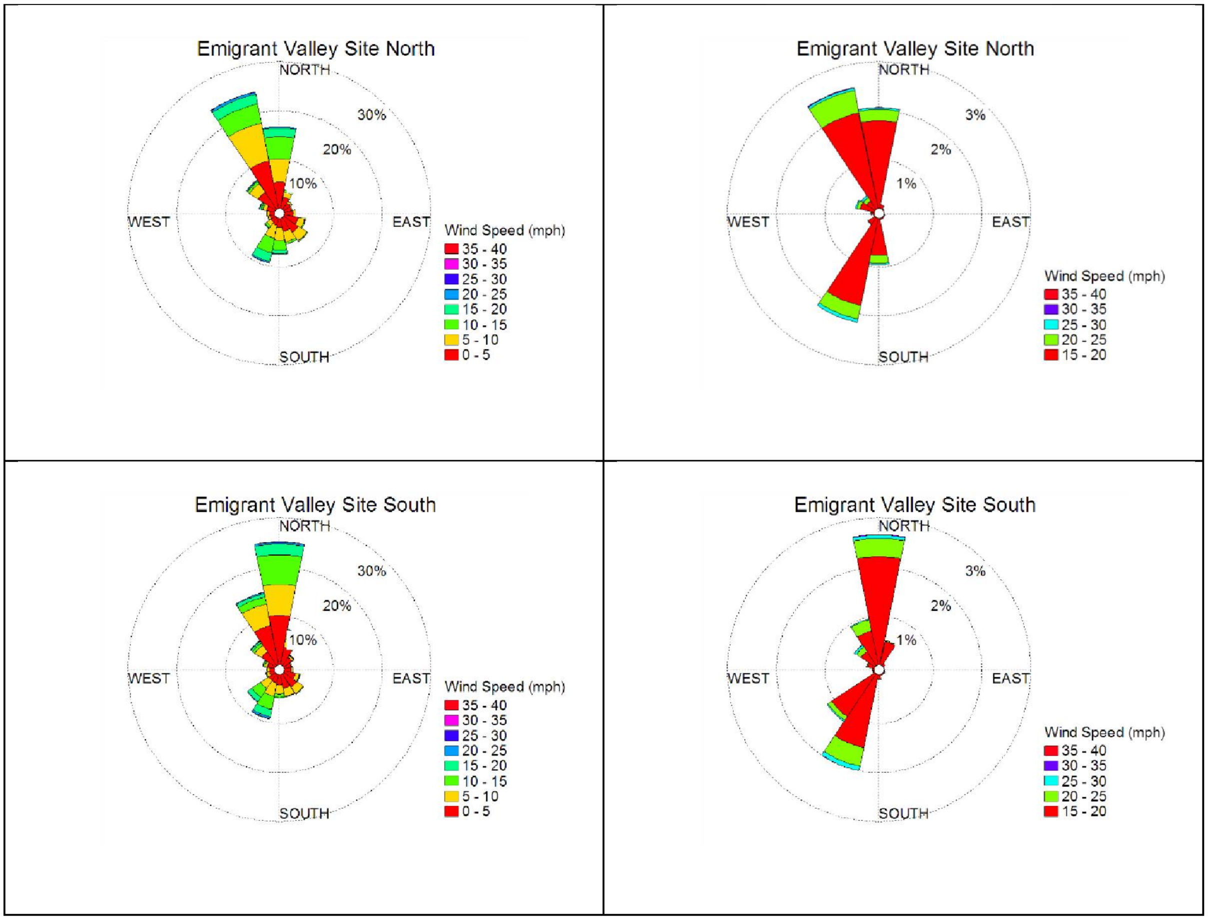


Figure 13. Wind roses for all wind speeds (left column) and for wind speeds in excess of 15 mph (right column) at P-57-1 (north) and P-57-2 (south) monitoring stations.

Both sites are exposed to large diurnal temperature ranges with infrequent precipitation events and seasonally directional winds, which is typical of a Great Basin Desert location. A comparison of the data from both stations shows only minor differences in temperature, precipitation, humidity, and barometric pressure. Wind patterns distinctly show two dominant directions. Soil temperature and moisture show strong similarities in general patterns, but there are clearly identifiable differences as well.

RADIOLOGICAL ASSESSMENT OF AIRBORNE PARTICULATES

Airborne dust particles are collected using Hi-Q™ air samplers located at each of the monitoring stations. These collectors draw ambient air through a 4 in (10 cm) diameter filter at a rate of 56.6 lpm (2 cfm). The collector is designed to maintain a constant flow rate as dust accumulates on the filter. Originally, samples were collected using a cellulose-fiber filter with a pore size of 20 µm to 25 µm. Because of the increased interest in the character of the inhalable dust fraction, the cellulose-fiber filters were replaced with glass-fiber filters (pore size: 0.3 µm) for all samples collected after February 4, 2014. The total volume of air passed through the filter and the total hours of operation are recorded when the filters are collected from the monitoring stations. The deployed filters are collected and new filters are deployed every two weeks. Filters are weighed before and after deployment to determine the mass of the particulates collected. Accumulated filters are periodically submitted to the Radiological Services Laboratory at the University of Nevada, Las Vegas, for gross alpha, gross beta, and gamma spectroscopy assessment.

Mizell *et al.* (2014), Nikolich *et al.* (2015), and Mizell and Shadel (in review) note that gross alpha and gross beta analyses of samples collected on the glass-fiber filters typically result in higher radionuclide concentrations than results obtained for comparable samples collected on cellulose-fiber filters. This is attributed to the greater mass of material, especially the smaller size fraction, that is retained on the glass-fiber filter. During the operational period covered in this report, sample filters were deployed for two-week intervals from September 30, 2013, through January 7, 2015. Therefore, 33 biweekly samples of airborne particulates were collected from monitoring stations P-57-1 and P-57-2. The first nine of these samples (September 30, 2013, through February 4, 2014) were collected on cellulose-fiber filters. The remaining 24 samples were collected on glass-fiber filters.

Tables 4 and 5 summarize the gross alpha and gross beta analyses for the reporting period. As anticipated, the mean gross alpha activity reported for the glass-fiber filter samples is greater than for the cellulose-fiber filter samples for both P-57-1 and P-57-2. Nonetheless, the glass-fiber filter samples also produced the lowest minimum gross alpha activity, as well as the maximum gross alpha activity at P-57-1 (Appendix E). The mean gross beta activity reported for the glass-fiber filter samples is greater than for the cellulose-fiber filter samples for both sites, and maximum activities are also associated with the glass-fiber filters (Table 5 and Appendix E).

Table 4. Gross alpha results for Project 57 sampling stations during FY2014 and the first quarter of FY2015.

Sampling Location	Number of samples	Concentration (x10^{-15} µCi/mL [3.7 x 10^{-5} Becquerel (Bq)/m^3])			
		Mean	**Standard Deviation**	**Minimum**	**Maximum**
P-57-1 (C)	9	1.26	0.64	0.45	2.39
P-57-1 (G)	24	1.57	0.68	0.28	2.76
P-57-2 (C)	9	1.30	0.78	0.36	2.73
P-57-2 (G)	24	1.49	0.67	0.29	2.67

NOTES: Bq = Becquerel; m^3 = cubic meter; µCi/ml = microcurie per milliliter; P-57 = Project 57; (G) = glass-fiber filter; (C) = cellulose-fiber filter; glass-fiber filters retain particulates greater than 0.3 µm; cellulose-fiber filters retain particulates greater than 20 µm. The conversion from cellulose- to glass-fiber filters followed the February 4, 2014, sample collection.

Table 5. Gross beta results for Project 57 sampling stations during FY2014 and the first quarter of FY2015.

Sampling Location	Number of samples	Concentration (x10^{-14} µCi/mL [3.7 x10^{-4} Becquerel (Bq)/m^3])			
		Mean	Standard Deviation	Minimum	Maximum
P-57-1 (C)	9	1.22	0.21	0.9	1.51
P-57-1 (G)	24	1.83	0.35	0.9	2.31
P-57-2 (C)	9	1.28	0.24	0.86	1.67
P-57-2 (G)	24	1.82	0.34	0.97	2.31

NOTES: Bq = Becquerel; m^3 = cubic meter; µCi/ml = microcurie per milliliter; P-57 = Project 57; (G) = glass-fiber filter; (C) = cellulose-fiber filter; glass-fiber filters retain particulates greater than 0.3 µm; cellulose-fiber filters retain particulates greater than 20 µm. The conversion from cellulose- to glass-fiber filters followed the February 4, 2014, sample collection.

Table 6 gives the calendar year (CY) 2014 gross alpha and gross beta concentrations reported for CEMP stations surrounding the northern ranges of the NTTR. Glass-fiber filters are used in the air samplers at the CEMP stations, so the following comparison is limited to the glass-fiber filter samples from the Project 57 monitoring stations. Mean gross alpha concentrations at the Project 57 stations are higher than the values at all of the surrounding CEMP stations with the exception of Sarcobatus Flat. Mean gross beta concentrations at the Project 57 stations are lower than the values at all of the surrounding CEMP stations with the exception of Tonopah, which is reported at a level close to the level observed at the Project 57 stations.

Table 6. Mean annual gross alpha and gross beta concentrations for 2014 reported at CEMP stations that surround the Tonopah Test Range.

Sampling Location	Gross alpha (x10^{-15} µCi/mL)			Gross beta (x10^{-14} µCi/mL)		
	Mean	Minimum	Maximum	Mean	Minimum	Maximum
Alamo	1.38	0.51	3.24	2.00	1.34	2.84
Beatty	0.91	0.25	1.35	1.92	1.11	2.91
Goldfield	1.02	0.63	2.83	1.97	1.28	3.34
Rachel	0.95	0.40	1.65	1.98	1.24	2.78
Sarcobatus Flat	1.71	0.67	3.50	2.10	1.19	3.74
Tonopah	0.90	0.50	1.93	1.81	1.12	3.01

Environmental monitoring on the NNSS collects airborne particulate samples at 16 stations for gross alpha and gross beta analyses. For 2014, the mean annual gross alpha values range from 1.73 x10^{-15} µCi/mL to 3.59 x10^{-15} µCi/mL and average 2.37 x10^{-15} µCi/mL (NSTec, 2015) and the gross beta values range from 1.95 x10^{-14} µCi/mL to 2 2.34 x10^{-14} µCi/mL and average 2.14 x10^{-14} µCi/mL (NSTec, 2015). Gross alpha and gross beta values for the Project 57 stations were less than the values for the NNSS sampling stations.

Gamma spectroscopy identified only naturally occurring radionuclides in the particulate samples collected from the Project 57 monitoring stations during the reporting period (Table 7). The detected radionuclides occurred with varying frequency. Beryllium-7 and lead-210 were the most commonly detected. No anthropogenic, gamma-emitting radionuclides were detected. No indicators of plutonium-239 or plutonium-240 were detected.

Table 7. Gamma spectroscopy analysis of the airborne particulate samples collected during FY2014 and the first quarter of FY2015 detected only four radionuclides. All detected radionuclides are naturally occurring, none are anthropogenic. The frequency of detection varied by radionuclide and location.

Ion	**Number of samples showing detectable concentrations**	
	P-57-1	**P-57-2**
Beryllium-7 (Be-7)	29	28
Lead-210 (Pb-210)	15	11
Potassium-40 (K-40)	1	1
Protactinium-234m (Pa-234m)	2	0

Two TLDs are deployed at each of the Project 57 monitoring stations to determine the radiation exposure dose, whether from natural environmental sources or radiation transported from Project 57 contamination area. The TLDs are collected and replaced quarterly. Tables 8 and 9 give the observed quarterly exposure dose and the estimated equivalent annual dose at the Project 57 monitoring stations. The estimated annual dose at the P-57-1 and P-57-2 monitoring stations is 155.2 millirem (mR) and 153.4 mR, respectively. The millirem (0.001 rem) is a measure of the dose equivalence pertaining to the human body and takes into account both the absorbed energy and the biological effect on the body because of the different types of radiation.

People are constantly exposed to radiation emitted by both the natural environment and anthropogenic sources. Natural environmental sources include cosmic radiation, radiation emitted by the soil and geology of the Earth's surface, radiation ingested in food and water, and radiation from radon gas. The magnitude of natural radiation exposure varies from place to place primarily as a result of differences in local geology and elevation. The general public is also exposed to anthropogenic sources of radiation associated with tobacco products, medical services, and consumer goods. The average annual radiation dose to the general public is estimated to be 620 mR (NRC, 2011), half of which is from natural sources and half of which is from anthropogenic sources (NRC, 2011). At the Project 57 monitoring stations, exposure to natural sources of radiation and any radiation transported from the contamination area is significantly less than (approximately half) the average annual dose experienced by the general public as a result of exposure to natural sources.

The estimated annual radiation dose at the Project 57 monitoring stations, 153 mR and 155 mR, (Table 9) is slightly greater than the dose amounts reported for the CEMP stations surrounding the NTTR which range from 112 mR at Alamo to 144 mR at Sarcobatus Flat (Table 10). These differences are likely because of differences in local geology and elevation.

Table 8. Annual radiological dose rate estimated from TLDs deployed at the P-57-1 monitoring station.

Fiscal Year	Quarter	Days Deployed	Observed Dose (mR)	Estimated Daily Dose (mR)	Estimated Annual Dose (mR)
2014	1	83	36	0.4337	155.2
			37	0.4458	
	2	84	38	0.4524	
			38	0.4524	
	3	91	37	0.4066	
			37	0.4066	
	4	94	39	0.4149	
			41	0.4362	
2015	1	96	39	0.4063	
			38	0.3958	

Table 9. Annual radiological dose rate estimated from TLDs deployed at the P-57-2 monitoring station.

Fiscal Year	Quarter	Days Deployed	Observed Dose (mR)	Estimated Daily Dose (mR)	Estimated Annual Dose (mR)
2014	1	83	35	0.4217	153.4
			36	0.4337	
	2	84	37	0.4405	
			37	0.4405	
	3	91	36	0.3956	
			37	0.4066	
	4	94	41	0.4362	
			40	0.4255	
2015	1	95	37	0.3895	
			39	0.4105	

Table 10. Estimated annual radiological dose (mR) determined from TLDs deployed at CEMP stations surrounding the NTTR.

Station	CY2013	CY2014	CY2015[1]
Alamo	115	119	112
Beatty	139	147	na
Goldfield	122	127	124
Rachel	126	134	120
Sarcobatus Flat	144	144	136
Tonopah	133	137	133

[1] CY2015 estimated dose is calculated from the first quarter data.
na = data not available

OBSERVATIONS OF SOIL TRANSPORT BY WIND

Soil movement initiated by wind forces is characterized as surface creep, saltation, and suspension (Figure 14). Surface creep is a process by which particles are rolled across the ground surface by wind and impacts from saltated particles. Creep particles are generally over 500 µm in aerodynamic diameter and are too heavy to be lifted into air. Saltation is the mechanism by which soil particles in the range of 50 µm to 500 µm are transported. These particles are dislodged and carried a small distance in the air before falling to the ground. Their transport paths usually follow a parabolic trajectory, so the particles essentially bounce across the ground surface. The amount of time the particles are in the air and the distances they travel are functions of wind speed and particle mass. Saltation is important because the impact of saltated particles may push creep particles and dislodge smaller particles and eject them into the air where they are transported by suspension. Suspended particles are usually smaller than 50 µm. Particles less than 20 µm in diameter can be ejected into the air by wind or from impact with saltation-sized particles. Once these particles are suspended in the air, they can be transported over extremely long distances. Fine particles, which are particles with an aerodynamic diameter less than 10 µm (PM_{10}), are small enough to be inhaled by humans and are called respirable suspended particles.

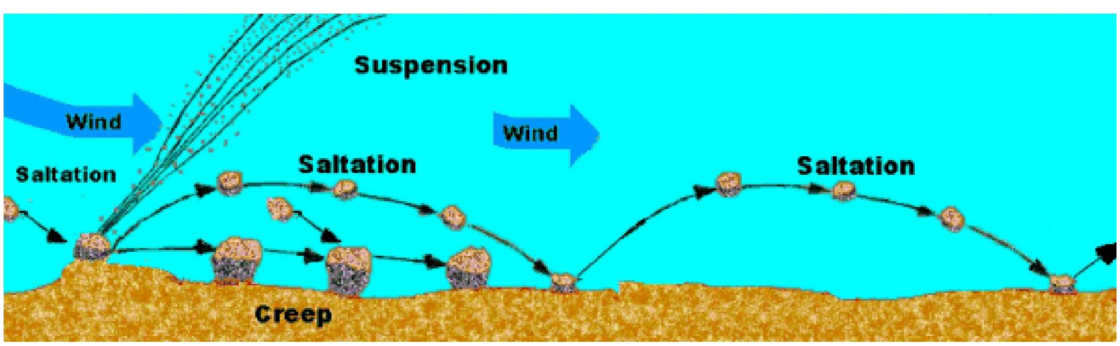


Figure 14. Illustration of the saltation process. (The Weather Doctor, http://www.islandnet.com/~see/weather/elements/dustwind.htm, accessed December 7, 2015.)

The Sensit H11-LIN™ (Sensit, Inc., 1652 Plum Lane, STE 106, Redlands, CA 92373-4594) is deployed at both Project 57 monitoring stations to count soil particles that move by saltation. The sensor impact area is made of piezoelectric material that wraps completely around the vertically oriented instrument. The sensor registers impacts from all directions and converts them to electrical impulses. The impact surface is centered 4 in (10 cm) above the ground surface based on the recommendation of the manufacturer (http://www.sensit.com/images/Tech_Note_5.pdf, accessed December 7, 2015). Particle counts are summed over 10-minute intervals and stored on the station data logger. Currently, the saltation sensors are located near the metrological towers at each station in areas that are free of vegetation and recent disturbances, which might interfere with their operation.

Because raindrop impact dislodges and ejects soil particles into the air, counts on the saltation sensors increase during precipitation events. This is not sand saltation and it does not result in the same type of particle trajectory or dust emission associated with wind-driven saltation. Raindrops can also be carried by wind and hit the saltation sensor and register as false saltation counts. The saltation sensor cannot distinguish between raindrop or soil particle impacts. Therefore, counting periods that are coincident with precipitation are removed from the data set to ensure that the analyses focus on wind driven saltation.

The Sensit™ device at the P-57-1 station operated properly during the reporting period, but the Sensit™ at the P-57-2 station malfunctioned. The P-57-2 Sensit™ instrument was replaced on April 15, 2014, but it started to malfunction again in December 2014. Because more than 40 percent of the saltation data from P-57-2 contains false or suspect saltation counts, all saltation count data from the southern Project 57 monitoring station are excluded from this analysis.

Suspended particles are counted using a Met One™ Ambient Particulate Profiler Model 212 (Met One Instruments, 1600 Washington Blvd., Grants Pass, OR 97526). The Met One™ detects and counts the suspended particle concentration in eight different size groups that range from 0.5 µm to 10 µm in diameter. These particle count concentrations are used to calculate PM_{10} and $PM_{2.5}$ concentrations. Particle counts are reported every minute and the average for each 10-minute interval is recorded in the data logger. The Met One™ instruments are mounted so that the air inlet of the instrument is between 1.5 meters and 1.7 meters from ground, which is the respirable zone for most people.

Wind speed and associated dust conditions observed at the Project 57 monitoring stations are summarized by 5 mph wind-speed classes in Table 11. Light winds (0 to 5 mph [0 to 8 km/hr]) are the most common. Wind speeds in excess of 15 mph (24 km/hr) occur less than nine percent of the time and wind speeds in excess of 20 mph (32 km/hr) occur less than two percent of the time. Figure 15 shows the frequency of occurrence of each wind-speed class. The various wind-speed classes occur with similar frequency at both stations. The frequency plot suggests that wind-speed frequency decays in an approximately exponential pattern as the speed increases.

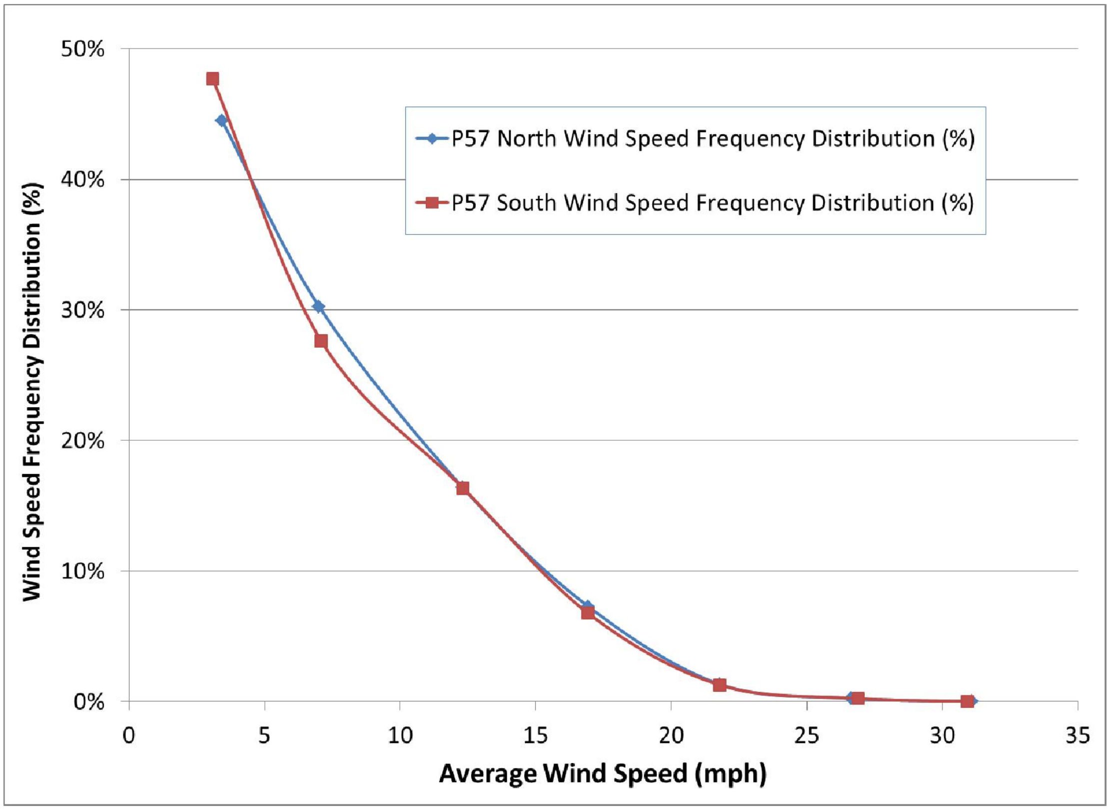


Figure 15. Wind-speed frequency by wind class for stations P-57-1 (north) and P-57-2 (south) from October 1, 2013, through December 31, 2014. The portion of time that wind speed falls within a given class is plotted against the average wind speed for that class.

Table 11. Average saltation particle counts by wind-speed class at Project 57 monitoring stations.

Wind-speed Class (mph)	Duration (hours)	Frequency (%)	Cumulative Frequency (%)	Average Wind Speed (mph)	Average Saltation Particle Counts (count/10 min)	Average PM_{10} (µg/m^3)	Average $PM_{2.5}$ (µg/m^3)
P-57-1							
0 – 5	4,832.83	44.462	44.462	3.44	0.01	5.95	0.69
5 – 10	3,287.33	30.243	74.705	7.02	0.02	5.58	0.69
10 – 15	1,782.00	16.394	91.099	12.31	0.08	5.40	0.71
15 – 20	791.67	7.283	98.382	16.94	0.11	7.79	0.88
20 – 25	145.50	1.339	99.721	21.78	0.80	19.21	1.50
25 – 30	28.00	0.258	99.979	26.64	16.95	53.04	3.58
30 – 35	2.33	0.021	100.000	31.09	7.21	102.12	6.34
Total	10869.7						
P-57-2							
0 – 5	4,990.83	47.669	47.669	3.09	No data	4.91	0.67
5 – 10	2,892.17	27.624	75.294	7.09	No data	4.98	0.69
10 – 15	1,713.33	16.365	91.658	12.32	No data	5.18	0.70
15 – 20	709.33	6.775	98.434	16.93	No data	7.83	0.82
20 – 25	135.17	1.291	99.725	21.77	No data	20.70	1.44
25 – 30	26.00	0.248	99.973	26.89	No data	69.87	3.71
30 – 35	2.83	0.027	100.000	30.91	No data	122.98	6.46
Total	8161.3						

Saltating particle counts are strongly dependent on wind speed. Although wind speeds below 15 mph occur approximately 91.1 percent of the time (Table 11), they only account for approximately 26.71 percent of all saltation counts. The 25 to 30 mph wind-speed class, which accounts for approximately 0.26 percent of the winds, had the highest average count per 10-minute period and accounts for approximately 67 percent of the saltation counts. Sustained winds of 30 to 35 mph occurred for a total of only two hours and twenty minutes, approximately 0.02 percent of time. This is the highest wind-speed class and it has an average saltation count of 7.21 per 10-minute period. This average is lower than the average for the 25 to 30 mph wind-speed class. Perhaps the decrease is the result of a limited supply of saltation-sized sand that is exhausted before winds exceed 30 mph. The limited saltation data associated with the highest wind-speed class may be inadequate to generate a statistically robust average. Figure 16 shows that the relationship between wind speed and saltation particle count is highly nonlinear and that saltation counts increase significantly for wind speeds over 20 mph.

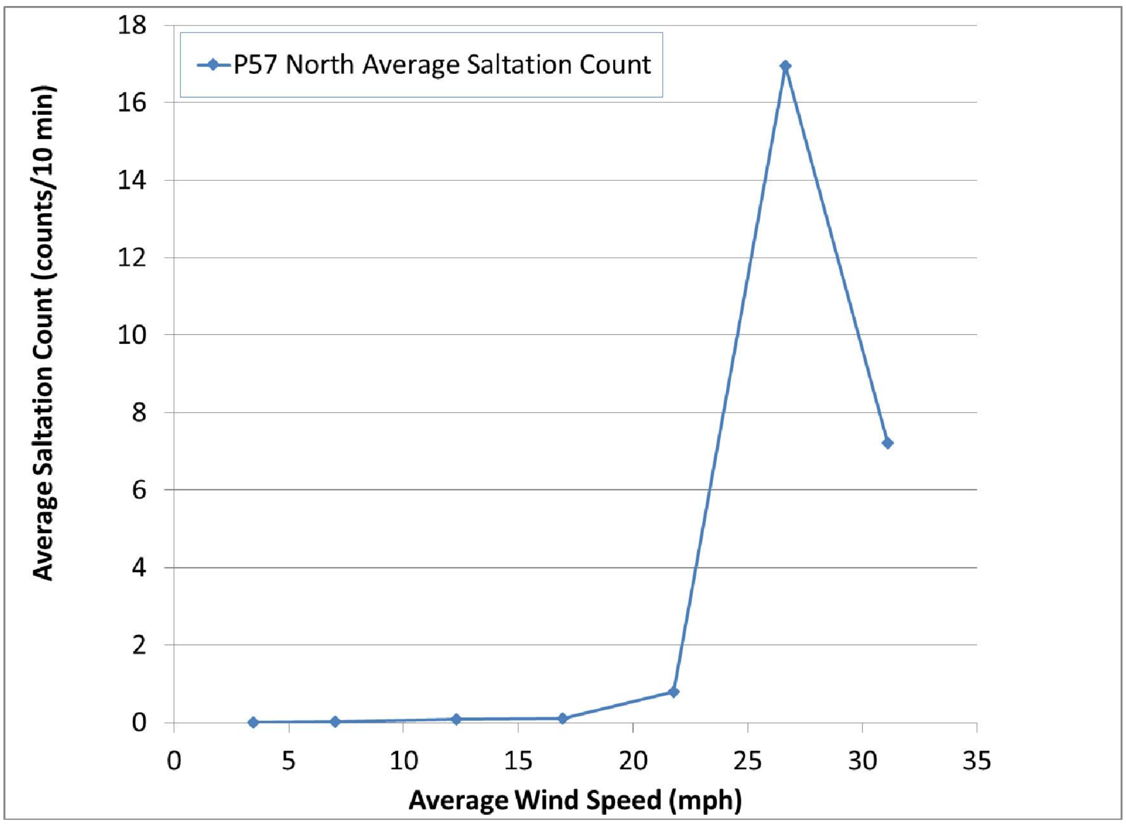


Figure 16. Average saltation counts generally increase rapidly as the wind speed exceeds 15-20 mph at the P-57-1 (north) monitoring station.

The PM_{10} concentrations generally increase as wind speed increases. The PM_{10} concentrations remain fairly low at wind speeds below approximately 20 mph (32 km/hr), which occur more than 98 percent of the time (Table 11). The PM_{10} concentration increases dramatically for wind speeds in excess of 20 mph (32 km/hr). At P-57-1, the PM_{10} concentration exceeds 100 µg/m^3 for winds in the highest wind-speed class. At P-57-2, the PM_{10} concentration exceeds 120 µg/m^3 for the highest wind-speed class. However, high wind and the corresponding high PM_{10} events are relatively rare and generally last for only short periods of time. Wind speed exceeds 30 mph (48 km/hr) only 0.02 percent of the time (< 3 hr) during the 15 month data collection period covered in this report.

At the P-57-1 and P-57-2 stations, the average PM_{10} concentration increases in an approximately exponential pattern (Figure 17). As expected, the two monitoring stations show similar trends and values for average PM_{10} concentrations. The values are nearly identical for wind speeds below 25 mph. For wind speeds over 25 mph, P-57-2 recorded slightly higher PM_{10} readings than P-57-1. Although the PM_{10} concentration increases approximately exponentially at high wind speeds, this does not imply that large volumes of soil material are moving because the wind speeds necessary to generate the higher PM_{10} concentrations occur less than approximately two percent of the time. The annual PM_{10} average for P-57-1 is 6.2 µg/m^3, of which only 0.41 µg/m^3 is associated with wind speeds greater than 20 mph. The trend is similar at P-57-2 where the annual PM_{10} average is 5.6 µg/m^3 and only 0.47 µg/m^3 is associated with wind speeds in excess of 20 mph.

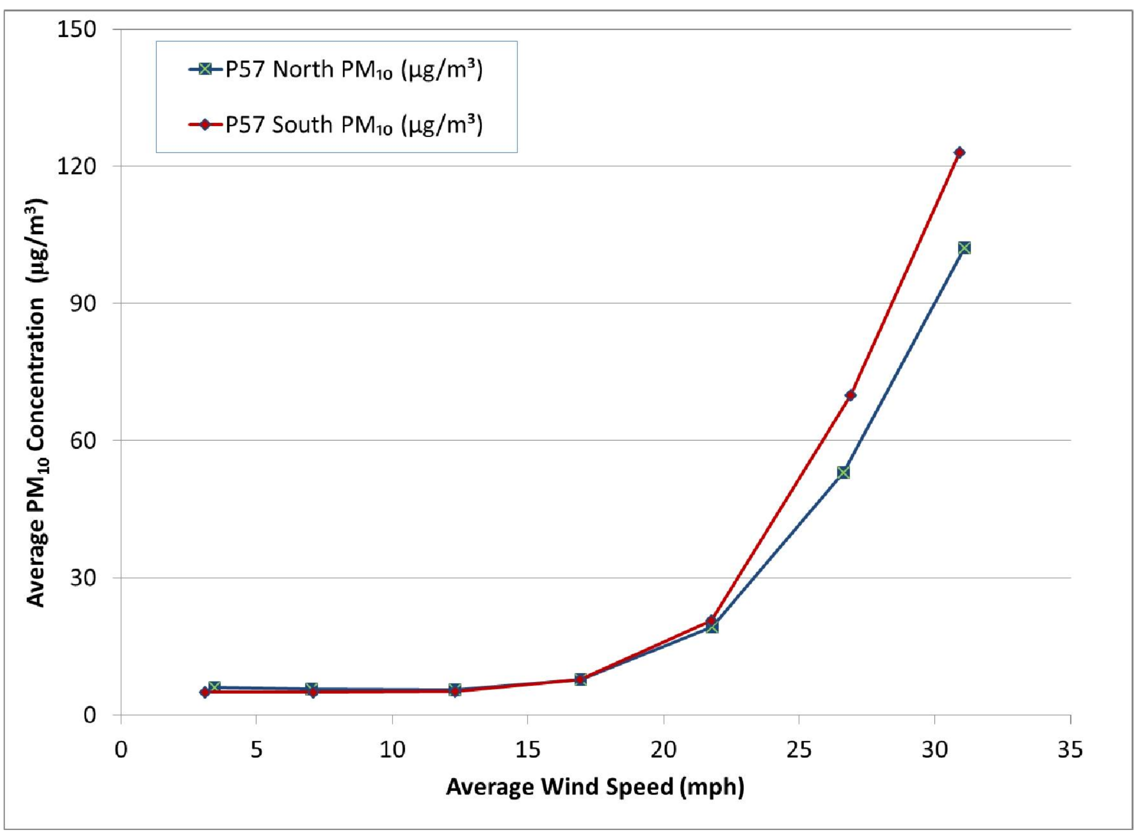


Figure 17. PM_{10} trends as a function of wind speed for stations P-57-1 (north) and P-57-2 (south).

The $PM_{2.5}$ concentration as a function of average wind-speed class is show in Figure 18. The average 10-minute $PM_{2.5}$ concentration is virtually identical at both Project 57 monitoring stations. The $PM_{2.5}$ concentration increases with increasing wind speed in a pattern similar to those observed for both saltation counts and PM_{10}. All three measures of dust transport exhibit an approximately exponential increase in dust concentration with increasing wind speed.

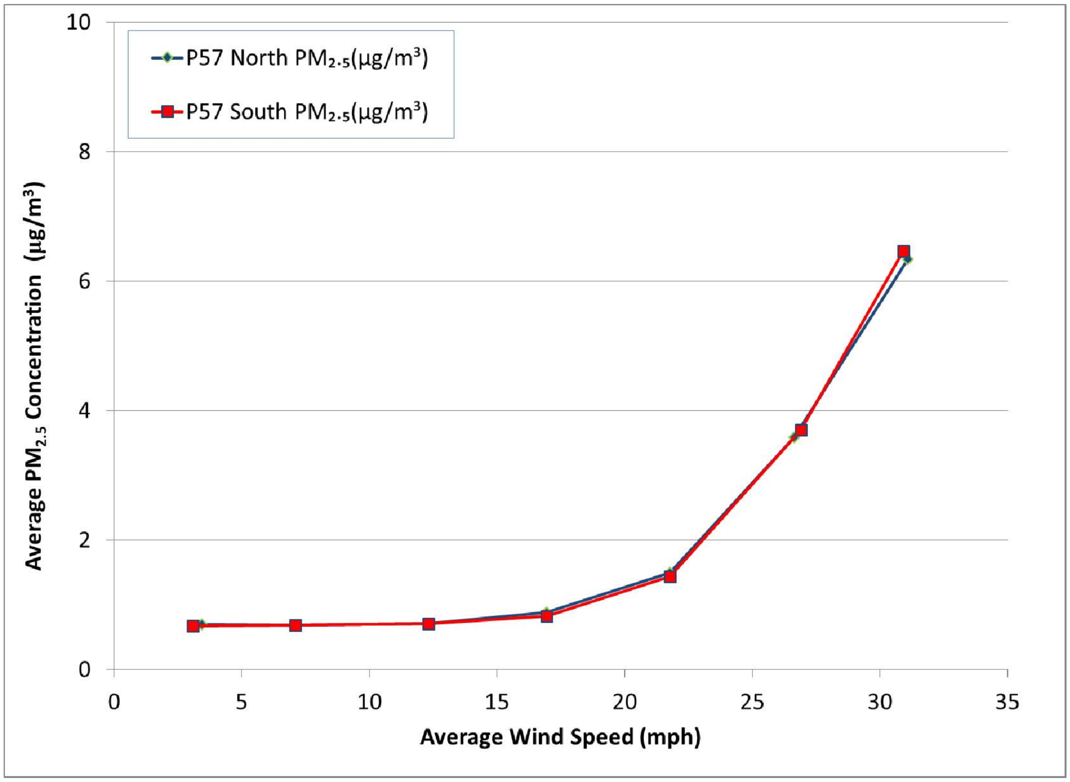


Figure 18. $PM_{2.5}$ trends as a function of wind speed for stations P-57-1 (north) and P-57-2 (south).

DUST SOURCE PROXIMITY ANALYSIS

Wind is the driving mechanism for the transport of dust, soil particles, and radionuclides attached to soil particles. In trying to ascertain dust and radionuclide transport from the Project 57 contamination area, it is difficult to decouple the Project 57 contamination area from other dust source areas that contribute to the observed dust conditions. Native, undistributed desert areas in the arid Southwest are known to emit dust under strong winds. The Project 57 contamination area is likely to exhibit the same or similar dust emission potential as the surrounding areas. The proximity of source areas to the point of dust observation is qualitatively indicated by the relative portions of saltated particles, PM_{10} concentration, and $PM_{2.5}$ concentration. Saltated particles are the largest and heaviest and will have shorter residence time in the atmosphere and travel shorter distances than the smaller and lighter PM_{10} particles. The $PM_{2.5}$ particles are the smallest and lightest particles. They have the lowest settling velocity and longest residence time in the atmosphere, and therefore will travel the farthest.

Saltated particles are likely to dislodge and eject smaller particles from the soil surface, which increases the concentration of resuspended PM_{10} and $PM_{2.5}$ beyond the concentration from wind resuspension alone. Because saltated particles do not travel great distances, saltation is essentially a local phenomenon. If observed saltation counts and PM_{10} concentrations are both high, it is probable that a significant portion of the PM_{10} material is locally derived. Also, if observed saltation counts are low and PM_{10} concentrations are high, it is probable that a significant portion of the PM_{10} material is derived from a somewhat more distant source.

Figures 16, 17, and 18 indicate that saltation particle count, PM_{10} concentration, and $PM_{2.5}$ concentration increase with wind speed, which suggests that the source area for the observed dust is local. Figure 19 shows the relationship between PM_{10} concentration and saltation particle counts when aggregated and averaged by wind-speed class. Although the correlation coefficient is positive (0.43), the functional relationship is not immediately clear. Although the correlation indicates that the PM_{10} increases as the saltation particle counts increase, it is not possible to establish a clear relationship between saltation particle counts and PM_{10} for high-wind conditions, which might be partially because of a limited supply of sand as mentioned previously.

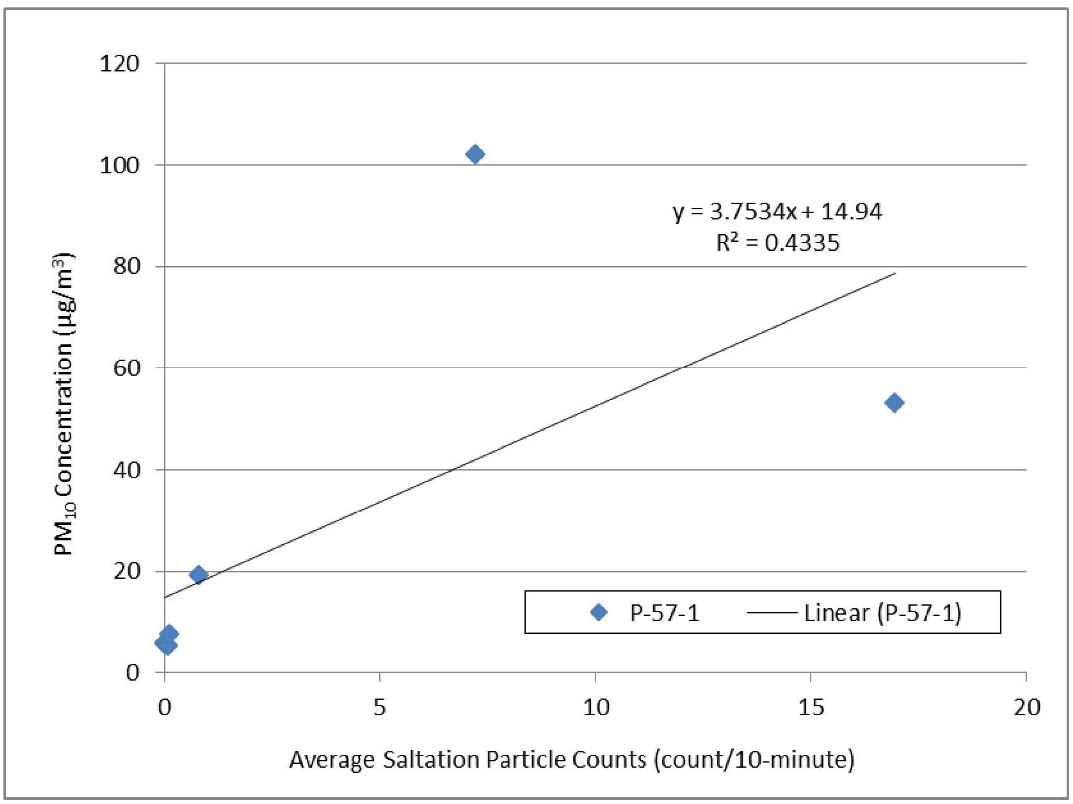


Figure 19. Regression of PM_{10} against saltation counts for wind-speed class shows a good linear relationship.

Under normal atmospheric conditions, PM_{10} concentrations are usually four to eight times higher than $PM_{2.5}$. Those values can be exceeded when there are local resuspension sources and windy conditions. A higher PM_{10} to $PM_{2.5}$ ratio indicates aerosol closer to the source area. The ratio between PM_{10} and $PM_{2.5}$ for increasing wind-speed classes is shown in Figure 20. Both stations show a significant increase in this ratio from around 6 to 8 for wind speeds under 20 mph to over 12 for wind speeds over 20 mph. Although the increase in the PM_{10} to $PM_{2.5}$ ratio is greater at P-57-2 than at P-57-1 the difference between the ratio at the two stations is small and the pattern of increase is similar suggesting that the soil particulate emission potential at the two stations is similar.

At wind speeds in excess of 20 mph saltation particle counts increase (Figure 16). The combination of these high winds and saltation activity results in a significant increase in the PM_{10} and $PM_{2.5}$ concentrations (Figures 17 and 18) and the PM_{10} to $PM_{2.5}$ ratio (Figure 20). This means that under high wind conditions some of the suspended PM_{10} is locally derived from the vicinity of the monitoring stations. The increase in saltation particle counts is the best indicator of local sand and dust transport but the increase in the PM_{10} to $PM_{2.5}$ ratio also indicates that suspended dust includes some locally sourced material.

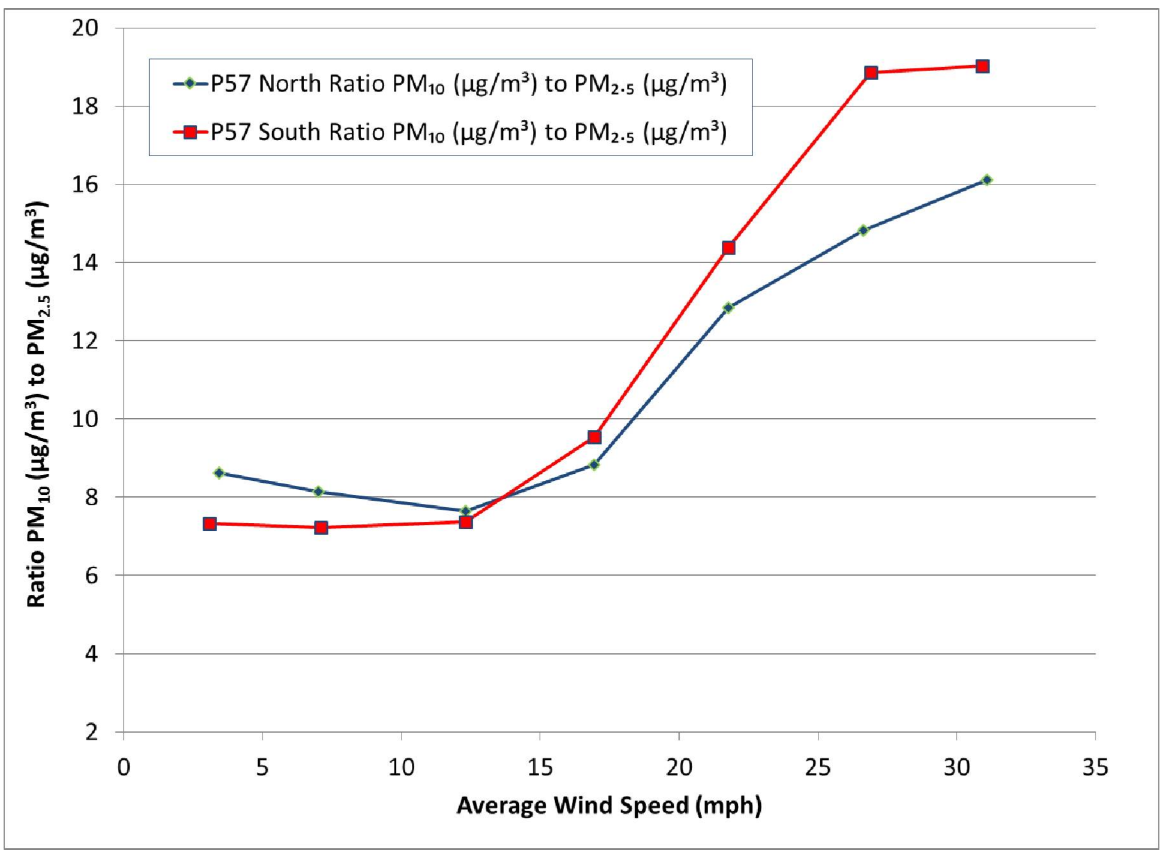


Figure 20. Ratio of PM_{10} to $PM_{2.5}$ as a function of wind-speed class for P-57-1 (north) and P-57-2 (south).

MAJOR DUST AND SALTATION TRANSPORT EPISODES

Most dust transport occurs during high-wind events that are usually short in duration. The strongest wind events usually occur between March and May and between October and January. Table 12 summarizes the wind and dust conditions associated with 10 of the most notable wind episodes observed during the reporting period. Appendix Figures D-1 through D-10 show the wind and dust conditions that were observed during the wind episodes at P-57-1 based on the available saltation and wind data.

During the high-wind episodes, wind speeds were above 15 mph and rose to between 20 mph and 35 mph. Wind directions during these events represented both of the predominant wind directions, north to northwest and south to southwest. The resuspended PM_{10} dust concentrations ranged from near 10 $\mu g/m^3$ to maximums in excess of 350 $\mu g/m^3$. Ten-minute saltation counts were also variable and ranged from zero to 1,300 counts/10-minute interval. High PM_{10} concentrations and low saltation counts are generally interpreted to indicate that the suspended dust was derived from a distant source area.

Table 12. Description of wind and dust conditions during selected high-wind episodes observed during the reporting period.

Date	Wind Speed (mph)	Wind Direction	PM_{10} ($\mu g/m^3$)	Saltation (#/10 min)	Figure	Comments
Oct 28, 2013	20 to 25	south	90	0	D-1	- little soil transport from immediate vicinity of monitoring stations - increase in PM_{10} because of long-range transport with small local addition
Nov 22, 2013	25	north	10 to 12	3 to 6	D-2	- minimal long range transport because of low PM_{10} - some local transport due to saltation -good correlation between local saltation counts and increase in PM_{10} -saltation counts correspond well with increase in measured wind speed
Dec 3, 2013	25 to 30	north	350	1,300	D-3	- some local dust transport during this episode due to very high saltation counts - transport limited by short duration and limited supply of saltation material - very good correlation between local saltation counts and PM_{10} concentration - local transport event lasted approximately 30 minutes
Mar 11, 2014	15	north	120	0	D-4	- nearby ground disturbance or possible long range transport may have caused PM_{10} increase - relative low wind speed (below resuspension threshold) resulted in elevated PM_{10} - no local saltation activity
Mar 17, 2014	25	northwest	80	7 to 10	D-5	- typical springtime wind episode accompanied with very strong sustained winds exceeding 20 mph - winds gusting over saltation threshold cause increase in PM_{10} - long range transport based on episode duration and wind speed with some local transport suggested by local saltation activity - brief periods of strong local activity when PM_{10} increases are correlated with local saltation activity and local winds

Table 12. Description of wind and dust conditions during selected high-wind episodes observed during the reporting period (continued).

Date	Wind Speed (mph)	Wind Direction	PM_{10} (µg/m³)	Saltation (#/10 min)	Figure	Comments
Mar 26, 2014	5 to 20	northeast to south	20 to 35, spike to 80	7	D-6	- long range transport episode based on episode duration, wind speed direction, and relatively limited increase in PM_{10} concentration -some local transport in which increase in local wind speed is well correlated with increase in saltation activity and PM_{10} -local relatively quick wind speed jumps correlate with jumps in PM_{10} indicating local resuspension of PM_{10}
Apr 22, 2014	25 to 30	south	40 to 80 spike to 270	0	D-7	- strong spring time wind episode results in the combination of long range and local transport - low saltation activity but correlated increases in wind speed and corresponding increases in PM_{10} indicate local contribution to dust transport
Apr 25, 2014	25 to 30	south	20 to 130	5	D-8	- spring time wind episode with consistent winds from the south resulted in long range transport with some local contribution to dust when 10 minute average wind speeds exceeded 25 mph - low saltation counts well correlated with wind speed and PM_{10} increases
May 11, 2014	20 to 35	north	0 to 350	0 to 25	D-9	- strong wind episode with strong local transport - wind speed peaks drive saltation and PM_{10} increases - initial wind maxima resulted in the local saltation and PM_{10} increase - subsequent wind maxima did not produce same PM_{10} level, suggesting limited availability of fine dust supply
Sep 25 and 26, 2014	20 to 25	south	5 to 80	0 to 3	D-10	- strong wind episode spanning two days with wind maxima around noon time of each day, winds consistently from south - long range transport indicated by modest increase in PM_{10} and steady concentration overnight when winds are well below 15 mph but still out of south - limited local contribution due to very low saltation counts but with some addition of local PM_{10}

DISCUSSION

Dust collected at the monitoring stations is analyzed for gross alpha, gross beta, and gamma spectroscopy to determine if radiological contaminants are being transported by wind from the Project 57 contamination area. Some gross alpha and gross beta radioactivity is expected because of natural radioactivity associated with the geologic environment and cosmic radiation. To determine if radioactivity at the Project 57 stations is the result of natural radiation or is because of contamination of the area during the safety experiment, values from the Project 57 stations are compared with values for other monitoring stations in the region. In contrast, gamma spectroscopy of dust samples objectively determines the presence or absence of radionuclides of concern. All of the gamma spectroscopy analyses during the reporting period indicate the presence of only naturally occurring radionuclides.

Neither background nor baseline values for gross alpha and gross beta have been established for the Project 57 region. Background can vary spatially because of many different environmental factors and in the case of the Project 57 site, the current baseline may be expected to differ from background because of the distribution of radionuclides during the Project 57 test. The CEMP station 2014 radiological results are used to compare gross alpha and gross beta concentrations in noncontaminated areas in the region. Generally, higher gross alpha values are observed for the Project 57 stations compared with most of the CEMP stations. The similar gross alpha measurements at the CEMP Sarcobatus Flat station are an exception, and suggest that gross alpha at the Project 57 stations reflects background conditions rather than an elevated baseline because of Project 57 contamination. These observations and interpretations lead to the conclusion that none of the radiological analyses indicate that radionuclide migration was captured by the Project 57 monitoring stations during the reporting period.

Project 57 monitoring stations, P-57-1 and P-57-2, are located in the predominant downwind directions for winds blowing across the southeast portion of the contamination area. At these locations the P-57-1 station is located in an area identified as having low Am-241 concentrations (Figure 2) but both stations are east of positions where the predominant winds blowing across the ground zero pass beyond the contamination area. Therefore, monitoring stations P-57-1 and P-57-2 are less likely to detect contaminant transport from the area of highest radioactivity levels in the Project 57 contamination area. These limitations on the spatial coverage of the current monitoring stations highlight the importance of another objective of the monitoring efforts, which is to identify conditions that could allow contaminant transport to occur.

Specifically, saltation sensors record the movement of larger particles (usually larger than 50 µm) across the ground surface. Saltation is found to be strongly correlated with PM_{10}, which indicates that saltation is important for increasing the concentration of fine material in suspension. The PM_{10} concentrations are generally low until winds exceed 15 to 20 mph. Meteorological data from the stations reveal that wind speeds exceed 20 mph less than two percent of the time, but the exponential relationship between dust and wind speed for both saltation and suspension indicates that these high winds are when more particles move.

The $PM_{2.5}$ concentration is virtually identical at both P-57-1 and P-57-2 at all wind speeds. However, the PM_{10} concentration is higher at P-57-2 for wind speeds above 25 mph. Thus, station P-57-2 has a larger PM_{10} to $PM_{2.5}$ ratio, which indicates a more local source for particles captured at P-57-2 compared with P-57-1. In total, these observations suggest that there are more favorable conditions for particle movement on the south side of the contamination area. These conditions may result from differences in local land disturbance, local vegetation density or type, or wind direction (all wind directions are combined in this preliminary analysis).

The combined results of the meteorological and particle monitoring at the Project 57 sites suggest that conditions for wind-borne contaminant migration exist but occur infrequently and for brief periods. Radiological monitoring did not detect contaminants at the stations. It remains undetermined whether contaminants at the sites are stabilized such that they are not subject to movement during wind events or whether such movement is occurring but has not reached, has bypassed, or has not been captured by the monitoring stations.

CONCLUSIONS

1. The Project 57 mean gross alpha and gross beta data are within the range of observations at CEMP stations in the region, suggesting that radiation at the Project 57 monitoring stations is due to natural (terrestrial and cosmic) sources.
2. Gamma spectrometry analyses of biweekly samples of airborne particulates collected at the Project 57 monitoring stations during the reporting period indicated only naturally occurring gamma-emitting radionuclides. No anthropogenic gamma-emitting radionuclides were identified in any sample.
3. Observations of radiation dose at the Project 57 monitoring stations indicate that the dose from natural sources and transport from the Project 57 contamination area is approximately half of the dose that the general public is expected to receive from natural sources alone. The low natural radiation dose exposure at the Project 57 monitoring stations is likely due to lower levels of radiation emitting from the local geology.
4. Generally, saltation counts, PM_{10} concentrations, and $PM_{2.5}$ concentrations increase exponentially with increasing wind speed. The greatest increase in dust occurs for winds exceeding 20 mph. At the maximum observed wind speeds the saltation counts drop, which suggests that the material available for saltation is temporarily expended. The PM_{10} and $PM_{2.5}$ concentrations do not exhibit a similar decline at the extremely high wind speeds, but instead continue to increase.
5. Wind speeds exceed 15 mph only approximately 9 percent of the time and 20 mph only approximately 1.6 percent of the time. Winds that are sufficient to generate significant dust are infrequent and generally of short duration. Therefore, significant dust events are also infrequent and short-lived.
6. Preliminary review of the 10 highest wind-speed events during the reporting period indicates that the PM_{10} concentration and the saltation count observations are highly variable.

RECOMMENDATIONS

1. As wind direction data was accumulated at the P-57-1 and P-57-2 stations project personnel recognized that the predominant wind directions did not traverse the Project 57 ground zero before reaching the monitoring stations. Project personnel recommended that the stations be relocated along the predominant wind directions in line with the ground zero. The stations were relocated in early January 2015 coincidentally with the start of Quarter #2 of FY2015.
2. Material from the BSNE collectors should be retrieved and analyzed to determine the radiological characteristics of the particles as this material is collected closer to the ground than the air filters. Additionally, it may be possible to compare the mass of collected saltation with the Sensit saltation counts or to assess variation in saltation flux along the fence line. If collection volumes allow, retrieval of material from the BSNEs should be performed frequently enough to permit seasonal evaluation of saltation transport. A procedure for collection, handling, and analysis of the collected saltation material requires coordination with other organizations.
3. Separating the monitoring data by predominant wind direction will allow wind speed, PM_{10} concentrations, and saltation activity associated with winds transiting the contamination area and winds transiting noncontaminated ground to be assessed separately. It may also allow the wind patterns evaluation of changes in wind and dust conditions as the winds transit the contamination area.
4. Size analysis of a representative sample of the soil material on the surface at each of the monitoring stations should be performed. This would facilitate characterization of the amount of PM_{10} and saltation material available at each site. This information would in turn be useful for interpreting the saltation and dust transport observations.
5. Establishing background/baseline conditions for the airborne particulate radionuclide concentrations is important for interpreting the Project 57 data. Monitoring data from the surrounding CEMP stations are important for bracketing the results from the Project 57 monitoring stations. These locations should be evaluated to identify comparable and contrasting characteristics. There may also be information on uncontaminated soil sites on the NNSS that are comparable. Another alternative is to establish an additional monitoring/sample collection station near Project 57 that is environmentally similar but not subject to potential transport from the Project 57 contamination area. This site would provide control samples from an area that presumably is clean, which could be compared with samples from the contamination area.
6. The analysis of PM_{10} to $PM_{2.5}$ ratio should be continued as an indication of the proximity of dust sources detected at the Project 57 monitoring stations. These analyses should be performed for individual high-wind/high-dust events as well as for average observations conditions.
7. Meteorological and other environmental conditions that potentially affect PM_{10} and $PM_{2.5}$ concentrations and saltation counts should be investigated. Although wind is the dominant force for suspension and transport of airborne dust other conditions are also likely to have an effect. Moist or frozen soil is less likely to be suspended than dry soil, therefore, an assessment of airborne dust and soil moisture and temperature and perhaps other factors should be performed.

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APPENDIX A: METEOROLOGICAL OBSERVATIONS AT PROJECT 57 MONITORING STATIONS FOR THE REPORTING PERIOD (OCTOBER 1, 2013, THROUGH JANUARY 7, 2015)

Definitions

10-minute average = average of 200 instantaneous observations made every 3 seconds during each 10-minute time period

Daily maximum = maximum of 144 10-minute averages of 3-second observations

Daily minimum = minimum of 144 10-minute averages of 3-second observations

Daily average = average of 144 10-minute averages made during the 24-hour period

Daily period of record maximum = maximum of daily maximums for specific calendar date during the period of record

Daily period of record minimum = minimum of daily minimums for specific calendar date during period of record

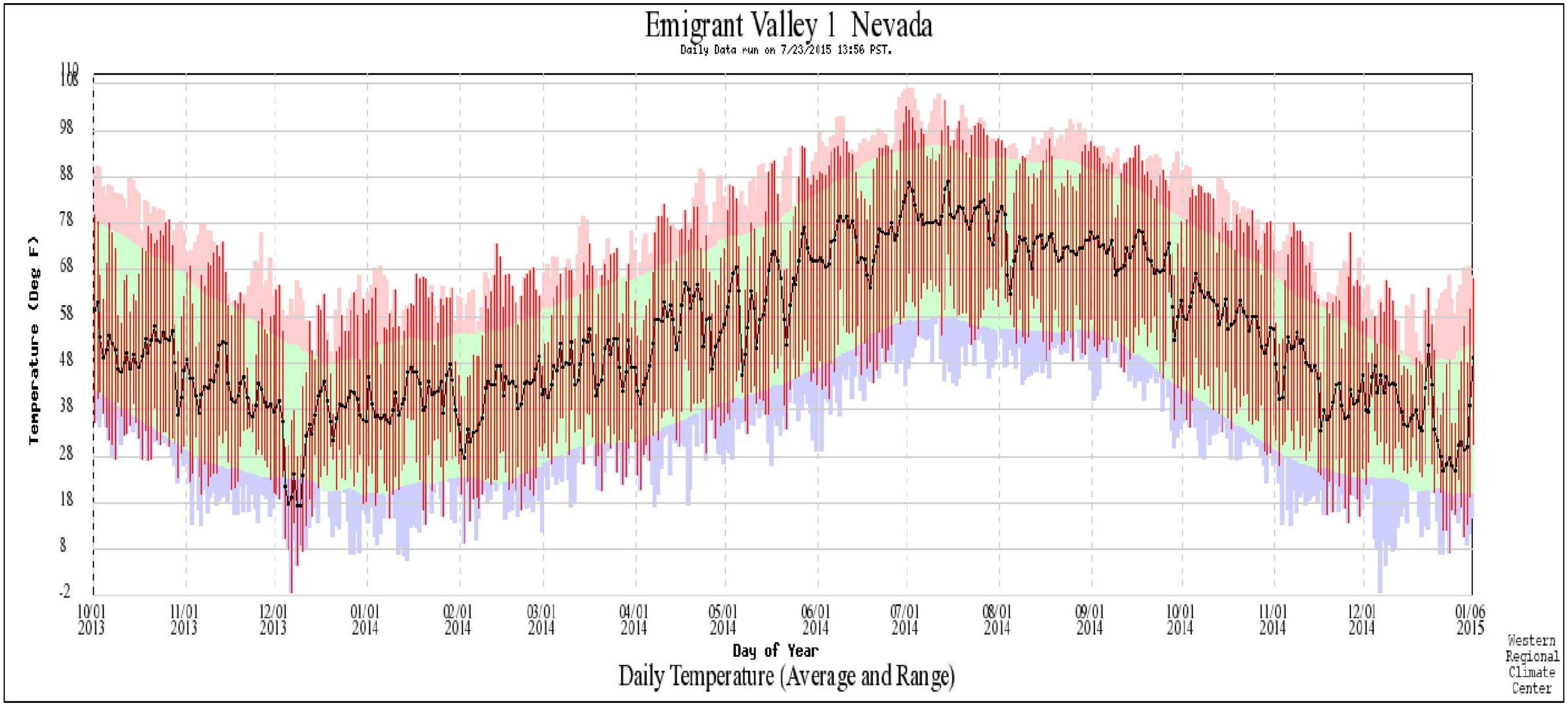

Figure A-1. Daily maximum, minimum, and average air temperature at P-57-1 for the reporting period and for the period of record. The black line connects the daily average temperature. The bright red vertical line connects the maximum and minimum temperature values for each day. The pastel green zone is bounded by the 29-day moving average of the maximum and minimum daily maximum and minimum temperatures for each calendar day for the period of record. The pastel red and pastel blue vertical lines mark the highest and lowest daily maximum and minimum, respectively, observed on the specific calendar day for the period of record.

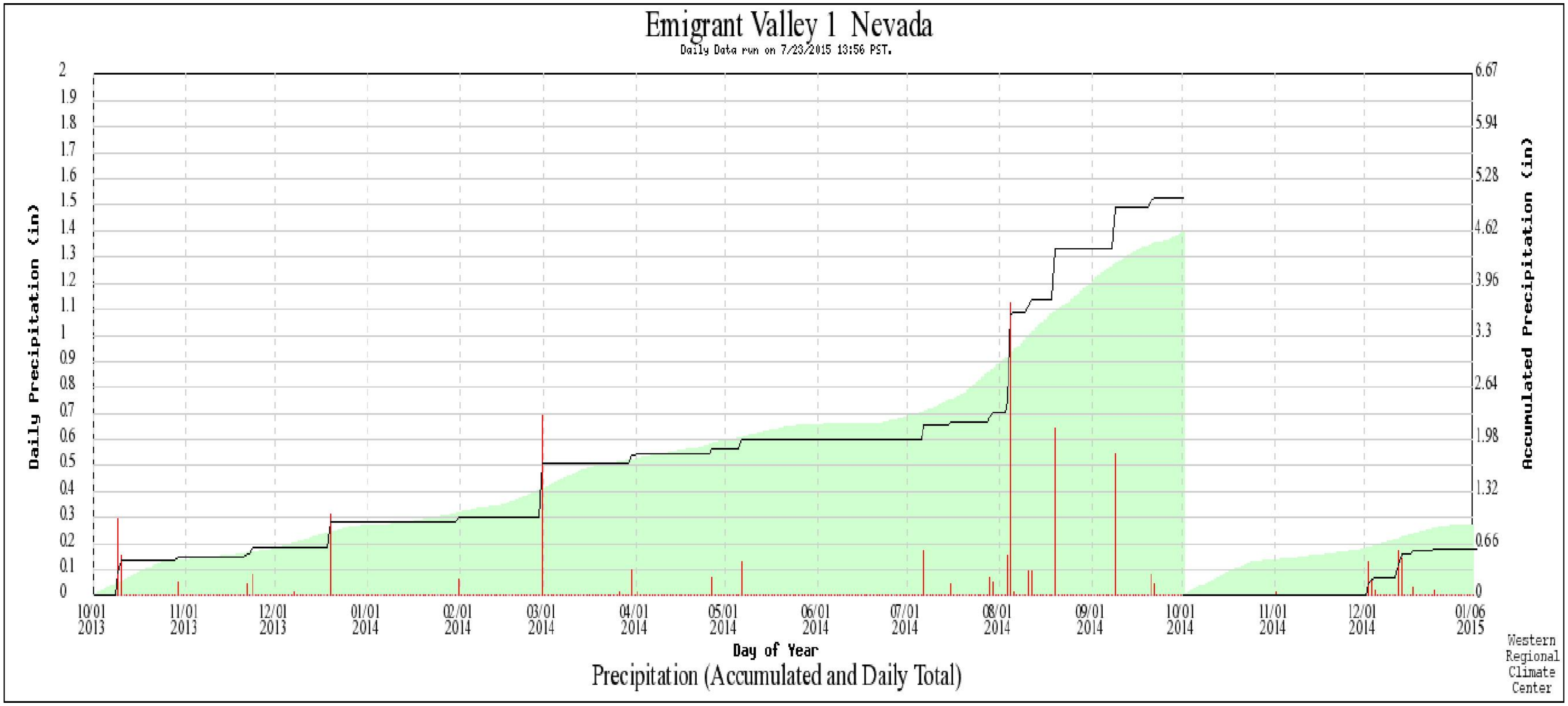

Figure A-2. Total daily precipitation (vertical red lines) and annual accumulated precipitation (black line) at P-57-1 for the reporting period. Note that the annual accumulation was reset to zero at the beginning of the fiscal year on October 1, 2014. The pastel green shaded area represents the average annual precipitation accumulation derived from the average total precipitation for the specific calendar day for the period of record.

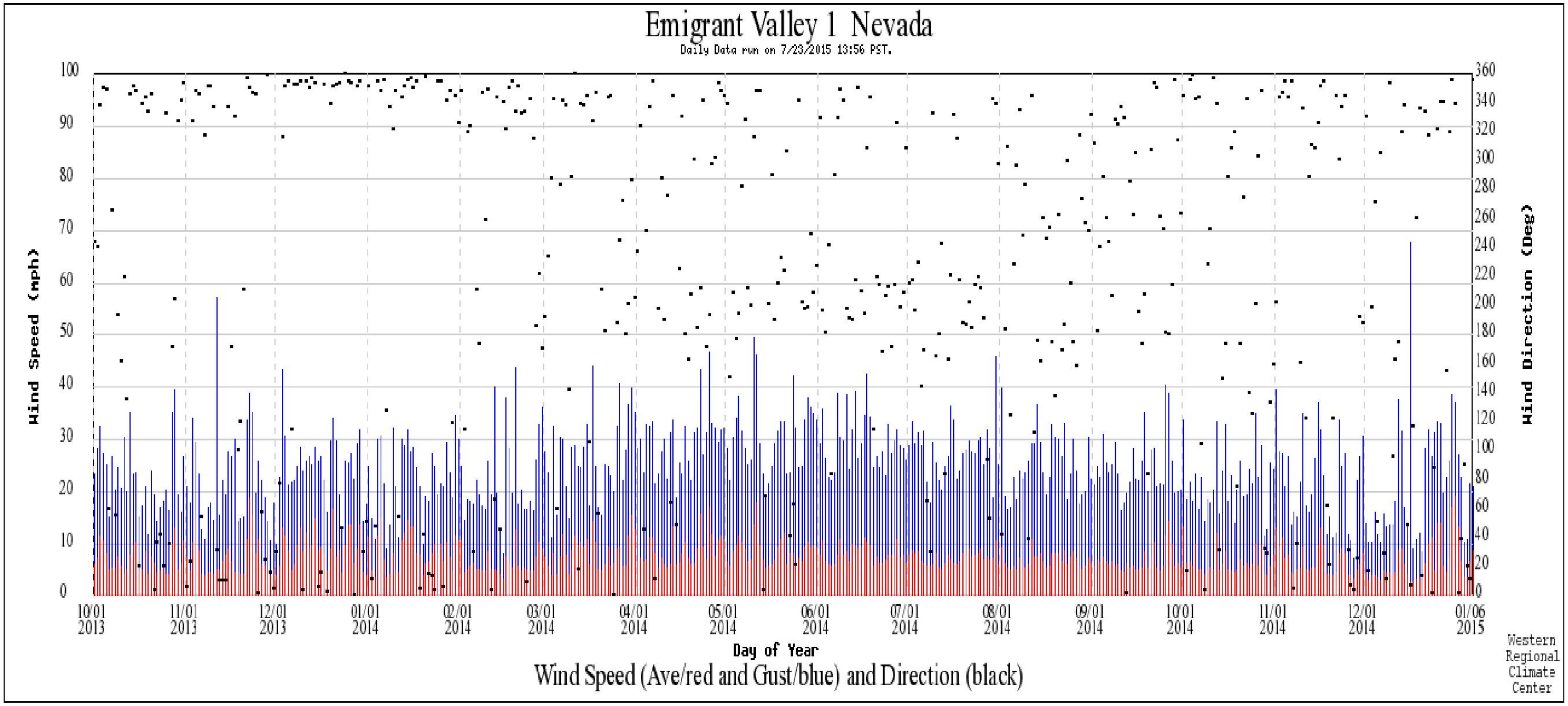

Figure A-3. Daily average (vertical red line) and maximum (vertical blue line) wind speed and daily average wind direction (black dot) at P-57-1 for the reporting period.

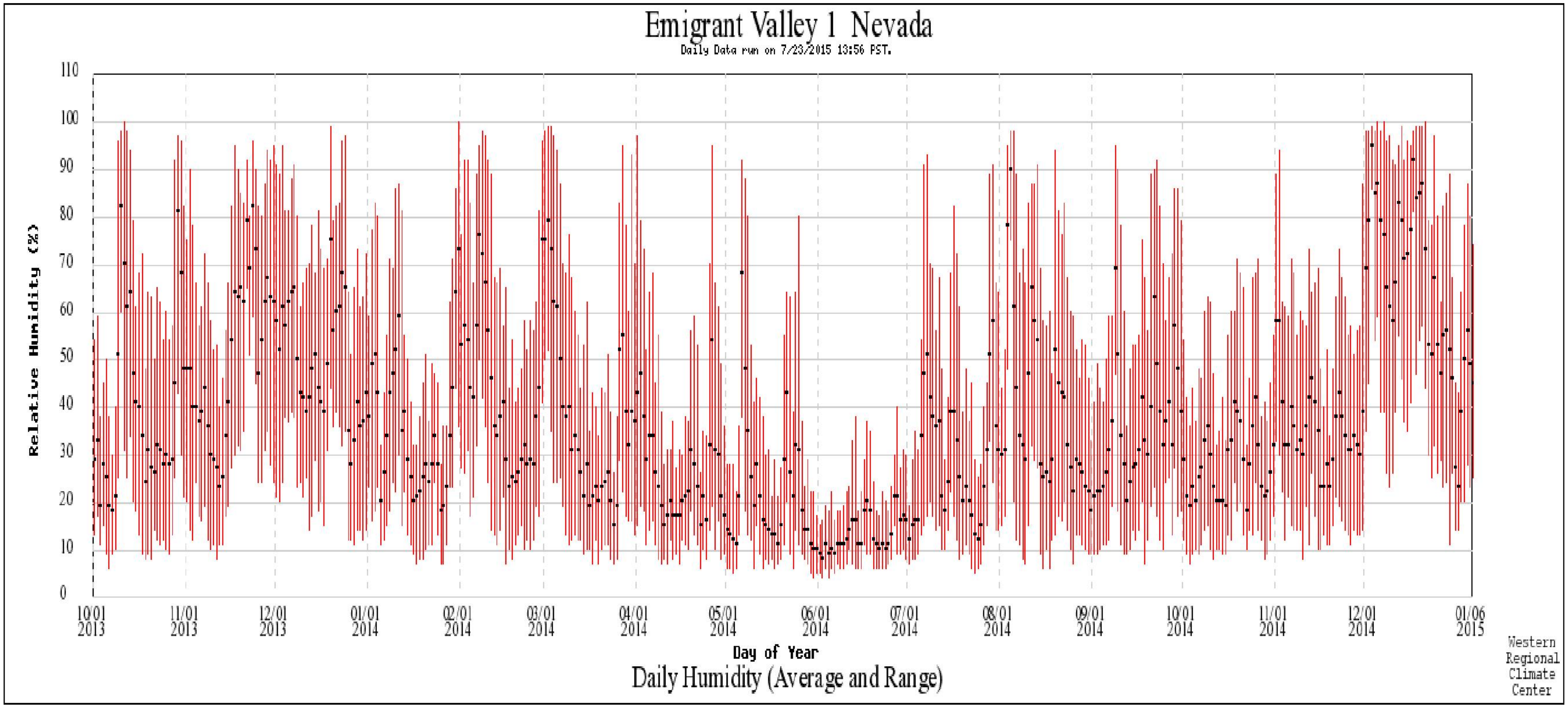

Figure A-4. Daily average relative humidity (black dots) and the daily range of relative humidity indicated by the red vertical lines that connect the daily maximum and minimum values at P-57-1 for the reporting period.

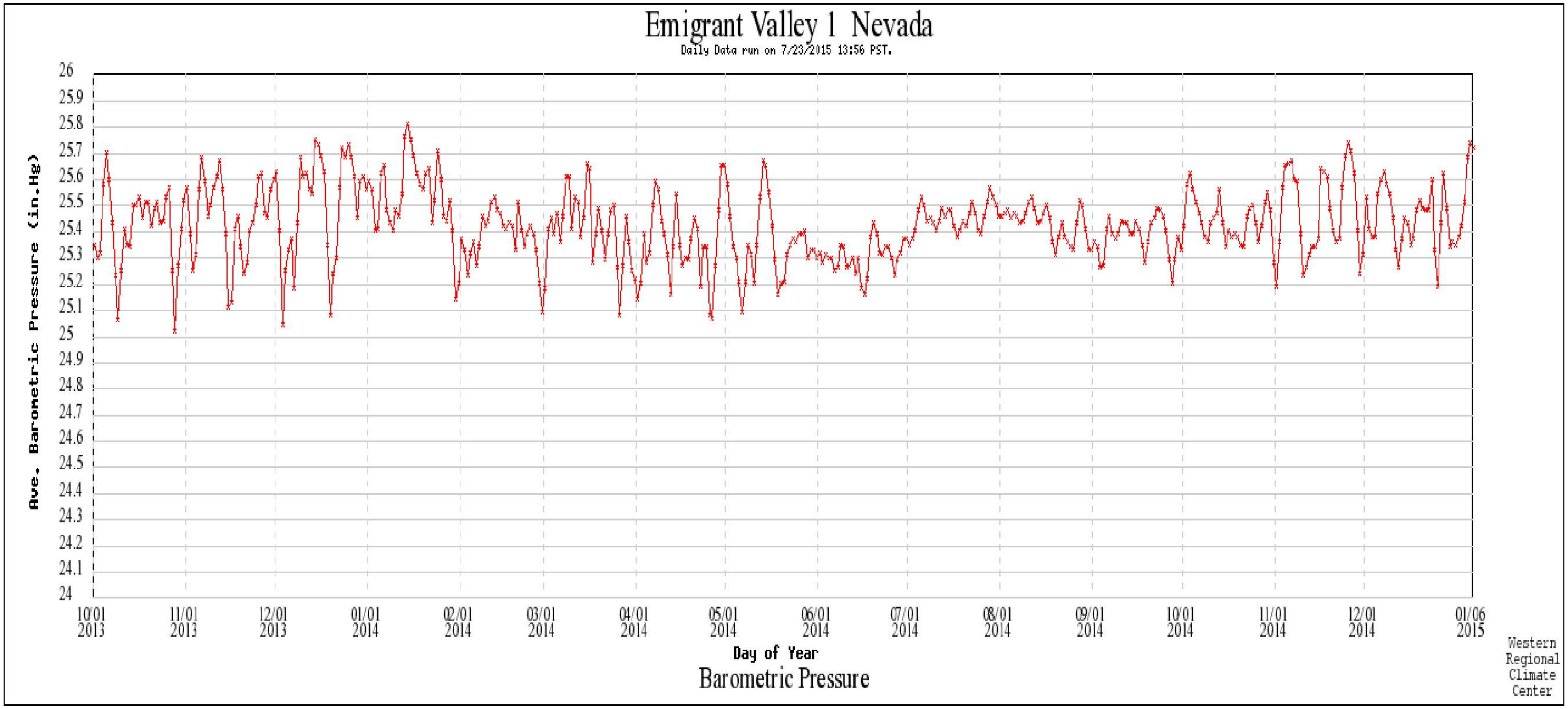

Figure A-5. Daily average barometric pressure at P-57-1 for the reporting period.

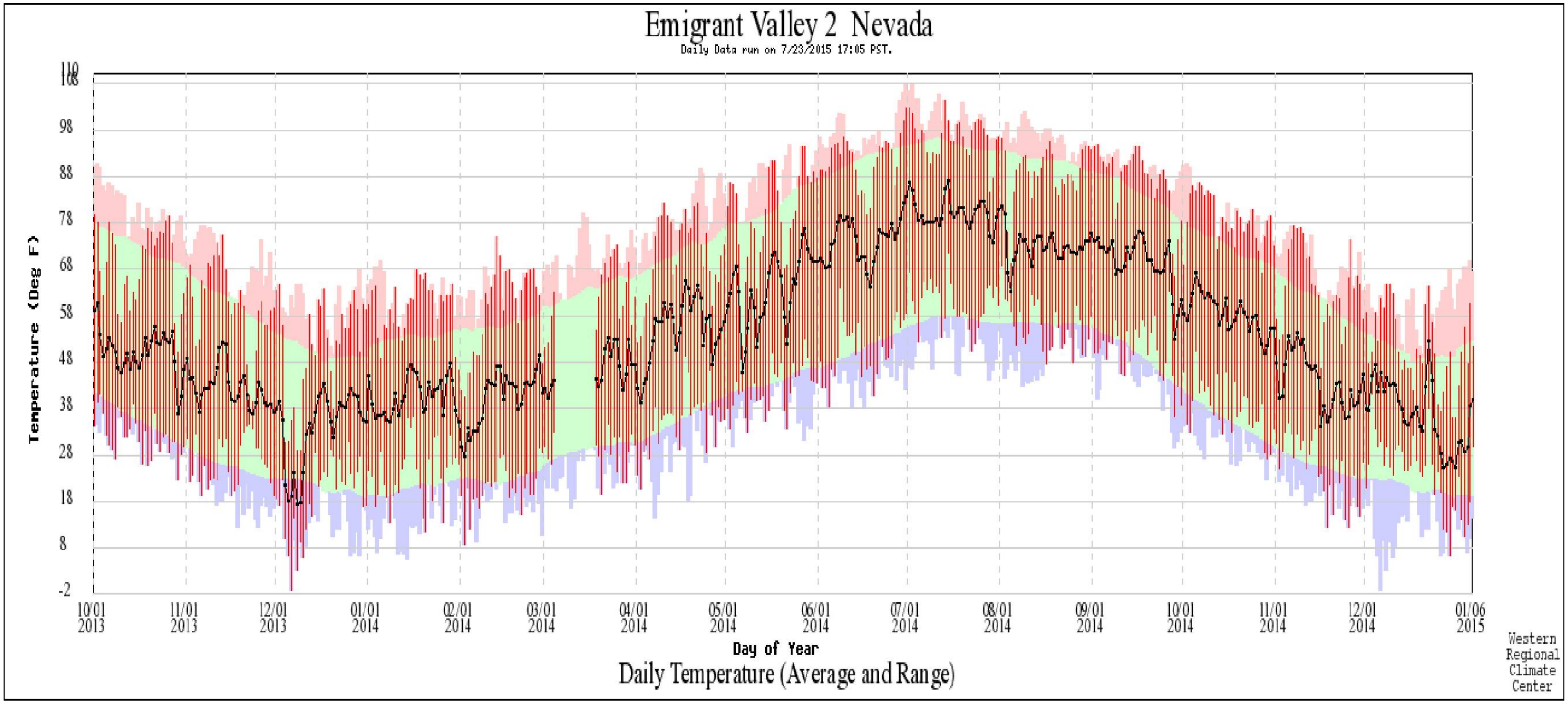

Figure A-6. Daily maximum, minimum, and average air temperature at P-57-2 for the reporting period and for the period of record. The black line connects the daily average temperature. The bright red vertical line connects the maximum and minimum temperature values for each day. The pastel green zone is bound by the 29-day moving average of the daily maximum and minimum temperatures for each calendar day for the period of record. The pastel red and pastel blue vertical lines mark the highest and lowest daily maximum and minimum, respectively, observed on the specific calendar day for the period of record.

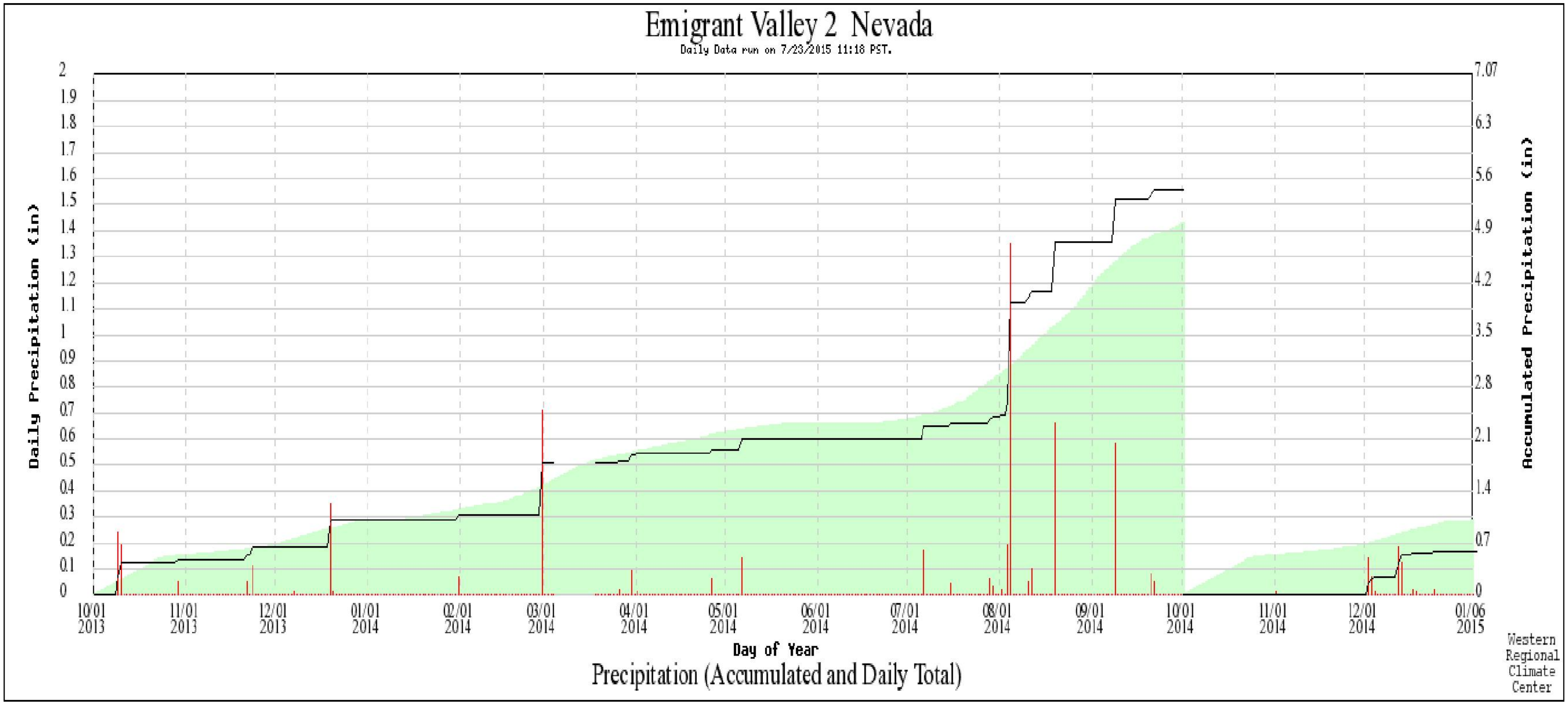

Figure A-7. Total daily precipitation (vertical red lines) and annual accumulated precipitation (black line) at P-57-2 for the reporting period. Note that the annual accumulation was reset to zero at the beginning of the fiscal year on October 1, 2014. The pastel green shaded area represents the average annual precipitation accumulation derived from the average total precipitation for the specific calendar day for the period of record.

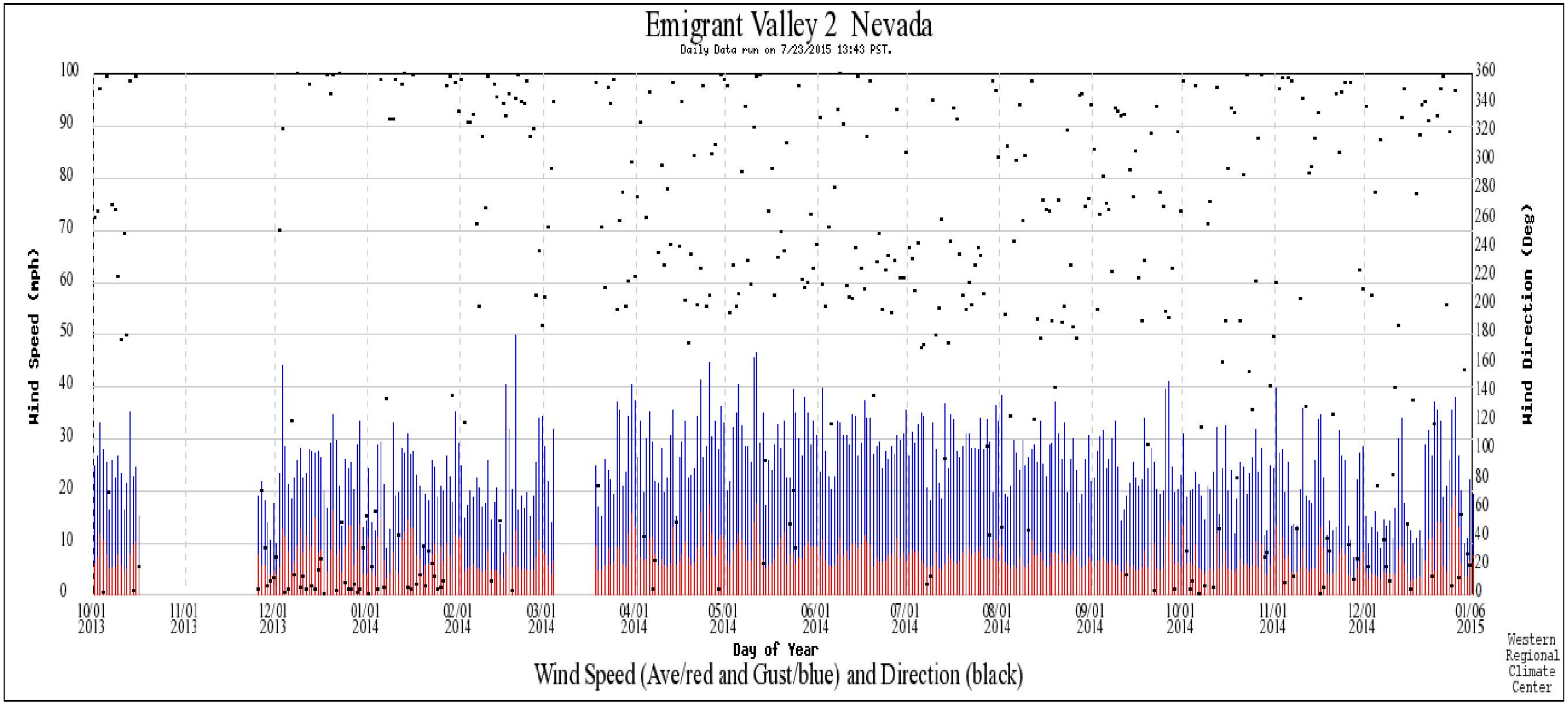

Figure A-8. Daily average (vertical red line) and maximum (vertical blue line) wind speed and daily average wind direction (black dot) at P-57-2 for the reporting period.

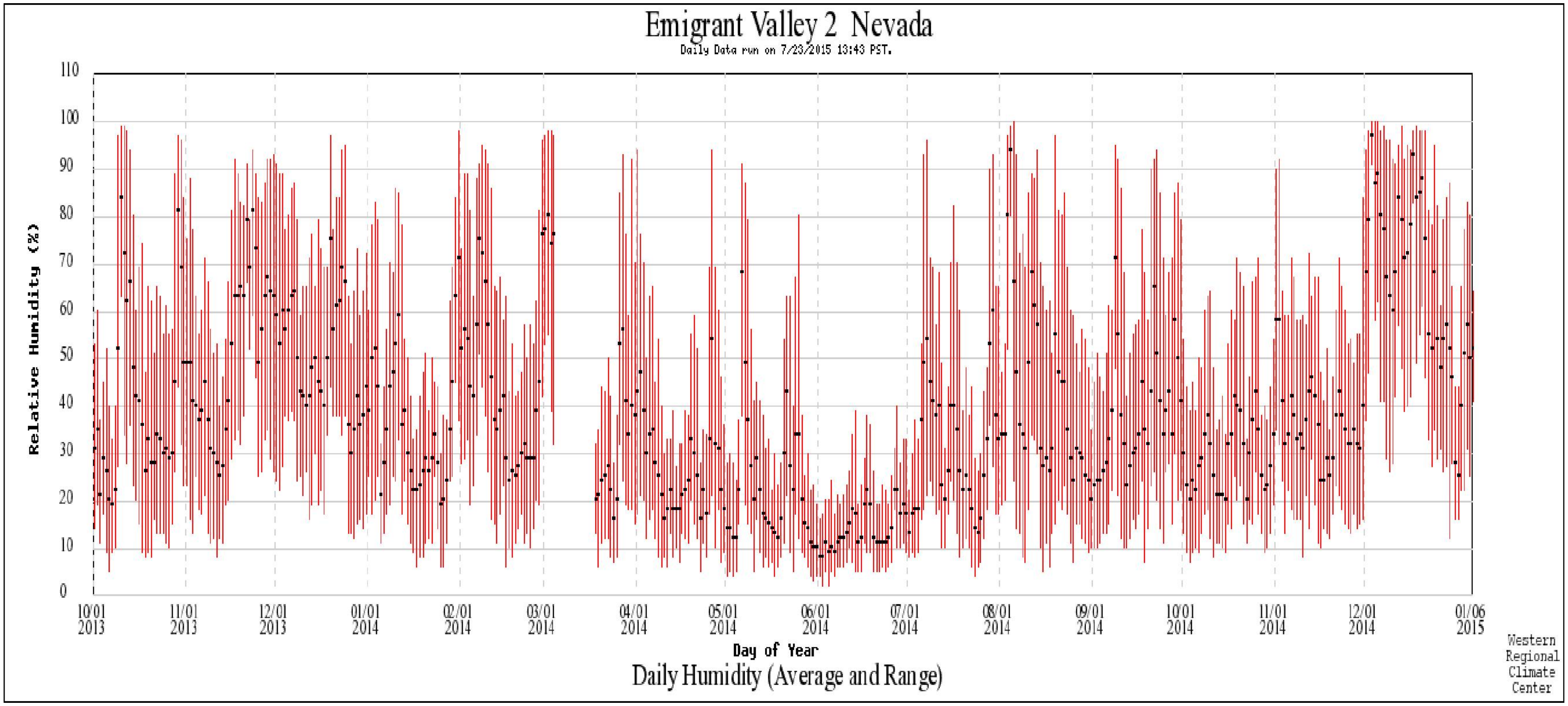

Figure A-9. Daily average relative humidity (black dots) and the daily range of relative humidity indicated by the red vertical lines that connect the daily maximum and minimum values at P-57-2 for the reporting period.

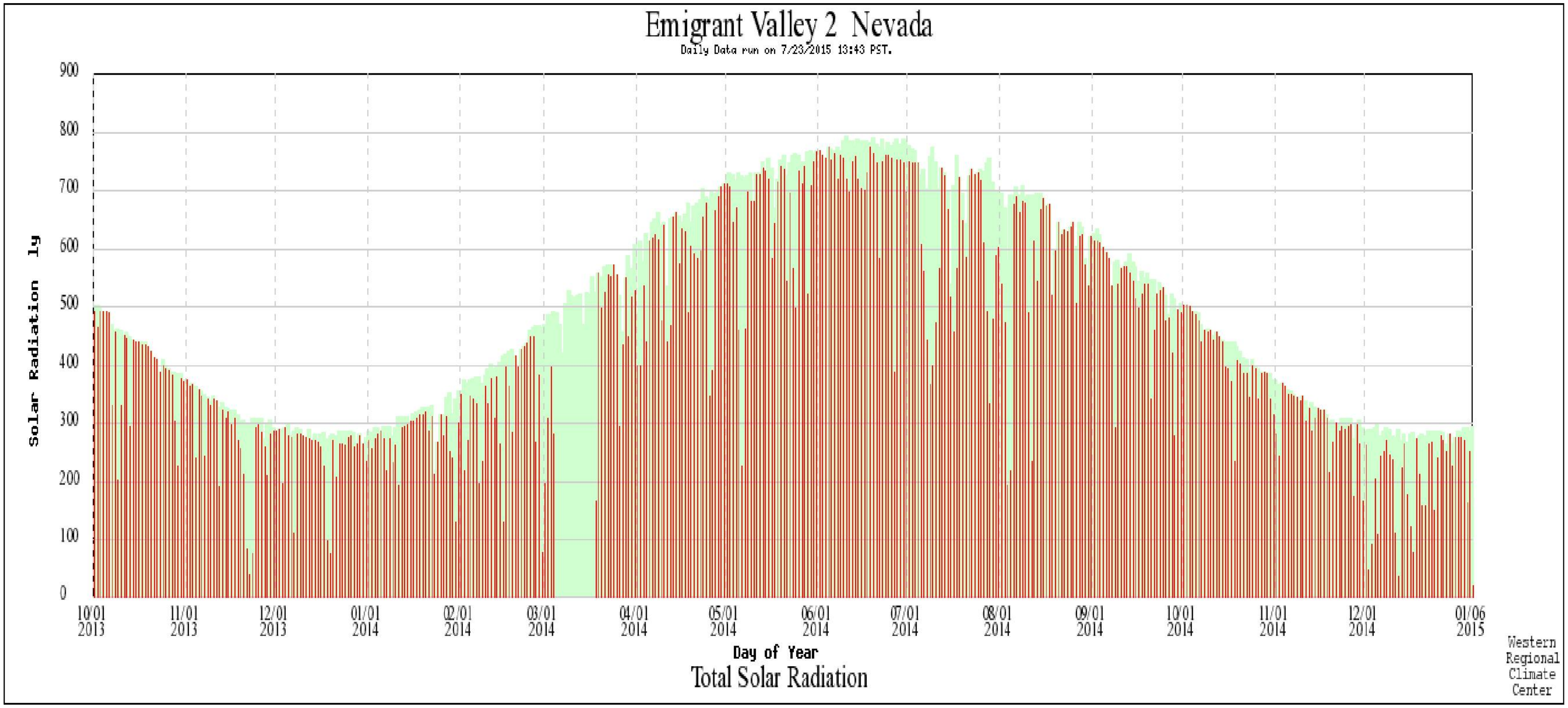

Figure A-10. Daily total solar radiation at P-57-2 is indicated by vertical red lines. The pastel green zone is marks the highest daily total solar radiation observed on the specific calendar day for the period of record.

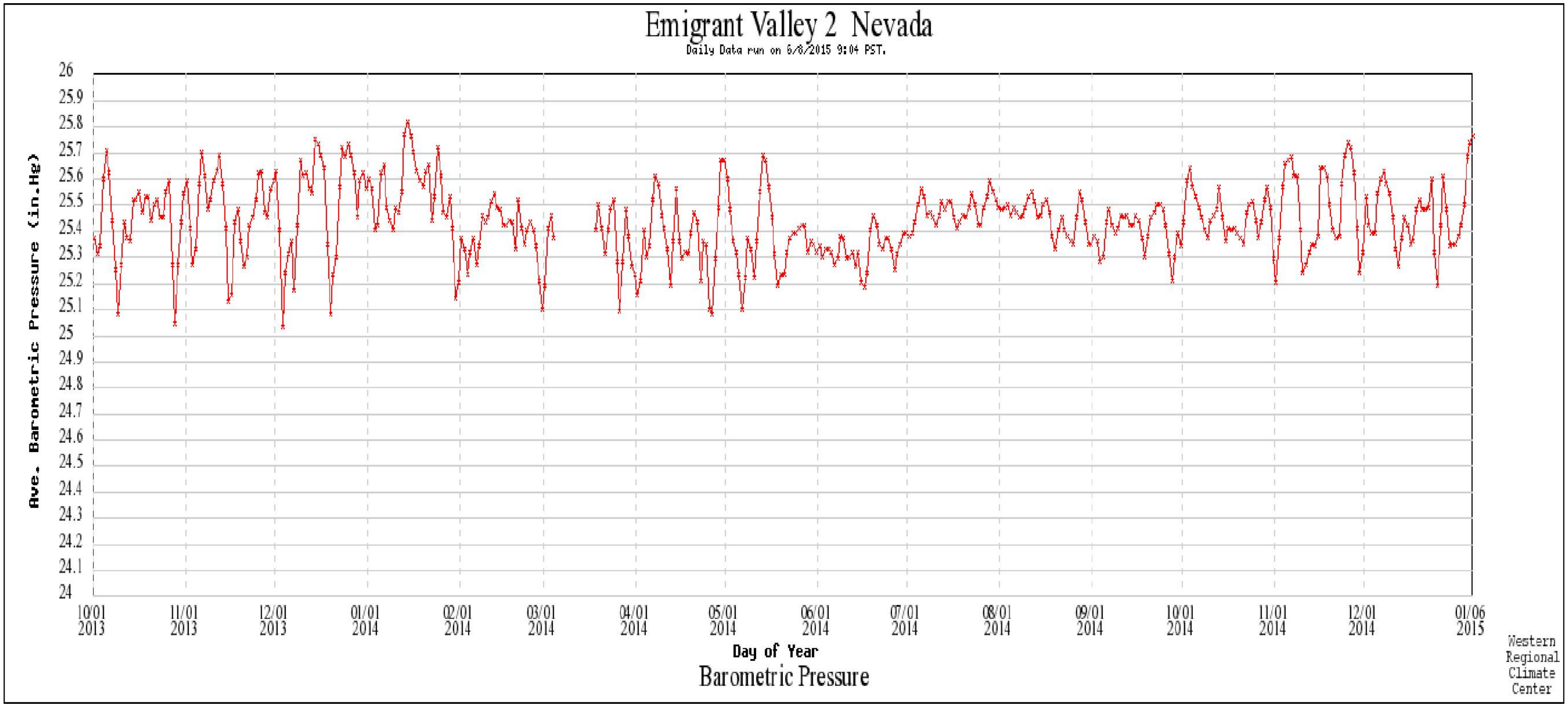

Figure A-11. Daily average barometric pressure at P-57-2 for the reporting period.

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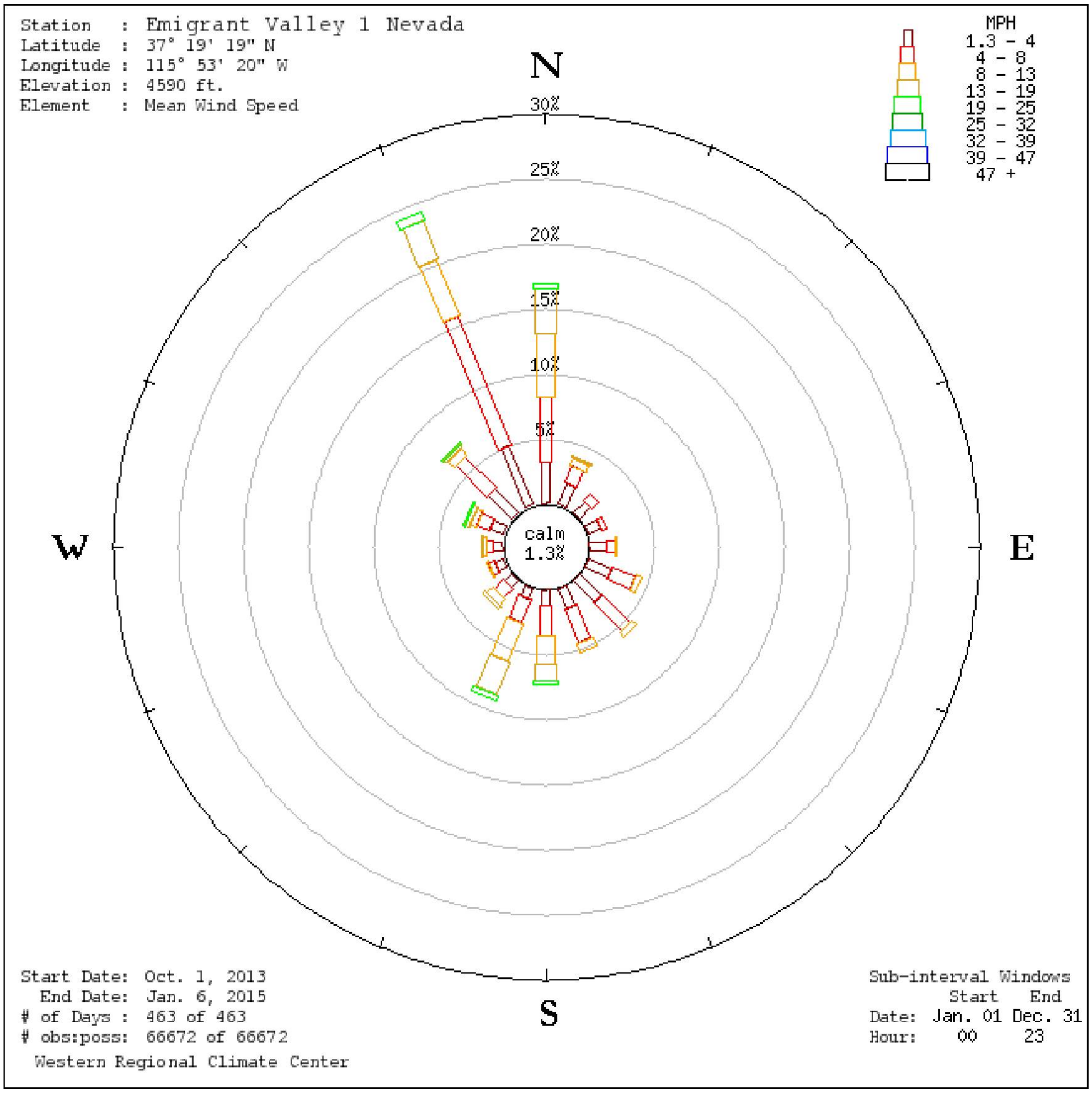

Figure A-12. P-57-1 wind rose for the reporting period (October 1, 2013, to January 7, 2015).

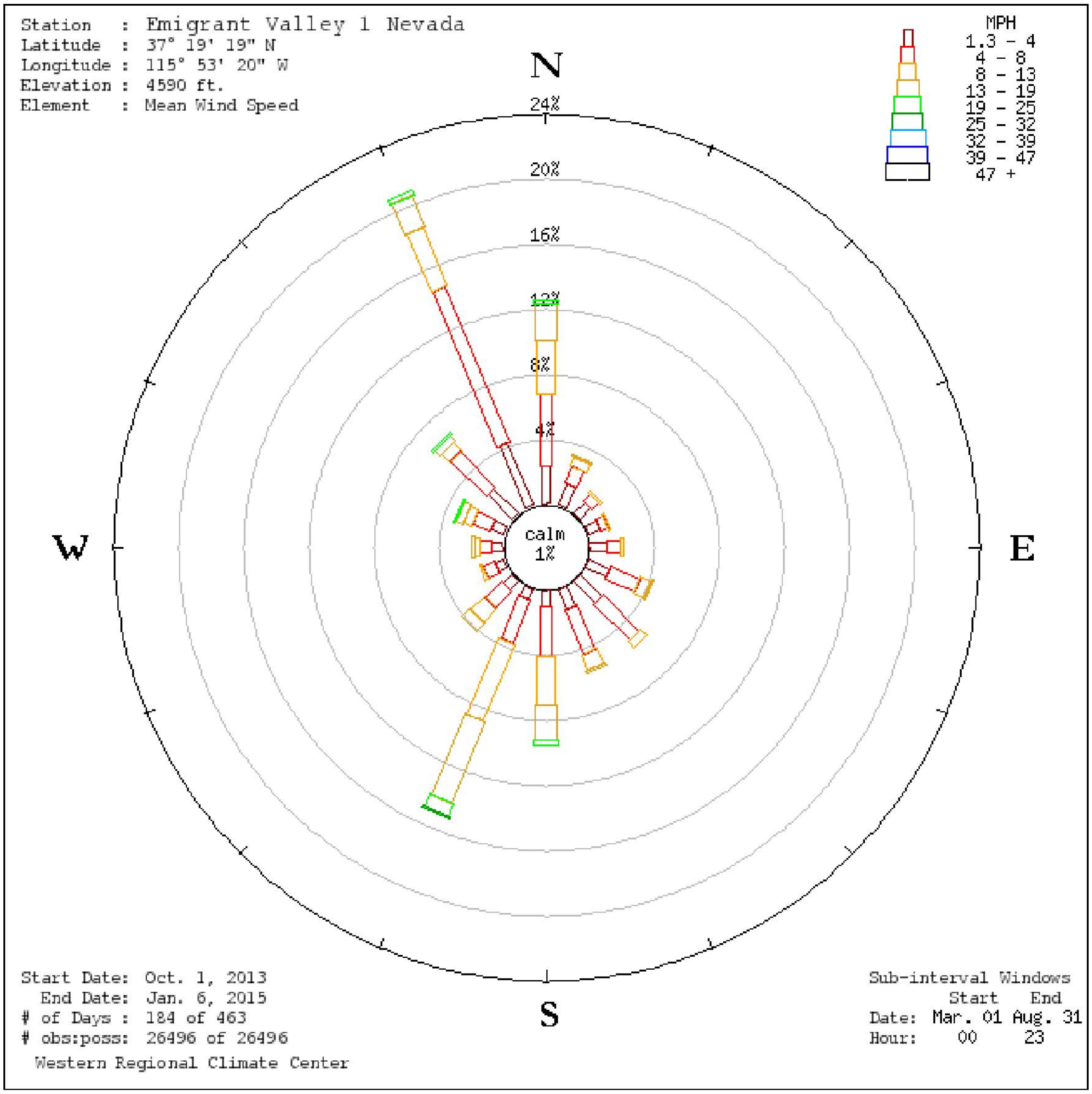

Figure A-13. P-57-1 wind rose for the summer season (includes data collected between March 1 and August 31 of each year during the reporting period).

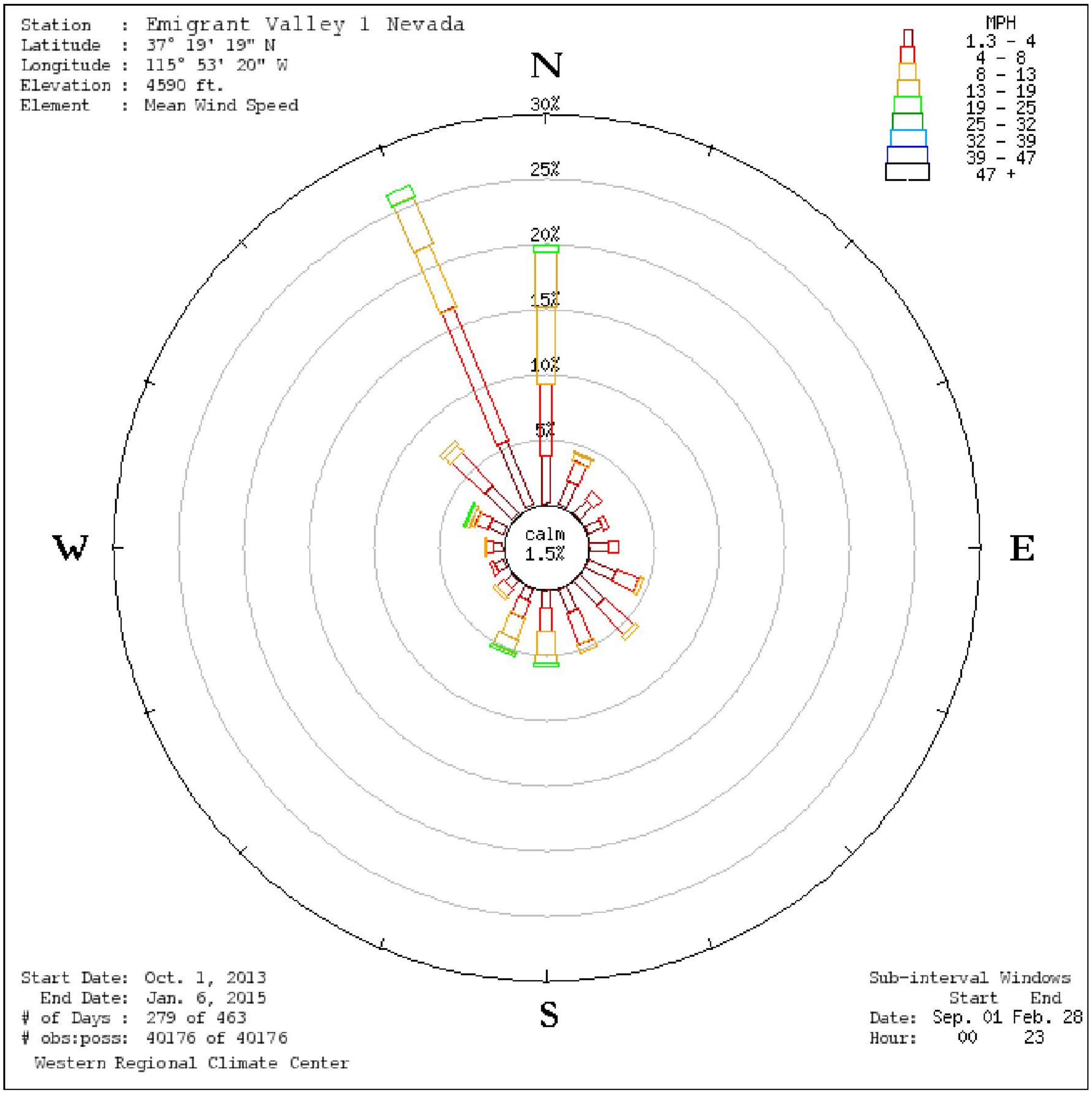

Figure A-14. P-57-1 wind rose for the winter season (includes data collected between September 1 and February 28 of each year during the reporting period).

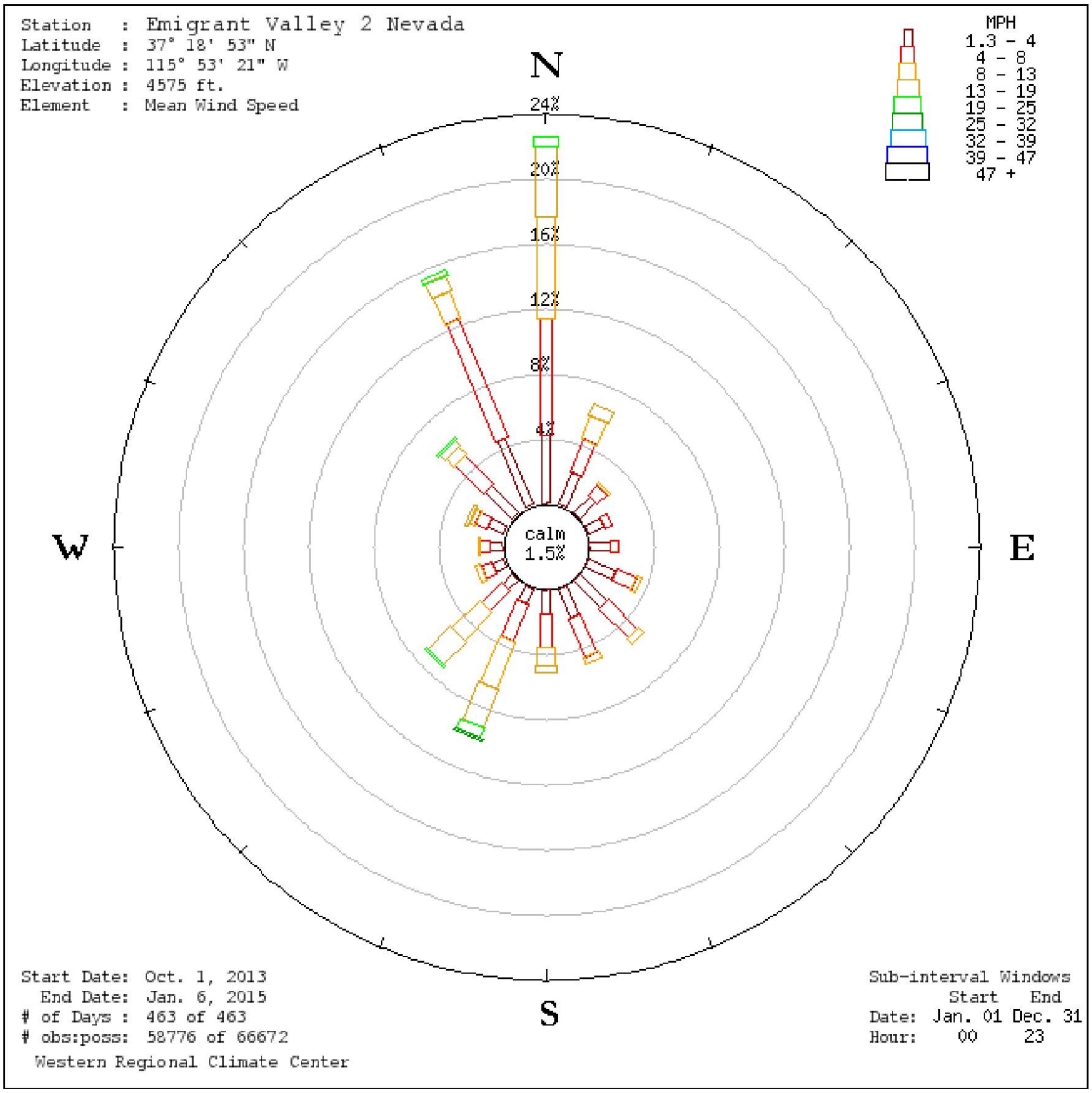

Figure A-15. P-57-2 wind rose for the reporting period (October 1, 2013, to January 7, 2015).

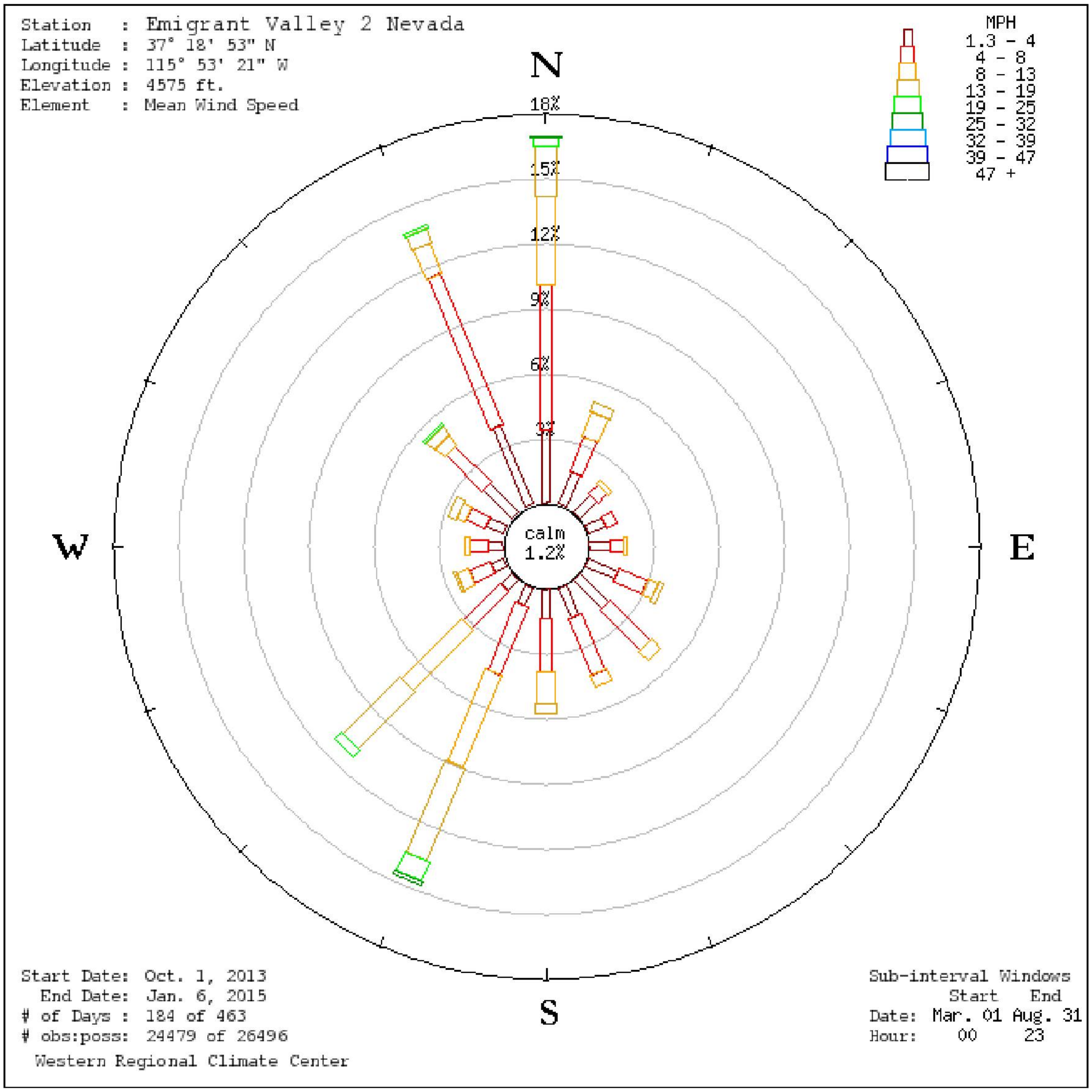

Figure A-16. P-57-2 wind rose for the summer season (includes data collected between March 1 and August 31 of each year during the reporting period).

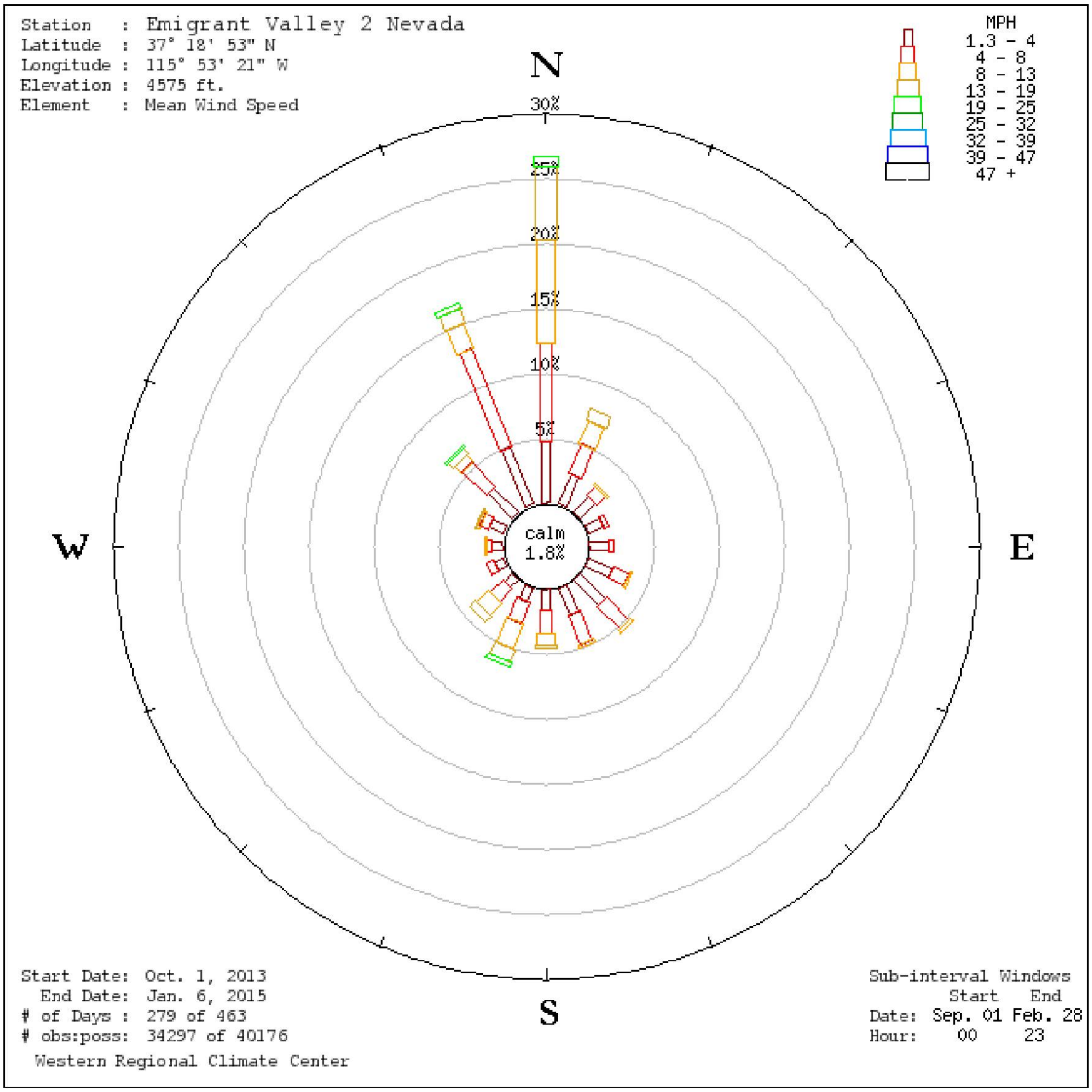

Figure A-17. P-57-2 wind rose for the winter season (includes data collected between September 1 and February 28 of each year during the reporting period).

APPENDIX B: SOIL TEMPERATURE AND WATER CONTENT

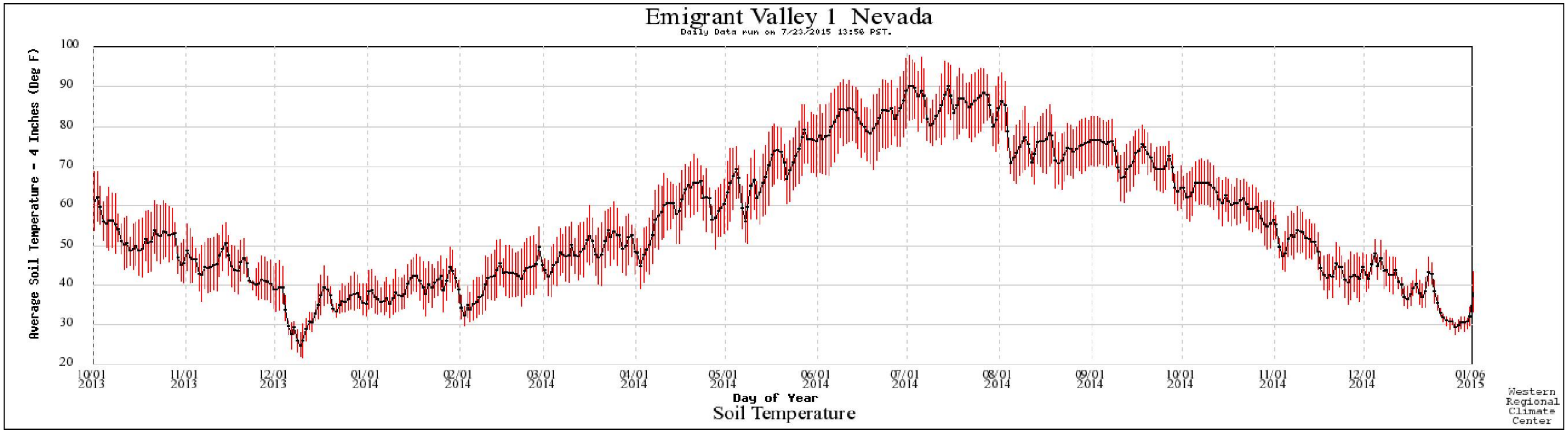

Figure B-1. Daily maximum, minimum, and average soil temperature at P-57-1.

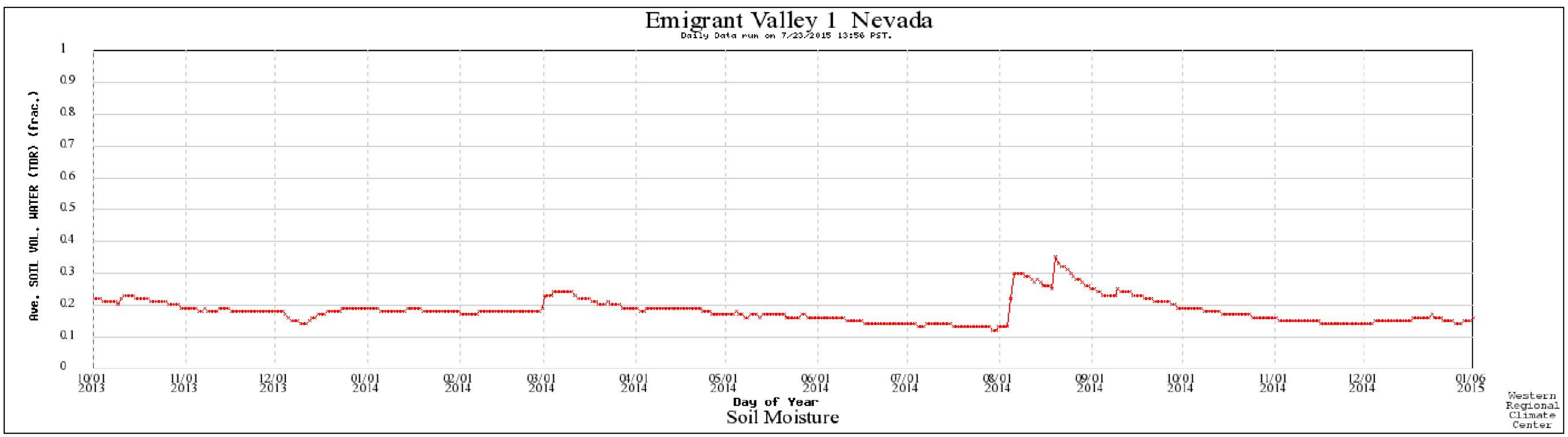

Figure B-2. Daily average soil moisture (volumetric water content [fraction]) at P-57-1.

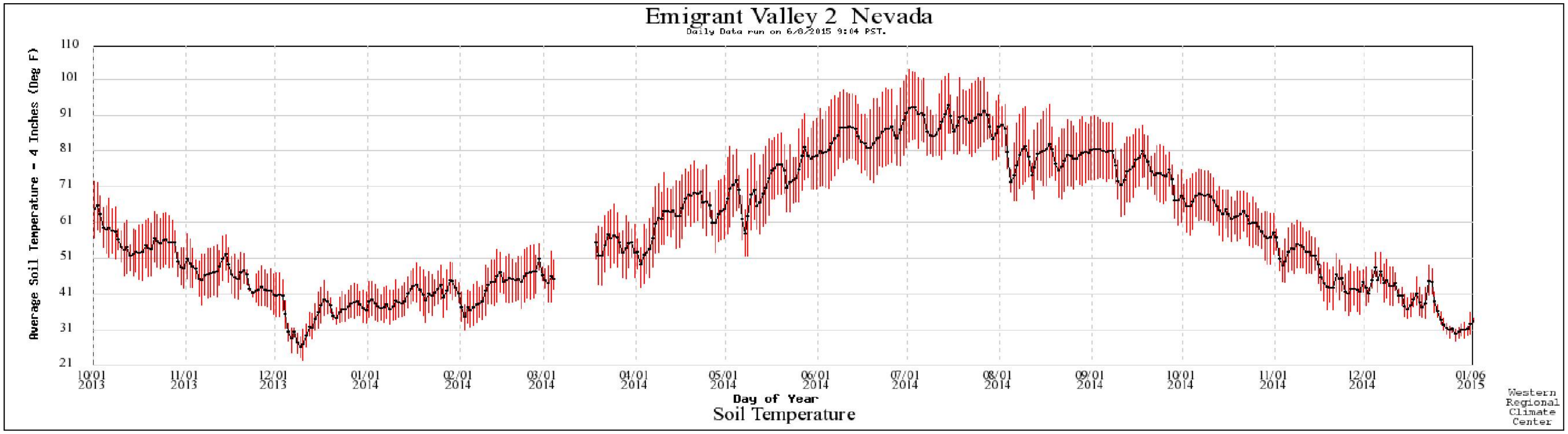

Figure B-3. Daily maximum, minimum, and average soil temperature at P-57-2.

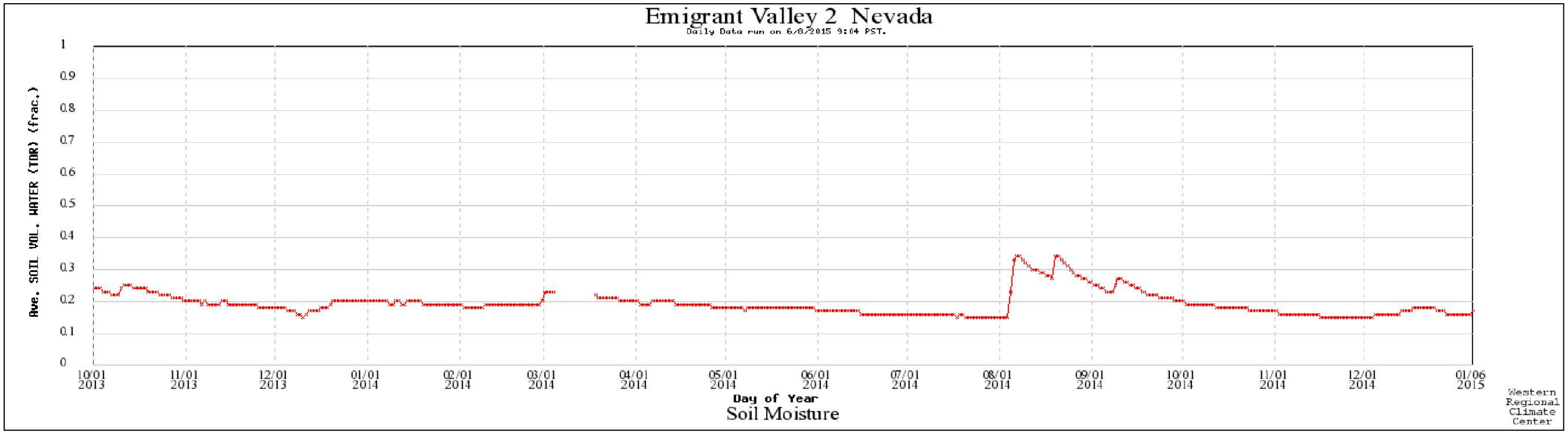

Figure B-4. Daily average soil moisture (volumetric water content [fraction]) at P-57-2.

APPENDIX C: AIRBORNE AND SALTATION DUST PARTICLE OBSERVATIONS

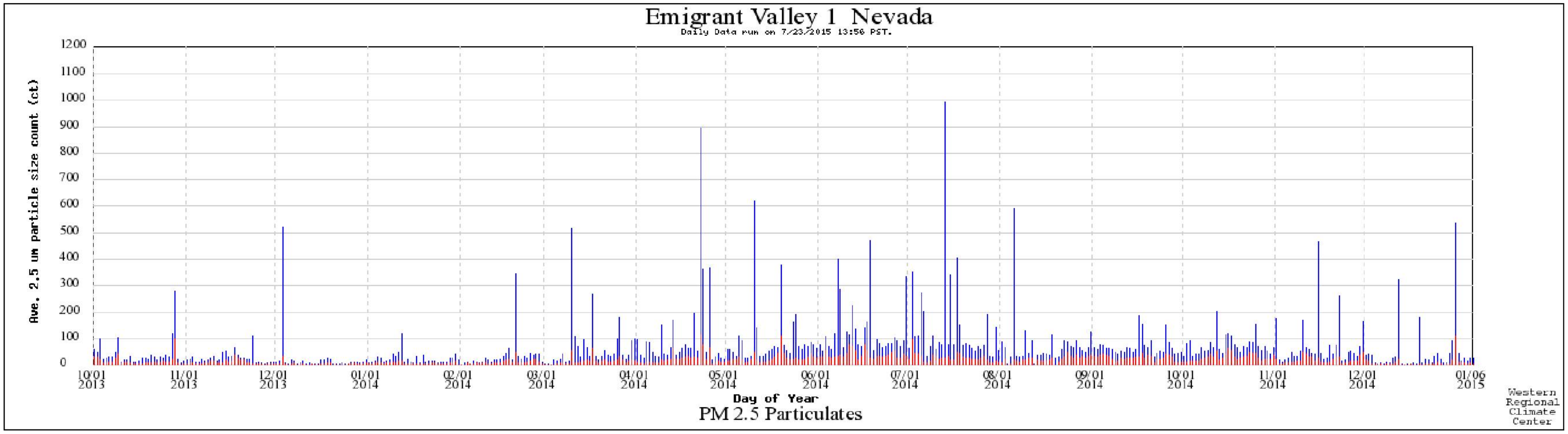

Figure C-1. Daily average and maximum $PM_{2.5}$ counts at P-57-1.

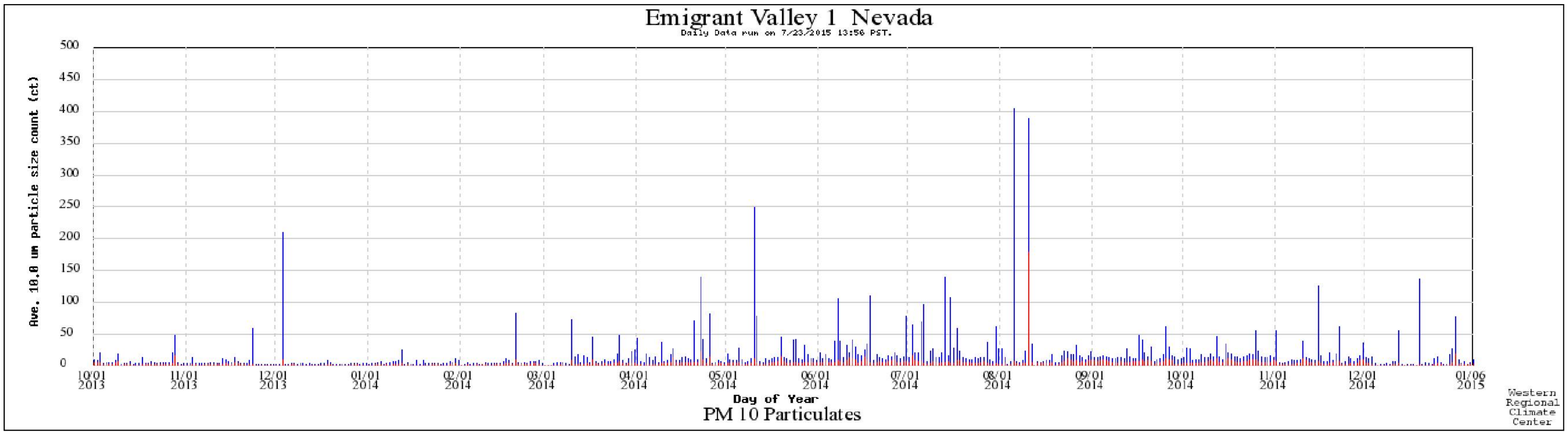

Figure C-2. Daily average and maximum PM_{10} counts at P-57-1.

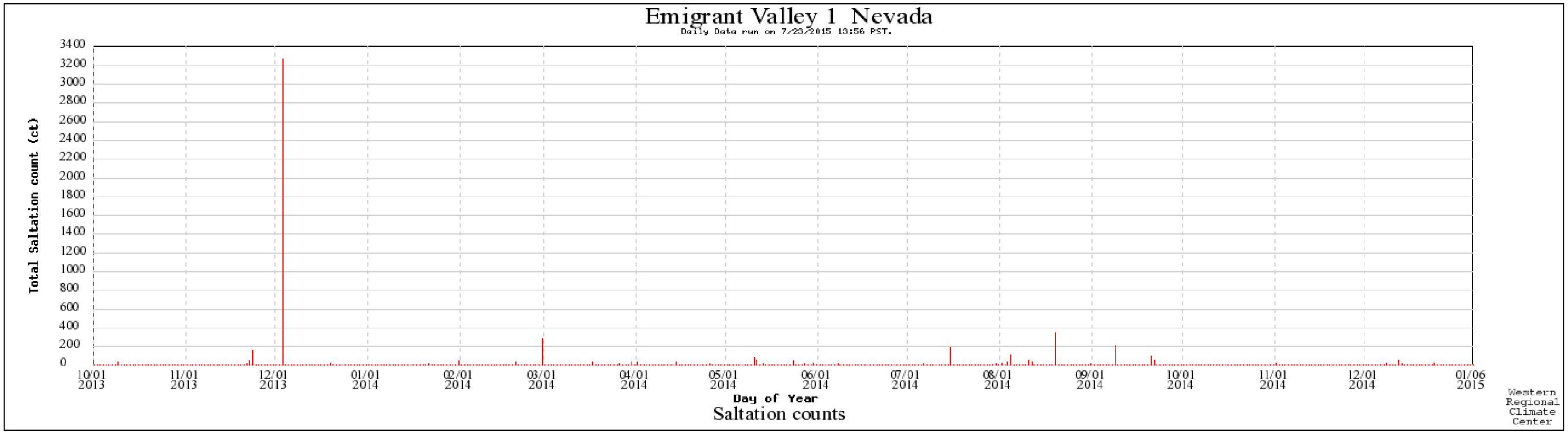

Figure C-3. Daily saltation counts at P-57-1.

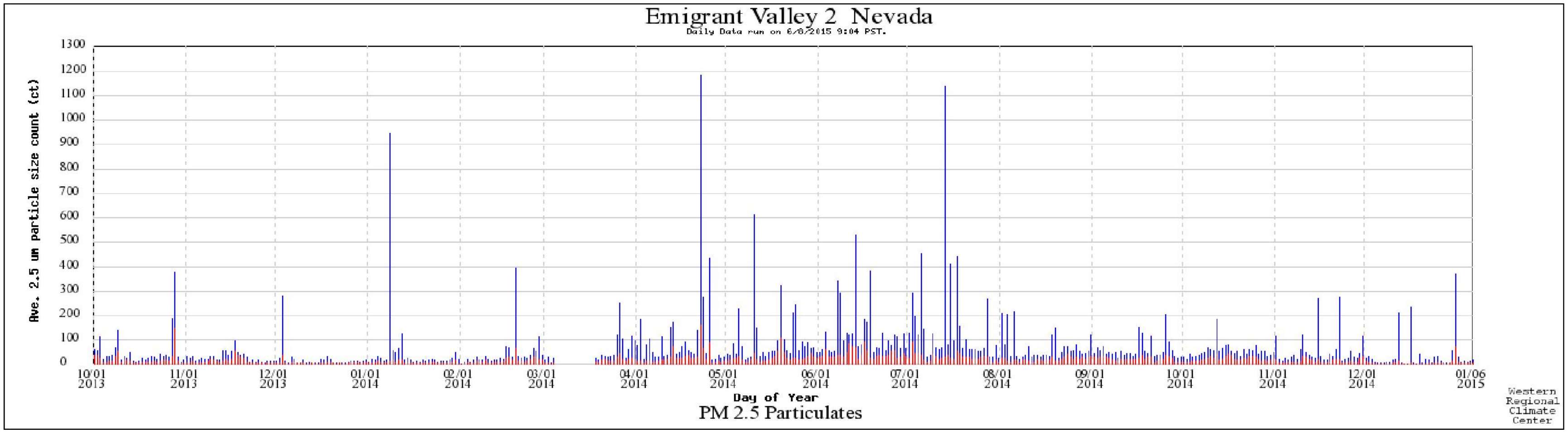

Figure C-4. Daily average and maximum $PM_{2.5}$ counts at P-57-2.

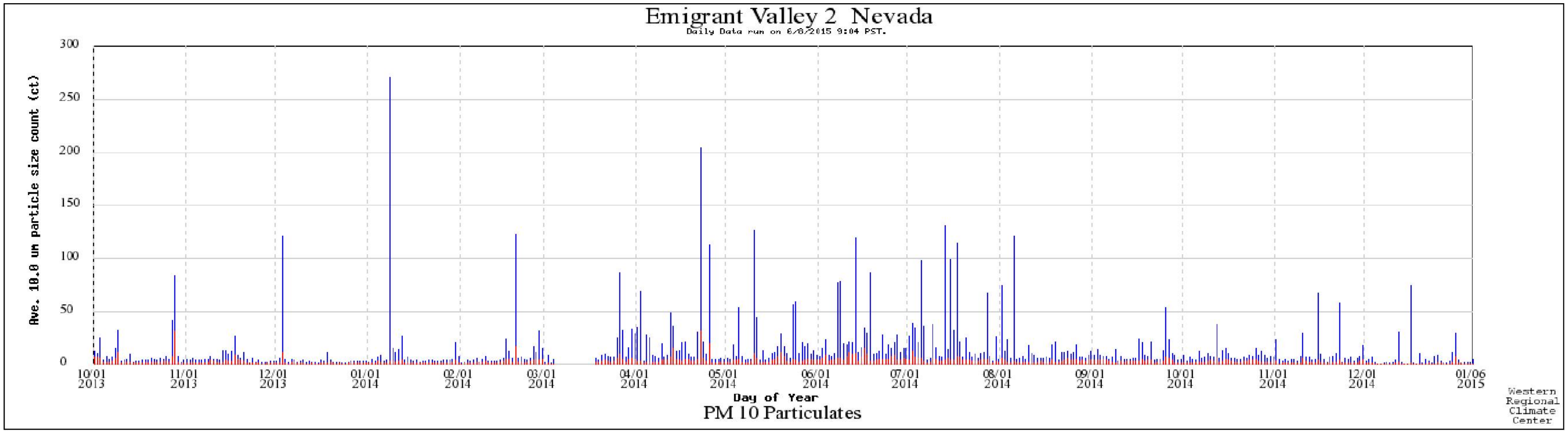

Figure C-5. Daily average and maximum PM_{10} counts at P-57-2.

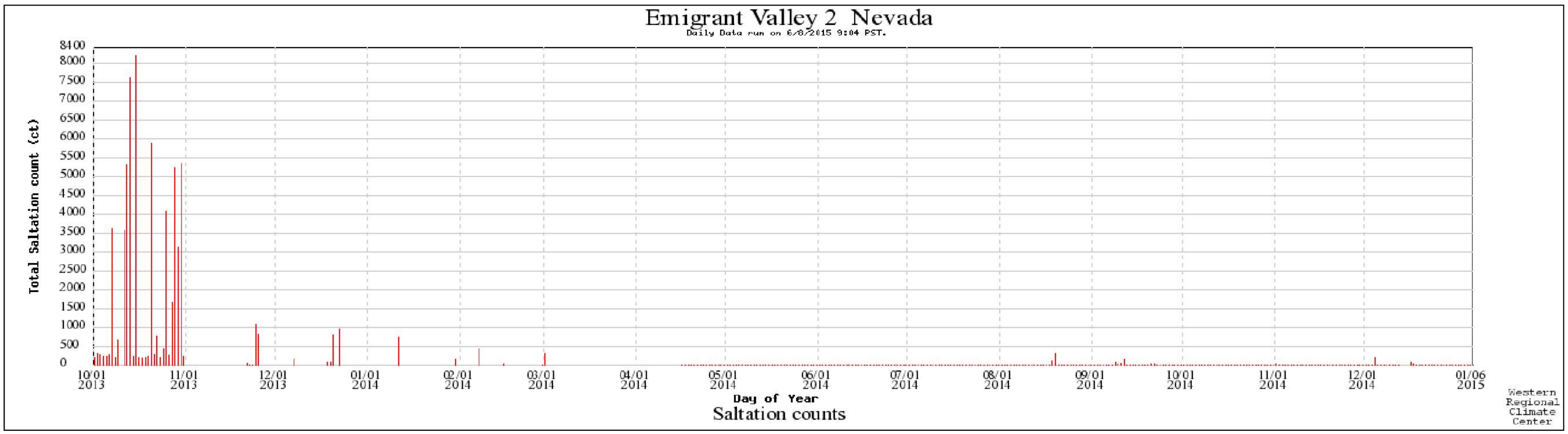

Figure C-6. Daily saltation counts at P-57-2. Note the excessive noise in the October 2013 data and the lack of zero designations between November 1, 2013, and mid-April 2014. These characteristics indicate the saltation sensor was not working at this time.

APPENDIX D: GRAPHICAL PRESENTATION OF WIND AND DUST CONDITIONS DURING MAJOR WIND EVENTS AT P-57-1

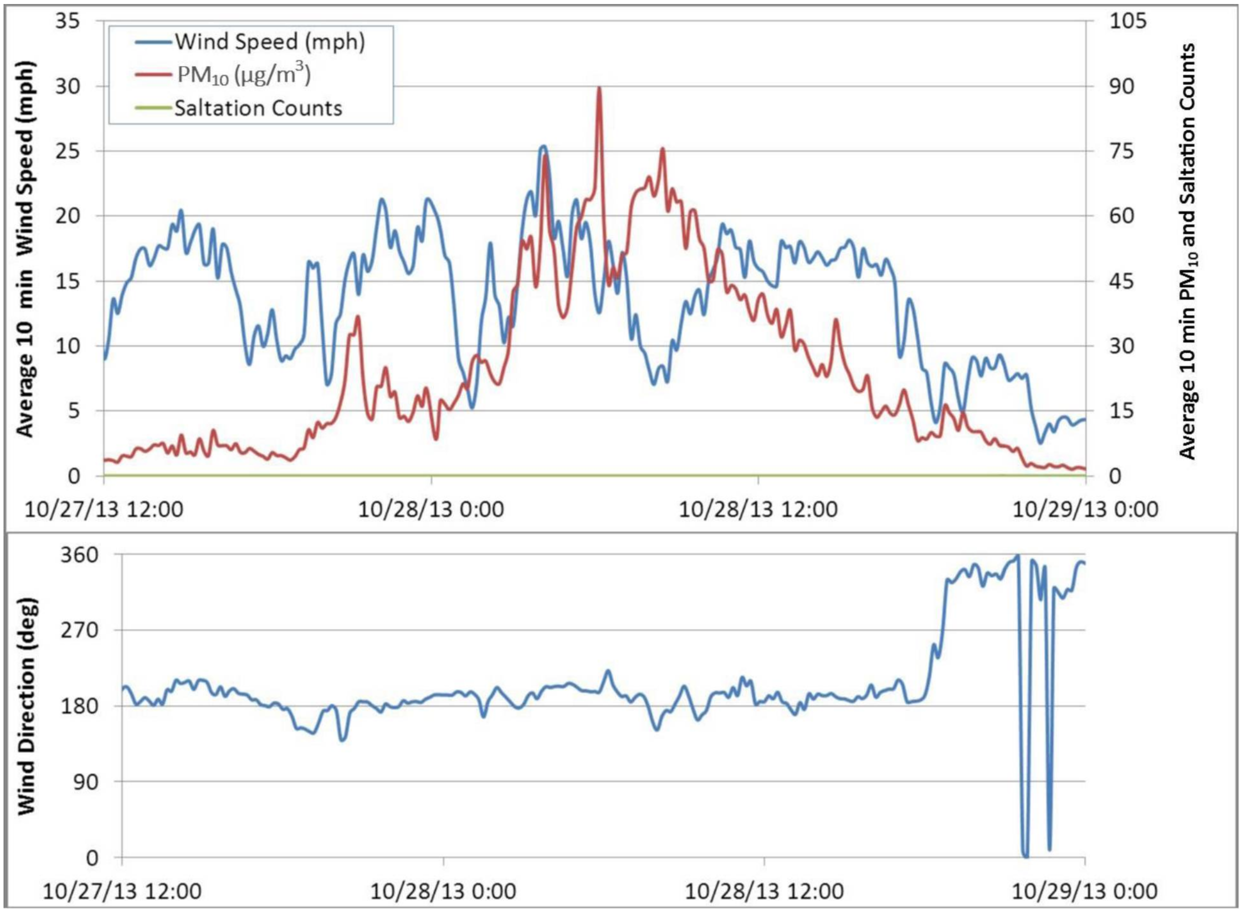

Figure D-1. Wind and dust episode October 28, 2013.

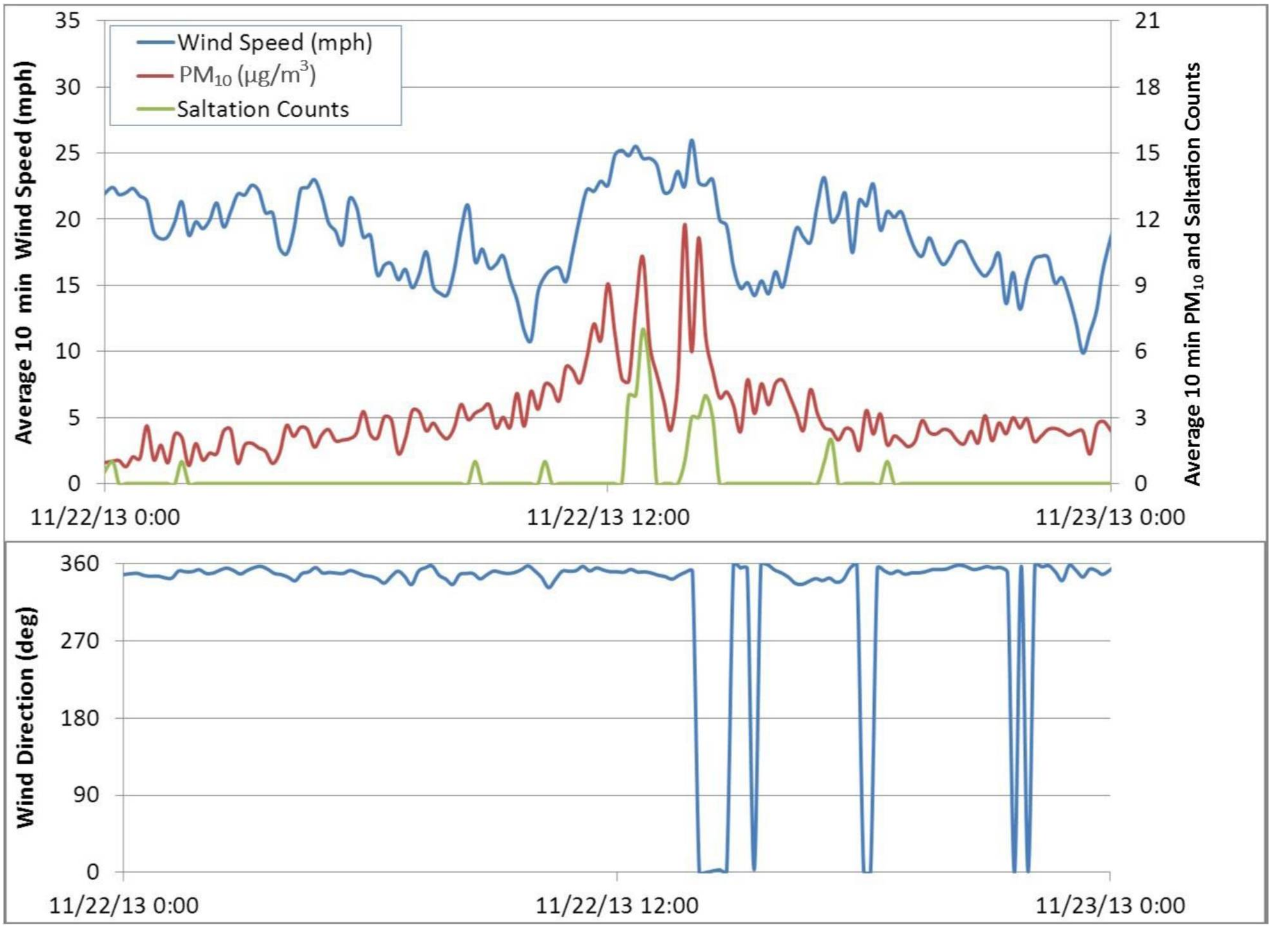

Figure D-2. Wind and dust episode November 22, 2013.

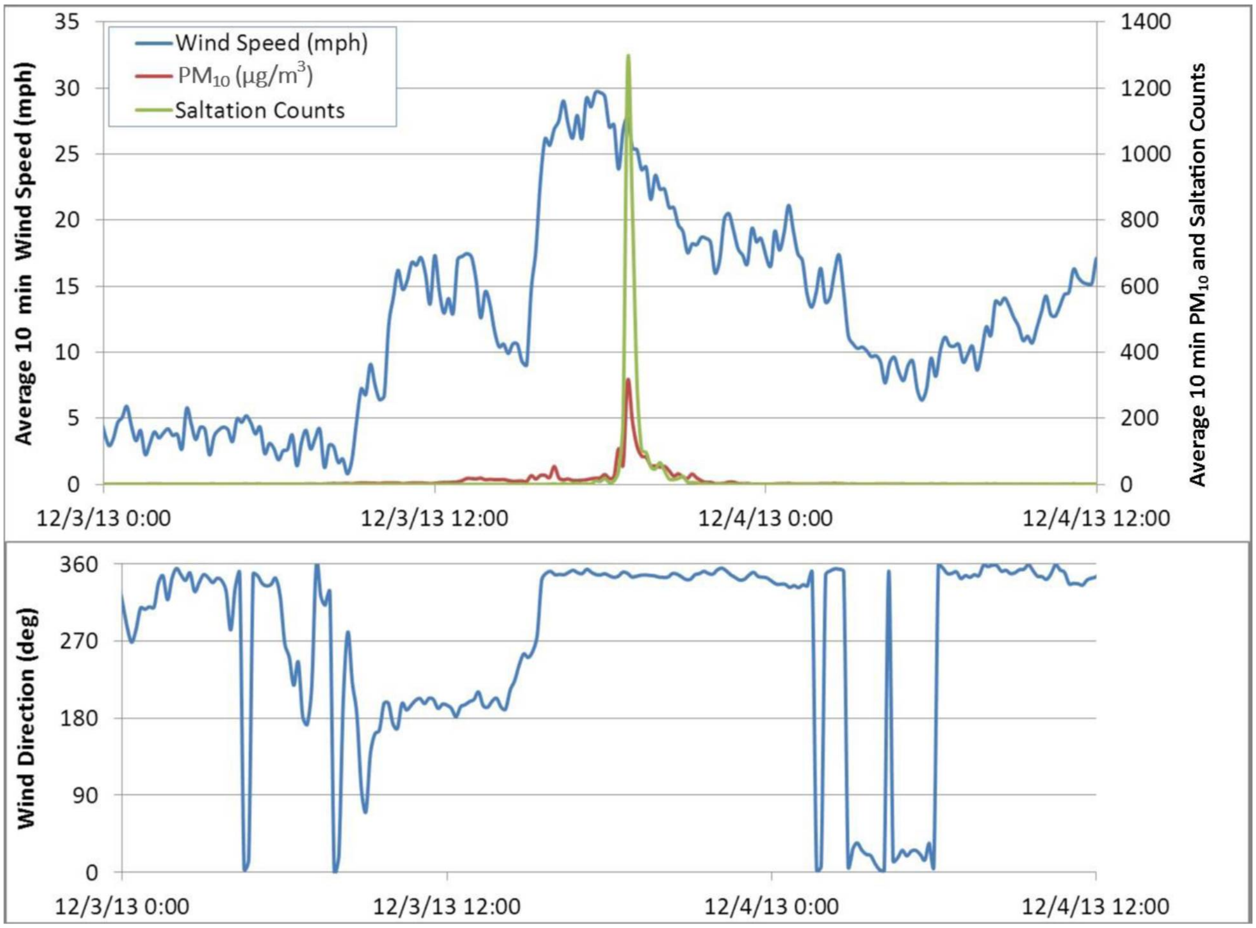

Figure D-3. Wind and dust episode December 3, 2013.

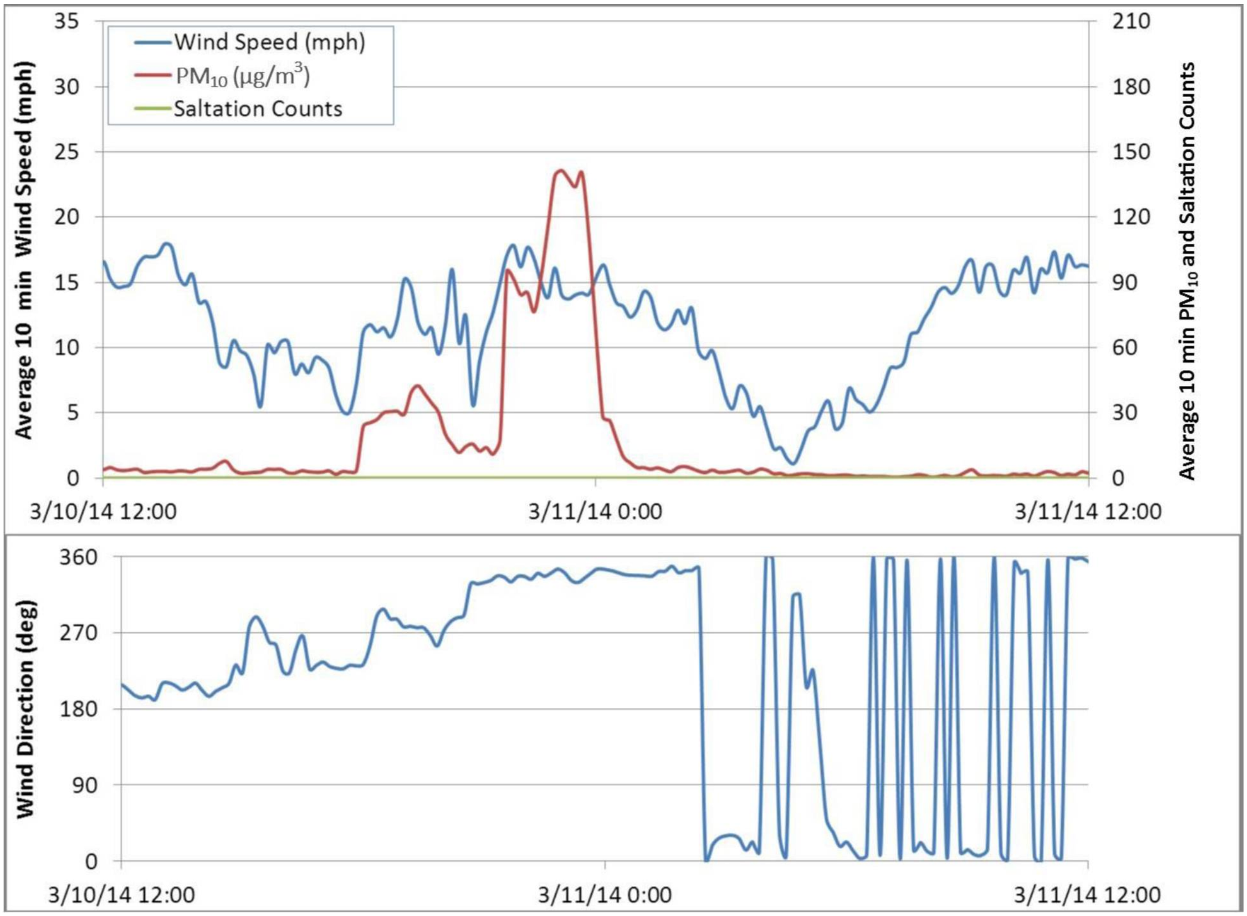

Figure D-4. Wind and dust episode March 11, 2014.

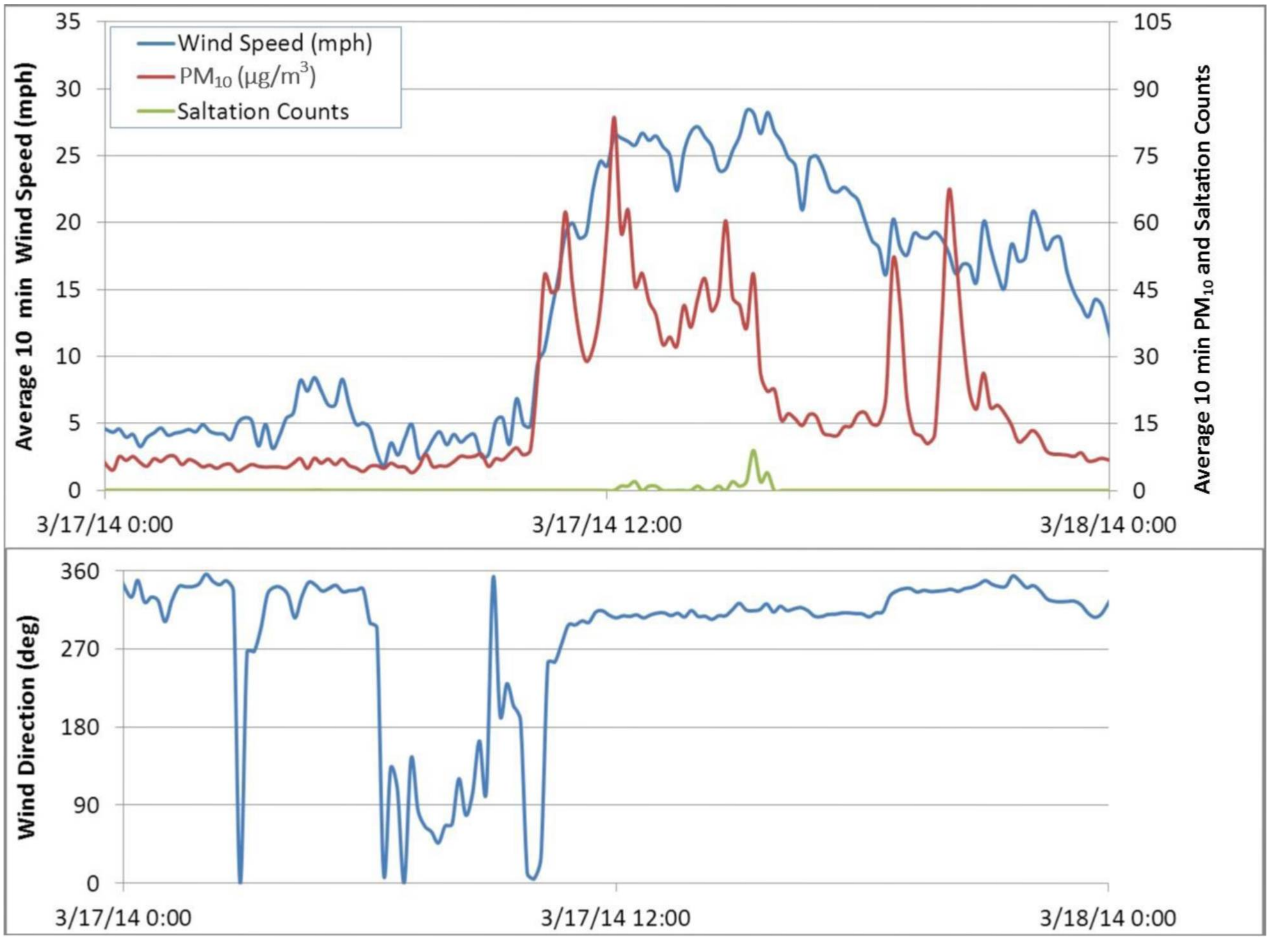

Figure D-5. Wind and dust episode March 17, 2014.

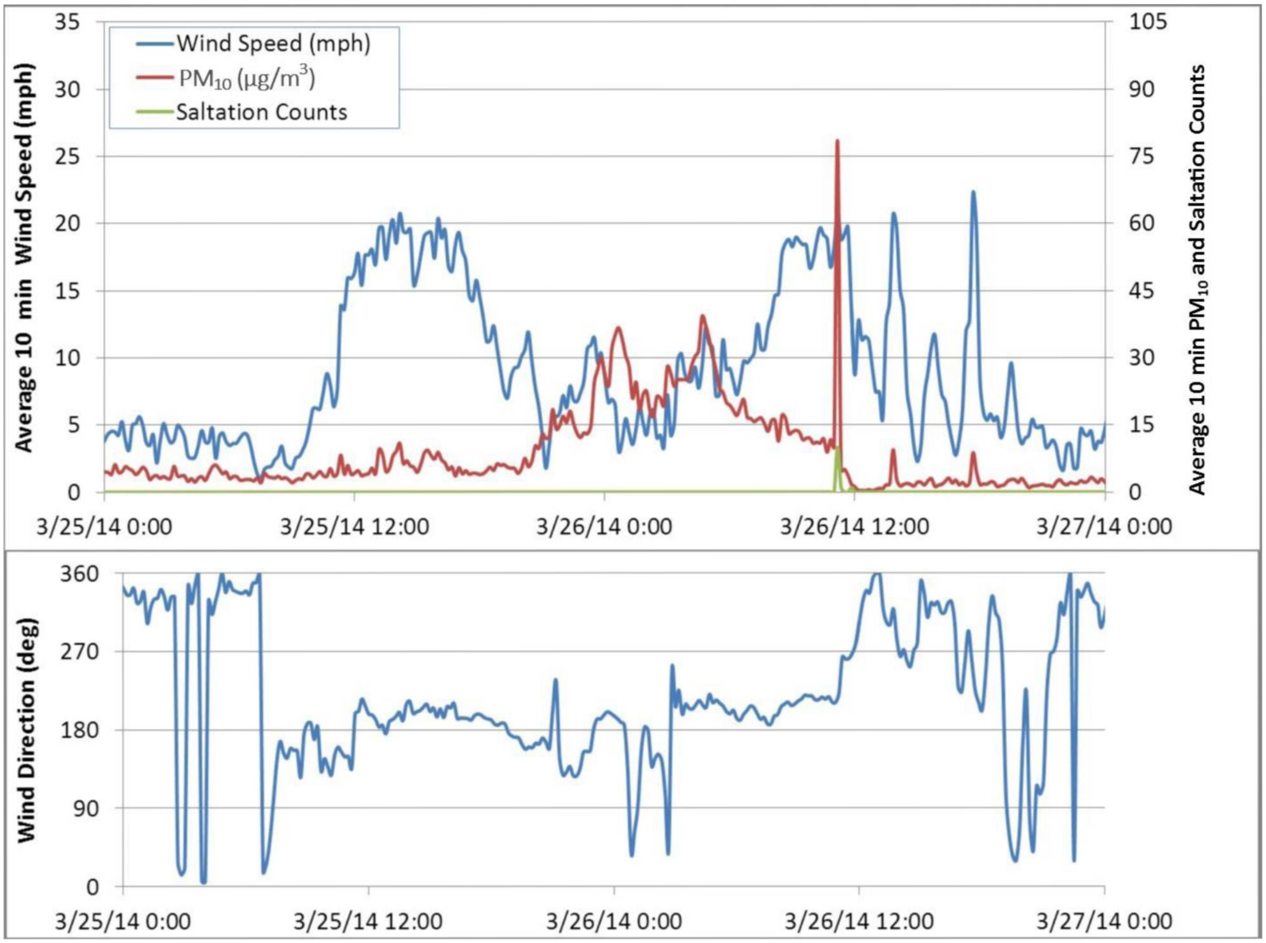

Figure D-6. Wind and dust episode March 26, 2014.

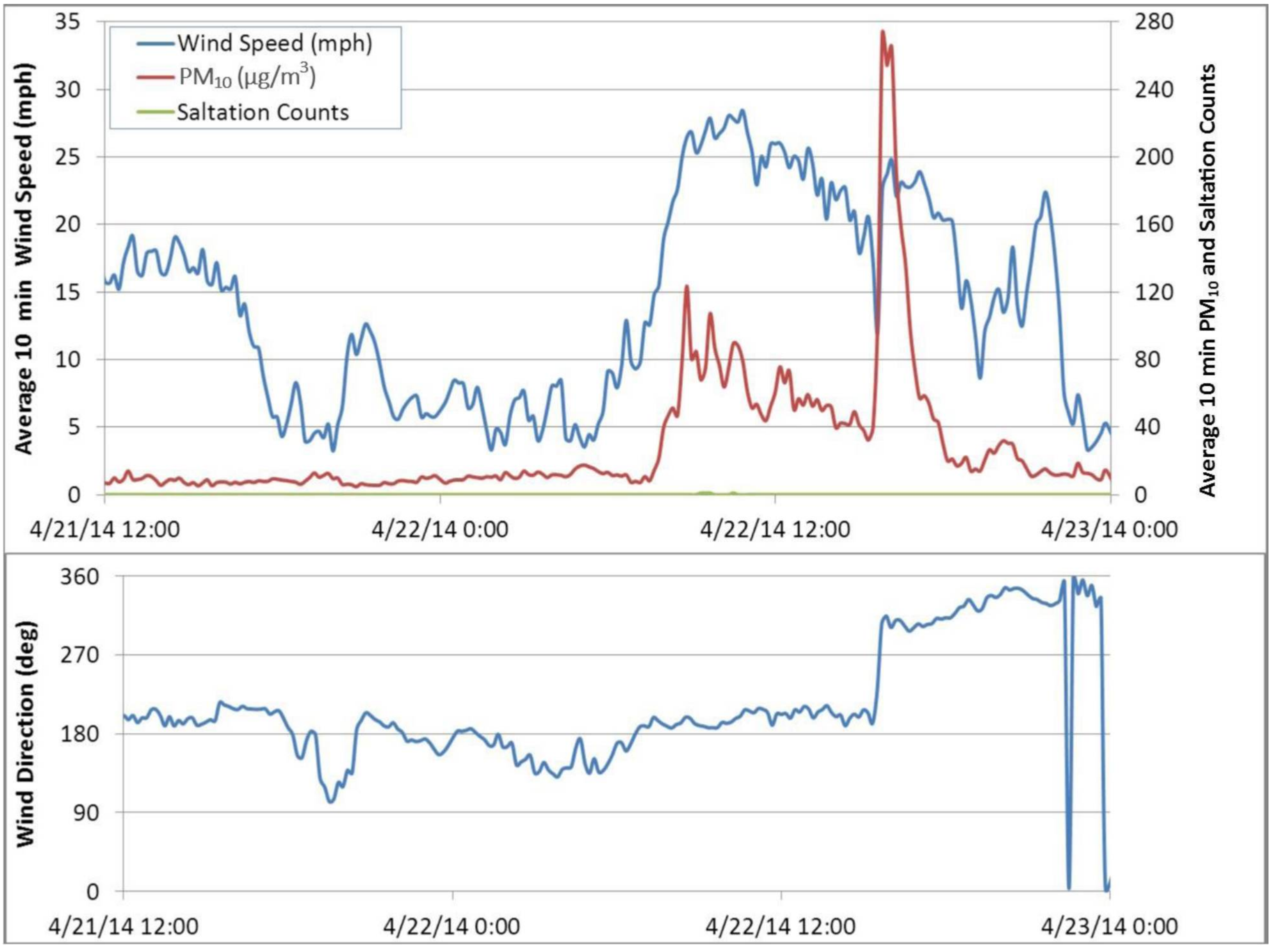

Figure D-7. Wind and dust episode April 22, 2014.

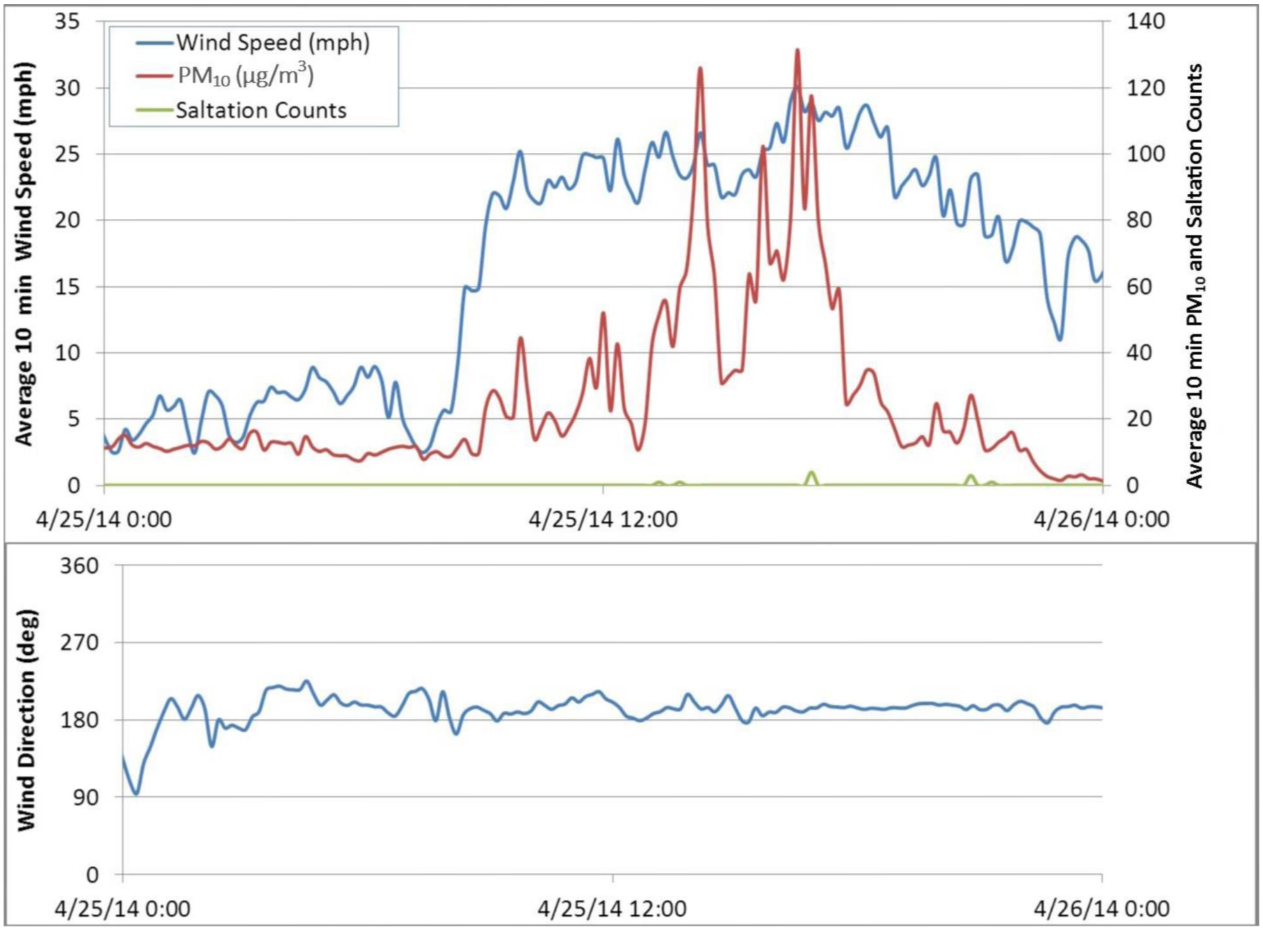

Figure D-8. Wind and dust episode April 25, 2014.

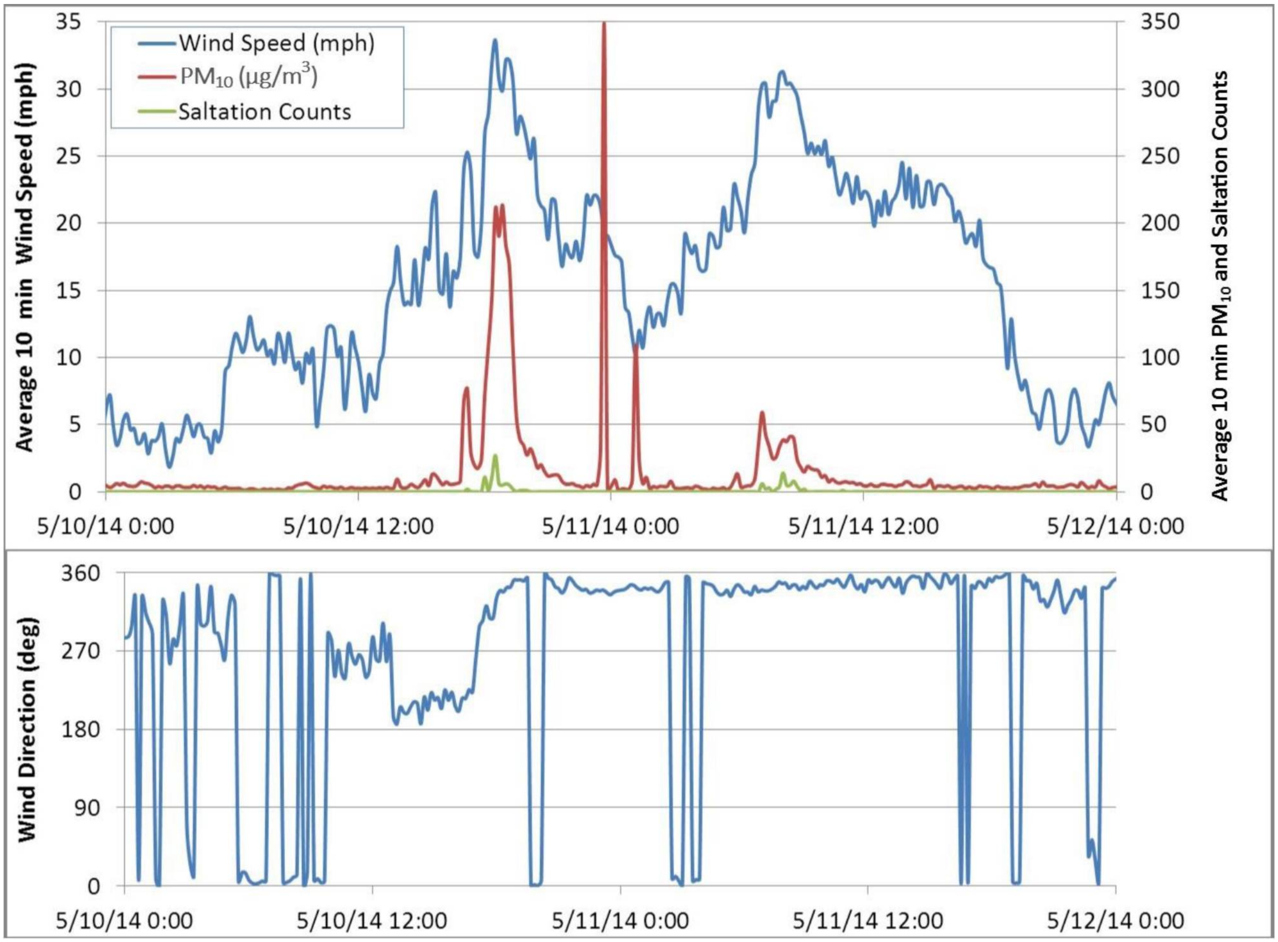

Figure D-9. Wind and dust episode May 10, 2014.

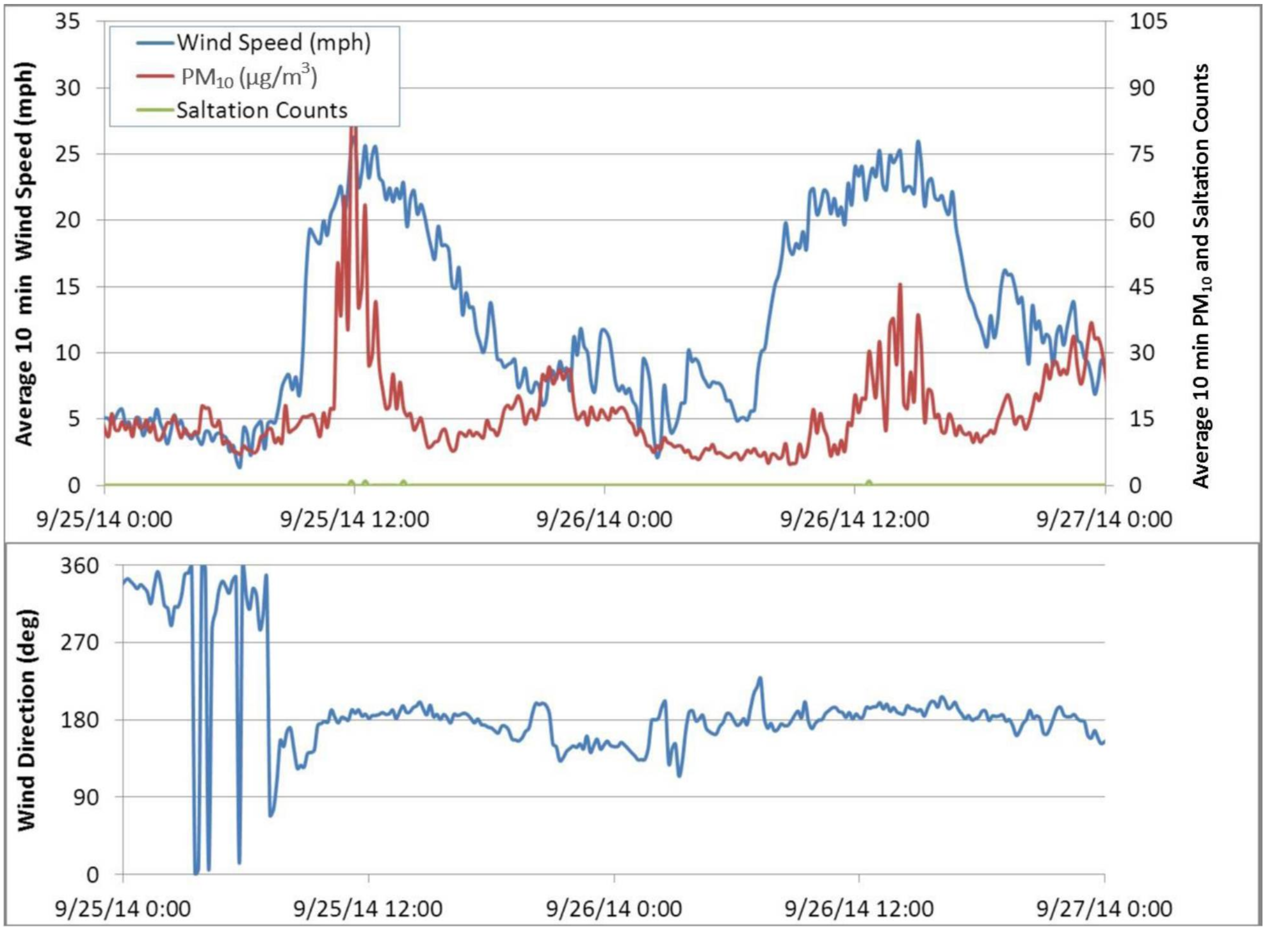

Figure D-10. Wind and dust episode September 25, 2014.

APPENDIX E: GROSS ALPHA AND GROSS BETA VALUES FOR THE PERIOD OF RECORD

Collection Date	Filter Type	P-57-1		P-57-2	
		Gross Alpha µCi/mL E-15	Gross Beta µCi/ml E-14	Gross Alpha µCi/mL E-15	Gross Beta µCi/ml E-14
10/16/13	Cellulose	2.15	1.39	1.63	1.39
10/29/13	Cellulose	1.46	1.48	2.04	1.40
11/13/13	Cellulose	0.98	1.05	0.88	1.30
11/25/13	Cellulose	2.39	1.51	2.73	1.67
12/10/13	Cellulose	0.77	1.24	0.88	1.36
12/23/13	Cellulose	1.01	0.9	0.43	0.86
1/7/14	Cellulose	0.94	1.11	1.11	0.98
1/21/14	Cellulose	0.45	1.27	0.36	1.37
2/4/14	Cellulose	1.16	1.03	1.62	1.18
2/19/14	Glass	1.60	1.79	1.34	1.96
3/4/14	Glass	2.30	1.23	2.09	1.34
3/18/14	Glass	1.68	0.90	1.95	0.97
4/1/14	Glass	2.76	1.54	2.35	1.43
4/14/14	Glass	2.32	1.41	2.67	1.32
4/29/14	Glass	2.69	1.8	2.43	1.75
5/13/14	Glass	1.20	1.31	1.56	1.35
5/28/14	Glass	1.66	1.67	1.72	1.67
6/9/14	Glass	2.32	2.31	2.03	2.00
6/24/14	Glass	1.47	2.01	1.02	1.84
7/8/14	Glass	0.66	1.73	0.42	1.73
7/21/14	Glass	2.14	1.92	1.87	1.88
8/6/14	Glass	1.51	1.9	1.43	1.91
8/18/14	Glass	0.37	1.85	0.29	1.75
9/2/14	Glass	1.02	2.14	1.17	2.07
9/15/14	Glass	1.18	2.25	0.88	2.11
9/29/14	Glass	1.56	1.76	0.62	1.76
10/14/14	Glass	1.80	1.88	1.85	1.94
10/28/14	Glass	1.68	2.23	1.60	2.23
11/12/14	Glass	0.57	2.02	1.15	2.22
11/25/14	Glass	1.98	2.29	1.38	2.31
12/8/14	Glass	1.06	1.95	0.96	1.99
12/22/14	Glass	0.28	2.16	0.67	2.21
1/7/15	Glass	1.86	1.80	2.39	1.90
Count		33	33	33	33
Maximum		2.76	2.31	2.73	2.31
Minimum		0.28	0.90	0.29	0.86
Average		1.48	1.66	1.44	1.67

APPENDIX F: QUALITY ASSURANCE PROGRAM

Although the current data collected for the Project 57 Air Monitoring study are considered for informational purposes to support conceptual models or guide investigations, the U.S. Department of Energy National Nuclear Security Administration Nevada Field Office (DOE/NNSA/NFO) Soils Activity Quality Assurance Plan (QAP) (2012) was used as a guideline for the collection and analysis of the airborne radiological data presented in the section of this report titled, "Radiological Assessment of Airborne Particulates." This QAP as well as the Desert Research Institute Quality Assurance Program Manual for the DOE Program (2010) ensures compliance with U.S. Department of Energy (DOE) Order DOE O 414.1D, "Quality Assurance", which implements a quality management system to ensure the generation and use of quality data. The following items are addressed by the aforementioned QA documents:

- Data quality objectives (DQOs)
- Sampling plan development appropriate to satisfy the DQOs
- Environmental health and safety
- Sampling plan execution
- Sample analyses
- Data review
- Continuous improvement

Data Quality Objectives (DQOs)

The DQO process is a strategic planning approach that is used to plan data collection activities. It provides a systematic process for defining the criteria that a data collection design should satisfy. These criteria include when and where samples should be collected, how many samples to collect, and the tolerable level of decision errors for the study. The DQOs are unique to the specific data collection or monitoring activity and their defined level of use (in this case, for informational purposes).

Measurement Quality Objectives (MQOs)

The MQOs are basically equivalent to DQOs for analytical processes. The MQOs provide direction to the laboratory concerning performance objectives or requirements for specific method performance characteristics. Default MQOs are established in the subcontract with the laboratory but may be altered to satisfy changes in the DQOs. The MQOs for the Project 57 Air Monitoring study are described in terms of precision, accuracy, representativeness, completeness, and comparability requirements. These terms are defined and discussed in the DOE/NNSA/NFO (QAP).

Sampling Quality Assurance Program

Quality Assurance (QA) in field operations for the Project 57 Air Monitoring study includes sampling assessments, surveillances, and oversight of the following supporting elements:

- The sampling plan, DQOs, and field data sheets accompanying the sample package
- Database support for field and laboratory results, including systems for long-term storage and retrieval
- Qualified personnel who are available and able to perform required tasks

Sample packages include the following items:

- Sample collectors field notes confirming all observable information pertinent to sample collection
- An Air Surveillance Network Sample Data Form that documents air sampler parameters, collection dates and times, and total sample volumes collected
- Chain-of-custody forms that also include some of the elements of the field notes

This managed approach to sampling ensures that the sampling is traceable and enhances the value of the final data available to the project manager. The sample package also ensures that the personnel responsible for sample collection have followed proper procedures for sample collection.

Data obtained in the course of executing field operations are entered in the documentation that accompany the sample package during sample collection and in the Project 57 Study database along with analytical results on their receipt and evaluation.

Completed sample packages are kept as hard copy in file archives. Analytical reports are kept as hard copy in file archives as well as in a dedicated and secure archival systems that are protected and maintained in accordance with the Desert Research Institute's Computer Protection Program.

Laboratory QA Oversight

Although the data for the Project 57 Air Monitoring study is for informational purposes, the main aspects of the DOE O 414.1D requirements are used as guidelines to evaluate laboratory services through review of the vendor laboratory policies formalized in a Laboratory Quality Assurance Plan (LQAP). The Project 57 study is assured of obtaining quality data from laboratory services through a multifaceted approach that involves specific procurement protocols, the conduct of quality assessments, and requirements for selected laboratories to have an acceptable QA Program. These elements are discussed below.

<u>Procurement</u>

Laboratory services are procured through subcontracts that establish the technical specifications required of the laboratory to provide the basis for determining compliance with those requirements and evaluating overall performance. A subcontract is usually awarded on a best-value basis as determined by pre-award audits, but because of the specific requirement requested for gamma spectroscopy analysis (24 hour count duration) for the Project 57 study, the laboratory was procured on a sole-proprietor basis. The laboratory was required to provide a review package that included the following items:

- All procedures pertinent to subcontract scope
- Environment, Safety, and Health Plan
- LQAP
- Example deliverables (hard copy and/or electronic)
- Proficiency testing (PT) results from the previous year from recognized PT programs
- Résumés
- Accreditations and certifications
- Licenses

Continuing Assessment

A continuing assessment of a selected laboratory involves the ongoing monitoring of a laboratory's performance against the contract terms and conditions, of which technical specifications are a part. The following tasks support continuing assessment:

- Tracking schedule compliance
- Reviewing analytical data deliverables
- Monitoring the laboratory's adherence to the LQAP
- Monitoring for continued successful participation in approved PT programs

Data Review

Essential components of process-based QA are data checks, verification, validation, and data quality assessment to evaluate data quality and usability.

Data Checks: Data checks are conducted to ensure accuracy and consistency of field data collection operations prior to and on data entry into Project 57 databases and data management systems.

Data Verification: Data verification is defined as a compliance and completeness review to ensure that all laboratory data and sample documentation are present and complete. Sample preservation, chain-of-custody, and other field sampling documentation shall be reviewed during the verification process. Data verification ensures that the reported results entered in Project 57 databases correctly represent the sampling and/or analyses performed and includes evaluation of quality control (QC) sample results.

Data Validation: Data validation is the process of reviewing a body of analytical data to determine if it meets the data quality criteria defined in operating instructions. Data validation ensures that the reported results correctly represent the sampling and/or analyses performed, determines the validity of the reported results, and assigns data qualifiers (or "flags") if required. The process of data validation consists of the following:

- Evaluating the quality of the data to ensure that all project requirements are met
- Determining the impact on data quality of those requirements if they are not met

- Verifying compliance with QA requirements
- Checking QC values against defined limits
- Applying qualifiers to analytical results in the Project 57 databases for the purposes of defining the limitations in the use of the reviewed data

Operating instructions, procedures, applicable project-specific work plans, field sampling plans, QA plans, analytical method references, and laboratory statements of work may all be used in the process of data validation. Documentation of data validation includes checklists, qualifier assignments, and summary forms.

Data Quality Assessment (DQA): The DQA is the scientific evaluation of data to determine if the data obtained from environmental data operations are of the right type, quality, and quantity to support their intended use. The DQA review is a systematic review against preestablished criteria to verify that the data are valid for their intended use.

2014 Sample QA Results

The QA assessments were performed by the Project 57 Air Monitoring study, including the laboratory responsible for sample analyses. These assessments ensure that sample collection procedures, analytical techniques, and data provided by the subcontracted laboratory comply with Project 57 study requirements. Data were provided by the University of Nevada, Las Vegas, Radiation Services Laboratory (gross alpha/beta and gamma spectroscopy data), and Mirion Technologies (TLD data). A brief discussion of the 2014 results for laboratory duplicates, control samples, blank analyses, and interlaboratory comparison studies is provided along with summary tables within this section.

Laboratory Duplicates (Precision)

A laboratory duplicate is a sample that is handled and analyzed following the same procedures as the primary sample analysis. The relative percent difference (RPD) between the initial result and the corresponding duplicate result is a measure of the variability in the analytical process of the laboratory, mainly overall measurement uncertainty. The average absolute RPD, expressed as a percentage, was determined for the calendar year 2014 samples and is listed in Table F-1. An RPD of zero indicates a perfect duplication of results of the duplicate pair, whereas an RPD greater than 100 percent generally indicates that a duplicate pair falls beyond QA requirements and is not considered valid for use in data interpretation. These samples are further evaluated to determine the reason for QA failure and if any corrective actions are required. Overall, the RPD values for all analyses indicate very good results with no samples exceeding an RPD of 100 percent.

Table F-1. Summary of laboratory duplicate samples for the Project 57 Air Monitoring study in 2014.

Analysis	Matrix	Number of Samples Reported[a]	Number of Samples Reported above MDC[b]	Average Absolute RPD of those above MDC (%)[c]
Gross Alpha	Air	10	10	24.0
Gross Beta	Air	10	10	4.5
Gamma – Beryllium-7	Air	7	7	16.5
Gamma – Lead- 210	Air	1	1	N.A.
TLDs	Ambient Radiation	12	NA	2.0

a) Represents the number of laboratory duplicates reported for the purpose of monitoring precision. If an associated field sample was not processed, the field duplicate was not included in this table.
b) Represents the number of laboratory duplicate sets reported above the minimum detectable concentration (MDC) (MDC is not applicable for TLDs). If either the original laboratory analysis or its duplicate was reported below the detection limit, the precision was not determined.
c) Reflects the average absolute RPD calculated for those field duplicates reported above the MDC.

The absolute RPD calculation is as follows:

$$Absolute\ RPD = \frac{|FD - FS|}{(FD + FS)/2} X \ 100\%$$

Where: FD = Field duplicate result
FS = Field sample result

Laboratory Control Samples (Accuracy)

Laboratory control samples (LCSs) (also known as matrix spikes) are performed by the subcontract laboratory to evaluate analytical accuracy, which is the degree of agreement of a measured value with the true or expected value. Samples of known concentration are analyzed using the same methods as employed for the project samples. The results are determined as the measured value divided by the true value, expressed as a percentage. To be considered valid, the results must fall within established control limits (or percentage ranges) for further analyses to be performed. The LCS results obtained for 2014 are summarized in Table F-2. The LCS results were satisfactory with all samples falling within control parameters for the air sample matrix.

Table F-2. Summary of laboratory control samples for the Project 57 Air Monitoring study in 2014.

Analysis	Matrix	Number of LCS Results Reported	Number Within Control Limits[a]
Gross Alpha	Air	8	8
Gross Beta	Air	8	8
Gamma	Air	8	8

a) Control limits are as follows: 78 percent to 115 percent for gross alpha, 87 percent to 115 percent for gross beta, 90 percent to 115 percent for gamma (137Cs, 60Co, 241Am).

Laboratory Blank Analysis

Laboratory blank sample analyses are essentially the opposite of LCSs discussed above. These samples do not contain any of the analyte of interest. Results of these analyses are expected to be zero, or more accurately below the MDC of a specific procedure. Blank analysis and control samples are used to evaluate overall laboratory procedures, including sample preparation and instrument performance. The laboratory blank sample results obtained for 2014 are summarized in Table F-3. The laboratory blank results were satisfactory with all of the alpha and beta blank samples falling within control parameters for the air sample matrix.

Table F-3. Summary of laboratory blank samples for the Project 57 Air Monitoring study in 2014.

Analysis	Matrix	Number of Blank Results Reported	Number within Control Limits[a]
Gross Alpha	Air	8	8
Gross Beta	Air	8	8
Gamma	Air	8	8

a) Control limit is less than the MDC.

Interlaboratory Comparison Studies

Interlaboratory comparison studies are conducted by the subcontracted laboratories to evaluate their performance relative to other laboratories providing the same service. These types of samples are commonly known as blind samples, in which the expected values are known only to the program conducting the study. The analyses are evaluated and if found satisfactory, the laboratory is certified that its procedures produce reliable results. The interlaboratory comparison sample results obtained for 2014 are summarized in Tables F-4 and F-5.

Table F-4 shows the summary of interlaboratory comparison sample results for the subcontract radiochemistry laboratory. The laboratory participated in the QA Program administered by Mixed Analyte Performance Evaluation Program (MAPEP) for gross alpha, gross beta, and gamma analyses. The subcontractors performed very well during the year by passing all of the parameters analyzed.

Table F-4. Summary of interlaboratory comparison samples of the radiochemistry laboratory for the Project 57 Air Monitoring study in 2014.

		MAPEP Results	
Analysis	Matrix	Number of Results Reported	Number Within Control Limits[a]
Gross Alpha	Air	2	2
Gross Beta	Air	2	2
Gamma	Air	2	2

a) Control limits are determined by the individual inter-laboratory comparison study.

Table F-5 shows the summary of the in-house performance evaluation results conducted by the subcontract dosimetry group. This internal evaluation was based on National Voluntary Laboratory Accreditation Program (NVLAP) criteria and was performed biannually. The dosimetry group performed very well during the year by passing 15 out of 15 of the TLDs analyzed.

Table F-5. Summary of interlaboratory comparison TLD samples of the subcontract dosimetry group for the Project 57 Air Monitoring study in 2014.

Analysis	Matrix	Number of Results Reported	Number Within Control Limits[a]
TLDs	Ambient Radiation	15	15

a) Based upon NVLAP criteria; absolute value of the bias plus one standard deviation < 0.3.

References

Desert Research Institute, 2010. *Desert Research Institute Quality Assurance Program Manual for the DOE Program*, October 2010.

U.S. Department of Energy, 2011. DOE O 414.1D, *Quality Assurance*, April 2011.

U.S. Department of Energy, 2013. *Soils Activity Quality Assurance Plan,* May 2012.