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November 25, 2015

Mr. James Webb
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Division of Waste Management and Environmental Protection
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Washington, DC 20555

SUBJECT: TECHNICAL BASIS DOCUMENT FOR REVISIONS TO NRC REGULATORY GUIDE 3.63, SECTION C.1, FOURTH PARAGRAPH (Final) (RFTA 14-011); DCN 5244-TR-01-1

Dear Mr. Webb:

Oak Ridge Associated Universities (ORAU), operating under the Oak Ridge Institute for Science and Education (ORISE) contract, is pleased to provide the enclosed final technical basis document (TBD). Significant technical and editorial changes were incorporated into this final version of the TBD based on the comments provided by the U.S. Nuclear Regulatory Commission (NRC) staff on the preliminary draft and subsequent appendices submitted for review.

Please feel free to contact me at 865.574.3459, or Tim Vitkus at 865.576.5073, if you have any questions or comments.

Sincerely,

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Prepared for the U.S. Nuclear Regulatory Commission

NOVEMBER 2015

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ACRONYMS

ALT	station barometric pressure
ANL	Argonne National Laboratory
ANS	American Nuclear Society
ANSI	American National Standards Institute
ASCE	American Society of Civil Engineers
ASOS	Automated Surface Observing System
BKN	broken (sky cover 5/10 to 9/10)
CD	(computer) card deck
CDD	cooling degree days
CFR	Code of Federal Regulations
CLG	ceiling (lowest level of sky cover at least BKN)
CLR	clear (no clouds in sky, sky cover 0/10)
DQO	data quality objective
DIR	wind direction
DOE	U.S. Department of Energy
DP	dew point (temperature)
EPA	U.S. Environmental Protection Agency
ER	environmental report
GDD	growing degree days
HDD	heating degree days
HVAC	heating, ventilating, and air conditioning
IML	Inter Mountain Labs
JFD	joint frequency distribution
LC	license condition
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MEA	Marsland Expansion Area
MIN	minute (time unit)
NCEI	National Centers for Environmental Information
NOAA	National Oceanic and Atmospheric Administration
NPH	natural phenomena hazard
NRC	U.S. Nuclear Regulatory Commission
NWS	National Weather Service
OBS	(sky) obscured
ORAU	Oak Ridge Associated Universities

ORISE	Oak Ridge Institute for Science and Education
OVC	overcast (complete cloud cover, 10/10)
PMP	probable maximum precipitation
RAI	request for additional information
RG	regulatory guide
R^2	R-squared (coefficient of determination for linear regression)
SEI	Structural Engineering Institute
SCT	scattered (cloud cover 1/10-4/10)
SKC	sky cover
SPD	wind speed
SSCs	structures, systems, and components
STAR	stability array (JFD of wind speed, wind direction, and stability class)
STD	standard
TEMP	temperature
TR	technical report
WMO	World Meteorological Organization

TECHNICAL BASIS DOCUMENT FOR REVISIONS TO NRC REGULATORY GUIDE 3.63, SECTION C.1, FOURTH PARAGRAPH

1. INTRODUCTION

Meteorological data and the decisions made with the data, when applied properly, positively contribute to the general safety and well-being of uranium recovery facility personnel and the general public, enhance operational efficiencies, and contribute to the protection of property, assets, and the environment. Accurate and representative meteorological information is one of the primary decision-making components for selecting environmental air sampling locations for preoperational, operational, and effluent monitoring at uranium recovery facilities. Regulatory Guide (RG) 4.14, *Radiological Effluent and Environmental Monitoring at Uranium Mills*, Revision 1, April 1980 (NRC, 1980), recommends that operational sampling locations be the same as the preoperational sampling locations. The preoperational monitoring program should take into account, among other factors, meteorological conditions (e.g., wind speed, wind direction, and atmospheric stability) from the onsite meteorological monitoring program data.

Regulatory Guide 3.63, *Onsite Meteorological Measurement Program for Uranium Recovery Facilities–Data Acquisition and Reporting*, March 1988 (NRC, 1988), provides guidance for the collection of meteorological data in the vicinity of the facility to determine the air monitoring locations, assessment of the potential impact of airborne effluent releases, and the monitoring of airborne effluents. This document also provides guidance regarding the correct siting of meteorological towers and associated instrumentation, the appropriate measurement of meteorological parameters, the maintenance and calibration of meteorological instruments, meteorological monitoring system accuracies, quality assurance of the meteorological data, and meteorological data recovery. Additional and more recent guidance for onsite meteorological measurement programs can be found in RG 1.23 Revision 1 (NRC, 2007) and ANSI/ANS-3.11-2005(R2010) (ANSI, 2010).

Specifically pertaining to the collection of onsite meteorological data and the demonstration of whether the collected data are representative of long-term conditions, RG 3.63 Section C.1 Regulatory Position (fourth paragraph) states the following:

"The minimum amount of meteorological data needed for a siting evaluation is considered to be that amount of data gathered on a continuous basis for a consecutive 12-month period that is representative of long-term (e.g., 30 years) meteorological conditions in the site vicinity. To determine whether the period during which the onsite data was collected is representational, compare a concurrent period of meteorological data from a National Weather Service (NWS) station with the long-term meteorological data from that NWS station. The NWS station selected for this comparison should, if possible, be in a similar geographical and topographical location and be reasonably close (preferably within 50 miles (80 kilometers)) to the site. In some sections of the country, the spacing between NWS stations may necessitate the selection of an NWS station more than 50 miles away. The reduced data and supportive documentation should be retained and should be available for review for the period of facility operation."

A temporal meteorological data representativeness demonstration is implied, but not clearly stated in RG 3.63. Specific information about acceptable methods to demonstrate temporal meteorological data representativeness is not presented in RG 3.63, RG 1.23 Revision 1, ANSI/ANS-3.11-2005 (R2010), nor any other U.S. Nuclear Regulatory Commission (NRC) NUREG or NUREG/CR. It should be noted that although spatial representativeness between the onsite and offsite (e.g., National Weather Service [NWS] station) monitoring locations may be important NRC staff do not seek this type of representativeness demonstration for wind speed, wind direction, and stability class. Without specific acceptable methodologies with which to demonstrate temporal representativeness, uranium recovery facility applicants and licensees have used a variety of data analysis methods in an attempt to demonstrate that the data collected in the onsite meteorological monitoring program for a consecutive 12-month period are temporally representative of long-term conditions (e.g., a consecutive period of 30 years). The methods employed include both qualitative (e.g., graphical) and quantitative (e.g., statistical) approaches, some of which may not be appropriate to demonstrate temporal representativeness, or may be acceptable, but are in many cases incorrectly applied.

The issue of adequacy in temporal representativeness demonstration has resulted in a number of requests for additional information (RAIs) and license conditions (LCs). For example, the NRC issued RAIs to both Strata Energy, Inc. (Strata) and AUC LLC (AUC) (NRC, 2014 and Strata, 2014). As a result of these RAIs, organizations such as Strata and AUC have provided evaluations of statistical methods to demonstrate long-term representativeness of onsite data (IML, 2014a and 2014b). The AUC evaluation (IML, 2014b), prepared by Inter-Mountain Labs, Inc. (IML) Air

Science, was reviewed and some of the methods employed by IML were independently tested with meteorological data for two different NWS stations (i.e., Scottsbluff, Nebraska and Gillette, Wyoming).

As a result of the challenges encountered by applicants and licensees in demonstrating temporal representativeness, the NRC staff has determined that more clarity and guidance is needed in this area to assist the applicants and licensees in their evaluations and subsequently reduce future issuances of RAIs and LCs.

2. ACQUISITION, PREPARATION, AND ANALYSIS OF NWS STATION DATA

Currently, there is no specific NRC guidance on acceptable methods for the acquisition, preparation, and analysis of offsite (e.g., NWS) meteorological data that is applicable to all uranium recovery facility locations. It is recognized that meteorological data collection, data preparation, and analysis may be site-specific due to local climate variability and other factors (e.g., topography, land use, or land cover). In order to provide more clarity and determine acceptable methods to demonstrate temporal representativeness, long-term datasets for two NWS stations, Scottsbluff, Nebraska and Gillette, Wyoming were obtained and these datasets prepared for subsequent analyses. These stations are reasonably close to uranium recovery facilities and have been used by applicants and licensees for demonstration of temporal representativeness.

The following subsections discuss methodologies used to ensure that the meteorological data are properly acquired, are accurate, contain minimal errors and biases, and are properly prepared for subsequent analyses and calculations. Acceptable methods to determine temporal representativeness are also discussed.

2.1 DATA ACQUISITION

Regulatory Guide 3.63 recommends that an applicant or licensee acquire a minimum of 12 consecutive months of onsite meteorological data and then demonstrate that this period of data is temporally representative of the long-term local mesoscale to microscale climatology. The determination as to whether the short-term meteorological data are representative of the long-term meteorological conditions necessitates the use of a surrogate analysis by acquiring a long-term period

(e.g., 30 years) of offsite data from a first-order NWS station, preferably within 50 miles (80 kilometers) of the site, to establish the general regional climatology. One year, or more as appropriate, of data that corresponds with the site's baseline monitoring period is also acquired from the NWS station for the temporal representativeness evaluation. Ultimately, the temporal representativeness surrogate evaluation determines whether the observed short-term, site-specific meteorological data are representative of the long-term meteorology at the licensee's or applicant's site, or alternatively, if the short-term meteorological data are indicative of an anomalous meteorological cycle, then further monitoring may be required to establish an appropriate baseline.

Prior to data collection, it is important to determine which meteorological parameters are required for subsequent analyses and to establish appropriate data quality objectives (DQOs) with respect to each of these parameters. For instance, wind speed, wind direction, and atmospheric stability are important for each type of uranium recovery facility. Other meteorological parameters (e.g., evaporation, precipitation, temperature, humidity), have to be classified in order of importance, based on the type of uranium recovery facility and the potential sources of radioactivity emitted from these facilities. Representativeness should then be demonstrated for each parameter that has a deterministic effect.

For the preparation of the recommendations provided in this technical basis document (TBD), datasets for Scottsbluff, Nebraska and Gillette, Wyoming NWS stations were acquired from the National Centers for Environmental Information (NCEI). These sites were selected because they provided data that were clearly different from one another. Table 2-1 includes the periods for which data were acquired for Scottsbluff, Nebraska and Gillette, Wyoming.

Table 2-1. Data Sets Acquired from NCEI

Period of Acquired Data	Scottsbluff, Nebraska	Gillette, Wyoming
01/01/1981 to 07/31/2010 (30 years)[a]	X	Not acquired[b]
08/01/1995 to 07/31/2010 (15 years)	X	X[c]
08/24/2010 to 08/29/2011 (1 year)	X	X

[a] The period of acquired data is actually 29 years and 7 months; almost 30 years.
[b] The NCEI website indicates that Gillette, Wyoming data are available starting in 1977. However, the inventory listing in NCEI showed there is significant missing data from 1977–1983. Starting in 1984, there seemed to be reasonable data recovery to enable construction of a 30-year dataset.
[c] Gillette, Wyoming data, downloaded from NCEI, had a lot of missing data.

The data that are downloaded from the NCEI are provided in the following format:

- DIR (degrees azimuth)—Wind direction
- SPD (miles per hour)—Wind speed
- CLG (hundreds of feet)—Ceiling height
- SKC (CLR-0/10; SCT-1/10 to 4/10; BKN-5/10 to 9/10; OVC-10/10; OBS-obscured)—Sky cover
- TEMP (°F)—Air temperature
- DP (°F)—Dew point temperature
- ALT (inches Hg)—Station barometric pressure

2.2 Data Preparation

The data processing technique is applicable to all NWS-observed parameters. Depending on the DQOs and the software or method to be used, data may need to be prepared. Preparation could include specific formatting, filtering, and/or organization. However, it should be taken into consideration that some factors do exist which may affect the data but cannot be mitigated by data preparation techniques. These factors include, but are not limited to, the relocation of a monitoring station and the conversion from human observer to an Automated Surface Observing System (ASOS) during the data period.

The NCEI data for Scottsbluff, Nebraska and Gillette, Wyoming were acquired to be used as input to the U.S. Environmental Protection Agency (EPA) Stability Array (STAR) program to establish atmospheric stability class, which is not directly observed or measured at NWS stations.

After acquiring the offsite meteorological data from NCEI, the datasets were copied to a spreadsheet in an Excel workbook. Using a second copy of the spreadsheet within the workbook, the desired meteorological parameters that are needed to create a dataset in NCEI Card Deck-144 (CD-144) were selected. In order to make the raw NCEI data compatible with STAR, they were

filtered by the MIN[1] parameter by selecting only the values 53 and 54 to avoid repeat observations for the same hour. The data were then manually screened to ensure that there were exactly 24 observations per day. When an hour was missing, the raw data spreadsheet for an entry for the missing hours with MIN=0 was checked. If available, the data were inserted into the missing hours. If not available, the observations were left blank to indicate missing data.

After creating a corrected chronological dataset, the data were manually screened to fill in any obviously[2] missing parameter values. Obvious cases included a consistent string of sky cover observations, ensuring that a CLG observation of 722 (i.e., unlimited ceiling) had a concurrent SKC observation of either CLR or SCT. A finite ceiling height observation can only have a concurrent SKC of BKN or OVC sky cover since a ceiling is defined as at least a broken (BKN) sky cover. Where only one hourly observation was missing, persistence was assumed and the previous hour's observations were copied. Where multiple hours of observations were missing, the observations were left blank to indicate missing data.

It is important to note that the STAR program uses a two-digit identifier for the year, causing execution errors for data reported in the 21st century. As a temporary work-around, the identifiers were set back 20 years (e.g., Scottsbluff, Nebraska data from 1981–2011 were labeled as 61–91) to keep the identifiers in bound and the leap years in phase. This allowed the program to execute normally and provide correct results.

Parameters from the filtered and screened spreadsheet which are needed for the CD-144[3] format were created with the following units and resolution:

DIR (tens of degrees azimuth)—Wind direction
SPD (miles per hour)/1.1508 = knots—Wind speed
CLG (hundreds of feet)—Ceiling height
SKC (CLR-0; SCT-3; BKN-8; OVC-"—"; OBS-"—")—Sky cover
TEMP (°F) —Air temperature

[1] The MIN parameter is the minute of the observation each hour. The standard is to take the observation at minute 53 or 54, but sometimes other minute values show up, resulting in multiple observations for the same hour.
[2] Missing data are obvious from the presence of asterisks. Another example of missing data is data embedded in a long string of the same sky cover or temperatures.
[3] This format is specific to STAR and is different from the NCEI data format.

DP (°F) —Dew point temperature

ALT (100ths inches Hg)—Station barometric pressure

Another spreadsheet was created with the aforementioned observations in CD-144 format as shown in Table 2-2.

Table 2-2. Meteorological Parameter Identification in CD-144 Format	
Position	**Element**
1–5	Surface station number
6–7	Year
8–9	Month
10–11	Day
12–13	Hour
14–16	Ceiling height (hundreds of feet)
39–40	Wind direction (tens of degrees azimuth)
41–42	Wind speed (knots)
47–49	Dry bulb temperature (°F)
79	Opaque cloud cover

The STAR program summarizes NWS meteorological data in CD-144 format by generating joint frequency distributions (JFDs) of six wind speed ranges, 16 wind direction sectors, and six stability classes (Pasquill-Gifford classes A through F) for the station and time period desired. The program generates a count of the number of entries (i.e., frequency) by stability class for each wind speed range and wind direction sector, along with the corresponding normalized frequency (i.e., relative frequency) expressed as percent of the total hours of observation.

For use by the STAR program, meteorological data are sorted into yearly station files consisting of hourly wind speed, wind direction, cloud ceiling height, and total cloud cover; the last is inferred from sky cover. STAR output provides columns displaying the number of occurrences within each wind speed range category for each wind direction sector and each stability class, respectively.

The following sections describe how the wind direction, wind speed, and other NWS data are binned into categories to establish the JFD. It also describes the technique for redistributing calm winds into the appropriate wind direction sector.

2.2.1 Wind Direction

By convention, wind direction is divided into 16 equally-sized 22.5-degree azimuth sectors, where the first sector, N, is centered on north (i.e., 0 or 360 degrees azimuth). Accordingly, any observation within 348.75 degrees azimuth and 11.25 degrees azimuth would be placed into the north sector. The remaining 15 wind direction sectors are defined by the same convention. Because the NWS wind direction observations have a resolution to the nearest 10 degrees azimuth, some sectors will have three wind directions assigned to them, while other sectors will only have two wind directions assigned. Table 2-3 shows this relationship.

Table 2-3. Wind Direction Separated into 16 Sectors

No.	Wind Direction Sector Identification	Sector Azimuth Range (degrees)	NWS Wind Directions (degrees)
1	N	348.76–11.25	350, 0, 10
2	NNE	11.26–33.75	20, 30
3	NE	33.76–56.25	40, 50
4	ENE	56.36–78.75	60, 70
5	E	78.76–101.25	80, 90, 100
6	ESE	101.26–123.75	110, 120
7	SE	123.76–146.25	130, 140
8	SSE	146.26–168.75	150, 160
9	S	168.76–191.25	170, 180, 190
10	SSW	191.26–213.75	200, 210
11	SW	213.76–236.25	220, 230
12	WSW	236.76–258.75	240, 250
13	W	258.76–281.25	260, 270, 280
14	WNW	281.26–303.75	290, 300
15	NW	303.76–326.25	310, 320
16	NNW	326.26–348.75	330, 340

A technique to remove the wind direction bias caused by assigning wind direction data given in tens of degrees of azimuth to 22.5-degree bins is presented in Applequist, 2011. This technique, which is outside the scope of this document and is not reflected in previously reviewed licensee or applicant documentation, was not applied to the wind direction data being used in this example.

2.2.2 Wind Speed

NWS wind speed observations are in miles per hour (mph). The six wind speed range categories are defined by the STAR program and are shown in Table 2-4. They mirror the light to moderate wind Beaufort Wind Scale categories (NOAA, 2015). These wind categories of speed range constitute one of the parameters the STAR program use to calculate atmospheric stability class.

Table 2-4. Six Wind Speed Range Categories	
Category No.	**Wind Speed Range (mph)**
1	1–3
2	4–7
3	8–12
4	13–18
5	19–24
6	greater than 24

The threshold wind speed that is measured by NWS airport anemometers is usually specified as 1 mph. Accordingly, the calms (i.e., wind speeds below anemometer threshold) have to be collected in a separate category.

2.2.3 Stability Class

Stability class is a function of wind speed, which drives turbulence mechanically, and is also a function of solar heating, which drives turbulence by generating buoyancy forces. During the nighttime, mechanical turbulence is suppressed by negative buoyancy due to the earth's cooling at the surface. The effect of solar heating is a function of the time of day, station latitude, ceiling height, and sky cover. The STAR program contains the logic to determine a stability class from specific combinations of these parameters for any time of the day and any month of the year.

The six Pasquill-Gifford stability classes are defined as shown in Table 2-5.

Table 2-5. Pasquill-Gifford Stability Classes	
Stability Class	**Turbulence Category**
A	Extremely unstable (daytime only)
B	Unstable (daytime only)

Table 2-5. Pasquill-Gifford Stability Classes	
Stability Class	**Turbulence Category**
C	Slightly unstable (daytime only)
D	Neutral (daytime and nighttime)
E	Slightly stable (nighttime only)
F	Stable (nighttime only)

Secondary data management was required to further bin the frequency distributions of wind speed ranges and wind direction sectors for each of the specific stability classes. From this secondary binning, the total number of observations should be calculated for each stability class. For each of the six stability classes, the total number of calm winds (i.e., calms) within each stability class, is redistributed to the wind direction sectors within the first wind speed range (i.e., 1–3 mph), which is representative of very light wind speeds. Regulatory Guide 3.63, Table 1 includes a note[4] recommending the distribution of calms for onsite meteorological stations. This cannot be followed for NWS offsite stations if the STAR program is used to determine the JFD. The STAR program will do the following as stated in the literature: "…Within each stability class, calms are distributed among the directions within the first wind speed class in proportion to the sum of the frequencies of winds in the first two classes for each direction" (EPA, 1997). The JFDs determined by the STAR program are frequently used as inputs into atmospheric dispersion modeling codes in lieu of using hourly data. For example, the MILDOS-AREA computer code (Yuan, 1989) uses JFDs as input and cannot use calm winds since it uses a steady-state Gaussian model which cannot calculate a finite concentration for a wind speed of 0 mph. Although this could be a rationale for the use of the six wind speed ranges in STAR, no rationale was found in the literature for this choice by the authors of the STAR program. The STAR program, however, has long-standing acceptance as a means to determine the JFD from NWS sites. Since the STAR program is applied equally to both the short-term and long-term data being compared, and since only NWS sites are involved in the comparison, there is full consistency in the methods.

[4] Regulatory Guide 3.63 Table 1 note states: "A calm is any average wind speed below the starting threshold of the wind speed or direction sensor, whichever is greater. Calms should be included in the table above by assigning to each calm a wind speed that is equal to the starting threshold of the wind speed or direction sensor, whichever is greater. Wind direction during calm conditions should be assigned in proportion to the directional distribution of noncalm winds in the lowest noncalm wind speed category. The directional distribution of calms should then be included in the lowest noncalm wind speed category."

2.3 Data Analyses

2.3.1 Avoiding Short-Term (Baseline) and Long-Term Dataset Overlap

Sample independence is a common assumption in statistical tests that seek to compare two or more groups of data. For determining temporal representativeness, if the baseline (i.e., short-term) data are included in the long-term dataset time period, the two comparison groups will no longer be independent and this assumption is violated. Thus, in order to avoid the introduction of statistical bias, non-temporally overlapping datasets should be used for all statistical analyses.

2.3.2 Acceptable Analyses to Demonstrate Temporal Representativeness

The evaluation for the acceptability of qualitative and quantitative methods for demonstrating temporal representativeness, which is provided in Appendix A, was limited to the 15-year period for long-term data for both airport stations to allow valid inter-site comparisons. In the case of Gillette, Wyoming airport station only 15 years were available from NCEI (see Table 2-1). There are various qualitative and quantitative techniques that can be applied to the offsite short-term and long-term datasets to determine whether representativeness is demonstrated for wind speed and wind direction in terms of the relative frequency distributions. Refer to Appendix A for details on the qualitative and quantitative methods evaluated. The qualitative techniques include visual comparisons of the relative frequency distributions of wind speed and wind direction, as bar charts, radar plots, and wind roses to determine obvious differences in the overall wind field. Although this will not provide a final determination due to the qualitative nature of the comparison, they provide initial evidence as to whether the datasets have similar characteristics or not.

After these qualitative comparisons are completed and initial inferences drawn, quantitative (e.g., statistical) techniques should be applied to learn more about the dataset relationships.

The comparison of a short-term dataset to a long-term dataset for the purpose of demonstrating representativeness, or distributional similarities in the relative frequencies of the data, can be approached from a variety of statistical techniques. Goodness-of-fit tests, like the chi-square or two-sample Kolmogrov-Smirnov, compare the distribution of the observed data (i.e., short-term) to the known or expected distribution (i.e., long-term data). The comparison of distributions may also be achieved through the comparisons of measures of central tendency, such as the mean or median,

where typical tests include the t-test (parametric) or Wilcoxon rank sum (non-parametric).

These methods were evaluated for acceptability for demonstrating temporal representativeness for specific meteorological parameters (e.g., wind speed and wind direction) for the Scottsbluff, Nebraska and Gillette, Wyoming airports, as well as an inter-site comparison for validation of identifying non-representativeness when it is present. While these methods may be acceptable methods for the statistical question of temporal representativeness for some sites, they were not deemed to be the most efficient or robust methodology for analyzing temporal representativeness for frequency distributions of these two meteorological parameters, as discussed in Appendix A. Further, these methods do not allow for the evaluation of the JFD of wind direction and wind speed combined with a third important parameter, atmospheric stability.

Correlation and linear regression, two closely-related statistical techniques, also provide insight into the nature of the relationship between two datasets. When the short-term data are assigned as the dependent variable, or unknown quantity, and the long-term data assigned as the independent (i.e., the known or expected distribution of the population), the regression (or trend) line will demonstrate the degree of agreement between the datasets, where a slope=1 and intercept=0 would indicate complete equivalence. The coefficient of determination for linear regression (R^2) value indicates the strength of this agreement such that when multiplied by 100, it signifies the percent of variation that is common to both the short- and long-term datasets. The R^2 value ranges from 0 to 1, where 1 indicates perfect agreement or correlation and 0 indicates no relationship.

The evaluation discussed in Appendix A demonstrated that the linear regression method provided the most consistent and accurate results for both the inter-site and intra-site comparisons for the Scottsbluff and Gillette data when compared to the other statistical methods. Based on those results, as well as subject matter expertise in both meteorology and statistics, it is the expectation of the technical staff that, of the statistical methods evaluated, the linear regression method, when properly applied, will likely be the most efficient and robust technique to the issues and limitations encountered with this type of data and under a wider set of site-specific conditions for determining temporal representativeness. With this robustness, as well as the relative ease of calculation and interpretation of linear regression, the ability to provide consistent regulatory guidance to the applicants and reliable interpretation of results is enhanced compared to other methods, which may

require more case-specific decision rules and methodological guidelines. Further, linear regression provides an efficient method for evaluating the temporal representativeness of the JFD of wind speed and wind direction by stability class, which would be difficult for the other methods evaluated to assess, given their limitations discussed in Appendix A.

2.3.3 Temporal Representativeness Demonstration of Stability Class

Appendix B shows results from the application of a linear regression technique for evaluating temporal representativeness for Gillette, Wyoming NWS data. Each linear regression for wind speed, wind direction, and the combined frequency distribution of wind speed and wind direction produced relatively high R^2 values as demonstrated in Figures 2, 4, and 5 of Appendix B. However, further in-depth examination of the stability class parameter revealed much lower R^2 values for several of the stability classes. Since very high values of R^2 are expected if a temporally representative relationship exists, R^2 values that are lower than 0.95, particularly with respect to more stable conditions (i.e., E and F stability classes) associated with less diffusion and a more significant impact on the calculated dose, may indicate that baseline data differs sufficiently from long-term data and dose estimates could be meaningfully different. The impact of those differences would therefore merit further evaluation.

The utility of using linear regression to also show the absence of temporal representativeness, was evaluated by comparing two spatially distinct sites that were not expected to be temporally representative (i.e., Gillette, Wyoming and Scottsbluff, Nebraska). Regressions for the evaluation, also presented in Appendix B, were performed for the Gillette, Wyoming short-term data to the Scottsbluff, Nebraska long-term data, as well as the alternate comparison of Scottsbluff, Nebraska short-term to Gillette, Wyoming long-term data. The regression results in both cases produced the predicted very low R^2 values, thus providing the supporting evidence that temporal representativeness does not exist and demonstrating the utility of the linear regression method. Further discussion regarding the importance of temporal representativeness of stability class is provided in Section 3.2.1, Recommendation B and Appendix B. A summary of the data evaluation process for demonstrating temporal representativeness is provided in Appendix C.

2.3.4 Additional Analyses to Evaluate Differences in Doses for the Long-Term Temporal Representativeness Demonstration

If the statistical analyses presented in Section 2.3.3 are ambiguous, then an additional evaluation should be performed to quantify the differences in the estimated doses between the short-term (baseline) and the long-term meteorological data. The procedure is considered non-statistical, and it involves running MILDOS-AREA or using another acceptable method with the offsite NWS meteorological data. For the analyses of Scottsbluff, Nebraska and Gillette, Wyoming, MILDOS-AREA Version 3.1 was run using the short-term (baseline) and long-term data. The intent of testing short-term versus long-term meteorological data is to determine if using the different data as MILDOS-AREA inputs would result in significantly different dose estimates at receptor locations. This scenario was tested via a site-specific conceptual model (e.g., radioactive sources, receptors and locations) using a scenario from Marsland Expansion Area (MEA), Crow Butte Resources, Inc., Crawford, Nebraska. Multiple runs were performed with the MEA conceptual site model with different meteorological datasets: MEA onsite 1-year; Scottsbluff Nebraska airport (NWS) 1-year, 15-year, and 30-year; and Gillette, Wyoming airport (NWS) 1-year and 15-year. The differences among the MILDOS-AREA results were evaluated for the datasets. Appendix D presents the details and results for the MILDOS-AREA runs.

If the differences in doses obtained from the short-term and long-term data are deemed acceptable, then further evaluations or onsite meteorological measurements may be unnecessary.

2.3.5 Appropriate Data Period to Demonstrate Long-Term Representativeness

Analysis of the temporal representativeness of a long-term set of offsite meteorological data with the short-term data from the same site should start with a definition of "long-term." A period of 30 years is recommended for long-term data representativeness purposes per RG 3.63. A study was performed at Scottsbluff, Nebraska airport to assess whether a 15-year period was sufficient to represent the long-term conditions to compare with a baseline year of data or whether the recommended 30 years was required. This study, which is presented in Appendix E, showed that the 1-year baseline data for Scottsbluff, Nebraska, were more closely correlated with the data for the 15-year than for the 30-year historical period. Longer-term decadal climatic oscillations were evident in that the correlation between 15 and 30 years is not as strong as the correlation of the 1-year with the 15-year. These results are supportive of the World Meteorological Organization (WMO)

recommendation of a 30-year period to represent long-term climate (refer to Recommendation A in Section 3.1.2).

3. FORMULATION OF THE TECHNICAL BASIS

This section includes recommendations and justifications to expand or modify the RG 3.63 statement in Section C.1, Paragraph 4, to bring more clarity to the term "representative." In bringing more clarity, the meteorological parameters and statistical methods necessary to demonstrate temporal representativeness are identified for each type of uranium recovery facility.

An example methodology is available in Section 2 to demonstrate long-term temporal representativeness for the meteorological data used for siting evaluations. The methodology includes acceptable statistical methods and subsequent analyses (e.g., MILDOS-AREA runs) to defensibly satisfy the term "representative."

Sections 3.1 and 3.2 provide recommendations and justifications for improving and revising the current section of RG 3.63 with respect to meteorological parameters necessary to demonstrate temporal representativeness and meteorological data acquisition, preparation, and analyses. The staff guidance is included separately, document control number (DCN) 5244-TR-03-0: *Staff Guidance Document Regulatory Guide 3.63 Section C.1, Paragraph 4 Revision.*

3.1 RECOMMENDATIONS

3.1.1 Meteorological Parameters

This section includes recommendations such as defining the term "representative," classifying the meteorological parameters by importance based on their applicability to each uranium recovery facility, as well as establishing the minimum number of parameters to demonstrate temporal representativeness.

A. Recommendation: A definition for the term "representative" or "representativeness" should be included in RG 3.63.

Justification: In order to bring clarity to the terms "representative," "representational," and "representativeness," a definition should be included in RG 3.63. NUREG-1575, Revision 1 *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)* (NRC, 2000) in Section 6.2.2.3 defines the term "representativeness" as: "a measure of the degree to which data accurately and precisely represent a characteristic of a population parameter at a sampling point or measurement location." Although this is not a document associated with meteorology, it provides a reference point for how representativeness is fundamentally defined. In the context of temporal representativeness of meteorological conditions in RG 3.63, the goal is to assess the degree to which distributional similarity exists between the short-term (baseline) data and long-term climate conditions, or whether the short-term data are indicative of anomalous meteorological conditions.

B. Recommendation: Regulatory Guide 3.63 should identify the minimum number of meteorological parameters, by facility type and potential sources of radioactivity, needed to satisfy the term "representative."

Justification: Regulatory Guide 3.63 should be revised to include a minimum number of meteorological parameters needed, by facility type and by potential sources of radioactivity, to satisfy the term "representative." Appendix F includes tables classifying meteorological parameters by level of importance (e.g., high, medium, low) for the three types of uranium recovery facilities (i.e., conventional mill, heap leach, and in situ recovery). The tables include the facility types subject to potential airborne particulate and radon-222 sources, but are not all inclusive of other possible site-specific sources of radioactivity. The level of importance should be assigned for each meteorological parameter relative to safety. If a particular meteorological parameter has a potential impact on public safety or environmental protection, the parameter should be included in the onsite meteorological monitoring program for the siting evaluation, and it may also be necessary to satisfy the term "representativeness." For example, wind speed, wind direction, and stability class are used for establishing environmental air monitoring locations and as modeling inputs for estimating radiation doses to individuals and the population. Therefore, these parameters are critical for all types of uranium recovery facilities, as indicated in the Appendix F tables, and temporal representativeness should be demonstrated.

Classifying the meteorological parameters by facility type and importance to safety should help determine whether or not temporal representativeness should be demonstrated for any of the less critical parameters. This should also help reduce regulatory burden by relieving the applicant or licensee of performing unnecessary representativeness demonstrations.

Wind speed

Wind speed is a critical meteorological parameter of high importance and is a required input parameter for atmospheric dispersion models, including MILDOS-AREA (Yuan et al., 1989). Wind dilutes the source term at the emission point or emission area. For a given contaminant emission rate (mass per time), the higher the wind speed the more the contaminant is immediately diluted. A higher wind speed also more effectively flushes the contaminant from the vicinity of the source.

For MILDOS-AREA dose calculations, wind speed could be placed into six wind speed categories, as shown in Table 2-4. In addition to supporting MILDOS-AREA dose calculations, wind speed is required to determine the Pasquill-Gifford stability class for certain types of turbulence classification techniques, as will be discussed further in the stability class parameter subsection.

Wind speed is also required for direct calculation of evaporation, as the overlying air motions above a pond remove aerosols as a function of wind speed. Direct measurement of evaporation using evaporation pans does not require wind speed and is discussed in the evaporation and evapotranspiration subsections (Jensen et al., 1990 and Rosenberg et al., 1983).

Wind direction

Wind direction is also a critical meteorological parameter of high importance and is a required input parameter for MILDOS-AREA (Yuan et al., 1989) and other atmospheric dispersion models.

For MILDOS-AREA dose calculations, wind direction sectors are determined by placing the average wind direction into one of 16 azimuth sectors of 22.5-degree azimuth width, centered on N, NNE, NE, ENE, E, ESE, SE, SSE, S, SSW, SW, WSW, W, WNW, NW, and NNW. By NWS convention, wind direction is the direction from which the wind is blowing. Thus, the downwind sector is in the direction opposite to the reported wind direction. As examples, a north-northeast

reported wind direction has a south-southwest downwind sector, and a west reported wind direction has an east downwind sector.

Wind direction determines which downwind sector is at risk for receiving a dose from a facility or area release. Hour-to-hour variations in wind direction may affect multiple azimuth sectors if wind shifts move the effluent to a different downwind sector. This exposes more than one sector but reduces the calculated dose received in any particular sector.

Stability class

Atmospheric stability class is also a critical meteorological parameter of high importance and is a required input parameter to dispersion models, including MILDOS-AREA. Atmospheric stability class determines the magnitude of both the horizontal and vertical diffusion of the release as it is transported downwind as a plume. Atmospheric stability class strongly influences the contaminant concentration at downwind receptors.

There are many empirically-based schemes to calculate the prevailing stability class from routine or readily-available observations. Such observations include wind speed and an estimate of solar radiation inferred from cloud cover, time of day, day of year, day versus night, and the latitude of the facility (Gifford, 1976). Software such as STAR (EPA, 1997), is available to implement one of these methods.

Other measurements, if available, can provide a more sophisticated determination of the stability class. These include direct measurement of the horizontal wind direction fluctuation, termed sigma-theta; the direct measurement of vertical wind fluctuation, termed sigma-phi; the direct measurement of temperature difference between two different levels above the ground, termed delta-T; and the solar radiation (e.g., split sigma method [Essa, 2005] and solar radiation, delta temperature method [EPA, 1993]). The split sigma method has been used where sigma-theta determines the horizontal diffusion intensity and delta temperature determines the vertical diffusion intensity.

For MILDOS-AREA dose calculations, the stability class parameter is usually placed into six categories or classes. The six Pasquill-Gifford stability classes are defined in Table 2-5.

An array of six wind speed categories, 16 wind direction sectors, and six stability classes, (termed a joint frequency distribution [JFD]) can be developed as a direct input into MILDOS-AREA. It should be noted that all three of the critical meteorological parameters (i.e., wind speed, wind direction, and atmospheric stability) are required for MILDOS-AREA calculations. If any one of these three parameters is not available during any hour of data, it cannot be placed into the JFD.

Regulatory Guide 3.63 should emphasize the importance of developing JFDs of wind speed, wind direction, and atmospheric stability class for offsite long-term meteorological data. As JFDs are needed for MILDOS-AREA execution using onsite data, JFDs are important for the temporal representativeness demonstration.

Mixing height (or depth)

Atmospheric mixing height (or depth) is of low importance when the default value of 100 m is used in MILDOS-AREA. However, this parameter can be a very important meteorological parameter if a greater mixing height is required to achieve acceptable dose, because of the potential significance to nuclear safety. If the mixing height is shallow (e.g., 100 m), the restricted mixing depth confines pollutants to a smaller vertical layer near the earth's surface and thus restricts vertical diffusion. The plume reflects off of the mixing height lid back to the ground instead of dispersing further upward, increasing downwind concentrations.

MILDOS-AREA uses a default mixing height of 100 m and has the option of using specified annual average morning and afternoon atmospheric mixing heights (ANL, 1998). Careful selection of mixing height is important to uranium recovery facilities with elevated releases from a stack. Based on communications with Argonne National Laboratory (ANL), newer versions of MILDOS-AREA (e.g., version 3.1 from 2012) verify when the input value for receptor height is below the input value for mixing height. If a receptor is above the input value for mixing height the code will not run. The software will display the following message: "Some relative height between a receptor and source is greater than a mixing height." The dose to such a receptor would otherwise be calculated by a Gaussian plume model to be zero because such models normally assume complete plume reflection at the mixing lid (Turner, 1970). For this reason, receptor heights should be below the mixing height; especially if the default 100 m mixing height is used. Sites that may have receptors above the

modeled mixing height should be input into the code at a height below the mixing depth. This is a conservative approach.

Temperature

Temperature provides the basis for many metrics of the prevailing climate (e.g., totals, means, and extreme values) at the location of measurement (Trewin et al., 2007). Temperature also establishes the general climatology in terms of monthly extremes and averages.

The importance of temperature for a temporal representativeness determination is facility-type dependent. If a uranium recovery facility has tailing impoundments or evaporation ponds, the design of these site features requires knowledge of the evaporation rate. If the evaporation rate is not directly measured, its calculation depends on wind speed, temperature, and relative humidity. Wind speed, temperature, and relative humidity are also important variables in determining the rate of fugitive dust generation. Wind speed will affect the rate of material removed and the temperature and relative humidity will determine the soil moisture (Rosenberg et al., 1983 and Jensen et al., 1990).

Temperature statistics also support the definition of the ecology climate of the applicant's or licensee's technical report (TR), affecting the habitats of local and regional aquatic and terrestrial ecosystems, including meat and fish ingestion pathways (Chapin et al., 2012).

For thermally hot releases from a stack, the temperature parameter may be required to determine the buoyancy component of plume rise. Buoyancy-driven plume rise is dependent on the difference in the effluent temperature with the ambient temperature (Briggs, 1979; Overcamp, 2005; and Overcamp, 2007). MILDOS-AREA Version 3.1 does not require temperature as an input.

Heating degree days

Heating degree days (HDDs) are calculated as the difference between the daily average temperature and a base temperature of 65 degrees Fahrenheit. HDDs represent a general estimate of space heating requirements for residential, commercial, and other buildings during the year. For days with an average temperature of 65 degrees Fahrenheit or greater, there are no HDDs recorded.

HDDs are a metric designed to reflect the demand for energy needed to heat a building and therefore assist mechanical engineers in their design of heating, ventilating, and air conditioning (HVAC) systems and provides a gross measure of general temperature climatology. A high annual number of heating degree days indicates a cold climate and vice-versa. HDDs may not be used to support any analyses in an applicant's or licensee's TR or environmental report (ER) and are therefore of low importance and not required for demonstrating temporal representativeness.

Cooling degree days

Cooling degree days (CDDs) are calculated as the difference between the daily average temperature and a base temperature of 65 degrees Fahrenheit. CDDs represent a general estimate of space cooling requirements for residential, commercial, and other buildings during the year. For days with an average temperature of 65 degrees Fahrenheit or less, there are CDDs recorded.

CDDs are a metric designed to reflect the demand for energy needed to cool a building, and therefore assist mechanical engineers in their design of HVAC systems and provides a gross measure of general temperature climatology. A high annual number of CDDs indicates a warm climate and vice-versa. CDDs are not used to support any analyses in an applicant's or licensee's TR or ER and are therefore of low importance and not required for demonstrating temporal representativeness.

Growing degree days

Growing degree days (GDDs) are calculated as the difference between the daily average temperature and a base temperature of 50 degrees Fahrenheit. GDDs represent a general amount of growing season potential during the year. The base temperature is defined as that temperature below which plant growth is zero. For days with an average temperature of 50 degrees Fahrenheit or less, there are no GDDs recorded.

GDDs are a metric that assists the agriculture industry in knowing what crops can be grown at a specific location and provides a gross measure of general temperature climatology. A higher annual number of growing degree days indicates a warm climate and vice-versa.

Agronomists occasionally use base temperatures of less than 50 degrees because the base temperature is a function of the crop grown and ranges from 43 to 54 degrees Fahrenheit (Cornell

University Cooperative Extension, 2009). GDDs are considered of low importance and not required for demonstrating temporal representativeness.

Relative humidity

Atmospheric moisture can be described by multiple metrics (e.g., relative humidity, dew point temperature, wet-bulb temperature, and absolute humidity), any one of which is acceptable and can be converted, as needed, to any of the others at a given temperature at standard atmospheric pressure. The relationship between all atmospheric moisture variables can be displayed on a psychrometric diagram (UGI, 2014), or may be readily calculated with commercial off–the-shelf software. Relative humidity is usually calculated from measured air temperature and dew point temperature at onsite meteorological monitoring locations and from measured air temperature and wet-bulb temperature at offsite NWS locations (NOAA, 2014a).

Both temperature and relative humidity are of medium importance and are interlinked with one another since the saturation vapor pressure is a function of air temperature. Relative humidity is the basis for many metrics of the prevailing climate (e.g., totals, means, and extreme values) at the location of measurement (Trewin et al., 2007), and is also needed to establish the general climatology in terms of monthly extremes and averages.

Relative humidity represents the fraction, expressed as a percent, of atmospheric moisture content relative to what the atmosphere can hold at saturation. Since warmer air possesses a greater ability to hold additional moisture, relative humidity is highly dependent on the air temperature. Therefore, the higher the air temperature with the same moisture content, the lower its relative humidity. This meteorological parameter is also an indicator of evaporation potential, as lower relative humidity values are associated with relatively dry air, which favors evaporation rate.

Absolute humidity, which can be calculated from the temperature and the relative humidity, dew point temperature, or wet-bulb temperature, gives the actual mass of water per volume in g/m^3.

Evaporation

Evaporation is of low importance unless evaporation ponds are part of the facility, in which case it is of high importance. Evaporation rate is a function of three meteorological variables: (1) saturation

vapor pressure curve and vapor pressure deficit, which are calculated from temperature and relative humidity; (2) net irradiance, which is related to solar radiation; and, (3) wind speed. Net irradiance needs to be measured or estimated. The Penman Equation can be used to calculate evaporation (Rosenberg et al., 1983; Jensen et al., 1990).

Regulatory Guide 1.27 and ANSI/ANS-2.21-2012 address the calculation of maximum evaporation, which is a function of moisture deficit in the air and wind speed. Although the focus is on nuclear reactor ultimate heat sinks, these documents contain useful information on evaporation rate methodologies.

Evaporation can also be directly measured with an evaporation pan. For uranium recovery facilities with evaporation ponds or tailing impoundments, the evaporation rate is required for design and engineering sizing calculations relative to waste management considerations to ensure that the area of the pond meets design criteria.

In addition, evaporation is one of the parameters needed for the Waste Management Alternatives section of the applicants' or licensees' TR and ER.

Evapotranspiration

Evapotranspiration is of low importance. Evapotranspiration is the sum of evaporation and plant transpiration from the ground and the surface of water bodies to the atmosphere. Evaporation accounts for the movement of water to the air from sources such as soil, canopy interception, and water bodies, while transpiration accounts for the movement of water within a plant and the subsequent loss of water as vapor through stomata in its leaves (Rosenberg et al., 1983; Jensen et al., 1990; and UNFAO, 2014).

Evapotranspiration rates, like evaporation rates, can be estimated using the Penman equation, with the appropriate parameters for evapotranspiration (Rosenberg et al., 1983 and Jensen et al., 1990). Direct measurement of evapotranspiration requires special, labor-intensive instrumentation.

Net radiation

Net radiation is of low importance because there are other available means of estimating atmospheric stability class and evaporation rate. However, if available, it can be used in more sophisticated estimates of these quantities (Rosenberg et al., 1983; Jensen et al., 1990; and EPA, 1993).

Net radiation is measured from a net radiometer, measuring downwelling minus upwelling visible and infrared light. It is used to calculate evaporation rate when direct measurements of evaporation, using an evaporation pan, are not made. Net radiation is also one of the parameters needed to calculate evapotranspiration by the Penman equation and must be estimated if not directly measured (Jensen et al., 1990).

Precipitation

Precipitation can be directly measured by a rain gauge and is needed to establish the general climatology in terms of monthly extremes and averages (NOAA, 2014b). This parameter provides data to civil structural engineers to design controls and barriers to prevent flooding and structure collapse due to excessive rain/snow loading (ASCE, 2010 and DOE, 2012). Precipitation affects storm water runoff and is a factor in the development of spill contingency plans associated with storm water pollution prevention controls and countermeasures (40 CFR 112).

Precipitation is of high importance if it is needed for the design and operation of tailings impoundments and evaporation ponds; otherwise it is considered of low importance. Precipitation also can be used as a water balance input when calculating evapotranspiration.

Meteorological natural phenomena hazards (NPHs)

Meteorological natural phenomena hazards (NPHs) are related to two meteorological variables: (1) wind speed; and, (2) precipitation. NPHs include extreme precipitation amounts from precipitation events, inclusive of thunderstorms, extreme wind events inclusive of extreme straight-line wind speeds from frontal passages and derechos, hurricanes (ANSI/ANS-2.3-2011, NUREG/CR-7005), and from tornadoes, inclusive of atmospheric pressure drop near its center of circulation (ANSI/ANS-2.3-2011; RG 1.76; RG 1.221; and NUREG/CR-4461). These NPHs are infrequent events and techniques are available to calculate the return period or frequency of

occurrence of precipitation rates and duration, and wind speed intensity and duration. Such calculations are used by civil structural engineers for facility design (ASCE, 2010) to ensure structural integrity under low-probability/high-consequence events. Hurricanes are not expected to occur at any existing uranium recovery site locations.

C. Recommendation: Atmospheric stability class is recommended for demonstration of temporal representativeness.

Justification: Atmospheric stability class, as well as wind speed and wind direction, is a key atmospheric dispersion parameter since it determines the horizontal and vertical diffusion of an effluent. An effluent emitted from a radioactive point or area source at a constant rate (e.g., Ci/s) is initially diluted in proportion to the wind speed at the point or area of emission and then transported downwind at the speed of the wind. Radioactive decay and ingrowth of daughter radionuclides occurs during transport. As the effluent is carried farther from the source, turbulent mixing spreads the plume in the horizontal and vertical planes further reducing the concentration of the released radionuclides and daughters and subsequent dose at a given receptor location. The atmospheric stability class parameterizes the strength of this turbulent mixing. Accordingly, wind speed and stability class each play a role in reducing the concentration of the effluent as it is transported in the downwind direction to a receptor.

When analyzing atmospheric stability classes for temporal representativeness, the overall JFD of wind speed and wind direction (i.e., for all stability classes) and the JFD within each individual class are important to evaluate. This way, wind speed, wind direction, and atmospheric stability class are simultaneously considered and the JFD should capture any departures from representativeness in either wind speed or direction.

Appendix B evaluated the appropriateness of demonstrating temporal representativeness for stability class using the linear regression technique described in Appendix A for the two sites, Scottsbluff, Nebraska and Gillette, Wyoming airports. While the results for linear regressions for wind speed, wind direction, and the JFD of wind speed and wind direction for all stability classes produced relatively high R^2 values at both sites, further in-depth examination of each stability class revealed much lower R^2 values for several of the stability classes, particularly at Gillette, Wyoming in Classes E and F. This is especially of concern since these poor dilution-diffusion conditions highly influence

the dose calculations (e.g., using MILDOS-AREA), which are used to evaluate compliance with applicable NRC and EPA regulations and the placement of environmental air monitors. These results highlight the risk of analyses that consider the individual distributions of wind speed and wind direction, as well as the JFD summed over all stability classes. The interpretation of those results, along with qualitative data (e.g., bar charts, wind roses, etc.), may have led to the conclusion that the short-term data were temporally representative of the long-term data. However, analyzing the JFDs for Classes E and F revealed significant departures from agreement between the short- and long-term data, calling into question whether temporal representativeness truly exists.

Accordingly, analyses for demonstrating temporal representativeness should focus on the overall JFD of speed and direction for all stability classes and then the specific JFDs for Classes E and F.

D. Recommendation: A spatial representativeness demonstration for precipitation and evaporation may be necessary when these parameters are directly used in safety-related design to ensure that such design criteria are sufficient for the lifecycle of the facility. This includes the design of tailing impoundments, evaporation ponds, and other uranium recovery facility structures, systems, and components (SSCs) that are deemed safety-related.

Justification: Earlier recommendations to the meteorology section of NUREG-1569 and RG 3.63 remain valid. However, this particular recommendation includes additional steps that applicants and/or licensees should undertake when certain meteorological parameters are directly used in safety-related design of tailing impoundments, evaporation ponds, and other uranium recovery SSCs.

Section 2.7.1 of NUREG-1569 notes the importance of describing hydrological features proximate to the retention and evaporation ponds located at some existing uranium recovery facilities since these ponds may be adversely affected by surface erosion or flooding so as to potentially compromise the safety of the workers and the public. The severity of the potential flood hazard is highly site-specific; subject to geographic variation, topographic orientation, and proximity to external sources of flooding. This includes the effects of local topography on the local precipitation amount. The probabilistic flood hazard assessment applies regionally. If topography or other site features locally raise the six-hour probable maximum precipitation amounts identified as design criteria in RG 3.11 (NRC, 2008) and NUREG-1623 (NRC, 2002), the design and subsequent

operation of the retention pond may not be sufficiently protected from all flood hazards that may be encountered during its lifecycle. This is especially true for sites where extreme precipitation is the primary flood hazard.

Accordingly, it may be prudent to enhance the regional probabilistic flood hazard assessment, which is performed to meet the design criteria in Section 2.2.1 of RG 3.11, to incorporate topographically-enhanced rainfall estimates, as indicated in Chapter 5 (flood design) and Chapter 7 (extreme precipitation design) of the U.S. Department of Energy (DOE) standard on natural phenomena hazards analysis and design criteria (DOE, 2012). A spatial representativeness demonstration can assist applicants and licensees in the design of tailing impoundments, evaporation ponds, and other uranium recovery SSCs to account for any localized effects. This spatial representativeness demonstration is solely intended to establish if the site is located in a region of locally-high precipitation, which may not be evident on a regional probable maximum precipitation (PMP) map. Similarly, if local topography or other local site features enhance evaporation rates, and are not specifically taken into account in the evaporation assessment, the evaporation pond may not perform its intended function, and worker and public safety may be compromised during the pond's lifecycle. It should be noted that local precipitation anomalies are normally larger than local evaporation anomalies except in a deep multi-year drought.

As part the spatial representativeness demonstration, short-term (i.e., baseline) and non-overlapping long-term (e.g., 30 years) precipitation and evaporation data from at least 3–5 regional stations (e.g., NWS), if available, should be compared. These regional stations should preferably be within 50 miles of the site. The comparison should include the annual mean and the 95% confidence interval for the annual mean for each station using hourly data from the stations. The purpose of the 95% confidence interval is to be able to compare the means from the different stations. If any overlap occurs between the confidence intervals, the means have no statistically significant difference.

In certain circumstances where intervals do not overlap, there may be evidence of significantly different microclimates such that the observed heterogeneity of the means can be explained by topography or land-water distribution. A determination of impact on safety should be made based on site-specific conditions. Additionally, if the comparison determines that the site has higher

rainfall relative to the surrounding region, the six-hour PMP, which is based on smoothed curves for the Continental United States and is thus more representative of regional rainfall, may not be sufficient for design and may require upward adjustment to compensate for the uncertainty. Therefore, the uranium recovery sites that have tailing impoundments, retention ponds, and/or evaporation ponds should compare the onsite precipitation and evaporation for the baseline year with the short-term (i.e., baseline) data from the regional station for that same year to determine if the site is, or is not, favored to receive greater rainfall and/or evaporation amounts than the region. Guidance can be found in ASCE/SEI 7-10 (ASCE, 2010) relative to the adjustment of design criteria.

E. Recommendation: Applicants and licensees should continue to follow the current recommendations in NUREG-1569 and RG 3.63 with respect to temperature and humidity.

Justification: Earlier recommendations to the meteorology section of NUREG-1569 and RG 3.63 remain valid. Since temperature and humidity data are not directly used in the safety design of tailing impoundments, evaporation ponds, or other uranium recovery SSCs, qualitative comparisons of the onsite data with long-term datasets in the vicinity of the site is acceptable. Applicants and licensees should use their own discretion to ensure that any temperature and humidity data used for the design of non-safety-related systems meets design criteria of applicable consensus standards.

Although temperature and humidity are important parameters to characterize the site relative to long-term climatology of the region, establish design criteria for HVAC systems, and determine effects on terrestrial and aquatic ecosystems, none of these evaluations are used in models or calculations which are nuclear-safety related. However, when temperature is used to calculate evaporation for safety-related designs, then the type of analysis described in Recommendation D for evaporation and precipitation should be applied to temperature.

3.1.2 Offsite Long-Term Meteorological Data Acquisition and Preparation

The following recommendations apply to offsite meteorological data acquisition and preparation.

A. Recommendation: Offsite meteorological data used to characterize long-term climate conditions in demonstrating temporal representativeness should cover the most recent 30-year period, excluding the baseline period, unless the applicant or licensee can justify a shorter period

should historical data of sufficient quality within an acceptable distance of the site be difficult to obtain or unavailable.

Justification: Acquiring offsite data, from a nearby station (e.g., NWS), for a period of 30 years is the world climatological standard, established by the WMO (WMO, 1989, and Trewin, 2007), and is the United States climatic normal period published every 10 years by NCEI. In general, climate "normal" needs to be long enough averages to capture longer-term (decadal) climatic oscillations (Karl, 1988), and short enough to reflect climatic trends for predictive purposes. The 30-year standard reflects the present consensus and is also recommended for long-term data representativeness purposes in RG 3.63. The results of Appendix E demonstrate these climatic oscillations in that the correlation between 15 and 30 years is not as strong as the correlation of the 1-year with the 15-year which suggests the 15-year is not fully representative of the long-term climate.

The long-term dataset should not include the baseline period, as the purpose of data comparison is to demonstrate that one period represents the other (i.e., short-term data is temporally representative of long-term conditions). If any data for the same time period are included in both datasets, there will be an unwanted bias towards temporal representativeness.

B. Recommendation: Regulatory Guide 3.63 should be revised to emphasize the importance of offsite data preparation for further analyses and/or calculations.

Justification: Offsite data should be screened for gaps and extra non-hourly data prior to performing any analyses and/or calculations. There should be no more than one value per hour, and no gaps large enough to favor either day or night or one season over other seasons of any year. Inadequate offsite data processing can introduce bias and produce misleading results, especially in statistical analyses. Offsite data are not necessarily quality-assured and have different DQOs than those for onsite meteorological monitoring programs. Moreover, NWS airport data may contain errors or gaps in observation and data handling (e.g., wind direction biases by observers may favor runway orientation). Station relocation and changes to instrument measurement height within the time period of the dataset can also introduce bias.

Additionally, there should be consistency in the definition of the wind speed bins and the treatment of calm winds for construction of JFDs. Depending on the data management system, there may be formatting requirements and data may have to be distributed in a particular way. However, regardless of format, wind speed distribution bins should not begin at zero, and calm winds (i.e., wind speed below the measurement threshold) should be displayed separately in a bar chart, as a calm wind will be treated differently from a non-zero wind (see the treatment by the EPA's STAR program described in Section 2.2.3).

3.1.3 Analyses for Demonstrating Long-Term Representativeness

The following recommendations apply to qualitative, statistical, and non-statistical meteorological data analyses.

A. Recommendation: Regulatory Guide 3.63 should explicitly state that the applicants or licensees should demonstrate temporal (i.e., not spatial) representativeness of offsite data. Furthermore, the terms "temporally" or "temporal" should be incorporated and defined for clarity.

Justification: Regulatory Guide 3.63 does not clearly specify that the applicants or licensees should demonstrate only temporal representativeness of the offsite data and do not have to demonstrate spatial representativeness. Although the temporal representativeness demonstration is the current practice, it should be clearly stated in RG 3.63.

The terms temporal and spatial should be incorporated in RG 3.63 and properly defined. Formal definitions applicable to the current RG 3.63 have not been located in the literature; therefore, the following definitions were developed for consideration:

- "Temporal" means that at a fixed location, a short-term dataset exhibits similar characteristics to a long-term dataset, thereby implying that the annual temporally-variable climate changes over time and consequently does not materially affect the results of the analyses.

- "Spatial" means that for a fixed time period, datasets at two different locations exhibit similar characteristics, thereby implying that meteorological conditions are not significantly

different between locations and consequently do not materially affect the results of the analyses.

B. Recommendation: Regulatory Guide 3.63 should recommend tabular and graphical comparisons for short-term (i.e., baseline) and long-term meteorological data.

Justification: Wind roses, radar plots, and bar charts (see Appendix A) are ways to view differences between datasets. Radar plots are particularly useful to simultaneously view the short-term and long-term data. These visual comparisons of the relative frequency distributions of meteorological parameters such as wind speed, and wind direction, can inform obvious differences in the wind field. Although this will not provide a final determination due to the qualitative nature of the comparison, it helps intuitive understanding of the region and its dispersion characteristics, provides initial identification of potential failures of temporal representativeness, and gives insight into the meaning of the statistical results. Additionally, the guidance will assist with ensuring consistent data presentations in license applications and TRs.

C. Recommendation: Regulatory Guide 3.63 should be revised to indicate that linear regression, when properly applied as described in Appendix A, should be considered an acceptable method for demonstrating temporal representativeness for the JFDs of wind speed, wind direction, and atmospheric stability.

Justification: Some conditions may affect the acceptability of linear regression as a valid temporal representativeness methodology. It is important that the long-term data should be set as the independent variable (X-axis), while the short-term data should be set as the dependent variable (Y-axis), in order to determine whether the baseline 1-year data are representative of the known, or historic, long-term meteorological conditions of the location. The assignment of dependent and independent variables will materially impact the calculation of the linear regression equation (i.e., slope and intercept) and thus the coefficient of determination (R^2) and the p-value of the test. It is recommended that appropriate fit diagnostics, such as normality tests and evaluation of plots of residuals, be evaluated to ensure there are no severe violations of assumptions. In addition, it is recommended that the regression equation should be forced to pass through the –XY origin since data are relative frequencies, such that data are bounded from 0 to 1. Subsequently, it is reasonable to expect that if the frequency of a particular wind parameter is 0 in the long-term dataset (x=0),

then it should be approximately 0 in the short-term data (y=0), with deviation from the line of slope=1 and intercept=0 likely indicating lack of agreement. While regression through the origin is expected to be appropriate in most cases, it would be prudent to evaluate this assumption as described in Appendix A.

The results of the evaluation presented in Appendix A indicate that there are several valid statistical methods, including linear regression, for assessing representativeness; however, limitations were outlined for each of the tests, with some more severe than others. The impact of these limitations will likely be specific to the conditions at each site. As site-specific conditions may vary, other statistical methods beyond the conventional techniques evaluated here, such as directional statistics (e.g., circular distribution) in the case of wind direction, may be applied to demonstrate temporal representativeness. However, the complexity of such methods likely precludes them from consideration for general applications, while the use of nonstandard methods will likely require a more detailed technical justification to determine acceptability.

D. Recommendation: Regulatory Guide 3.63 should provide for using MILDOS-AREA, or another acceptable dose calculation methodology, as a means to compare computed dose from short-term meteorological data to determine how well it represents the computed dose from long-term meteorological data.

Justification: An additional evaluation using MILDOS-AREA or other acceptable method should be used when the statistical methods produce inconclusive statistical results. This particular evaluation provides a means to quantify the impact of the observed difference between short-term (i.e., baseline) and long-term period JFDs of the wind speed, wind direction, and atmospheric stability class on the estimated dose.

The procedure is to run MILDOS-AREA or use another acceptable method with the offsite NWS meteorological data for both the short-term (baseline) period and long-term period. The intent of testing short-term versus long-term meteorological data is to determine if using the different data as MILDOS-AREA inputs would result in significantly different dose estimates at receptor locations.

If the differences in doses obtained from the short- and long-term data are deemed acceptable, then it is possible that no further evaluations or meteorological measurements are necessary. An example of this evaluation using airport data is included in Appendix D.

4. CONCLUSIONS

In this technical basis document, ORAU recommends the following to expand and clarify the RG 3.63 statement in Section C.1, Paragraph 4:

1. While several statistical methods for demonstrating temporal representativeness were found to be acceptable, linear regression was determined to be the most efficient and robust method. (Refer to Appendix A.)[5]
2. Short- and long-term dataset overlap should be avoided when selecting datasets for analysis. (Refer to Appendix A.)
3. Offsite meteorological data should be prepared appropriately for calculations (e.g., atmospheric stability class) and subsequent analyses (e.g., qualitative and quantitative). (Refer to Section 2 and Appendix C.)
4. The term "representative" should be clarified and defined. (Refer to Section 3.2.1, Recommendation A.)
5. Temporal and spatial representativeness should be defined. (Refer to Section 3.2.3, Recommendation A.)
6. The appropriate length of record for the long-term, offsite data (e.g., from a nearby NWS station) should be 30 years, unless the applicant or licensee can demonstrate that this length of record is unavailable. (Refer to Appendix E.)
7. The minimum parameters necessary for demonstrating temporal representativeness for all types of uranium recovery facilities should be evaluated. These are wind speed, wind direction, and stability class. (Refer to Section 3.2.1, Recommendation C; Appendix B; and Appendix F.)

[5] Note: This technical basis document was limited to evaluating the statistical methods thus far used by uranium recovery applicants and licensees.

8. A spatial representativeness demonstration should be performed for precipitation and evaporation dependent on facility type and potential sources of radioactivity. (Refer to Section 3.2.1, Recommendation D and Appendix F.)

In this technical basis document, ORAU also recommends that MILDOS-AREA be explored as a possible non-statistical method to evaluate representativeness. However, quantitative criteria (e.g., safety margin) should be determined; otherwise this approach is not feasible. The determination of quantitative criteria was outside the scope of this TBD.

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APPENDIX A

EVALUATION OF QUALITATIVE AND QUANTITATIVE METHODS FOR DEMONSTRATING TEMPORAL REPRESENTATIVENESS OF WIND SPEED AND WIND DIRECTION

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EVALUATION OF QUALITATIVE AND QUANTITATIVE METHODS FOR DEMONSTRATING TEMPORAL REPRESENTATIVENESS OF WIND SPEED AND WIND DIRECTION (FINAL)

A.1. INTRODUCTION

The question of temporal representativeness of short-term, or baseline, data to the long-term meteorological conditions, specifically wind speed and wind direction, can be evaluated through both qualitative and quantitative—including statistical—methods. Essentially, the statistics are designed to test for distributional similarities between groups, where the goal is to provide the decision framework as to whether a distributional similarity exists between the short-term data and past long-term conditions, or whether the short-term data are indicative of an anomalous period. There are a variety of statistical techniques that could be applied to these types of meteorological data in order to compare the two time periods, including, but not limited to:

- Tests of summary statistics
- Tests of goodness-of-fit
- Tests of relationship strength

Many of the statistical tests associated with these methods require that data be interval or ratio data. While wind speed (mph) is by nature ratio, wind directions are vector quantities that are categorical with no inherent numeric ranking. Thus, wind direction is evaluated through its frequency distribution, categorized by the 16 compass directions and a category for calms, where calms are defined by the wind speed below the threshold speed of the anemometer or wind vane use for measurement. The data management process for generating the frequency distributions, relative frequency distributions and joint frequency distributions (JFDs) is summarized in Appendix C. It has been recommended in the literature (Brooks, 1978) and by meteorological subject matter experts that meteorological observations, like wind direction and wind speed, be analyzed by their frequency distributions (which is simply the number of occurrences for a single parameter within each of some defined categorical bins). This method provides a basis for direct comparisons between important categories (e.g., calms for the short-term data are compared with calms of the long-term data) instead of relying on overall distributional characteristics, like summary statistics, which may minimize (or average out) important differences in the extremes of the distributions. Further,

evaluations of the frequency distributions allow for a consistent method to analyze both continuous and categorical parameters, as is the case for wind speed and direction, respectively, thereby simplifying the approach. This efficiency is exhibited in that the meteorological data inputs used in dispersion models to determine radiological doses to the worker and public, in particular the MILDOS-AREA code, are the JFDs of wind speed and direction for each of six atmospheric stability classes, where the wind parameters are categorized into six wind speed classes that are then binned into the 16 wind direction categories. Additional discussion on the nature of the subject matter-driven process of this categorization is presented in Section 2.2 of the technical basis document.

In addition to this technical rationale, the evaluation of the frequency distributions of wind speed and wind direction also provides favorable conditions for addressing some of the assumptions and limitations for statistical analyses. Since the presence of very large sample sizes will tend to result in statistical tests that have very high power to detect minuscule differences between the mean/median of the distributions that are not of practical significance (Hoenig and Heisey, 2001), the evaluation by frequency distribution serves as a data reduction technique to limit Type II errors (incorrect rejection of the null hypothesis). Preliminary analyses of the raw wind speed data as a continuous variable confirmed this sensitivity with all results indicating that the short- and long-term datasets were not statistically similar, even under circumstances where representativeness was expected to exist based on prior knowledge and qualitative (graphical) evaluation, which is presented in Section A.2 of this appendix.

However, simply considering the frequencies for which particular categories of wind speed or direction are observed is still problematic given the magnitude of the difference in sample sizes between the short- and long-term datasets. Conversion of the frequency distribution to the relative frequency distribution, dataset where the observed frequency for each wind speed or direction category is divided by the total number of observations (i.e., number of occurrences) in each dataset, normalizes the distributions between 0 and 1 (or 0 and 100 when considered as a percentage), thus making it easier to compare between datasets (Triola, 2005). Additionally, this analytical decision is favorable as it is expected to satisfy the requirement for interval or ratio data, particularly for wind direction, as well as lessen potential violations of parametric assumptions associated with many statistical tests.

This appendix provides an evaluation of common qualitative assessments and quantitative statistical tests that may be utilized to evaluate temporal representativeness of two meteorological parameters (i.e., wind speed and wind direction), as the relative frequency distributions of the individual parameters, the combined frequency distribution both speed and direction (i.e., the combination of six wind speed categories by the 16 wind directions), and the joint frequency of both parameters with stability class. The data used in the evaluations that follow were obtained for each of two study locations where licensed uranium recovery facilities are located nearby: (1) Scottsbluff, Nebraska and (2) Gillette, Wyoming. The short-term dataset from Scottsbluff is also compared against the long-term dataset from Gillette as a validation comparison for which temporal representativeness would not be expected given the 200 mile distance between the sites, supported by qualitative visual examination of the data.

A.2. QUALITATIVE EVALUATION OF WIND ROSES, RADAR PLOTS AND BAR CHARTS

One of the main elements of preliminary data review is the graphical representation of the data. Graphing and/or plotting the data allows the data user to visually identify patterns or trends that may not be apparent when reviewing numerical values alone. A further advantage is that the graphical presentation in many cases may be used to initially summarize the results and to identify patterns in one dataset and relationships between two or more datasets, where dissimilarities may be identified. Several traditional meteorological qualitative techniques have been used to promote visual understanding of the relative frequency distributions of wind speed and wind direction including wind roses, radar plots, and bar charts. An explanation of each technique follows:

Wind roses: Wind roses are polar-coordinate bar charts displaying the relative frequency at which wind comes from each of, typically, 16 wind direction sectors. Together with a stacked-bar format, they can also depict the joint distribution of wind direction with wind speed. The wind rose shows at a glance the prevailing wind direction(s) and their associated typical wind speeds for any of the directions. Calm winds are not included in the plot since their direction is undefined. Their relative frequency is instead given in text as part of the legend on the plot. Wind rose depiction shows the range of variation in wind direction experienced at the site and provides an understanding of the overall climate and favored topographically-induced flows, if they are present.

Radar plots: Radar plots are polar-coordinate line plots, which provide an alternative depiction of the wind direction bar chart from traditional wind roses in a form that facilitates simultaneous comparison of the distributions of two or more wind-data populations. Graphical representations of the individual distributions of winds appear as separate continuous curves on the same plot. Radar plots do not contain any wind speed information. As with wind roses, the frequency of calms is given in text in the legend of the plot.

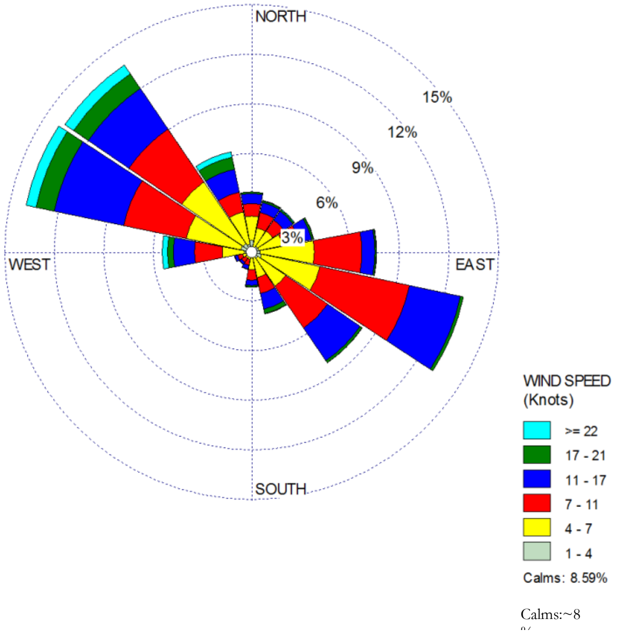
Bar charts: The wind speed data may be plotted in the more commonly-used rectangular bar format (i.e., bar charts) to facilitate the visual comparison of two or more related wind-data sets, such as short-term versus long-term. Wind directions are also often plotted in this format, although separately from wind speed. Such plots show at a glance the degree of similarity or dissimilarity between the distributions of the wind-data populations displayed in them. In this evaluation, bar charts are used qualitatively to compare the relative frequency distributions between the short- and long-term data, where these data are categorized, or binned, to be compatible with the well-established U.S. Environmental Protection Agency (EPA) STAR program that was used to calculate stability classes from the National Weather Service (NWS) data. The wind speed classes, which have been commonly used since the 1970s, are traceable to the Beaufort wind categories. Visualizing the data with these discipline-specific categories, as opposed to using quantitative methods to bin the continuous data, provides qualitative evidence for comparing the similarity between specific wind speed and direction categories between datasets. Specifically, it allows for the direct comparison of important categories like calms and low winds speeds, as well as reduces the influence of unimportant small differences, such as that between speeds of 10 m/s and 11 m/s or between directions, for example 300º and 301º. Thus, the evaluation of bar charts of the relative frequency distributions for wind speed and direction serve as qualitative evidence to support the nature of the relationship between short- and long-term data, but does not provide a quantitative mechanism for assessing the overall distributional fit (i.e., degree of normality).

The above three qualitative assessment methods do not replace more quantitative techniques, but at a minimum, provide a visual context in which to interpret quantitative results. They are a hedge against missing important results or over-emphasizing unimportant ones. These techniques applied to short- and long-term wind datasets provide a visual understanding of temporal representativeness.

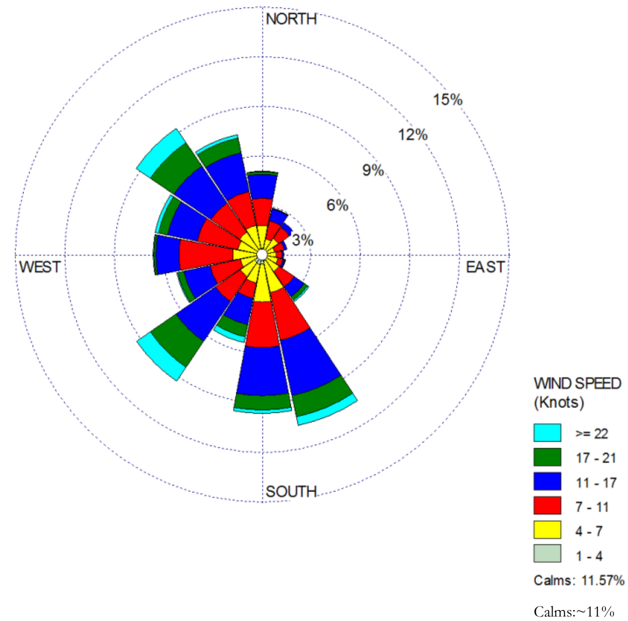
Examples of the application of these qualitative assessments are provided below for two sites using wind roses, radar plots, and bar charts.

Figure 1 (A–D) illustrates wind roses for Scottsbluff, Nebraska and Gillette, Wyoming. The value of wind roses is to present a visual characterization of both wind direction and wind speed at the sites of interest. The four panels in Figure 1 (A–D) provide an overview of the short- and long-term non-overlapping datasets at each of the two sites, Scottsbluff, Nebraska, and Gillette, Wyoming. Details of these distributions will be covered in the discussion below, but the overall similarity in both direction and speed between the short- and long-term datasets at each site is apparent, as is the dissimilarity from site to site. One feature to note at Scottsbluff is that although the wind comes from the southeast nearly as frequently as from the northwest, the stronger wind comes from the northwest.

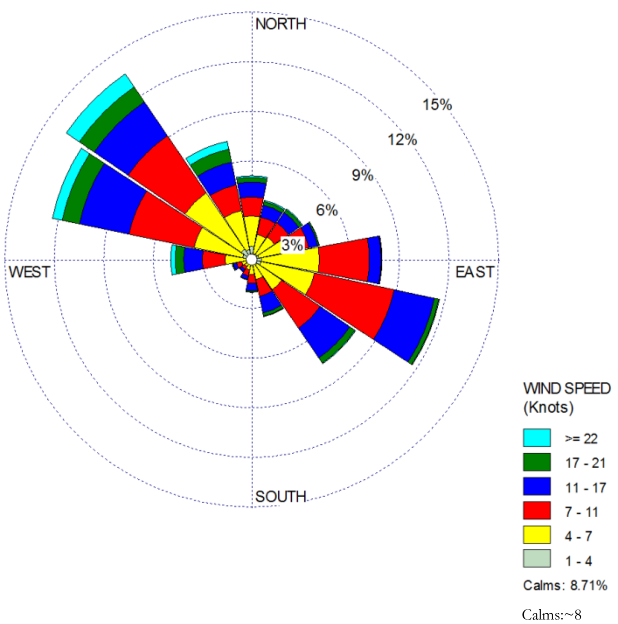
Scottsbluff Airport 1 year (A): 08/24/2010 to 08/29/2011



Gillette Airport 1 year (B): 08/24/2010 to 08/29/2011



Scottsbluff Airport 15 years (C): 08/01/1995 to 07/31/2010



Gillette Airport 15 years (D): 08/01/1995 to 07/31/2010

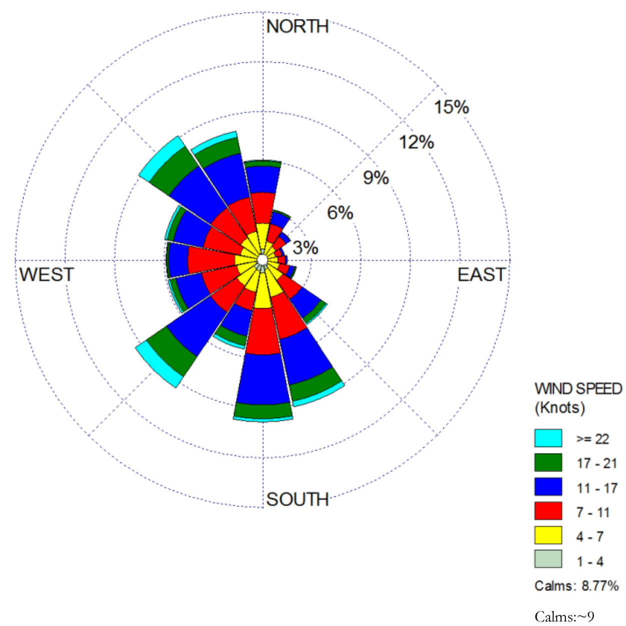


Figure 1 (A–D). Wind Roses for Scottsbluff, Nebraska and Gillette, Wyoming Airports

Scottsbluff, Nebraska 1-year versus 15-year temporal representativeness comparisons

Figure 2 displays the pattern of relative frequency of the 16 wind direction segments for Scottsbluff, Nebraska for 1 year and for 15 years of data.

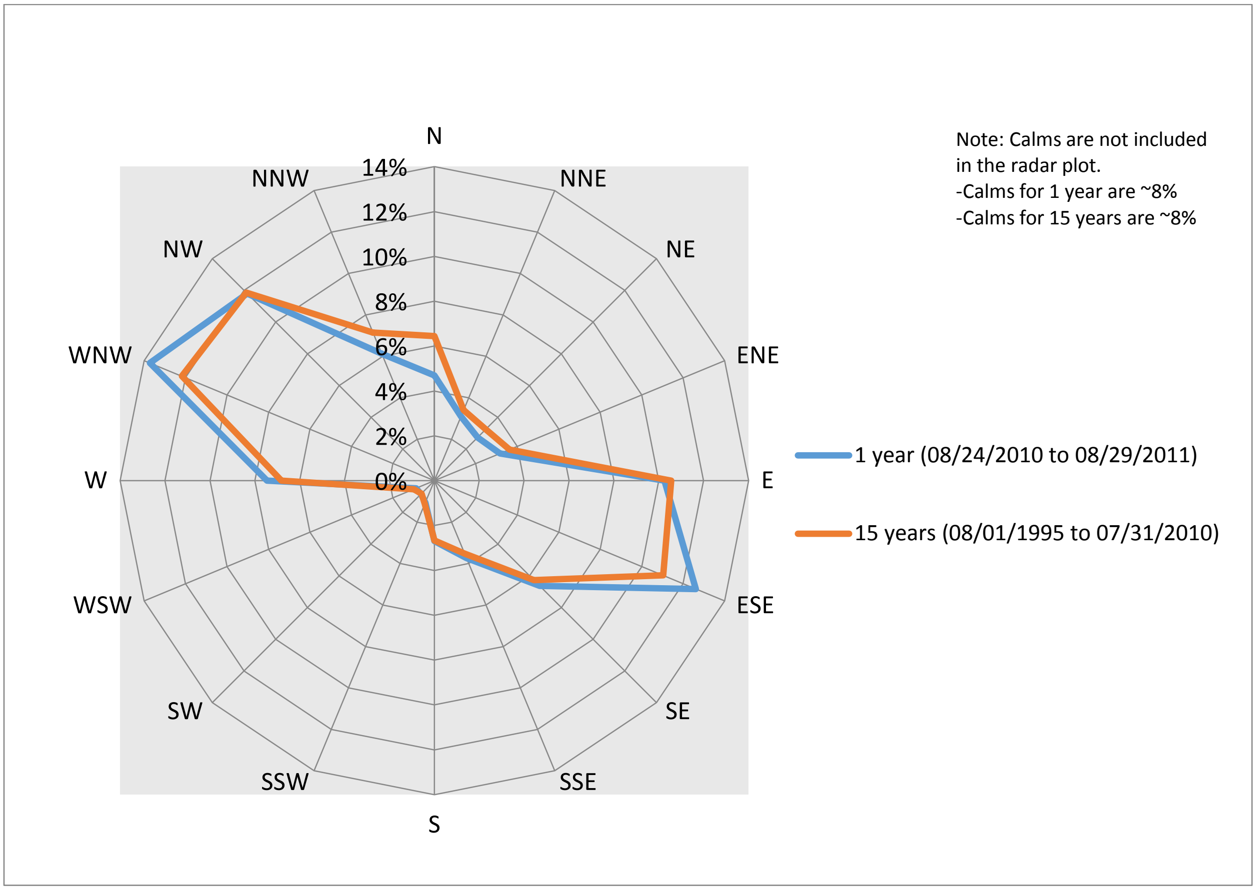


Figure 2. Radar Plot of Wind Direction Relative Frequency Distributions for Scottsbluff, Nebraska Airport: 1 year and 15 years

As can be seen in the legend, these datasets include 1 year of baseline data compared against a non-overlapping historical 15-year period. Calm winds, other than the percentage of occurrence provided in the legend, are not included in the plot since their direction is undefined. Overall, the two distributions appear quite comparable. Further visual examination also indicates that the wind direction for both the short- and long-term wind-data populations is concentrated along the WNW to ESE axis. This is found from a topographic map to be aligned with the North Platte River Valley through Scottsbluff, strongly suggesting local terrain influence on the wind direction distribution. From these initial visual examinations, the quantitative statistical evaluation would likely be expected to demonstrate that the 1-year wind data appropriately represent the 15-year wind data.

Visual comparison between datasets is also possible using bar charts, which display the relative frequency distributions. As will be demonstrated, this approach can be used for wind direction distributions, but is particularly useful in visually comparing wind speed distributions. Figure 3 displays the same data as those in the Figure 2 radar plot, but with the wind data presented in bar-chart format.

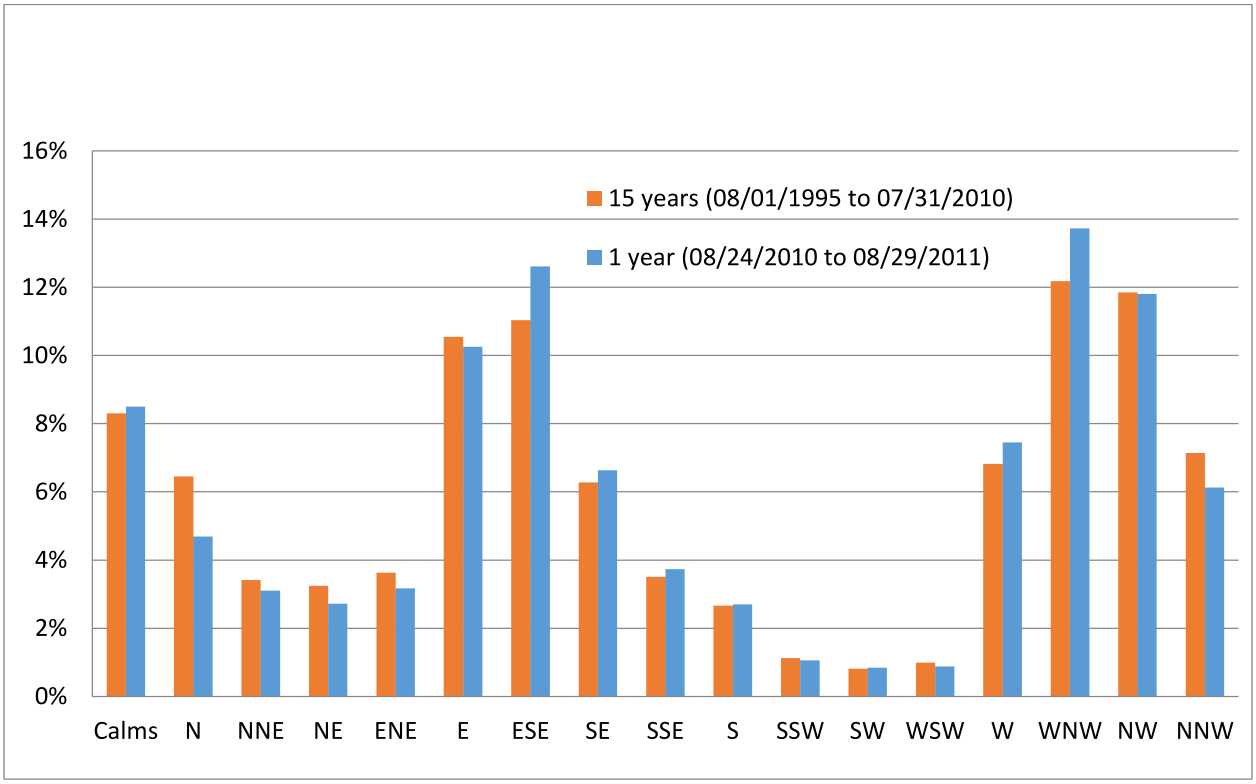


Figure 3. Scottsbluff Nebraska Airport Wind Direction Relative Frequency Distribution: 1 year vs. 15 years

Based on the bar heights, it can be clearly discerned that the wind direction is most frequently from the northwesterly and southeasterly directions, as also illustrated by the radar plot. The chart also reveals that several important wind directions have different frequencies between the 1-year and the 15-year period. The short-term period has somewhat more frequent WNW and ESE wind directions, while the long-term has somewhat more frequent wind directions from N and NNW. However, overall, the difference between the short- and long-term patterns does not appear to be particularly large or meaningful, varying between the two data sets by only 1–2% for any given direction. One advantage of a straight-line bar chart over radar plots or wind roses is the ability to depict, and then compare the frequency of the very important calm conditions.

Figure 4 shows the distribution of wind speed over six ranges, plus calms, at Scottsbluff. Again the long-term (i.e., 15 years) and short-term (1 year) are compared as adjacent bars. The bar heights, indicating the relative frequency—illustrated as the percentile that wind speed was observed in a given speed range category during the respective data collection period—are very similar for each of the seven categories and the resultant shapes of the two distributions serve as visual evidence that the two wind speed populations are very similar to one another.

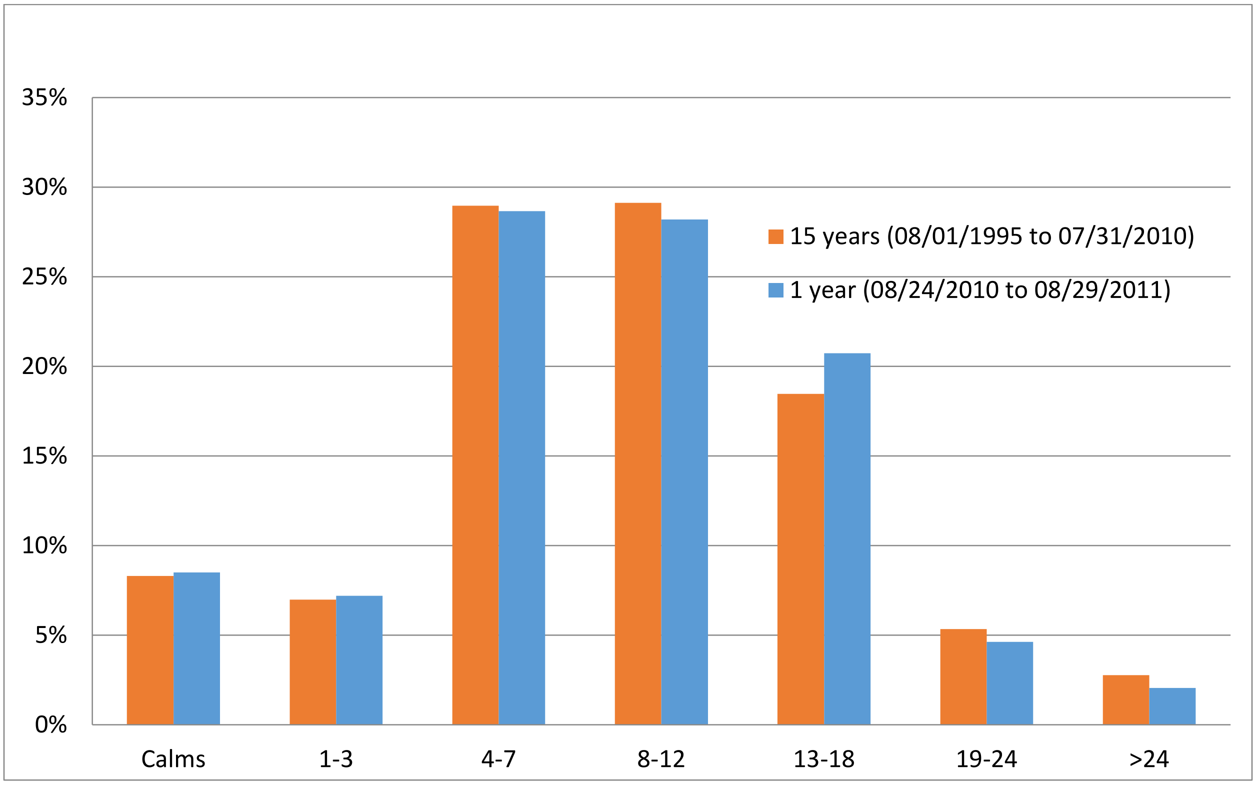


Figure 4. Scottsbluff Nebraska Airport Wind Speed Relative Frequency Distribution

Gillette, Wyoming 1-year versus 15-year temporal representativeness comparisons

Figure 5 shows the comparison of the wind direction distributions over the same 1-year and 15-year periods at Gillette, Wyoming, located about 200 miles (320 km) NNW of Scottsbluff, Nebraska. The two wind direction radar plot distributions again appear to match quite well. There is also a clear N–S orientation of the most commonly occurring wind directions with the wind coming from the west side of the compass the vast majority of the time and far less frequent wind from the east side. This also strongly suggests local terrain influence on the wind-direction distribution. A topographic

map shows the hills and valleys to be oriented slightly west of north to slightly east of south at the airport, which supports this terrain influence assumption.

From a visual perspective, the quantitative statistics would again be expected to indicate that the 1-year wind data appropriately represent the 15-years wind data, therefore demonstrating temporal representativeness.

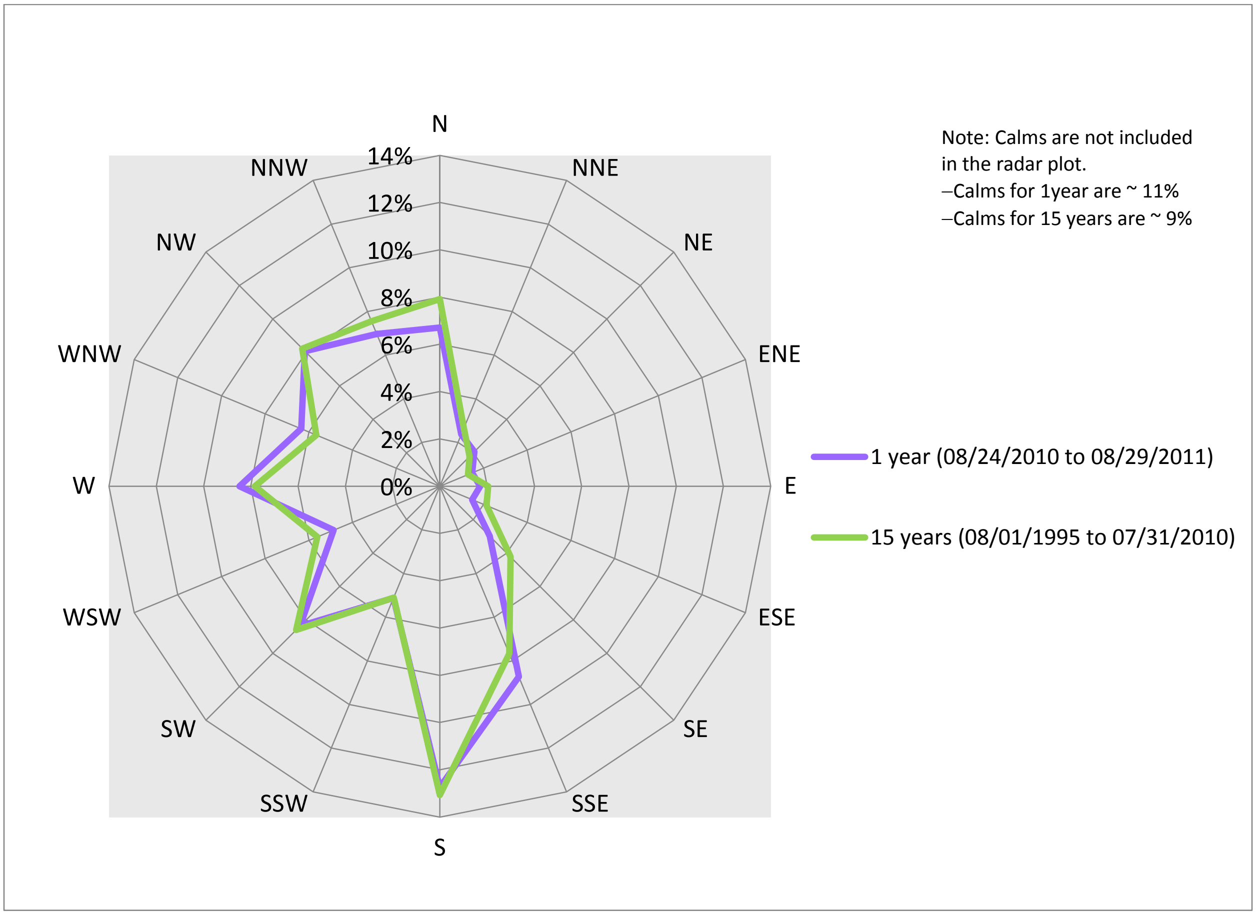


Figure 5. Radar Plot of Wind Direction Relative Frequency Distributions for Gillette, Wyoming Airport

Figure 6 depicts wind direction distributions for the same time periods at Gillette, Wyoming in a bar chart. Wind direction is more common from the general westerly directions than from the general easterly directions. There appears again to be limited differences between the short- and long-term distributions of wind direction. The noticeable difference between the frequency of calms in the short- and long-term datasets may not be as important when examined in light of the distribution of wind speeds in Figure 7.

Though calm conditions' frequency is often usefully displayed on the same chart with wind direction, it more directly belongs with the wind speed chart, shown in Figure 7. Note that the scale in Figure 7 has more than twice the range compared to the wind-direction chart, Figure 6 (maximum 35% on Figure 7 vs. 14% on Figure 6). This can lead to visual misinterpretations of significance simply due to relevance of scale. On Figure 6, the discrepancy in calms between the short- and long-term datasets appears noteworthy. In Figure 7, however, the discrepancy in calms, though still the largest of the collection, does not appear extraordinary. It is expected that in combination with the visual evaluation, quantitative analyses will provide more definitive conclusions to confirm temporal representativeness.

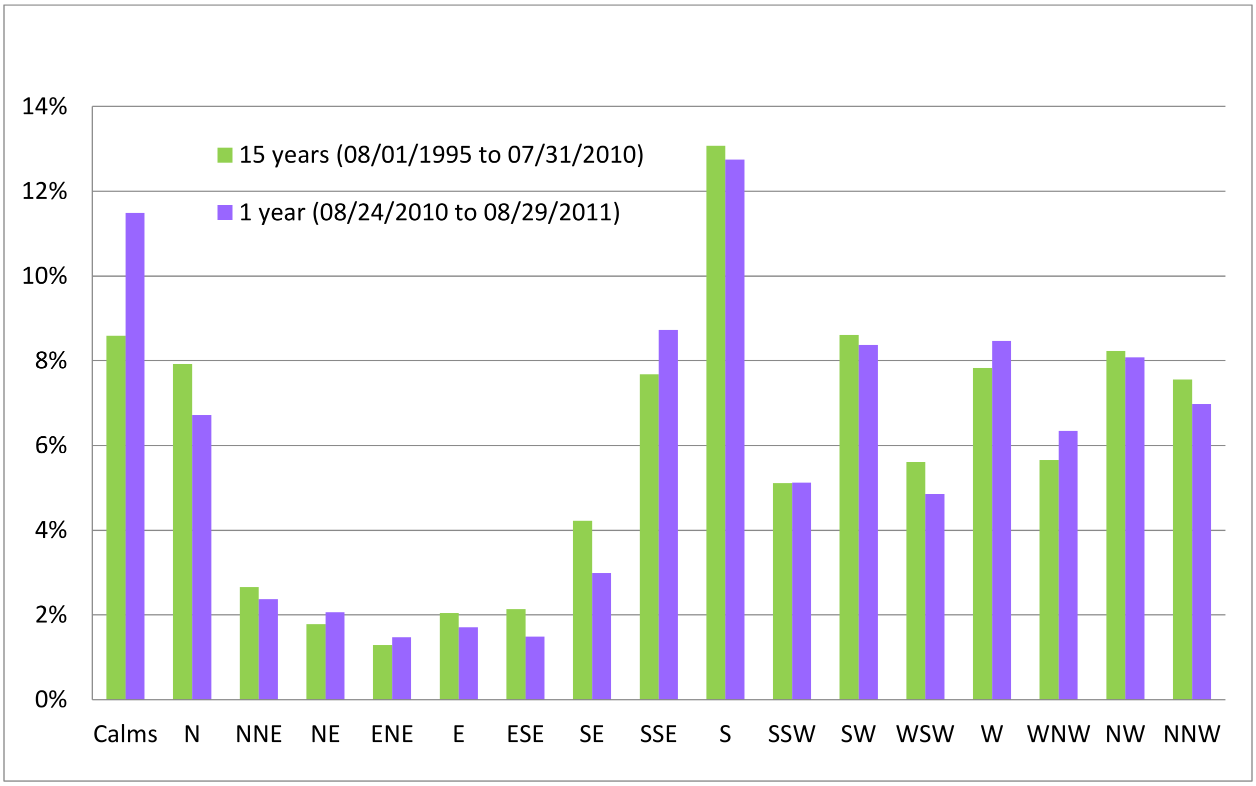


Figure 6. Gillette, Wyoming Airport Wind Direction Relative Frequency Distribution

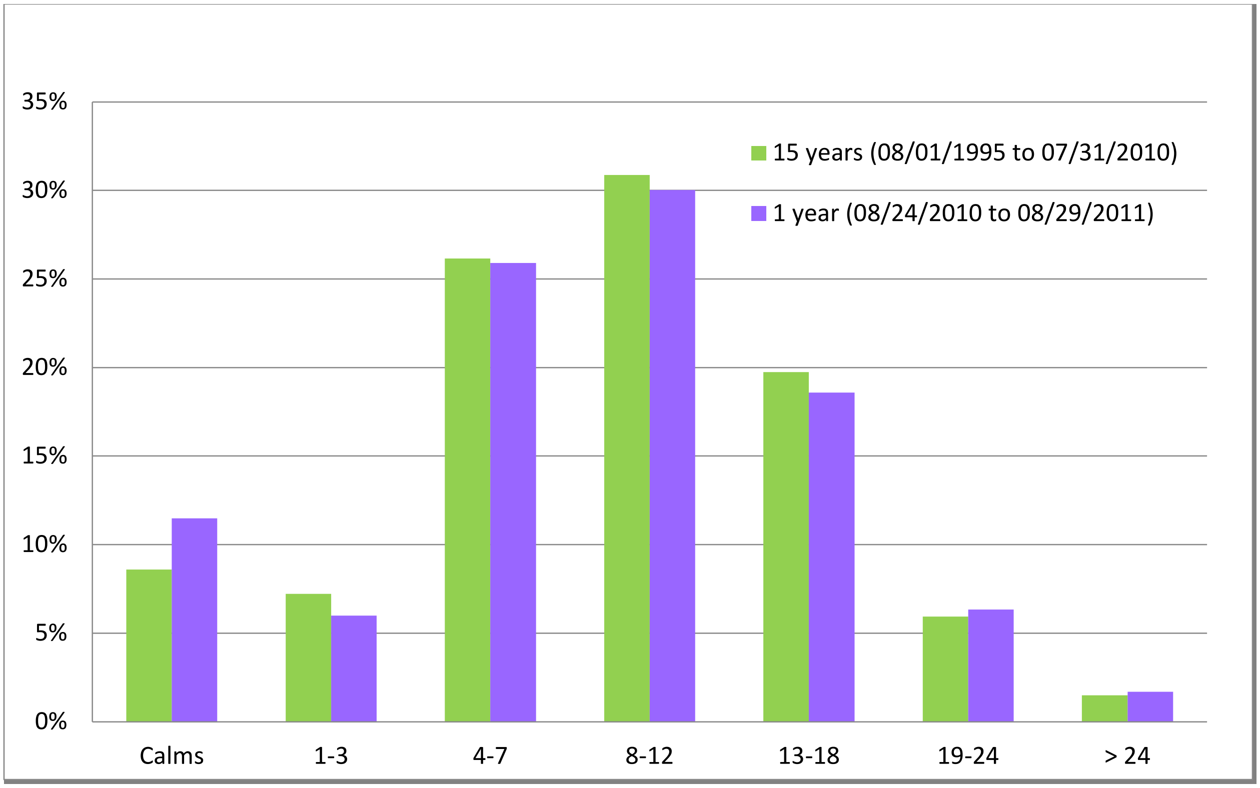


Figure 7. Gillette Wind Speed Relative Frequency Distribution

Inter-site wind direction radar plot distributions differing both spatially and temporally: short-term at Scottsbluff; long-term at Gillette

The examples that follow use data from two different airports as illustrative surrogates to demonstrate how the previous qualitative methods can be used to identify an anomalous short-term result when compared with the long-term site meteorology. Figure 8 presents radar plots of 1-year Scottsbluff versus 15-year Gillette wind direction data. Visual comparison indicates very different wind direction and confirms what would logically be expected for sites separated by 200 miles (320 km) and with different mountain-valley orientations. The conclusion from the visual examination would be to expect the quantitative methods to find that significant differences exist.

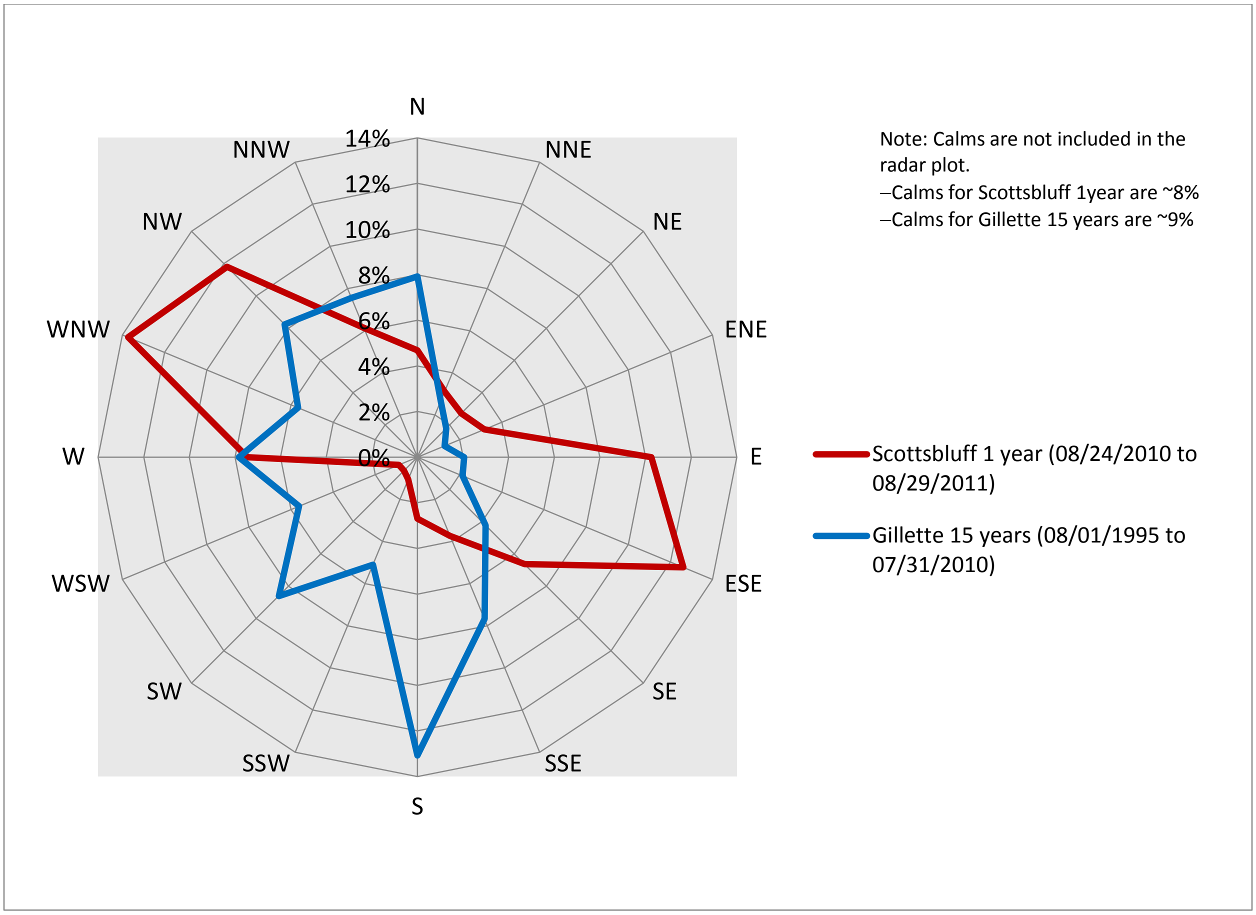


Figure 8. Inter-site Comparison Radar Plot of Wind Direction Relative Frequency Distribution: Scottsbluff 1 year vs. Gillette 15 years

The bar charts shown in Figures 9 and 10 compare the 15-year long-term data from Gillette with the 1-year short-term wind direction and wind speed data from Scottsbluff, respectively. As was seen in the relative frequency distribution radar plot for the two sites, the wind direction distribution is also visibly different. Gillette has more frequent wind directions from SSE around to WSW, while Scottsbluff has more frequent wind from E, ESE, WNW, and NW, likely due to differences in valley orientations at the two sites.

However, when wind speed is visually compared, there appear to be very little differences between the 1 year at Scottsbluff and the 15 years at Gillette, such that it would be expected that quantitative analysis may conclude that the distributions are similar. This might be expected given that the two sites are in the same general climate and the valley orientation differences on wind flow do not generally affect wind speed.

However, it is important to note that winds that are light (i.e., the 1–3 mph bin) or calm have a disproportionate influence on the maximum dose received, especially if they most often occur at night, accompanying the extremely stable class F. Contaminants released under such conditions, especially from ground level, will be minimally diluted, and the transporting horizontal wind and the spreading vertical diffusion are both of small magnitude. Thus, qualitative methods can aid in visualizing differences in frequencies in categories that may have a disproportionate impact on the dose computed in dispersion models, such as MILDOS-AREA.

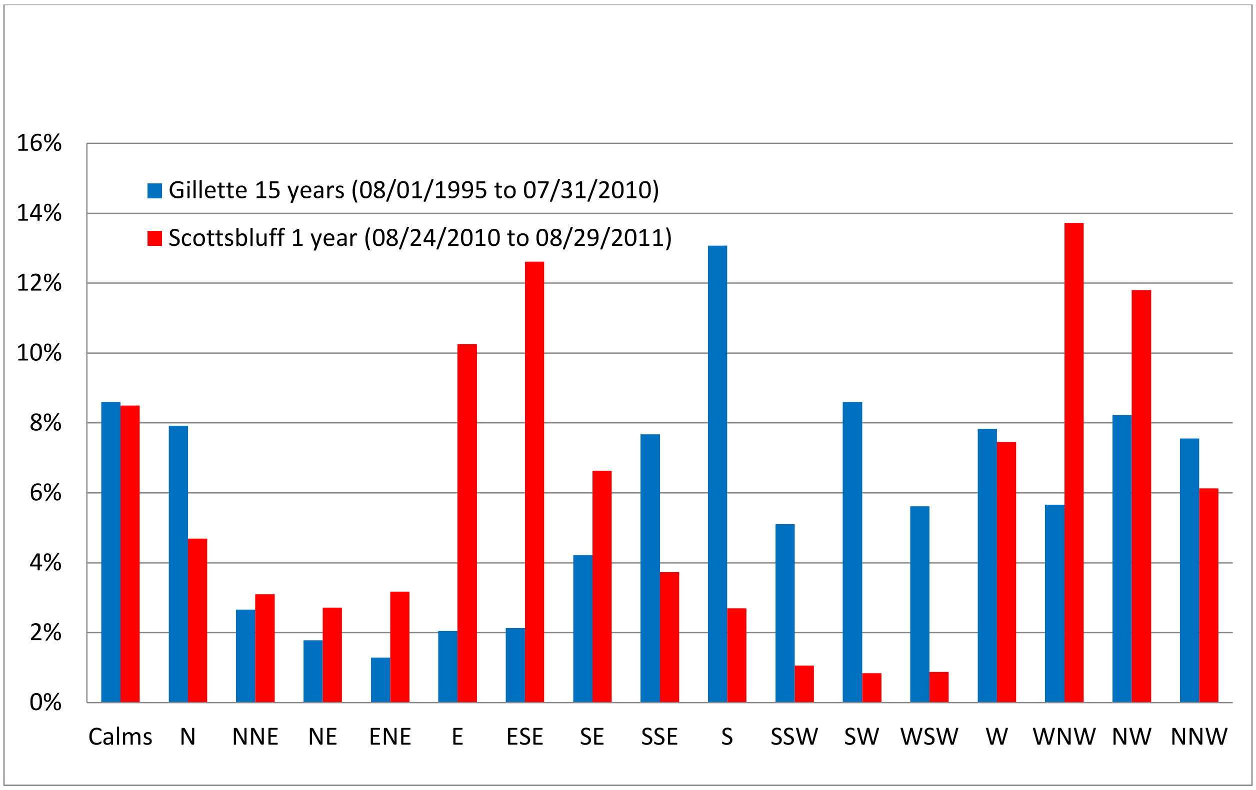


Figure 9. Inter-site Comparison of Wind Direction Relative Frequency Distribution: Scottsbluff 1 year vs. Gillette 15 years

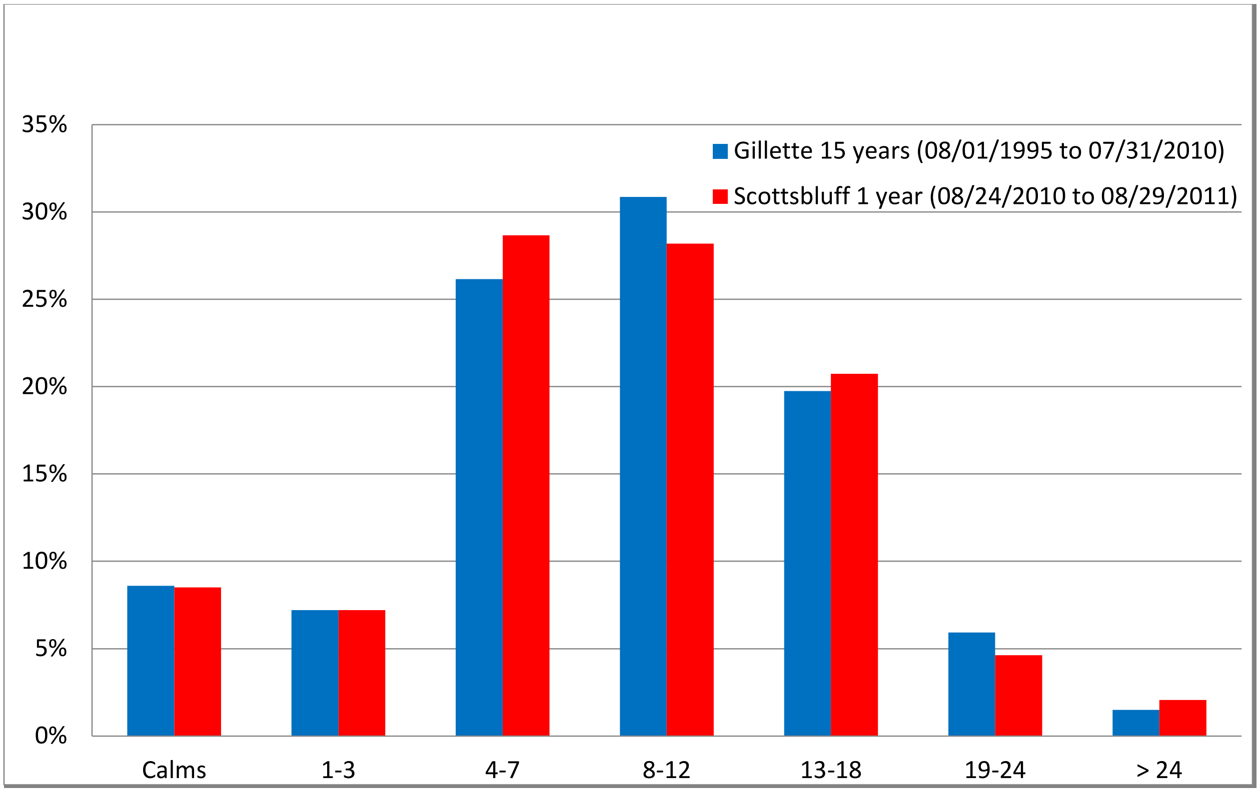


Figure 10. Inter-site Comparison of Wind Speed Relative Frequency Distribution: Scottsbluff 1 year vs. Gillette 15 years

Although visual evidence will not provide a final determination due to the qualitative nature of the comparison, these qualitative techniques described provide initial indication as to whether the datasets have similar characteristics or not and serve as support for continuing the assessment with the quantitative aspects of demonstrating temporal representativeness.

A.3. QUANTITATIVE EVALUATION OF WIND DIRECTION AND WIND SPEED

This section provides an overview of concepts and a summary of results for the evaluation of common statistical methods that may be appropriate for demonstrating temporal representativeness, including: tests of summary statistics (i.e., two sample t test, one sample t test), tests of goodness of fit (i.e., chi-square and Kolmogorov-Smirnov), and test of strength of linear association (i.e., correlation and linear regression). These and similar methods have been used by uranium recovery applicants and licensees to demonstrate temporal representativeness. For additional information and definitions of statistical terms in this section, refer to NUREG-1475.

A.3.1 Evaluation of Tests of Summary Statistics

For tests of summary statistics, the statistical premise is that if two groups have statistically similar measures of central tendency (i.e., means or medians), then the groups are assumed to have arisen from the same distribution. Typical tests include the t test (parametric) or Wilcoxon rank sum (non-parametric). More information about the application of these tests can be found in Chapters 13, 15, and 25 of NUREG-1475 (NUREG-1475, 2011). The two-sample tests do not directly lend themselves to evaluating the difference between relative frequency distributions since such data are bound between zero and one, and the mean is $1/n$, where n is the number of categories. This can lead to a failure to find statistical difference (i.e., reject the null hypothesis) even when a meaningful difference may exist.

Two-sample t test

It has been suggested (IML, 2014b) that a class-wise two sample t test could be applied separately to each category for frequency data by comparing the mean annual frequencies when the short-term dataset is constructed from more than one year of baseline data. For wind direction and wind speed, this would entail conducting 17 and 7, respectively, unique tests with a demonstration of representativeness if each of the 24 tests fails to reject the null hypothesis that the short- and long-term frequency distributions are similar (i.e., concluding there is no evidence to suggest the short- and long-term datasets differ). While a valid statistical technique, there are two concerning drawbacks: the requirement of two or more years of baseline data and the issue of multiple testing leading to an increased familywise error rate, or increased probability of making a Type I error (i.e., rejecting the null hypothesis when, in fact, it is true). The class-wise t test was not evaluated for this study, as the applicants predominantly use a baseline period of only one year of data, which is the minimum amount of data that should be gathered by the applicants, as recommended in Regulatory Guide 3.63. Should more than one year of data be available for the baseline period, this statistical technique may be acceptable for demonstrating representativeness, but it is recommend that a familywise error rate correction, such as Bonferroni (Shaffer, 1995), be applied to control the Type I error rate. However, given the constraints of this method and because the increased complexity and difficulty in interpretation reduces the efficiency of demonstrating representativeness, this method is not recommended and was not further evaluated.

One sample t test

A more efficient approach to determining the similarity between relative frequency distributions by central tendency is to apply the one sample t test to the distribution of ratios of short- to long-term frequencies, evaluating whether the mean is equal to 1 which is the equality value of a ratio. If the short-term data are temporally representative of the long-term distribution, then the mean of the ratios for each wind direction or speed category should be approximately equal to 1, while dissimilar distributions should yield a mean statistically different than 1. The results are presented in Table 1.

Table 1. One Sample t test for the Ratio of Short-term to Long-term Relative Frequencies

Comparison	Parameter	Mean	t statistic	Critical t value	p-value	Conclusion
Scottsbluff 1 yr vs. 15 yr	Wind direction	0.97	0.956	2.12	0.353	Fail to reject H_o
Scottsbluff 1 yr vs. 15 yr	Wind speed	0.96	0.785	2.45	0.462	Fail to reject H_o
Gillette 1 yr vs. 15 yr	Wind direction	0.98	0.462	2.12	0.65	Fail to reject H_o
Gillette 1 yr vs. 15 yr	Wind speed	1.04	0.62	2.45	0.56	Fail to reject H_o
Scottsbluff 1yr vs. Gillette 15 yr	Wind direction	1.53	2.18	2.12	0.04	Reject H_o
Scottsbluff 1 yr vs. Gillette 15 yr	Wind speed	1.03	0.43	2.45	0.69	Fail to reject H_o

The Table 1 conclusions support the expectations identified in the initial visual evaluations, with the test failing to reject the null hypothesis (i.e., no evidence that the mean is different than 1) for the intra-site comparisons at both Scottsbluff and Gillette, and rejecting the null hypothesis (i.e., the mean is different than 1) for expected dissimilar distributions as observed for the inter-site comparison for wind direction. The test also confirmed similar distributions in the inter-site comparison for wind speed, resulting in a failure to reject the null hypothesis. Although not demonstrated with these data, a potential issue with the one sample t test could occur in cases where frequencies vary in both directions such that short-term frequencies are greater than the long-term frequencies in some direction or speed categories, but less in others. This distribution of differences may effectively result in a mean that the one sample t test concludes is not statistically different from 1, leading to the suspicion that a Type II error (i.e., incorrect failure to reject the null hypothesis) has been made. This concern is particularly important when there are noticeable

differences in categories such as low wind speeds or calms. By calculating the average, these differences may be masked. Thus, while the one sample t test may be appropriate for evaluating representativeness in some datasets, it may lack the power to detect distributional differences for important categories of wind speed or wind direction.

A.3.2 Evaluation of Tests of Goodness-of-Fit

Tests of goodness-of-fit like chi-square and Kolmogorov-Smirnov compare the frequency distribution of a sample of the observed data to the population distribution that can be either known/expected, as is the case of the long-term dataset, or hypothesized, which is the case in testing for normality of data. If there is no evidence that the distributions differ statistically, then the sample is considered to be representative of the population. More information about these tests can be found in Chapter 11 of NUREG-1475 (NRC, 2011).

Chi-square (χ^2) test

The null hypothesis of the chi-square goodness-of-fit test is that there is no difference between the observed and expected frequency distributions. The short-term data constitute the observed frequencies, while the long-term data are the expected or known population. An important limitation of the chi-square test is that it is sensitive to very large sample sizes but also is not appropriate for small sample sizes, which can be defined by two or fewer observations in any category (i.e., cell count) of expected frequencies (NRC, 2011). In both the Scottsbluff and Gillette datasets some categories of wind direction and wind speeds had frequencies less than 2%. U.S. Nuclear Regulatory Commission (NRC) guidance (NRC, 2011) states that the two strategies for overcoming this limitation is to either increase the sample size or combine categories, which may not be appropriate for wind direction or speed classes.

One way to increase the sample size without collecting more data is to scale the data by a multiplier. Since meteorological data are collected on an hourly basis at the NWS, an intuitive multiplier would be 8,760 (i.e., the number of hours in a year), which would serve to transform the relative frequencies into annual hours observed for each category. The results for the chi-square test of annual hours for wind direction and wind speed distributions are displayed in Tables 2 and 3, respectively. The rejection of the null hypothesis of similarity for intra-site temporal comparisons

seem to contradict the visual evidence (wind roses, radar plots, and bar charts) provided in Section 2 of this appendix that suggested quite similar distributions for both parameters at each site. This result may be a consequence of the artificial scaling factor. To demonstrate this sensitivity, the relative frequencies for each wind speed and direction category were scaled by 500 for Scottsbluff and 350 for Gillette, which were the minimum multipliers to ensure that no cell counts were below 2%. Those results, also shown in Tables 2 and 3, provide the expected conclusions for the Scottsbluff and Gillette intra-site comparison of similar distributions, while also continuing to reject the null hypothesis for the inter-site comparison for wind direction (i.e., conclude dissimilar distributions).

While the chi-square test provides a valid comparison for determining whether short- and long-term distributions are similar, the arbitrary nature of selecting an appropriate scaling factor diminishes the robustness of this method for consistently demonstrating temporal representativeness. This issue makes providing consistent regulatory guidance to the applicants, as well as consistent interpretation of results, difficult to achieve.

Table 2. Chi-square χ^2 Test for Short-term (1 year) vs. Long-term (15 years) Wind Direction Distributions

Comparison	Chi-square	P-value	Conclusion
Scottsbluff annual hours	118	<0.001	Reject H_o
Scottsbluff frequency scaled × 500	6.73	0.98	Fail to reject H_o
Gillette annual hours	202	<0.001	Reject H_o
Gillette frequency scaled × 350	8.08	0.94	Fail to reject H_o
Scottsbluff 1 yr vs. Gillette 15 yr annual hours	11225	<0.001	Reject H_o
Scottsbluff 1 yr vs. Gillette 15 yr frequency scaled × 500	640	<0.001	Reject H_o

Table 3. Chi-square χ^2 Test for Short-term (observed) vs. Long-term (expected) Wind Speed Distributions			
Comparison	**Chi-square**	**P-value**	**Conclusion**
Scottsbluff annual hours	52	<0.001	Reject H_o
Scottsbluff frequency scaled × 500	2.98	0.81	Fail to reject H_o
Gillette annual hours	116.7	<0.001	Reject H_o
Gillette frequency scaled × 350	4.6	0.99	Fail to reject H_o
Scottsbluff 1 yr vs. Gillette 15 annual hours	89.7	<0.001	Reject H_o
Scottsbluff 1 yr vs. Gillette 15 yr frequency scaled × 500	5.12	0.53	Fail to reject H_o

Kolmogorov-Smirnov test

Similar to the chi-square goodness-of-fit test, the two-sample Kolmogorov-Smirnov (K-S) is a non-parametric test that can be used to evaluate whether two datasets arise from the same population. The K-S statistic is based on the maximum difference between the empirical cumulative distribution functions of the datasets. Unlike the chi-square test, the K-S test is robust to sample size; however, the power of the test may be reduced with ratio or ordinal data (Conover, 1999). The results of the application of the K-S to these data are presented in Table 4, providing conclusions that are consistent with the visual evidence for similar distributions (fail to reject the null hypothesis for intra-site comparisons and inter-site comparison of wind speed) and dissimilar distributions (reject the null hypothesis for inter-site comparison of wind direction). While not demonstrated in these data, the statistical literature cautions that the K-S test tends to have low power against the null hypothesis, tending to fail to reject and conclude that distributions are similar, especially for small samples (Conover, 1999). Two datasets would need to be obviously different, as is the case for the inter-site comparison of wind direction, in order for the test to conclude a significant difference exists.

The K-S goodness of fit test may be an acceptable method for evaluating temporal representativeness, but may suffer from a lack of sensitivity in being able to detect important differences between short- and long-term data that would suggest representativeness is not present

to a high degree. If the K-S test is used for evaluating temporal representativeness, it is recommended that additional, more robust methods be utilized to verify that a Type I error (incorrect failure to reject the null hypothesis) is not committed.

Table 4. Kolmogorov-Smirnov Test for Short-term (1 year) vs. Long-term (15 years) Wind Direction and Wind Speed Distributions

Comparison	Parameter	K-S statistic	Critical K-S value	Conclusion
Scottsbluff 1 yr vs. 15 yrs	Wind direction	0.12	0.32	Fail to reject H_o
Scottsbluff 1 yr vs. 15 yrs	Wind speed	0.09	0.48	Fail to reject H_o
Gillette 1yr vs. 15 yr	Wind direction	0.11	0.32	Fail to reject H_o
Gillette 1 yr vs. 15 yrs	Wind speed	0.14	0.48	Fail to reject H_o
Scottsbluff 1 yr vs. Gillette 15 yrs	Wind direction	0.57	0.32	Reject H_o
Scottsbluff 1 yr vs. Gillette 15 yrs	Wind speed	0.27	0.48	Fail to reject H_o

A.3.3 Evaluation of Correlation and Linear Regression

From a statistical standpoint, the typical intent of linear regression, utilizing ordinary least squares (OLS), is to determine how an independent variable will effect and/or predict the values of a dependent variable; i.e. by how much does y increase or decrease if x increases or decreases. Correlation is a complementary statistical technique that seeks to describe the strength and direction of the linear relationship between two datasets, with values of R (Pearson's coefficient) ranging between -1 and 1 with a value of zero indicating no linear relationship. The coefficient of determination, R^2, which is a measure of how well a linear regression equation fits the data, is approximately the square of the correlation coefficient and when multiplied by 100 is interpreted as the "the % of variance in y that is explained by x." The R^2 value ranges from 0 to 1, where 1 indicates perfect agreement or correlation and 0 indicates no relationship. More information about these tests and their assumptions can be found in Chapters 18 and 19 of NUREG-1475 (NRC, 2011).

While many may consider these tools mainly for prediction, it is valid to employ linear correlation and regression to provide insight into the nature of the relationship between two datasets as a method for evaluating the similarity between them, where the goal is not predictive but to merely make inference about one variable from a second variable (Jaccard and Becker, 1997). In relation to demonstrating temporal representativeness, when the short-term relative frequency distribution is assigned as the dependent variable, or unknown quantity, and the long-term data frequency distribution as the independent (i.e., the known or expected distribution of the population), the regression line will demonstrate the degree of agreement between the frequencies within each wind speed and wind direction class, where a slope of 1 for the regression line would indicate complete equivalence. It is expected that if the short-term data are truly representative of the long-term data, the variance in the long-term data should explain the variance observed in the short-term data to a high degree, signified by a high R^2 value. Essentially, the question being asked is whether the past (i.e., long-term data) can explain or describe the current conditions (i.e., short-term data), which serves as the baseline for future comparisons. This concept is supported within the wind power generation field (Liléo et al., 2013). However, the goal in wind power is very high precision in prediction, rather than the goal of demonstrating distributional similarity in the case of temporal representativeness. In addition to high prediction precision, the wind power generation field also requires significantly more complex statistical techniques than are needed for establishing that the baseline year was not anomalous compared to past conditions. Liléo et al. (2013) is being referenced here only to support the use of the long-term conditions as the independent variable (x) to predict/explain the short-term conditions as the dependent variable (y).

Assessing the linear association with regression between two relative frequency distributions provides two benefits:

1. Normalizing wind speed and wind direction data as relative frequency distributions is expected to lessen potential violations of the parametric assumptions of correlation and linear regression; however, it is still recommended that appropriate fit diagnostics, such as normality tests and evaluation of plots of residuals versus predicted values or observed versus predicted values, be evaluated to ensure there are no severe violations of assumptions.

2. Similar to the concept of a probability or quantile-quantile plot, if the two distributions are similar, they will closely fall around a unity line of slope=1 and intercept=0, thus providing visual information of how paired points (between the short- and long-term frequencies) vary about the line, giving indications of important disagreement, as well as providing quantitative evidence of the impact of potential dissimilarity through the R^2 value.

The second point above indicates that the regression line should be forced to pass through the –XY origin to obtain an intercept=0. While regression through the origin is not a common practice, it is valid in the instance that the data are relative frequencies, such that data are bounded from 0 to 1, and thus fitting the points to the unity line. In the case of temporal representativeness, it is reasonable to expect that if the frequency of a particular wind parameter is 0 in the long-term dataset (x=0), then it should be approximately 0 in the short-term dataset (y=0), with deviation from the line of slope=1 and intercept=0 likely indicating lack of agreement. It has been suggested that the appropriateness of excluding the intercept from the regression model is best assessed by running the model with an intercept and testing the null hypothesis that the intercept constant is equal to zero using the Student's t statistic to determine significance (Eisenhauer, 2003). Preliminary analyses in this evaluation of Scottsbluff and Gillette data considered each of the regression models with an intercept by assessing the p-values for test of significance for the hypothesis $\beta_0 = 0$ (i.e., intercept =0). The p-value was greater than 0.05 for all intra-site comparisons, indicating that the intercept term was not significant, thus confirming the appropriateness of regression through the origin. While regression through the origin is expected to be appropriate in most cases, it would be prudent to evaluate this assumption as described above.

Additional discussion on regression through the origin is available elsewhere (Casella, 1983 and Eisenhauer, 2003). On a technical note, it was observed during this evaluation that the R^2 value calculated from the "trendline" option, specifying a zero constant, for an XY scatter plot in Microsoft Excel 2010 did not match the values calculated in the statistical software program SAS (Version 9.3, Cary, NC) or the regression analysis function of the data analysis tool of Excel. The paper by Eisenhauer (Eisenhauer, 2003) discusses why some programs calculate R^2 differently for regression through the origin. Discussion on this issue and how Microsoft corrected the LINEST function, which drives the regression analysis within the data analysis tool, was found (Microsoft,

2012); however, no explanation of why the "trendline" option of the XY scatter plot was incorrect could be identified.

While regression techniques other than the standard OLS, such as variations of the probit and tobit regression models, have been recommend for limited dependent variables (i.e., bound or truncated data like proportions and percentages) (Long, 1997), it has been suggested that the added complexity in computation and interpretation is not favorable as long as the majority of data do not fall on or very close to each of the limits (i.e., 0 and 1) (Martin, 2013). Since the relative frequency distributions, where proportions sum to one, are being utilized in this application of linear regression, only a few wind speed or direction categories might be expected to be zero or very close to zero, but no relative frequencies would be one.

The linear regression methodology also provides an efficient and straight-forward way to consider the representativeness of the joint frequency distribution of wind direction and speed with stability class, which are the necessary inputs for MILDOS-AREA. In this analysis, the joint frequencies for the 16 wind directions with the appropriate wind speed[1] and atmospheric stability class combinations[2] are compared between the short- and long-term distributions. While the other methods evaluated in this appendix could also be used to assess the joint frequency distribution (where the sample size could be as large as 96 for some stability classes), the issue of sensitivity to large sample sizes was encountered, such that the detection of minuscule differences led to the rejection of the null hypothesis even when the distributions were very similar.

The linear regression results (R^2 values) for the temporal representativeness of wind direction, wind speed relative frequency distribution, and the joint frequency distribution of speed and direction for the intra-site and inter-site comparisons are presented in Table 5. The regression plots for the intra-site comparisons for Scottsbluff (short- vs. long-term) and Gillette (short- vs. long-term) relative frequency and joint frequency distributions are presented in Figures 11–16. The inter-site comparison between Scottsbluff short-term and Gillette long-term relative frequency and joint frequency distributions are provided in Figures 17–19. The data used for generating the regression plots for the intra- and inter-site comparisons are included in Tables 6–14. The regression plots and tables for these comparisons are available in the attachment to this appendix.

[1] Where calms are distributed by the STAR program within each stability class as described in Section 2.2.3 of the TBD.
[2] Where not all six wind speed categories are observed in each of the six stability classes.

Table 5. Linear Regression Results for Temporal Representativeness			
Comparison	**R^2 for Relative Frequency of Wind Direction**	**R^2 for Relative Frequency of Wind Speed**	**R^2 for Joint Frequency of Wind Direction and Speed**
Scottsbluff 1 yr vs. 15 yrs	0.989	0.997	0.978
Gillette 1 yr vs. 15 yrs	0.981	0.995	0.980
Scottsbluff 1 yr vs. Gillette 15 yrs	0.483	0.993	0.368

As expected, the R^2 values for both of the intra-site comparisons performed individually for Scottsbluff and Gillette and the inter-site comparison for wind speed are very high, signifying that a high degree of variance in the baseline data is explained by the variance in the long-term meteorology: strong evidence for temporal representativeness. Likewise, the R^2 value is substantially lower for the inter-site comparison for wind direction (Figure 17: R^2=0.483), as would be expected for dissimilar distributions that are not representative. It is also apparent from these results that the combined frequency of speed and direction appropriately demonstrates the dissimilarities between categories for the individual parameters. For the inter-site comparisons, the lack of representativeness for wind direction is captured in the low R^2 value (0.368) in Figure 19, despite the fact that wind speed was determined to be temporally representative (Figure 18: R^2=0.993). Thus, analysis of the combined frequency is likely sufficient for providing evidence of temporal representativeness for direction and speed simultaneously.

Further, the regression line on the scatter plots provides the opportunity to observe this dissimilarity between the paired data points as variance about the regression line, thus potentially identifying differences in important speed categories, like calms. This could be potentially important in cases where the R^2 values are approximately in the range 0.90–0.95, but dissimilar frequencies in important categories could result in different safety concerns related to dose. The other methods evaluated in this report do not readily provide such direct comparisons.

Unfortunately, ambiguity exists in interpreting what constitutes a strong enough relationship or agreement to constitute temporal representativeness. Based on the results in this report, R^2 ≥0.95 corresponded to highly similar distributions. Generally, R^2 ≥0.90 (correlation of R=0.95) are

considered evidence for a strong relationship; however, since dissimilarity in specific direction/speed categories may be more important than others, it is recommended that if any such differences are identified, despite an acceptable R^2 value, that the differences be evaluated for practical importance to safety. Appendix C (MILDOS-AREA Evaluation) of the technical basis document provides further discussion on this issue.

Thus, based on these results linear regression, when properly applied, is a robust and valid method for demonstrating temporal representativeness for wind speed and wind direction. This method provided the most consistent and accurate results for both the inter-site and intra-site comparisons in this evaluation when compared to the other methods. Further, linear regression provides an efficient method for evaluating the temporal representativeness of the joint frequency distribution of wind speed and wind direction by stability class, which would be difficult for the other methods evaluated to assess given their limitations demonstrated in this report. Further discussion regarding the importance of temporal representativeness of stability class is provided in Section 3.2.1, Recommendation B and Appendix B of the technical basis document.

A.4. CONCLUSIONS

This evaluation at two specific study sites presents acceptable qualitative and quantitative methods for assessing temporal representativeness of wind speed, wind direction, and stability class. It is recommended that any quantitative or statistical method utilized be considered only in conjunction with the qualitative information (graphical methods) gained from the site-specific data.

The results of this evaluation indicate that there are several valid statistical methods for assessing representativeness; however, limitations were outlined for each of the tests, with some more severe than others. The impact of these limitations will likely be specific to the conditions at each site. Based on the data and results observed in this evaluation, as well as subject matter expertise in both meteorology and statistics, it is the expectation of the technical staff that, of the statistical methods evaluated, the linear regression method as previously described will likely be the most efficient and robust technique to the issues and limitations encountered with these types of data and under a wider set of site-specific conditions. With this robustness, as well as the relative ease of calculation and interpretation of linear regression, the ability to provide consistent regulatory guidance to the

applicants and reliable interpretation of results is enhanced compared to other methods, like chi-square, which may require more case-specific decision rules and methodological guidelines.

While possible to consider more than one statistical method for evaluating representativeness, caution should be taken to consider the issue of multiple testing such that as more tests are done, the higher the likelihood of disagreement between tests based on random chance alone. Divergent responses from multiple tests may be difficult to interpret; requiring decision rules about how to globally interpret the results of the evaluation. It would be very time consuming and difficult to model all possible scenarios of the statistical methods discussed in this evaluation so as to create sets of deterministic rules for global interpretation of multiple tests. Thus, it is recommended that the applicant apply the more efficient and robust technique of linear regression, interpreted in light of qualitative analyses of data.

As site-specific conditions may vary, other statistical methods beyond the conventional techniques evaluated here, such as directional statistics (e.g., circular distribution) in the case of wind direction, may be applied to demonstrate temporal representativeness. However, the complexity of such methods likely precludes them from consideration for general applications, while the use of nonstandard methods will likely require a more detailed justification to determine acceptability.

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ATTACHMENT OF APPENDIX A: TABLES AND FIGURES

This attachment contains the regression plots and pertinent data for statistical evaluations of the intra- and inter-site comparisons. Tables and figures are numbered following the order of those presented within Appendix A. The process for acquiring and preparing the data is described in Section 2 of the TBD and summarized in Appendix C.

1. INTRA-SITE COMPARISON: SCOTTSBLUFF 1 YEAR VS. 15 YEARS

1.1. SCOTTSBLUFF WIND DIRECTION RELATIVE FREQUENCY DISTRIBUTION

Table 6 contains the Scottsbluff wind direction relative frequency distribution data used to create the wind direction frequency regression in Figure 11.

Table 6. Scottsbluff Wind Direction Relative Frequency Distribution

Direction	15 years (X-axis)	1 year (Y-axis)	Diff* 1 year vs. 15 years (pp)
N	6.45 %	4.69%	1.76
NNE	3.41%	3.10%	0.31
NE	3.24%	2.72%	0.52
ENE	3.63%	3.17%	0.46
E	10.55%	10.25%	0.29
ESE	11.03%	12.61%	-1.58
SE	6.27%	6.63%	-0.36
SSE	3.51%	3.73%	-0.22
S	2.67%	2.70%	-0.03
SSW	1.13%	1.06%	0.07
SW	0.81%	0.84%	-0.03
WSW	0.99%	0.88%	0.12
W	6.82%	7.45%	-0.63
WNW	12.18%	13.73%	-1.55
NW	11.85%	11.80%	0.05
NNW	7.14%	6.13%	1.02
Calms	8.31%	8.50%	-0.19

*Where 'diff' is the difference in percentage points (pp) calculated between the long- and short-term relative frequencies. The actual numbers used for the percent point calculations include greater than three significant figures. Therefore, the calculated difference as shown in this table may vary slightly due to rounding.

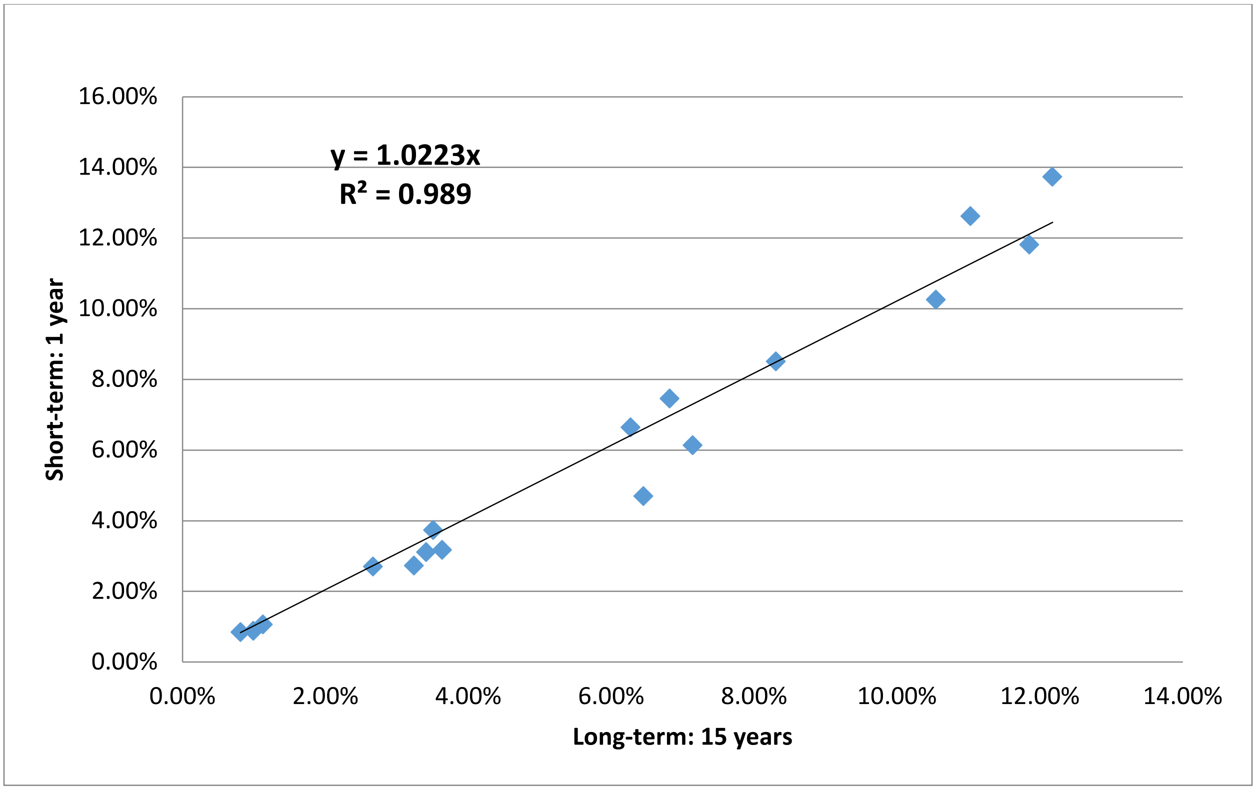

Figure 11. Wind Direction Relative Frequency Distribution: Scottsbluff 1 year vs. 15 years

1.2. SCOTTSBLUFF WIND SPEED RELATIVE FREQUENCY DISTRIBUTION

Table 7 contains the Scottsbluff wind speed relative frequency distribution data used to create the wind speed frequency regression in Figure 12.

Table 7. Scottsbluff Wind Speed Relative Frequency Distribution

Speed (mph)	15 years (X-axis)	1 year (Y-Axis)	Diff* 1 year vs. 15 years (pp)
1–3	6.99%	7.21%	-0.21
4–7	28.97%	28.67%	0.30
8–12	29.13%	28.20%	0.93
13–18	18.48%	20.73%	-2.25
19–24	5.35%	4.63%	0.72
>24	2.78%	2.07%	0.71
Calms	8.31%	8.50%	-0.19

*Where 'diff' is the difference in percentage points (pp) calculated between the long- and short-term relative frequencies. The actual numbers used for the percent point calculations include greater than three significant figures. Therefore, the calculated difference as shown in this table may vary slightly due to rounding.

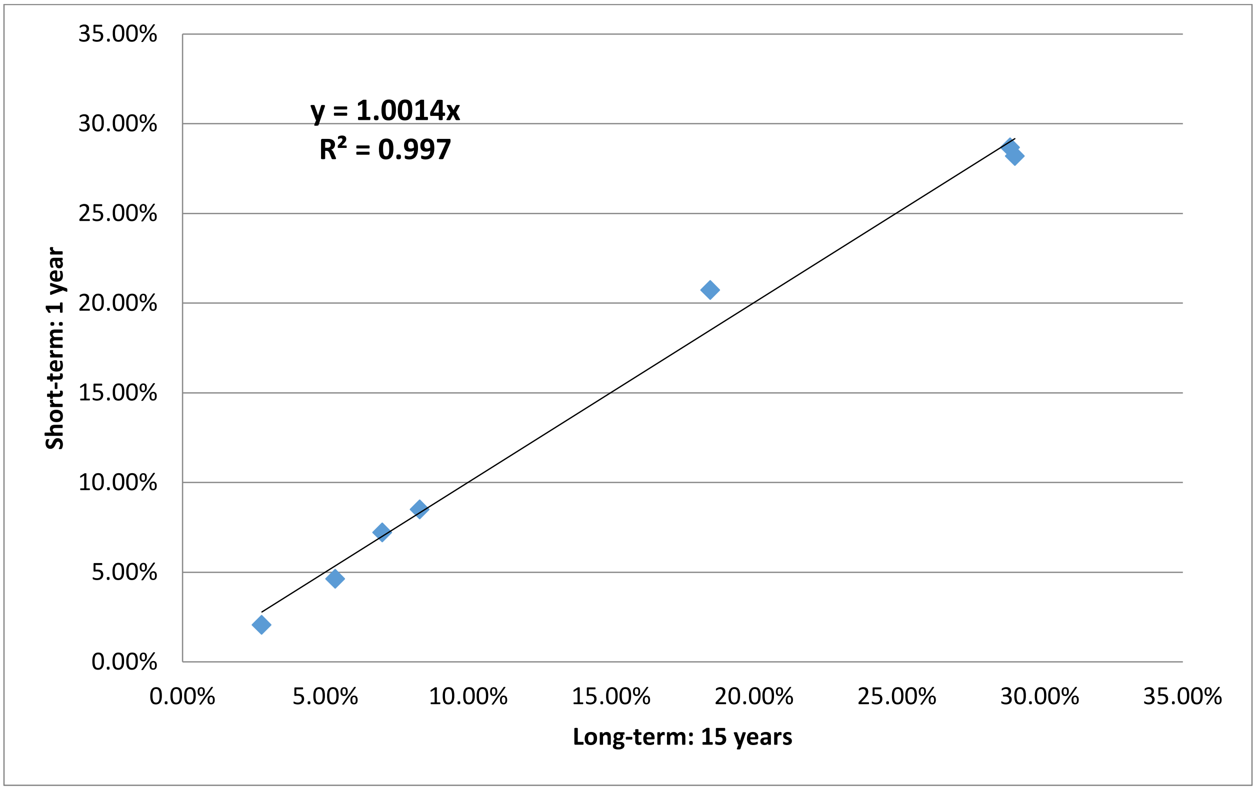

Figure 12. Wind Speed Relative Frequency Distribution: Scottsbluff 1 year vs. 15 years

1.3. ALL STABILITY CLASSES WIND DIRECTION AND WIND SPEED JOINT FREQUENCY DISTRIBUTION FOR SCOTTSBLUFF AIRPORT

Table 8 contains the Scottsbluff wind direction and wind speed joint frequency distributions (JFDs) data used to create the wind direction and wind speed JFD regression for all classes in Figure 13.

Table 8. Scottsbluff Wind Direction and Wind Speed Joint Frequency Distributions for All Stability Classes Summed

Class*	Speed (mph)	Direction	15 years (X-axis)	1 year (Y-axis)	Diff** 1 year vs. 15 years (pp)
A–F	1–3	N	1.40%	1.25%	0.15
A–F	1–3	NNE	0.73%	0.69%	0.04
A–F	1–3	NE	0.77%	0.75%	0.03
A–F	1–3	ENE	0.91%	0.82%	0.09
A–F	1–3	E	2.23%	2.02%	0.20
A–F	1–3	ESE	1.40%	1.49%	-0.10
A–F	1–3	SE	0.81%	0.95%	-0.14
A–F	1–3	SSE	0.54%	0.72%	-0.18
A–F	1–3	S	0.63%	0.66%	-0.03
A–F	1–3	SSW	0.30%	0.23%	0.07

Table 8. Scottsbluff Wind Direction and Wind Speed Joint Frequency Distributions for All Stability Classes Summed

Class*	Speed (mph)	Direction	15 years (X-axis)	1 year (Y-axis)	Diff** 1 year vs. 15 years (pp)
A–F	1–3	SW	0.24%	0.26%	-0.02
A–F	1–3	WSW	0.31%	0.32%	-0.01
A–F	1–3	W	1.03%	1.27%	-0.24
A–F	1–3	WNW	1.43%	1.51%	-0.08
A–F	1–3	NW	1.77%	1.64%	0.13
A–F	1–3	NNW	1.38%	1.03%	0.35
A–F	4–7	N	2.05%	1.73%	0.32
A–F	4–7	NNE	1.09%	1.11%	-0.02
A–F	4–7	NE	1.09%	0.99%	0.10
A–F	4–7	ENE	1.43%	1.15%	0.28
A–F	4–7	E	4.60%	4.37%	0.22
A–F	4–7	ESE	2.85%	3.15%	-0.30
A–F	4–7	SE	1.50%	1.67%	-0.17
A–F	4–7	SSE	0.96%	1.30%	-0.34
A–F	4–7	S	0.94%	1.04%	-0.10
A–F	4–7	SSW	0.44%	0.37%	0.07
A–F	4–7	SW	0.33%	0.32%	0.02
A–F	4–7	WSW	0.38%	0.35%	0.03
A–F	4–7	W	1.76%	1.70%	0.05
A–F	4–7	WNW	3.02%	3.53%	-0.51
A–F	4–7	NW	3.63%	3.95%	-0.32
A–F	4–7	NNW	2.31%	1.92%	0.39
A–F	8–12	N	1.48%	1.00%	0.48
A–F	8–12	NNE	1.00%	0.96%	0.04
A–F	8–12	NE	0.88%	0.68%	0.20
A–F	8–12	ENE	1.13%	0.73%	0.40
A–F	8–12	E	4.07%	3.89%	0.18
A–F	8–12	ESE	4.64%	5.34%	-0.70
A–F	8–12	SE	2.30%	2.51%	-0.21
A–F	8–12	SSE	1.04%	0.94%	0.10
A–F	8–12	S	0.72%	0.77%	-0.05
A–F	8–12	SSW	0.33%	0.35%	-0.02
A–F	8–12	SW	0.19%	0.27%	-0.08
A–F	8–12	WSW	0.25%	0.20%	0.05
A–F	8–12	W	1.91%	2.21%	-0.30
A–F	8–12	WNW	4.09%	3.91%	0.18
A–F	8–12	NW	3.61%	3.33%	0.28
A–F	8–12	NNW	1.52%	1.17%	0.35
A–F	13–18	N	1.17%	0.81%	0.36
A–F	13–18	NNE	0.68%	0.54%	0.14
A–F	13–18	NE	0.66%	0.58%	0.08
A–F	13–18	ENE	0.54%	0.72%	-0.18
A–F	13–18	E	0.96%	1.13%	-0.17
A–F	13–18	ESE	2.63%	3.38%	-0.75

Table 8. Scottsbluff Wind Direction and Wind Speed Joint Frequency Distributions for All Stability Classes Summed					
Class*	Speed (mph)	Direction	15 years (X-axis)	1 year (Y-axis)	Diff** 1 year vs. 15 years (pp)
A–F	13–18	SE	1.78%	1.88%	-0.11
A–F	13–18	SSE	1.03%	0.94%	0.09
A–F	13–18	S	0.58%	0.45%	0.13
A–F	13-18	SSW	0.18%	0.20%	-0.02
A–F	13–18	SW	0.14%	0.10%	0.04
A–F	13–18	WSW	0.15%	0.11%	0.04
A–F	13–18	W	1.56%	1.93%	-0.37
A–F	13–18	WNW	3.02%	4.09%	-1.08
A–F	13–18	NW	2.07%	2.45%	-0.38
A–F	13–18	NNW	1.36%	1.48%	-0.11
A–F	19–24	N	0.38%	0.10%	0.28
A–F	19–24	NNE	0.21%	0.14%	0.07
A–F	19–24	NE	0.18%	0.07%	0.11
A–F	19–24	ENE	0.09%	0.12%	-0.03
A–F	19–24	E	0.06%	0.11%	-0.05
A–F	19–24	ESE	0.31%	0.19%	0.12
A–F	19–24	SE	0.30%	0.12%	0.18
A–F	19–24	SSE	0.21%	0.26%	-0.05
A–F	19–24	S	0.10%	0.12%	-0.03
A–F	19–24	SSW	0.03%	0.02%	0.01
A–F	19–24	SW	0.02%	0.03%	-0.01
A–F	19–24	WSW	0.04%	0.02%	0.02
A–F	19–24	W	0.71%	0.52%	0.19
A–F	19–24	WNW	0.96%	1.07%	-0.11
A–F	19–24	NW	0.94%	0.97%	-0.03
A–F	19–24	NNW	0.80%	0.77%	0.04
A–F	>24	N	0.12%	0.00%	0.12
A–F	>24	NNE	0.08%	0.02%	0.06
A–F	>24	NE	0.05%	0.05%	0.00
A–F	>24	ENE	0.02%	0.02%	-0.01
A–F	>24	E	0.02%	0.02%	0.00
A–F	>24	ESE	0.05%	0.00%	0.05
A–F	>24	SE	0.04%	0.01%	0.03
A–F	>24	SSE	0.04%	0.02%	0.01
A–F	>24	S	0.02%	0.01%	0.01
A–F	>24	SSW	0.00%	0.00%	0.00
A–F	>24	SW	0.00%	0.00%	0.00
A–F	>24	WSW	0.01%	0.01%	-0.01
A–F	>24	W	0.41%	0.44%	-0.03
A–F	>24	WNW	0.52%	0.56%	-0.04
A–F	>24	NW	0.89%	0.56%	0.32
A–F	>24	NNW	0.52%	0.34%	0.18

* The stability classes A–F were summed for each wind speed and wind direction. Calms were distributed by the STAR program within each stability class as described in Section 2.2.3 of the TBD.

** Where 'diff' is the difference in percentage points (pp) calculated between the long- and short-term relative frequencies. The actual numbers used for the percent point calculations include greater than three significant figures. Therefore, the calculated difference as shown in this table may vary slightly due to rounding.

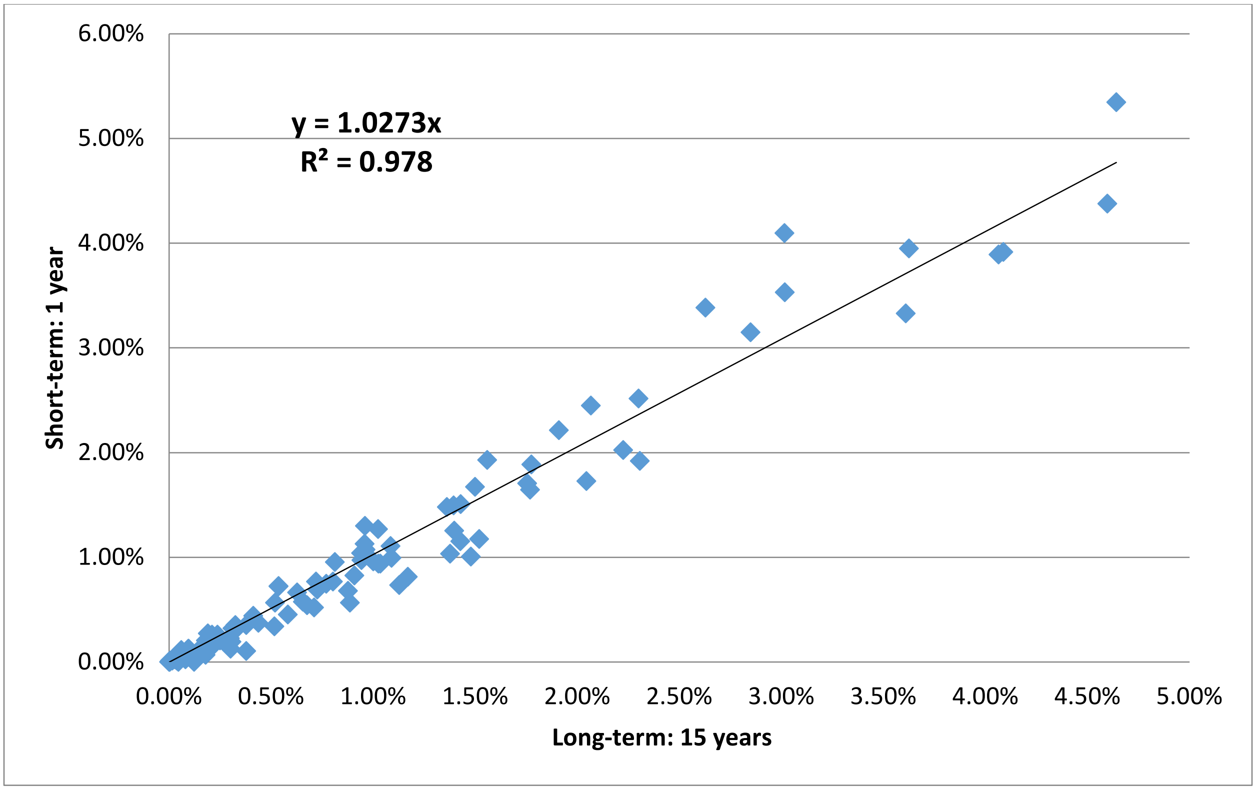

Figure 13. Wind Direction and Wind Speed Joint Frequency Distribution for All Classes: Scottsbluff 1 year vs. 15 years

2. INTRA-SITE COMPARISON: GILLETTE 1 YEAR VS. 15 YEARS

2.1. GILLETTE WIND DIRECTION RELATIVE FREQUENCY DISTRIBUTION

Table 9 contains the Gillette wind direction relative frequency distribution data used to create the wind direction frequency regression in Figure 14.

Table 9. Gillette Wind Direction Relative Frequency Distribution

Direction	15 year (X-axis)	1 year (Y-axis)	Diff* 1 year vs. 15 years (pp)
N	7.92%	6.72%	1.20
NNE	2.66%	2.37%	0.29
NE	1.78%	2.06%	-0.28

Table 9. Gillette Wind Direction Relative Frequency Distribution			
Direction	**15 year (X-axis)**	**1 year (Y-axis)**	**Diff* 1 year vs. 15 years (pp)**
ENE	1.29%	1.47%	-0.18
E	2.05%	1.71%	0.34
ESE	2.13%	1.49%	0.65
SE	4.22%	2.99%	1.23
SSE	7.68%	8.73%	-1.05
S	13.08%	12.75%	0.33
SSW	5.11%	5.12%	-0.01
SW	8.60%	8.37%	0.23
WSW	5.62%	4.86%	0.76
W	7.83%	8.47%	-0.64
WNW	5.66%	6.35%	-0.68
NW	8.23%	8.08%	0.15
NNW	7.55%	6.98%	0.58
Calms	8.59%	11.49%	-2.89

* Where 'diff' is the difference calculated in percentage points (pp) between the long- and short-term relative frequencies. The actual numbers used for the percent point calculations include greater than three significant figures. Therefore, the calculated difference as shown in this table may vary slightly due to rounding.

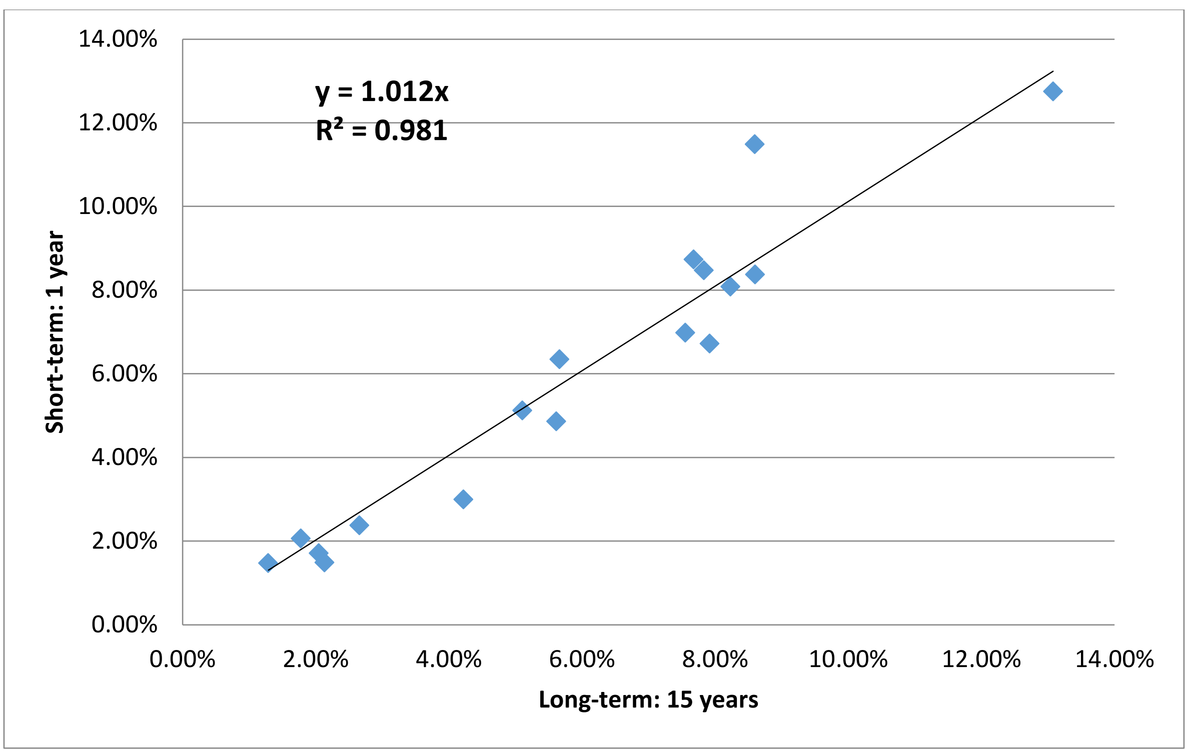

Figure 14. Wind Direction Relative Frequency Distribution: Gillette 1 year vs. 15 years

2.2. Gillette Wind Speed Relative Frequency Distribution

Table 10 contains the Gillette wind speed relative frequency distribution data used to create the wind direction frequency regression in Figure 15.

Table 10. Gillette Wind Speed Relative Frequency Distribution			
Speed (mph)	**15 years (X-axis)**	**1 year (Y-axis)**	**Diff* 1 year vs. 15 years (pp)**
1–3	7.21%	5.99%	1.22
4–7	26.15%	25.90%	0.25
8–12	30.86%	30.02%	0.85
13–18	19.75%	18.58%	1.16
19–24	5.93%	6.34%	-0.41
>24	1.50%	1.69%	-0.19
Calms	8.59%	11.48%	-2.88

* Where 'diff' is the difference in percentage points (pp) calculated between the long- and short-term relative frequencies. The actual numbers used for the percent point calculations include greater than three significant figures. Therefore, the calculated difference as shown in this table may vary slightly due to rounding.

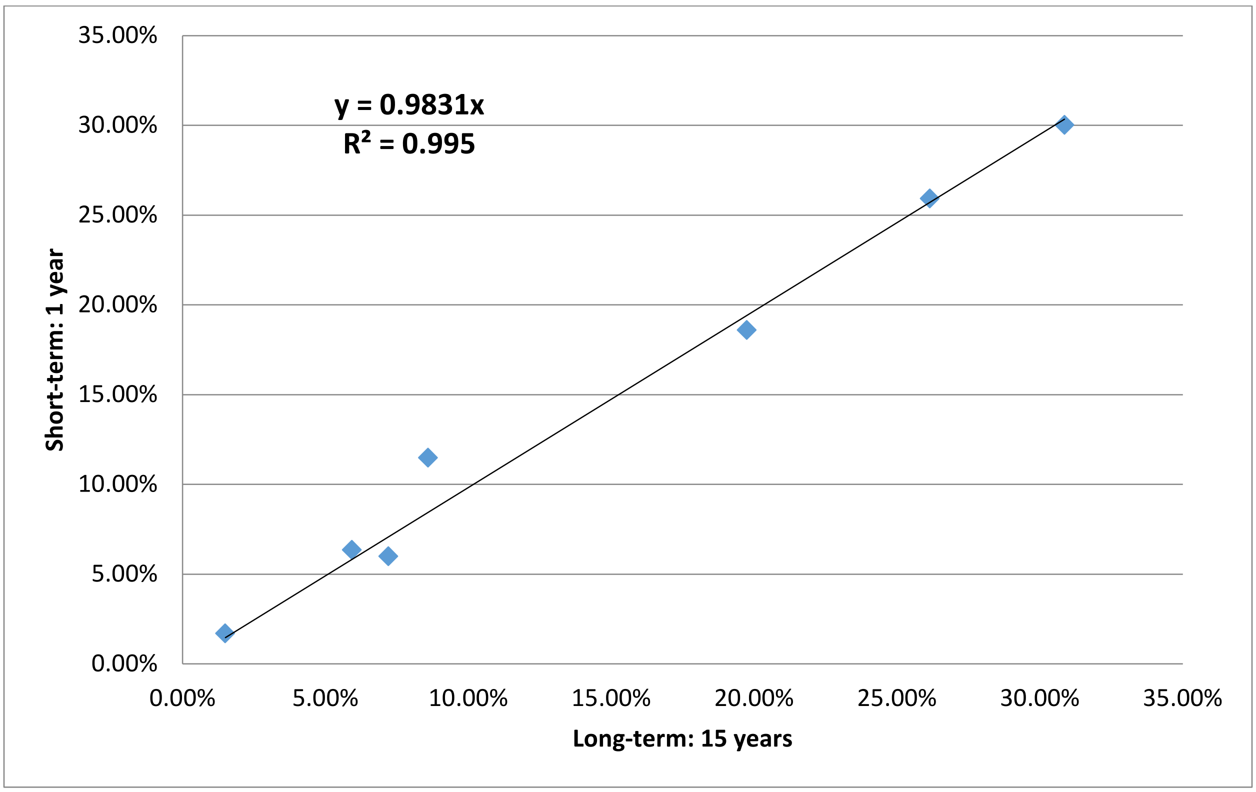

Figure 15. Wind Speed Relative Frequency Distribution: Gillette 1 year vs. 15 years

2.3. All Stability Classes Wind Direction and Wind Speed Joint Frequency Distribution for Gillette Airport

Table 11 contains the Gillette wind direction and wind speed JFDs data used to create the wind direction and wind speed JFD regression for all classes in Figure 16.

Table 11. Gillette Wind Direction and Wind Speed Joint Frequency Distributions for All Stability Classes Summed

Class*	Speed (mph)	Direction	15 years (X-axis)	1 year (Y-axis)	Diff** 1 year vs. 15 years (pp)
A–F	1–3	N	1.14%	0.83%	0.31
A–F	1–3	NNE	0.58%	0.55%	0.03
A–F	1–3	NE	0.52%	0.67%	-0.15
A–F	1–3	ENE	0.46%	0.48%	-0.02
A–F	1–3	E	0.80%	0.68%	0.12
A–F	1–3	ESE	0.65%	0.46%	0.20
A–F	1–3	SE	0.83%	0.90%	-0.07
A–F	1–3	SSE	1.26%	1.40%	-0.14
A–F	1–3	S	2.65%	3.24%	-0.59
A–F	1–3	SSW	1.37%	1.81%	-0.44
A–F	1–3	SW	1.23%	1.51%	-0.28
A–F	1–3	WSW	1.02%	1.03%	-0.01
A–F	1–3	W	1.28%	1.48%	-0.20
A–F	1–3	WNW	0.68%	0.66%	0.02
A–F	1–3	NW	0.74%	0.72%	0.02
A–F	1–3	NNW	0.83%	1.13%	-0.30
A–F	4–7	N	1.71%	1.44%	0.27
A–F	4–7	NNE	0.75%	0.76%	-0.01
A–F	4–7	NE	0.63%	0.87%	-0.24
A–F	4–7	ENE	0.55%	0.54%	0.01
A–F	4–7	E	0.88%	0.89%	-0.01
A–F	4–7	ESE	0.75%	0.79%	-0.04
A–F	4–7	SE	0.95%	0.83%	0.12
A–F	4–7	SSE	1.47%	1.75%	-0.28
A–F	4–7	S	2.86%	3.10%	-0.24
A–F	4–7	SSW	1.19%	0.96%	0.23
A–F	4–7	SW	1.13%	0.98%	0.15
A–F	4–7	WSW	1.07%	0.96%	0.11
A–F	4–7	W	1.80%	1.67%	0.13

Table 11. Gillette Wind Direction and Wind Speed Joint Frequency Distributions for All Stability Classes Summed

Class*	Speed (mph)	Direction	15 years (X-axis)	1 year (Y-axis)	Diff** 1 year vs. 15 years (pp)
A–F	4–7	WNW	0.97%	1.13%	-0.16
A–F	4–7	NW	1.14%	1.13%	0.00
A–F	4–7	NNW	1.23%	1.20%	0.04
A–F	8–12	N	2.47%	2.28%	0.19
A–F	8–12	NNE	0.93%	0.84%	0.09
A–F	8–12	NE	0.64%	0.78%	-0.13
A–F	8–12	ENE	0.38%	0.56%	-0.18
A–F	8–12	E	0.61%	0.47%	0.14
A–F	8–12	ESE	0.62%	0.36%	0.26
A–F	8–12	SE	1.27%	0.97%	0.30
A–F	8-12	SSE	2.14%	2.46%	-0.32
A–F	8-12	S	3.78%	3.81%	-0.02
A–F	8–12	SSW	1.04%	0.94%	0.10
A–F	8–12	SW	1.79%	1.71%	0.08
A–F	8–12	WSW	1.95%	1.59%	0.36
A–F	8–12	W	3.66%	3.85%	-0.19
A–F	8–12	WNW	2.00%	2.08%	-0.08
A–F	8–12	NW	1.91%	1.80%	0.11
A–F	8–12	NNW	1.94%	1.76%	0.18
A–F	13–18	N	2.09%	1.81%	0.28
A–F	13–18	NNE	0.62%	0.68%	-0.05
A–F	13–18	NE	0.25%	0.23%	0.03
A–F	13–18	ENE	0.13%	0.18%	-0.05
A–F	13–18	E	0.16%	0.09%	0.07
A–F	13–18	ESE	0.32%	0.13%	0.20
A–F	13–18	SE	1.28%	0.65%	0.63
A–F	13–18	SSE	2.38%	2.83%	-0.44
A–F	13–18	S	4.13%	4.25%	-0.13
A–F	13–18	SSW	1.53%	1.54%	-0.02
A–F	13–18	SW	3.06%	2.92%	0.14
A–F	13–18	WSW	1.61%	1.49%	0.12
A–F	13–18	W	1.55%	1.64%	-0.09
A–F	13–18	WNW	1.75%	1.58%	0.17
A–F	13–18	NW	2.70%	2.22%	0.49
A–F	13–18	NNW	2.51%	2.15%	0.36

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Table 11. Gillette Wind Direction and Wind Speed Joint Frequency Distributions for All Stability Classes Summed

Class*	Speed (mph)	Direction	15 years (X-axis)	1 year (Y-axis)	Diff** 1 year vs. 15 years (pp)
A–F	19–24	N	0.43%	0.14%	0.29
A–F	19–24	NNE	0.08%	0.03%	0.06
A–F	19–24	NE	0.03%	0.00%	0.03
A–F	19–24	ENE	0.00%	0.00%	0.00
A–F	19–24	E	0.01%	0.00%	0.01
A–F	19–24	ESE	0.10%	0.04%	0.06
A–F	19–24	SE	0.34%	0.18%	0.16
A–F	19–24	SSE	0.90%	1.15%	-0.25
A–F	19–24	S	1.16%	1.25%	-0.09
A–F	19–24	SSW	0.61%	0.88%	-0.27
A–F	19–24	SW	1.44%	1.80%	-0.36
A–F	19–24	WSW	0.39%	0.39%	-0.01
A–F	19–24	W	0.18%	0.15%	0.03
A–F	19–24	WNW	0.39%	0.60%	-0.21
A–F	19–24	NW	1.31%	1.43%	-0.11
A–F	19–24	NNW	0.96%	0.92%	0.05
A–F	>24	N	0.08%	0.04%	0.04
A–F	>24	NNE	0.01%	0.00%	0.01
A–F	>24	NE	0.00%	0.00%	0.00
A–F	>24	ENE	0.00%	0.00%	0.00
A–F	>24	E	0.00%	0.00%	0.00
A–F	>24	ESE	0.03%	0.01%	0.02
A–F	>24	SE	0.09%	0.09%	0.00
A–F	>24	SSE	0.34%	0.51%	-0.17
A–F	>24	S	0.28%	0.33%	-0.05
A–F	>24	SSW	0.23%	0.43%	-0.20
A–F	>24	SW	0.82%	1.04%	-0.22
A–F	>24	WSW	0.14%	0.09%	0.06
A–F	>24	W	0.05%	0.04%	0.01%
A–F	>24	WNW	0.16%	0.29%	-0.13
A–F	>24	NW	0.71%	0.83%	-0.12
A–F	>24	NNW	0.39%	0.22%	0.18

* The stability classes A–F were summed for each wind speed and wind direction. Calms were distributed by the STAR program within each stability class as described in Section 2.2.3 of the TBD.

**Where 'diff' is the difference in percentage points (pp) calculated between the long- and short-term frequencies. The actual numbers used for the percent point calculations include greater than three significant figures. Therefore, the

calculated difference as shown in this table may vary slightly due to rounding.

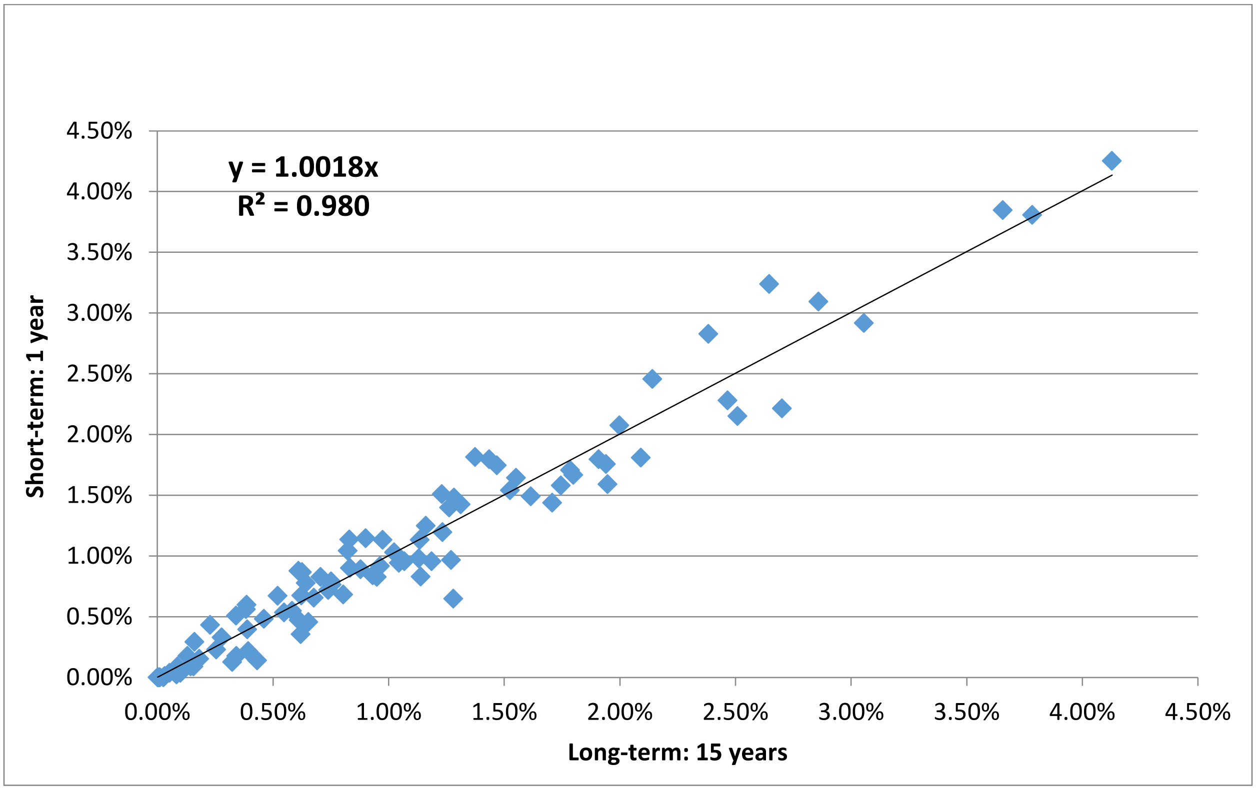

Figure 16. Wind Direction and Wind Speed Joint Frequency Distribution for All Stability Classes Summed: Gillette 1 year vs. 15 years

3. INTER-SITE COMPARISON: SCOTTSBLUFF 1 YEAR VS. GILLETTE 15 YEARS

3.1. SCOTTSBLUFF 1 YEAR VS. GILLETTE 15 YEARS WIND DIRECTION RELATIVE FREQUENCY DISTRIBUTION

Table 12 contains the Scottsbluff and Gillette wind direction relative frequency distribution data used to create the wind direction frequency regression in Figure 17. The reverse comparison of Gillette 1 year versus Scottsbluff 15 years was evaluated; however, the overall results and conclusions were very similar to those of the Scottsbluff 1 year versus Gillette 15 years presented here, thus the reverse comparison results were deemed unnecessary for presentation.

Table 12. Scottsbluff 1 year and Gillette 15 years Wind Direction Relative Frequency Distribution			
Direction	**Gillette 15 years (X-axis)**	**Scottsbluff 1 year (Y-axis)**	**Diff* 1 year vs. 15 years (pp)**
N	7.92%	4.69%	3.23
NNE	2.66%	3.10%	-0.44
NE	1.78%	2.72%	-0.94
ENE	1.29%	3.17%	-1.88
E	2.05%	10.25%	-8.21
ESE	2.13%	12.61%	-10.48
SE	4.22%	6.63%	-2.41
SSE	7.68%	3.73%	3.94
S	13.08%	2.70%	10.38
SSW	5.11%	1.06%	4.05
SW	8.60%	0.84%	7.76
WSW	5.62%	0.88%	4.74
W	7.83%	7.45%	0.38
WNW	5.66%	13.73%	-8.06
NW	8.23%	11.80%	-3.58
NNW	7.55%	6.13%	1.43
Calms	8.59%	8.50%	0.10

*Where 'diff' is the difference calculated in percentage points (pp) between the long- and short-term frequencies. The actual numbers used for the percent point calculations include greater than three significant figures. Therefore, the calculated difference as shown in this table may vary slightly due to rounding.

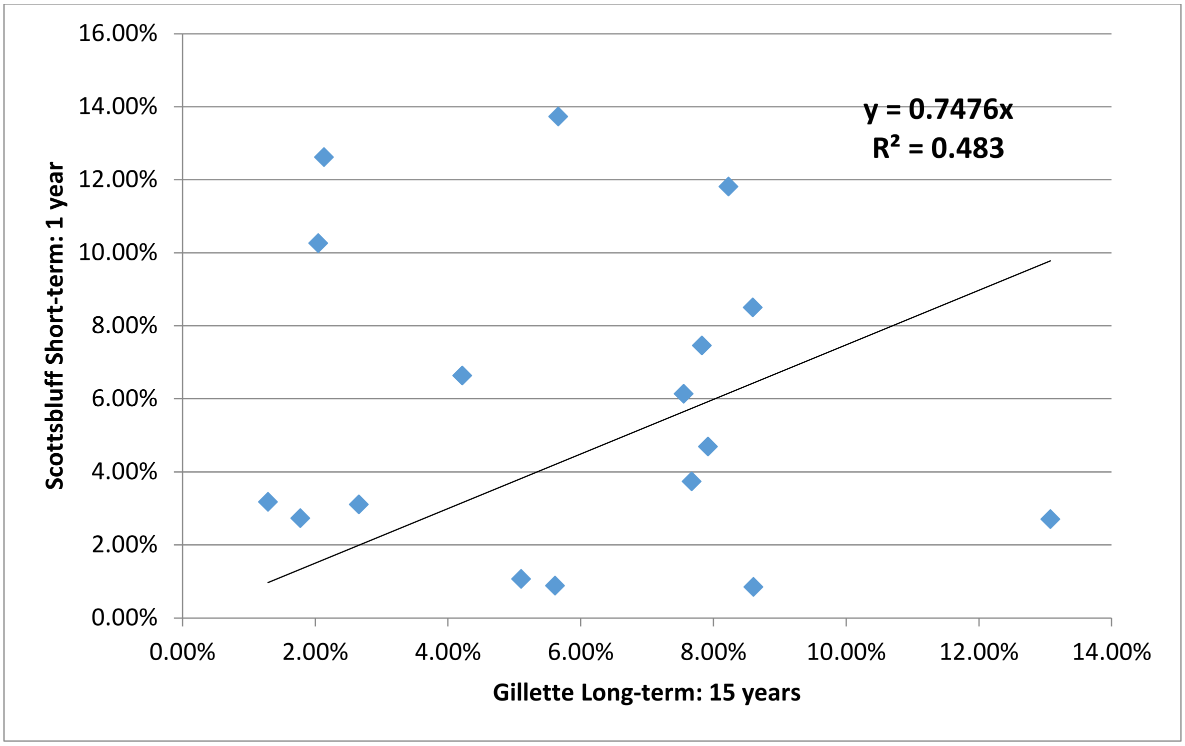

Figure 17. Wind Direction Relative Frequency Distribution: Scottsbluff 1 year vs. Gillette 15 years

3.2. Scottsbluff 1 year vs. Gillette 15 years Wind Speed Relative Frequency Distribution

Table 13 contains the Scottsbluff and Gillette wind speed relative frequency distribution data used to create the wind direction frequency regression in Figure 18.

Table 13. Scottsbluff 1 year and Gillette 15 years Wind Speed Relative Frequency Distribution

Speed (mph)	Gillette 15 years (X-axis)	Scottsbluff 1 year (Y-axis)	Diff* 1 year vs. 15 years (pp)
1–3	7.21%	7.21%	0.01
4–7	26.15%	28.67%	-2.52
8–12	30.86%	28.20%	2.67
13–18	19.75%	20.73%	-0.98
19–24	5.93%	4.63%	1.30
>24	1.50%	2.07%	-0.57
Calms	8.59%	8.50%	0.10

*Where 'diff' is the difference calculated in percentage points (pp) between long- and short-term frequencies. The actual numbers used for the percent point calculations include greater than three significant figures. Therefore, the calculated difference as shown in this table may vary slightly due to rounding.

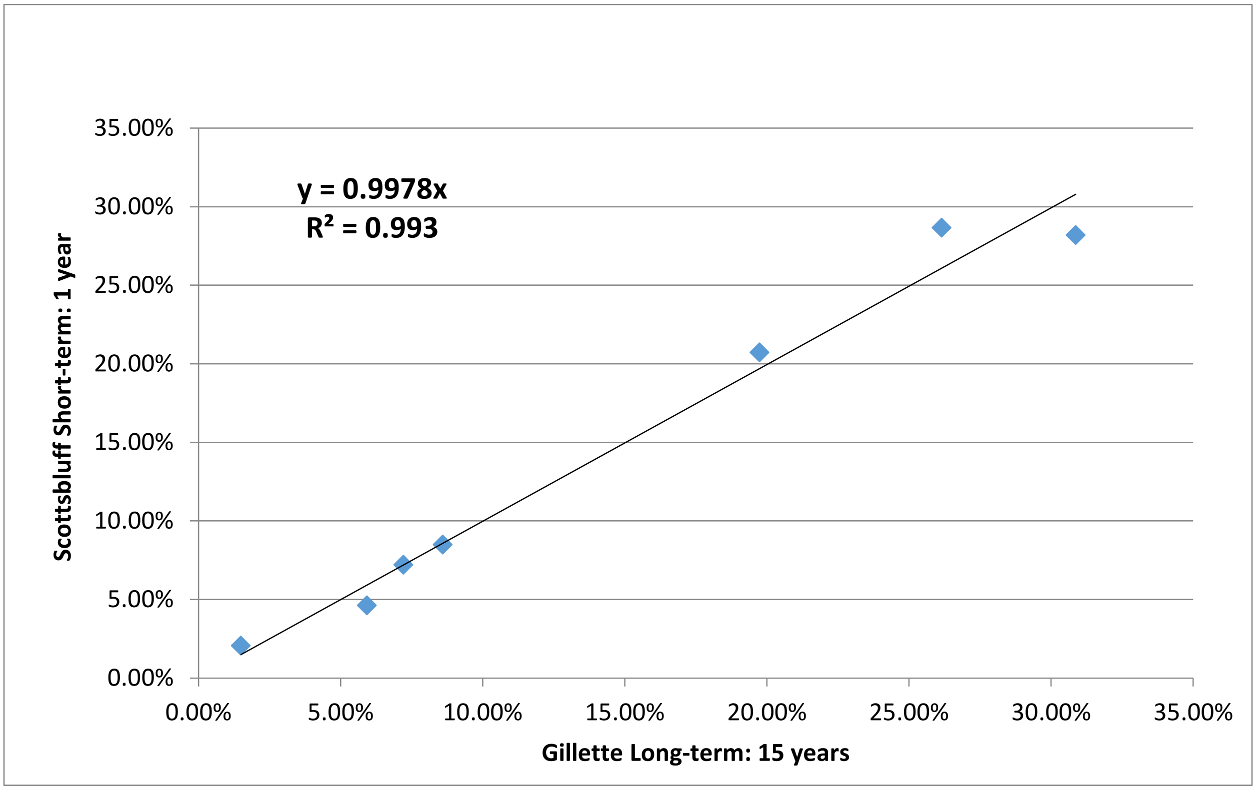

Figure 18. Wind Speed Relative Frequency Distribution: Scottsbluff 1 year vs. Gillette 15 years

3.3. ALL STABILITY CLASSES WIND DIRECTION AND WIND SPEED JOINT FREQUENCY DISTRIBUTION FOR SCOTTSBLUFF AND GILLETTE AIRPORTS

Table 14 contains the Scottsbluff and Gillette wind direction and wind speed joint frequency distributions (JFDs) data used to create the wind direction and wind speed JFD regression for all classes in Figure 17.

Table 14. Scottsbluff 1 year and Gillette 15 years Wind Direction and Wind Speed Joint Frequency Distributions for All Stability Classes Summed

Class*	Speed (mph)	Direction	Gillette 15 years (X-axis)	Scottsbluff 1 year (Y-axis)	Diff** 1 year vs. 15 years (pp)
A–F	**1–3**	**N**	1.14%	1.25%	-0.11
A–F	**1–3**	**NNE**	0.58%	0.69%	-0.11
A–F	**1–3**	**NE**	0.52%	0.75%	-0.22
A–F	**1–3**	**ENE**	0.46%	0.82%	-0.36

Table 14. Scottsbluff 1 year and Gillette 15 years Wind Direction and Wind Speed Joint Frequency Distributions for All Stability Classes Summed					
Class*	**Speed (mph)**	**Direction**	**Gillette 15 years (X-axis)**	**Scottsbluff 1 year (Y-axis)**	**Diff** 1 year vs. 15 years (pp)**
A–F	**1–3**	**E**	0.80%	2.02%	-1.22
A–F	**1–3**	**ESE**	0.65%	1.49%	-0.84
A–F	**1–3**	**SE**	0.83%	0.95%	-0.12
A–F	**1–3**	**SSE**	1.26%	0.72%	0.54
A–F	**1-3**	**S**	2.65%	0.66%	1.98
A–F	**1–3**	**SSW**	1.37%	0.23%	1.15
A–F	**1–3**	**SW**	1.23%	0.26%	0.97
A–F	**1–3**	**WSW**	1.02%	0.32%	0.70
A–F	**1–3**	**W**	1.28%	1.27%	0.02
A–F	**1–3**	**WNW**	0.68%	1.51%	-0.83
A–F	**1–3**	**NW**	0.74%	1.64%	-0.90
A–F	**1–3**	**NNW**	0.83%	1.03%	-0.20
A–F	**4–7**	**N**	1.71%	1.73%	-0.02
A–F	**4–7**	**NNE**	0.75%	1.11%	-0.35
A–F	**4–7**	**NE**	0.63%	0.99%	-0.37
A–F	**4–7**	**ENE**	0.55%	1.15%	-0.60
A–F	**4–7**	**E**	0.88%	4.37%	-3.50
A–F	**4–7**	**ESE**	0.75%	3.15%	-2.39
A–F	**4–7**	**SE**	0.95%	1.67%	-0.72
A–F	**4–7**	**SSE**	1.47%	1.30%	0.17
A–F	**4–7**	**S**	2.86%	1.04%	1.82
A–F	**4–7**	**SSW**	1.19%	0.37%	0.81
A–F	**4–7**	**SW**	1.13%	0.32%	0.81
A–F	**4–7**	**WSW**	1.07%	0.35%	0.72
A–F	**4–7**	**W**	1.80%	1.70%	0.10
A–F	**4–7**	**WNW**	0.97%	3.53%	-2.55
A–F	**4–7**	**NW**	1.14%	3.95%	-2.81
A–F	**4–7**	**NNW**	1.23%	1.92%	-0.68
A–F	**8–12**	**N**	2.47%	1.00%	1.46
A–F	**8–12**	**NNE**	0.93%	0.96%	-0.03
A–F	**8–12**	**NE**	0.64%	0.68%	-0.0
A–F	**8–12**	**ENE**	0.38%	0.73%	-0.35
A–F	**8–12**	**E**	0.61%	3.89%	-3.28
A–F	**8–12**	**ESE**	0.62%	5.34%	-4.72
A–F	**8–12**	**SE**	1.27%	2.51%	-1.24

Table 14. Scottsbluff 1 year and Gillette 15 years Wind Direction and Wind Speed Joint Frequency Distributions for All Stability Classes Summed					
Class*	**Speed (mph)**	**Direction**	**Gillette 15 years (X-axis)**	**Scottsbluff 1 year (Y-axis)**	**Diff** 1 year vs. 15 years (pp)**
A–F	**8–12**	**SSE**	2.14%	0.94%	1.21
A–F	**8–12**	**S**	3.78%	0.77%	3.02
A–F	**8–12**	**SSW**	1.04%	0.35%	0.70
A–F	**8–12**	**SW**	1.79%	0.27%	1.51
A–F	**8–12**	**WSW**	1.95%	0.20%	1.74
A–F	**8–12**	**W**	3.66%	2.21%	1.45
A–F	**8–12**	**WNW**	2.00%	3.91%	-1.91
A–F	**8–12**	**NW**	1.91%	3.33%	-1.42
A–F	**8–12**	**NNW**	1.94%	1.17%	0.77
A–F	**13–18**	**N**	2.09%	0.81%	1.28
A–F	**13–18**	**NNE**	0.62%	0.54%	0.08
A–F	**13–18**	**NE**	0.25%	0.58%	-0.32
A–F	**13–18**	**ENE**	0.13%	0.72%	-0.59
A–F	**13–18**	**E**	0.16%	1.13%	-0.97
A–F	**13–18**	**ESE**	0.32%	3.38%	-3.06
A–F	**13–18**	**SE**	1.28%	1.88%	-0.60
A–F	**13–18**	**SSE**	2.38%	0.94%	1.45
A–F	**13–18**	**S**	4.13%	0.45%	3.68
A–F	**13–18**	**SSW**	1.53%	0.20%	1.32
A–F	**13–18**	**SW**	3.06%	0.10%	2.95
A–F	**13–18**	**WSW**	1.61%	0.11%	1.50
A–F	**13–18**	**W**	1.55%	1.93%	-0.38
A–F	**13–18**	**WNW**	1.75%	4.09%	-2.35
A–F	**13–18**	**NW**	2.70%	2.45%	0.25
A–F	**13-18**	**NNW**	2.51%	1.48%	1.03
A–F	**19–24**	**N**	0.43%	0.10%	0.33
A–F	**19–24**	**NNE**	0.08%	0.14%	-0.05
A–F	**19–24**	**NE**	0.03%	0.07%	-0.04
A–F	**19–-24**	**ENE**	0.00%	0.12%	-0.12
A–F	**19–24**	**E**	0.01%	0.11%	-0.10
A–F	**19–24**	**ESE**	0.10%	0.19%	-0.09
A–F	**19–24**	**SE**	0.34%	0.12%	0.22
A–F	**19–24**	**SSE**	0.90%	0.26%	0.64
A–F	**19–24**	**S**	1.16%	0.12%	1.04
A–F	**19–24**	**SSW**	0.61%	0.02%	0.59

Table 14. Scottsbluff 1 year and Gillette 15 years Wind Direction and Wind Speed Joint Frequency Distributions for All Stability Classes Summed

Class*	Speed (mph)	Direction	Gillette 15 years (X-axis)	Scottsbluff 1 year (Y-axis)	Diff** 1 year vs. 15 years (pp)
A–F	**19–24**	**SW**	1.44%	0.03%	1.40
A–F	**19–24**	**WSW**	0.39%	0.02%	0.37
A–F	**19–24**	**W**	0.18%	0.52%	-0.34
A–F	**19–24**	**WNW**	0.39%	1.07%	-0.68
A–F	**19–24**	**NW**	1.31%	0.97%	0.34
A–F	**19–24**	**NNW**	0.96%	0.77%	0.20
A–F	**>24**	**N**	0.08%	0.00%	0.08
A–F	**>24**	**NNE**	0.01%	0.02%	-0.01
A–F	**>24**	**NE**	0.00%	0.05%	-0.04
A–F	**>24**	**ENE**	0.00%	0.02%	-0.02
A–F	**>24**	**E**	0.00%	0.02%	-0.02
A–F	**>24**	**ESE**	0.03%	0.00%	0.03
A–F	**>24**	**SE**	0.09%	0.01%	0.08
A–F	**>24**	**SSE**	0.34%	0.02%	0.32
A–F	**>24**	**S**	0.28%	0.01%	0.27
A–F	**>24**	**SSW**	0.23%	0.00%	0.23
A–F	**>24**	**SW**	0.82%	0.00%	0.82
A–F	**>24**	**WSW**	0.14%	0.01%	0.13
A–F	**>24**	**W**	0.05%	0.44%	-0.39
A–F	**>24**	**WNW**	0.16%	0.56%	-0.40
A–F	**>24**	**NW**	0.71%	0.56%	0.14
A–F	**>24**	**NNW**	0.39%	0.34%	0.05

* The stability classes A–F were summed for each wind speed and wind direction. Calms were distributed by the STAR program within each stability class as described in Section 2.2.3 of the TBD.

**Where 'diff' is the difference calculated in percentage points (pp) between the long- and short-term frequencies. The actual numbers used for the percent point calculations include greater than three significant figures. Therefore, the calculated difference as shown in this table may vary slightly due to rounding.

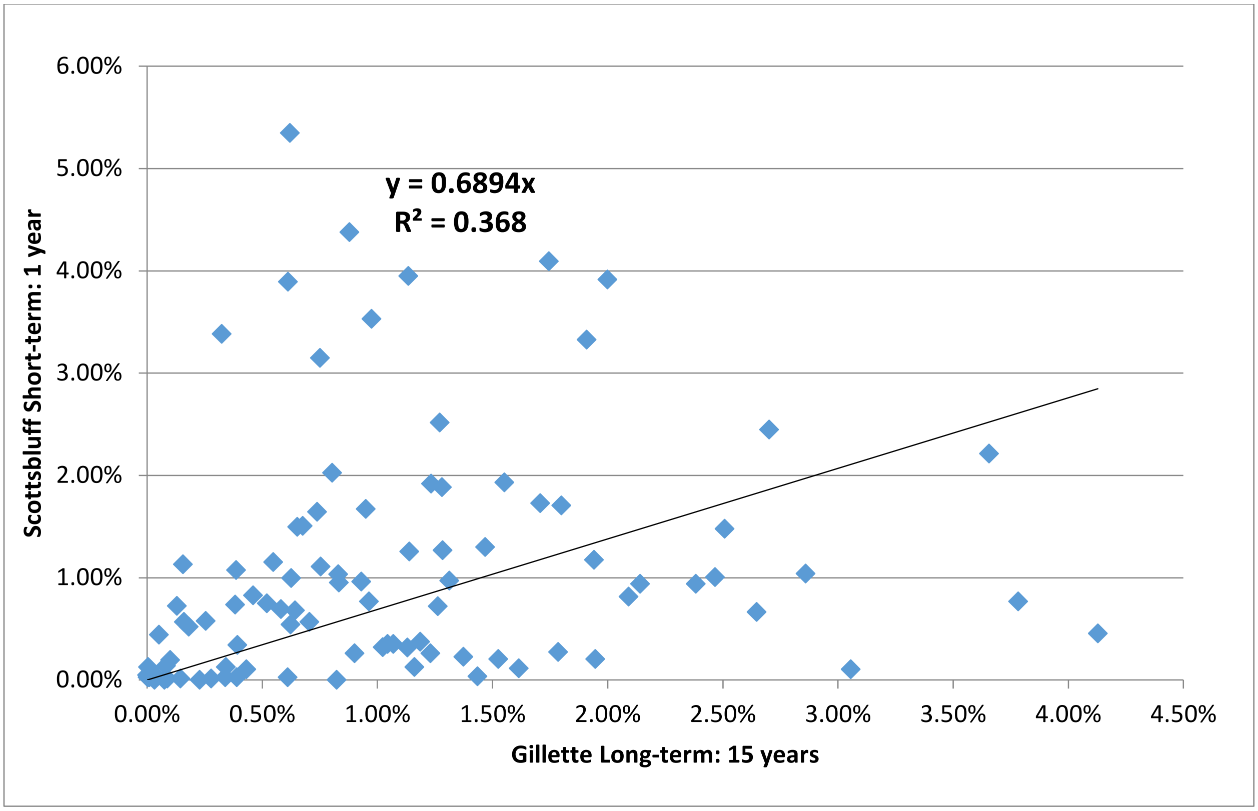

Figure 19: Wind Direction and Wind Speed Joint Frequency Distribution: Scottsbluff 1 year vs. Gillette 15 years

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APPENDIX B
EVALUATION FOR DEMONSTRATING LONG-TERM TEMPORAL REPRESENTATIVENESS OF STABILITY CLASS

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APPENDIX B. EVALUATION FOR DEMONSTRATING LONG-TERM TEMPORAL REPRESENTATIVENESS OF STABILITY CLASS

1. INTRODUCTION

When considering temporal representativeness of meteorological data, wind speed and wind direction are the most common parameters evaluated due to their application in the estimation of effluent dispersion from which dose to the receptor(s) is calculated. Wind speed determines the dilution of an effluent while wind direction establishes the direction of transport. Atmospheric stability class is also a key atmospheric dispersion parameter since it determines the horizontal and vertical diffusion of an effluent. An effluent emitted from a radioactive point or area source at a constant rate (e.g., Ci/s) is initially diluted in proportion to the wind speed at the point or area of emission and subsequently transported downwind at the speed of the wind. As the effluent is carried farther from the source, turbulent mixing (i.e., diffusion) spreads the plume in the horizontal and vertical planes, further reducing the concentration of the radioactive effluent and subsequent dose at a given receptor location. The atmospheric stability class parameterizes the strength of this turbulent diffusion. Accordingly, wind speed and stability class each play a role in reducing the concentration of the effluent as it is transported downwind, while the wind direction determines the direction of transport to receptors.

Diffusion can be typed into six distinct stability classes which embody turbulence, both mechanical and buoyant. Mechanical turbulence arises from the break-up of wind flow when it hits the ground. Buoyant turbulence is generated by heating the ground during the day and suppressed by cooling the ground at night. During windy and cloudy days and nights, mechanical turbulence dominates. During sunny days, any mechanical turbulence is enhanced by buoyancy, while during clear nights the mechanical turbulence is suppressed by ground cooling.

Stability classes are defined as follows:

- A Extremely unstable: daytime with light wind speed and strong incoming solar radiation (insolation)
- B Moderately unstable: daytime with moderate wind speed with strong insolation
- C Slightly unstable: daytime with moderate wind speed with light-to-moderate insolation

- D Neutral: cloudy or windy conditions anytime of the day or night
- E Slightly stable: nighttime with moderate wind speeds
- F Stable: nighttime with light wind speeds, clear sky

The "A" stability class is a condition of strong horizontal and vertical diffusion, while the "F" stability class represents poor dispersion conditions. The "B" through "E" stability classes represent step-wise decreases in dispersion magnitude from the "A" stability class. For more information on stability class determination using the U.S. Environmental Protection Agency's (EPA's) STAR program, refer to Section 2.2.3 of the technical basis document (TBD).

As part of the long-term temporal representativeness demonstration, the applicant/licensee should perform quantitative analyses on the distribution of atmospheric stability classes. The approach, as with wind speed and wind direction, is to establish that the short-term data (i.e., baseline year) from the National Weather Service (NWS) station properly represent the long-term meteorological data, particularly with respect to poor dilution-dispersion conditions (i.e., light-moderate wind speeds with the "E" and "F" stability classes).

This appendix presents the application of the linear regression methodology described in Appendix A for demonstrating temporal representativeness for stability class.

2. METHODS

The entire process for acquiring and preparing data to determine stability class—and then develop joint frequency distributions (JFDs) of wind speed, wind direction, and atmospheric stability class—is described in Section 2 of the TBD and summarized in Appendix C.

2.1 DESCRIPTIVE ANALYSES OF STABILITY CLASS

Although there are 36 mathematical permutations of wind speed and stability class (i.e., six wind speed categories multiplied by six stability classes), not all can physically occur in the atmosphere. The STAR program, which is based on the physical principles of mechanical turbulence with buoyancy enhancement or ground cooling suppression, identifies 21 specific non-zero wind speed-stability class combinations within the JFD which is then used as input to MILDOS-AREA

for calculating doses to individual receptors and population. The other 15 mathematically possible combinations do not occur by definition of the stability classes used by STAR (e.g., "A" and "F" only occur under light wind conditions). Of these 21 dilution-diffusion wind speed-stability class combinations, there are three combinations with poor dilution-diffusion that more greatly influence the MILDOS-AREA dose results: (1) E-stability at 4–7 mph; (2) F-stability at 4–7 mph; and, (3) F-stability at 1–3 mph. The last combination represents the meteorological condition producing the potential highest doses to the public. Thus, these combinations are important to the dose calculations which are used to evaluate compliance with applicable U.S. Nuclear Regulatory Commission (NRC) and EPA regulations and the placement of environmental air monitors.

Table B-1 shows an example of a relative frequency distribution by stability class and wind speed. It is for a 15-year period from Scottsbluff, Nebraska in a region typical of uranium recovery facilities' locations. It reveals 21 possible dispersion combinations. By the definition used by STAR, the very stable and very unstable stability classes (F and A) do not occur when wind speed is strong; hence the zeros for wind speed above 8 mph in these classes in Table B-1. The lower left corner has minimum wind speed (1–3 mph) and very stable (Class F) conditions, which provide minimal initial dilution and minimal diffusion spreading. Moreover, the light winds only slowly remove the released contaminant from the vicinity of the source. This is clearly the least favorable dispersion condition. It typically occurs during clear nights with light wind speeds. Even in characteristically windy regions such as western Nebraska, this condition can occur significantly often (~10% of the time in Table B-1, for example—~25% if the next lowest speed class is included). The highly unstable Class A has the strongest diffusion, but the associated light winds provide limited dilution and transport. Class A is characterized by turbulence that is primarily driven by buoyancy, with minimal mechanical mixing. The most favorable dispersion conditions are under stability Classes C and D in the higher wind speed categories, especially when solar heating is also strong.

Table B-1. Frequency Distribution among Classes of Wind Speed and Atmospheric Stability as a Percentage of the Total Observations Scottsbluff, Nebraska, 1995–2010						
15-year	1–3 (mph)	4–7 (mph)	8–12 (mph)	13–18 (mph)	19–24 (mph)	>24 (mph)
A	0.83%	0.45%	NA	NA	NA	NA
B	2.36%	2.75%	1.69%	NA	NA	NA
C	0.82%	2.99%	5.87%	1.50%	0.22%	0.08%
D	1.99%	4.70%	9.43%	17.01%	5.13%	2.70%
E	NA	2.09%	12.17%	NA	NA	NA
F	9.87%	15.39%	NA	NA	NA	NA

2.2 Statistical Analyses of Atmospheric Stability

When analyzing atmospheric stability classes for temporal representativeness, the combined frequency distribution of wind speed and wind direction (from all stability classes) and the JFD within each individual stability class are important to evaluate. This way, wind speed, wind direction, and atmospheric stability class are simultaneously considered and the JFD should capture any departures from representativeness in either wind speed or direction.

Appendix A of this TBD described and evaluated the appropriateness of several statistical methods for demonstrating temporal representativeness of wind speed and wind direction. The conclusion of that evaluation was that the linear regression method, when properly applied, is a robust and valid method for demonstrating temporal representativeness for wind speed and wind direction. In that evaluation, the joint frequencies for the 16 wind directions with the appropriate wind speed and atmospheric stability class combinations were compared between the short- and long-term datasets. While the other statistical methods evaluated in Appendix A could also be used to assess the JFD (where the sample size could be as large as 96 for some stability classes), the issue of sensitivity to large sample size was encountered, such that the detection of minuscule differences led to the rejection of the null hypothesis even when the distributions were very similar. Thus, the linear regression methodology was used to provide an efficient method for evaluating the temporal representativeness of the joint frequency distribution of wind speed and wind direction for each

stability class, which would be difficult for the other methods evaluated to assess given their limitations.

In this appendix, the linear regression method is utilized to evaluate temporal representativeness by stability class for two locations: Scottsbluff, Nebraska and Gillette, Wyoming. The short-term dataset from Scottsbluff is also compared against the long-term dataset from Gillette as an inter-site comparison for which temporal representativeness would not be expected. Results of the linear regression analyses are interpreted such that if the short-term data are representative of the long-term data, a high value of R^2 and slope of approximately 1 is expected. Lower values of R^2 and deviation from the slope of 1 are indications of dissimilar distributions, or lack of temporal representativeness.

3. RESULTS

For each intra-site evaluation and the inter-site evaluation, the linear regression results (R^2 values and slope) are presented for each of the following comparisons of the short-term to long-term data:

- The relative frequency distribution of wind speed
- The relative frequency distribution of wind direction
- The joint frequency distribution of wind speed and wind direction for all stability classes
- The joint frequency distributions of wind speed and wind direction for each stability class (A–F)

3.1 SCOTTSBLUFF

Table B-2 provides the frequency of occurrence of each stability class for the one-year and 15-year datasets, as well as the difference between the two datasets, at Scottsbluff. Class D was the most frequent stability class observed, while Class A was the least frequent for both datasets. There were minimal differences in the frequency of occurrence of each stability class between the short and long-term data. The greatest difference occurred for Class E, where the frequency went up one percentage point (pp) between the long- and short-term datasets.

Table B-2. Frequency of Stability Classes: Scottsbluff			
Class	**15 years**	**1 year**	**Diff* 1 year vs. 15 years (pp)**
A	1.28%	1.33%	-0.05
B	6.80%	7.44%	-0.64
C	11.46%	11.18%	0.28
D	40.96%	41.40%	-0.44
E	14.26%	13.26%	1.00
F	25.26%	25.40%	-0.14

*Where 'diff' is the difference in percentage points calculated between the long- and short-term frequencies. The actual numbers used for the percent point calculations include greater than three significant figures. Therefore, the calculated difference as shown in this table may vary slightly due to rounding.

The linear regression results for the temporal representativeness of the short-term (1 year) vs. long-term (15 years) data from Scottsbluff are presented in Table B-3. The regression plots for each comparison in Table B-3 are available in the Attachment of this appendix, Figures 2, 4, and 5–11. Likewise, the data used to generate those regression plots are included in Tables 1–9 in the Attachment.

Per the analysis approach described in Appendix A, the high R^2 values for wind speed and direction individually, as well as the combined frequency distribution of speed and direction for all classes, are evidence to suggest that the short-term dataset was temporally representative of the long-term data at Scottsbluff. The conclusion of representativeness is also supported by the qualitative comparison depicted in Figures 1 and 2 of the Attachment of this appendix. The regression results for the joint frequency distributions for each stability class are also indicative of representativeness, except for Class A where the R^2 value is quite low compared to the other classes. The low value represents the large variance (i.e., vertical distance between the points and the regression line) observed in Figure 6 of the Attachment, indicating poorer agreement between the short- and long-term datasets for the Class A condition. Even so, this lack of agreement does not appear to impact the R^2 value for the JFD for all classes combined, likely due to the fact that Class A conditions occurred with very low frequency.

Table B-3. Linear Regression Results for Intra-site Comparisons: Scottsbluff 1 year vs. 15 years		
Comparison	**R^2 value**	**Slope**
Relative Frequency Distribution - Speed	0.997	1.001
Relative Frequency Distribution - Direction	0.989	1.022
Joint Frequency Distribution - All classes	0.978	1.027
Joint Frequency Distribution - Class A	0.754	1.008
Joint Frequency Distribution - Class B	0.943	1.116
Joint Frequency Distribution - Class C	0.962	0.953
Joint Frequency Distribution - Class D	0.960	1.127
Joint Frequency Distribution - Class E	0.960	0.963
Joint Frequency Distribution - Class F	0.976	1.008

3.2 GILLETTE

Table B-4 below provides the frequency of occurrence of each stability class for the one-year and 15-year datasets, as well as the difference between the two datasets, at Gillette. Similar to the data from Scottsbluff, Class D was the most frequent stability class observed, while Class A was the least frequent. There were notable differences in the frequency of occurrence of each stability class between the short- and long-term data, where the greatest difference occurred for Class D at -7.58 pp and notable differences for Classes E and F.

Table B-4. Frequency of Stability Classes: Gillette			
Class	**15 years (long-term)**	**1 year (short-term)**	***Diff 1 year vs. 15 years (pp)**
A	1.10%	1.48%	-0.38
B	6.38%	6.91%	-0.53
C	11.33%	11.02%	0.31
D	50.73%	58.31%	-7.58
E	11.48%	8.41%	3.07
F	19.00%	13.90%	5.11

*Where 'diff' is the difference calculated between the long- and short-term frequencies in percentage points (pp).

The linear regression results for the temporal representativeness of the short-term (1 year) vs. long-term (15 years) data from Gillette are presented in Table B-5. The regression plots for each comparison in Table B-5 are available in the Attachment of this appendix, Figures 13, 15–22.

Likewise, the data used to generate those regression plots are included in Tables 10–18 in the Attachment.

The regression results for the individual speed and direction distributions, as well as the JFD over all classes would seem to indicate very high agreement between the short- and long-term datasets. However, the results from the analyses by each stability class suggest a different conclusion. The R^2 values for the linear regressions of Classes A, B, E, and F are lower than 0.90, which could correspond to dissimilar distributions. For Class E, the extremely low R^2 value of 0.261 and slope of 0.305 signify a very weak agreement between the short- and long-term data at Gillette. This is especially of concern as the more stable conditions, primarily Class E and Class F, are disproportionately important for estimating potential dose. The safety impact of the observed dissimilarity would require further assessment, such as using MILDOS-AREA to compare the estimated doses using the short-term data versus the long-term data.

Table B-5. Linear Regression Results for Intra-site Comparisons: Gillette 1 year vs. 15 years

Comparison	R^2 value	Slope
Relative Frequency Distribution - Speed	0.995	0.983
Relative Frequency Distribution - Direction	0.981	1.012
Joint Frequency Distribution - All classes	0.980	1.002
Joint Frequency Distribution - Class A	0.661	1.250
Joint Frequency Distribution - Class B	0.886	1.032
Joint Frequency Distribution - Class C	0.956	0.975
Joint Frequency Distribution - Class D	0.905	1.054
Joint Frequency Distribution - Class E	0.261	0.305
Joint Frequency Distribution - Class F	0.801	0.856

3.3 Inter-Site Comparison

Table B-6 below provides the frequency of occurrence of each stability class for the Scottsbluff one-year and Gillette 15-year datasets, as well as the difference between the two datasets for each class. Again, Class D was the most frequent stability class observed, while Class A was the least frequent. There were prominent differences in the frequency of occurrence between the short- and

long-term data for Classes D and F; however, other classes were relatively similar in the frequency of occurrence.

Table B-6. Frequency of Stability Classes: Scottsbluff 1 year vs. Gillette 15 years			
Class	**Gillette 15 years (long-term)**	**Scottsbluff 1 year (short-term)**	***Diff 1 year vs. 15 years (pp)**
A	1.10%	1.33%	-0.23
B	6.38%	7.44%	-1.07
C	11.33%	11.18%	0.16
D	50.73%	41.40%	9.32
E	11.48%	13.26%	-1.78
F	19.00%	25.40%	-6.40

*Where 'diff' is the difference calculated between the long- and short-term frequencies in percentage points (pp).

The linear regression results for the temporal representativeness of the Scottsbluff short-term (1 year) vs. Gillette long-term (15 years) data are presented in Table B-7. The regression plots for each comparison are available in the Attachment of this appendix, Figures 24, 26–33. Likewise, the data used to generate those regression plots are included in Tables 19–27 in the Attachment.

As would be expected for two different sites, the R^2 values for all the linear regressions are considerably lower than 0.90, which correspond to dissimilar distributions between the short- and long-term data of the inter-site comparison. The only exception is the regression for the relative frequency distribution for wind speed, where there is high agreement. Regionally, the high plains in Nebraska and Wyoming have windy conditions which is the result of large-scale (i.e., synoptic) weather patterns. Thus, locations separated by even hundreds of miles should show good wind speed correlations. However, wind direction can be influenced more by topographic effects (e.g., mountain-valley orientation) and correlation of sites with different orientations, such as Gillette, Wyoming and Scottsbluff, Nebraska, should not be as good. Smaller-scale local topography may also have a marked effect on stability class.

The greatest variance or dissimilarity, as evidenced by the lowest R^2 values, in the inter-site comparison is for the two most stable classes: E and F. While the MILDOS-AREA analyses would provide the quantitative impact, it is expected that such lack of representativeness would result in different estimates of dose such that the placement of air monitors and the potential safety implications would be affected. Since this would be the expected outcome for comparing the long-

and short-term data from two different sites, these results validate the use of regression and interpretation of the R^2 value, along with attention to slope and the qualitative comparisons (bar charts, wind roses, etc.) for assessment of lack of representativeness.

Table B-7. Linear Regression Results for Inter-site Comparisons: Scottsbluff 1 year vs. Gillette 15 years

Comparison	R^2 value	Slope
Relative Frequency Distribution - Speed	0.993	0.998
Relative Frequency Distribution - Direction	0.483	0.748
Joint Frequency Distribution - All classes	0.368	0.689
Joint Frequency Distribution - Class A	0.694	1.132
Joint Frequency Distribution - Class B	0.674	1.068
Joint Frequency Distribution - Class C	0.540	0.805
Joint Frequency Distribution - Class D	0.333	0.506
Joint Frequency Distribution - Class E	0.115	0.404
Joint Frequency Distribution - Class F	0.183	0.596

4. CONCLUSIONS

This appendix evaluated the appropriateness of demonstrating temporal representativeness for stability class using the linear regression technique for intra-site comparisons at Scottsbluff and Gillette airports. While the results for linear regressions for wind speed, wind direction, and the joint frequency distribution of wind speed and wind direction for all stability classes produced relatively high R^2 values at both sites, further in-depth examination of each stability class revealed much lower R^2 values for several of the stability classes, particularly at Gillette. Based on the results of the evaluation of the linear regression method for demonstrating temporal representativeness in Appendix A, R^2 ≥0.95 corresponded to highly similar distributions. Generally, R^2 ≥0.90 (correlation of R=0.95) are considered evidence for a strong relationship. However, R^2 values that are lower, particularly for the more stable conditions (i.e., E and F stability classes), may be an indication of important departures from temporal representativeness. Classes E and F are associated with weaker diffusion potentially increasing significantly the calculated dose, especially at the

receptors closer to the source. The impact of those differences would therefore merit further evaluation for practical importance to safety.

The results of this appendix for the Gillette site highlight the risk of analyses that consider the individual distributions of wind speed and direction, as well as the JFD summed over all stability classes. The interpretation of those results, along with qualitative data (bar charts, wind roses, etc.), may have led to the conclusion that the short-term data were temporally representative of the long-term data. However, analyzing the JFDs for Classes E and F revealed significant departures from agreement between the short- and long-term data, calling into question whether temporal representativeness exists. The validity of using linear regression to also show the absence of temporal representativeness was evaluated by comparing two spatially distinct sites that were not expected to be temporally representative (i.e., Gillette, Wyoming and Scottsbluff, Nebraska). The regression results produced very low R^2 values, thus providing the supporting evidence that temporal representativeness did not exist for the inter-site comparison.

Based on the results of this evaluation, it can be concluded that stability class is an important meteorological parameter that should be evaluated through the JFDs of wind speed and direction for temporal representativeness. Analyses of wind speed and direction that do not account for stability class may overlook important differences in atmospheric conditions that can impact safety. Poor dilution/dispersion conditions, such as Classes E and F, are important since they highly influence the dose calculations (e.g., using MILDOS-AREA) which are used to evaluate compliance with applicable NRC and EPA regulations and the placement of environmental air monitors. Thus, it is recommended that analyses for demonstrating temporal representativeness focus on the overall JFD of speed and direction for all stability classes and then the specific JFDs for Classes E and F. While not demonstrated in the data described here, it is possible that Classes E and F could demonstrate strong agreement ($R^2 \geq 0.95$) but other classes have lower values, which could drive down the R^2 value for the overall JFD of speed and direction for all classes. The technical staff expect that considering a threshold of $R^2 \geq 0.90$ for the overall value, and then $R^2 \geq 0.95$ for Classes E and F, would provide the greatest level of discrimination for determining temporal representativeness considering stability class while restricting the influence to only those classes which are expected to have the greatest impact on safety. If the R^2 thresholds are not satisfied

and/or not supported by qualitative evidence, the applicant/licensee can further attempt to evaluate the difference in doses by estimating individual and population doses using short- and long-term JFDs for NWS data in MILDOS-AREA. Appendix D of this TBD has a MILDOS-AREA evaluation, which would not normally be recommended in the case of Scottsbluff since both of the R^2 values are satisfied; however, it was done as an exercise to evaluate the differences in the doses. Besides the intra-site evaluation for Scottsbluff, Appendix D includes a MILDOS-AREA intra-site evaluation for Scottsbluff and Gillette respectively, as well as an inter-site evaluation of Scottsbluff vs. Gillette and vice versa. Appendix D contains results on the differences in predicted doses.

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ATTACHMENT OF APPENDIX B: TABLES AND FIGURES

This attachment contains bar charts, regression plots, and tables with pertinent data for the intra- and inter-site comparison for Scottsbluff and Gillette.

1. INTRA-SITE COMPARISON: SCOTTSBLUFF 1 YEAR VS. 15 YEARS

1.1. SCOTTSBLUFF WIND DIRECTION RELATIVE FREQUENCY DISTRIBUTION

Table 1 contains the Scottsbluff wind direction relative frequency distribution data used to create the wind direction frequency bar chart and regression in Figures 1 and 2.

Table 1. Scottsbluff Wind Direction Relative Frequency Distribution

Direction	15 years (X-axis)	1 year (Y-axis)	Diff* 1 year vs. 15 years (pp)
N	6.45%	4.69%	1.76
NNE	3.41%	3.10%	0.31
NE	3.24%	2.72%	0.52
ENE	3.63%	3.17%	0.46
E	10.55%	10.25%	0.29
ESE	11.03%	12.61%	-1.58
SE	6.27%	6.63%	-0.36
SSE	3.51%	3.73%	-0.22
S	2.67%	2.70%	-0.03
SSW	1.13%	1.06%	0.07
SW	0.81%	0.84%	-0.03
WSW	0.99%	0.88%	0.12
W	6.82%	7.45%	-0.63
WNW	12.18%	13.73%	-1.55
NW	11.85%	11.80%	0.05
NNW	7.14%	6.13%	1.02
Calms	8.31%	8.50%	-0.19

*Where 'diff' is the difference in percentage points (pp) calculated between the long- and short-term relative frequencies. The actual numbers used for the percent point calculations include greater than three significant figures. Therefore, the calculated difference as shown in this table may vary slightly due to rounding.

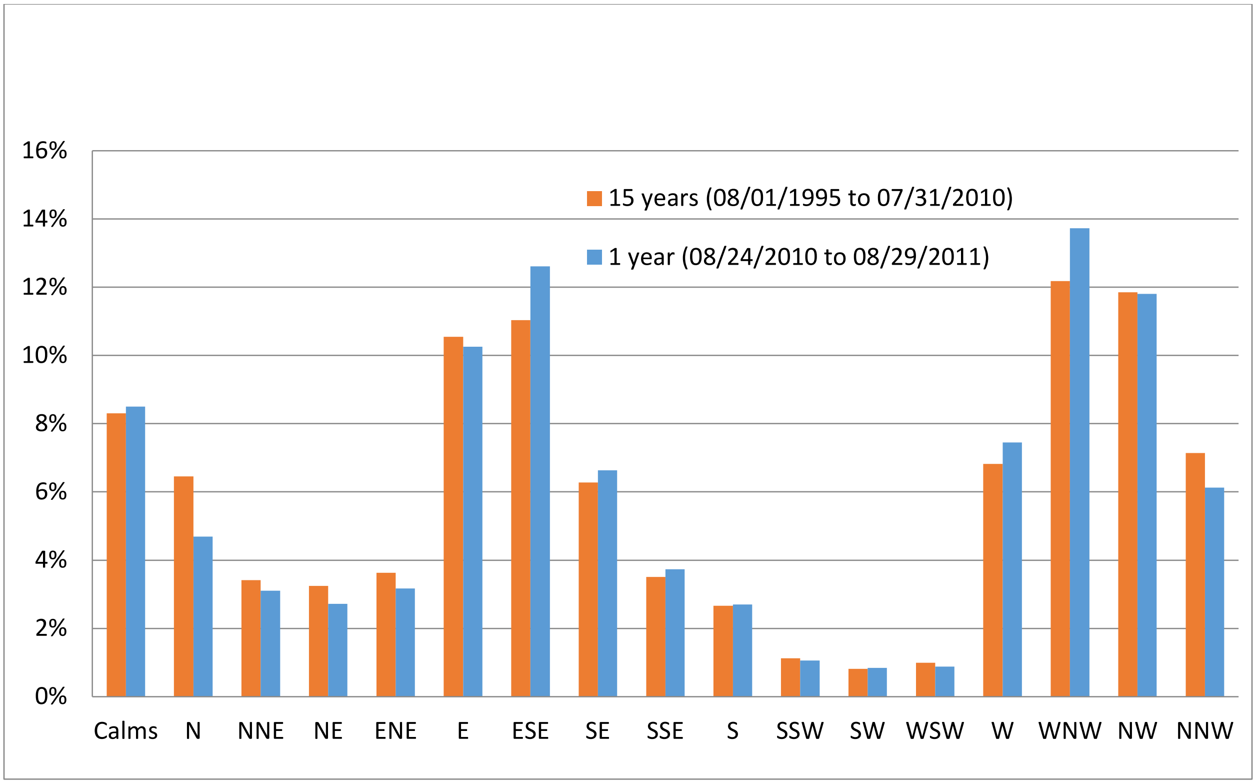

Figure 1. Scottsbluff Nebraska Airport Wind Direction Relative Frequency Distribution: 1 year vs. 15 years

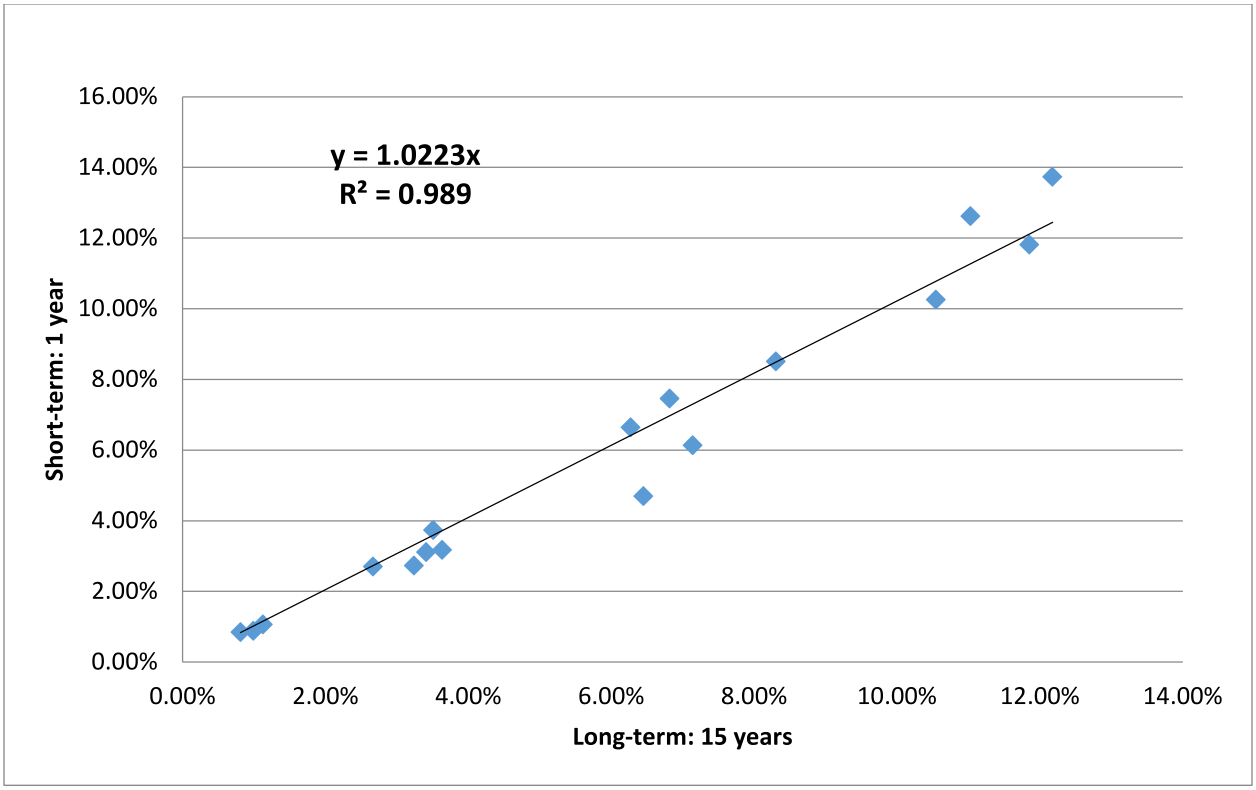

Figure 2. Wind Direction Relative Frequency Distribution: Scottsbluff 1 year vs. 15 years

1.2. SCOTTSBLUFF WIND SPEED FREQUENCY DISTRIBUTION

Table 2 contains the Scottsbluff wind speed relative frequency distribution data used to create the wind direction frequency bar chart and regression in Figure 3 and 4.

Table 2. Scottsbluff Wind Speed Relative Frequency Distribution

Speed (mph)	15 years (X-axis)	1 year (Y-Axis)	Diff* 1 year vs 15 years (pp)
1–3	6.99%	7.21%	-0.21
4–7	28.97%	28.67%	0.30
8–12	29.13%	28.20%	0.93
13–18	18.48%	20.73%	-2.25
19-24	5.35%	4.63%	0.72
>24	2.78%	2.07%	0.71
Calms	8.31%	8.50%	-0.19

*Where 'diff' is the difference in percentage points (pp) calculated between the long- and short-term frequencies. The actual numbers used for the percent point calculations include greater than three significant figures. Therefore, the calculated difference as shown in this table may vary slightly due to rounding.

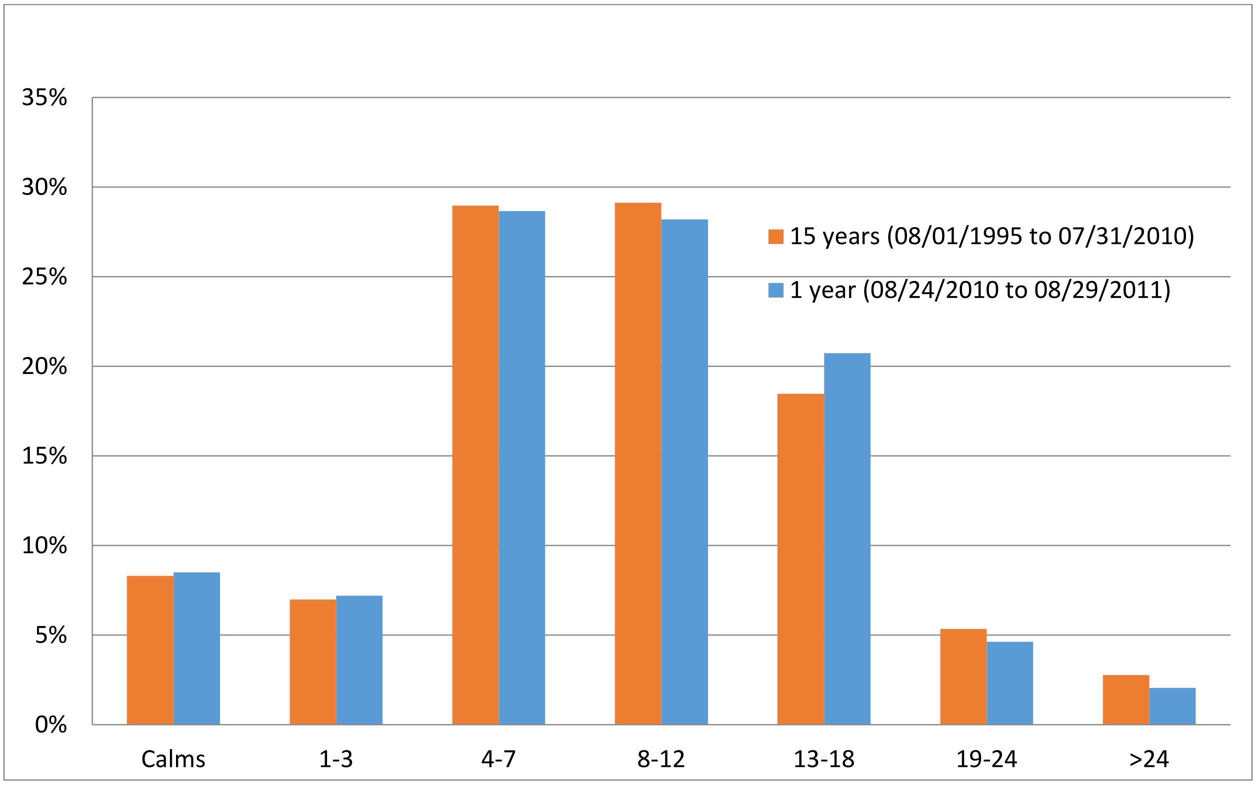

Figure 3. Scottsbluff Nebraska Airport Wind Speed Relative Frequency Distribution

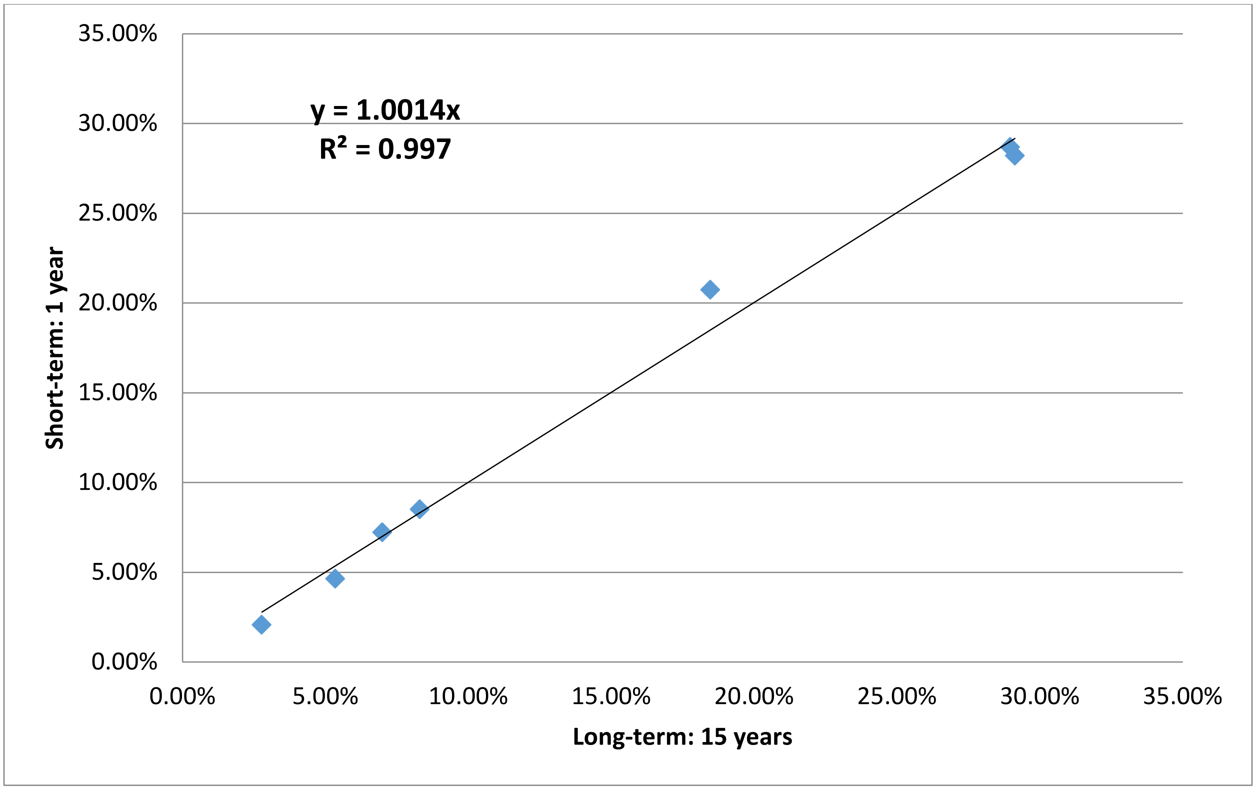

Figure 4. Wind Speed Relative Frequency Distribution: Scottsbluff 1 year vs. 15 years

1.3. ALL STABILITY CLASSES WIND DIRECTION AND WIND SPEED JOINT FREQUENCY DISTRIBUTION FOR SCOTTSBLUFF AIRPORT

Table 3 contains the Scottsbluff wind direction and wind speed joint frequency distributions (JFDs) data used to create the wind direction and wind speed JFD regression for all classes in Figure 5.

Table 3. Scottsbluff Wind Direction and Wind Speed Joint Frequency Distributions for All Stability Classes Summed

Class*	Speed (mph)	Direction	15 years (X-axis)	1 year (Y-axis)	Diff** 1 year vs 15 years (pp)
A-F	1–3	N	1.40%	1.25%	0.15
A-F	1–3	NNE	0.73%	0.69%	0.04
A-F	1–3	NE	0.77%	0.75%	0.03
A-F	1–3	ENE	0.91%	0.82%	0.09
A-F	1–3	E	2.23%	2.02%	0.20
A-F	1–3	ESE	1.40%	1.49%	-0.10
A-F	1–3	SE	0.81%	0.95%	-0.14

Table 3. Scottsbluff Wind Direction and Wind Speed Joint Frequency Distributions for All Stability Classes Summed

Class*	Speed (mph)	Direction	15 years (X-axis)	1 year (Y-axis)	Diff** 1 year vs 15 years (pp)
A-F	1–3	SSE	0.54%	0.72%	-0.18
A-F	1–3	S	0.63%	0.66%	-0.03
A–F	1–3	SSW	0.30%	0.23%	0.07
A–F	1–3	SW	0.24%	0.26%	-0.02
A–F	1–3	WSW	0.31%	0.32%	-0.01
A–F	1–3	W	1.03%	1.27%	-0.24
A–F	1–3	WNW	1.43%	1.51%	-0.08
A–F	1–3	NW	1.77%	1.64%	0.13
A–F	1–3	NNW	1.38%	1.03%	0.35
A–F	4–7	N	2.05%	1.73%	0.32
A–F	4–7	NNE	1.09%	1.11%	-0.02
A–F	4–7	NE	1.09%	0.99%	0.10
A–F	4–7	ENE	1.43%	1.15%	0.28
A–F	4–7	E	4.60%	4.37%	0.22
A–F	4–7	ESE	2.85%	3.15%	-0.30
A–F	4–7	SE	1.50%	1.67%	-0.17
A–F	4–7	SSE	0.96%	1.30%	-0.34
A–F	4–7	S	0.94%	1.04%	-0.10
A–F	4–7	SSW	0.44%	0.37%	0.07
A–F	4–7	SW	0.33%	0.32%	0.02
A–F	4–7	WSW	0.38%	0.35%	0.03
A–F	4–7	W	1.76%	1.70%	0.05
A–F	4–7	WNW	3.02%	3.53%	-0.51
A–F	4–7	NW	3.63%	3.95%	-0.32
A–F	4–7	NNW	2.31%	1.92%	0.39
A–F	8–12	N	1.48%	1.00%	0.48
A–F	8–12	NNE	1.00%	0.96%	0.04
A–F	8–12	NE	0.88%	0.68%	0.20
A–F	8–12	ENE	1.13%	0.73%	0.40
A–F	8–12	E	4.07%	3.89%	0.18
A–F	8–12	ESE	4.64%	5.34%	-0.70
A–F	8–12	SE	2.30%	2.51%	-0.21
A–F	8–12	SSE	1.04%	0.94%	0.10
A–F	8–12	S	0.72%	0.77%	-0.05
A–F	8–12	SSW	0.33%	0.35%	-0.02
A–F	8–12	SW	0.19%	0.27%	-0.08
A–F	8–12	WSW	0.25%	0.20%	0.05
A–F	8–12	W	1.91%	2.21%	-0.30
A–F	8–12	WNW	4.09%	3.91%	0.18
A–F	8–12	NW	3.61%	3.33%	0.28
A–F	8–12	NNW	1.52%	1.17%	0.35
A–F	13–18	N	1.17%	0.81%	0.36
A–F	13–18	NNE	0.68%	0.54%	0.14
A–F	13–18	NE	0.66%	0.58%	0.08

Table 3. Scottsbluff Wind Direction and Wind Speed Joint Frequency Distributions for All Stability Classes Summed

Class*	Speed (mph)	Direction	15 years (X-axis)	1 year (Y-axis)	Diff** 1 year vs 15 years (pp)
A–F	13–18	ENE	0.54%	0.72%	-0.18
A–F	13–18	E	0.96%	1.13%	-0.17
A–F	13–18	ESE	2.63%	3.38%	-0.75
A–F	13–18	SE	1.78%	1.88%	-0.11
A–F	13–18	SSE	1.03%	0.94%	0.09
A–F	13-18	S	0.58%	0.45%	0.13
A–F	13-18	SSW	0.18%	0.20%	-0.02
A–F	13–18	SW	0.14%	0.10%	0.04
A–F	13–18	WSW	0.15%	0.11%	0.04
A–F	13–18	W	1.56%	1.93%	-0.37
A–F	13–18	WNW	3.02%	4.09%	-1.08
A–F	13–18	NW	2.07%	2.45%	-0.38
A–F	13–18	NNW	1.36%	1.48%	-0.11
A–F	19–24	N	0.38%	0.10%	0.28
A–F	19–24	NNE	0.21%	0.14%	0.07
A–F	19–24	NE	0.18%	0.07%	0.11
A–F	19–24	ENE	0.09%	0.12%	-0.03
A–F	19–24	E	0.06%	0.11%	-0.05
A–F	19–24	ESE	0.31%	0.19%	0.12
A–F	19–24	SE	0.30%	0.12%	0.18
A–F	19–24	SSE	0.21%	0.26%	-0.05
A–F	19–24	S	0.10%	0.12%	-0.03
A–F	19–24	SSW	0.03%	0.02%	0.01
A–F	19–24	SW	0.02%	0.03%	-0.01
A–F	19–24	WSW	0.04%	0.02%	0.02
A–F	19–24	W	0.71%	0.52%	0.19
A–F	19–24	WNW	0.96%	1.07%	-0.11
A–F	19–24	NW	0.94%	0.97%	-0.03
A–F	19–24	NNW	0.80%	0.77%	0.04
A–F	>24	N	0.12%	0.00%	0.12
A–F	>24	NNE	0.08%	0.02%	0.06
A–F	>24	NE	0.05%	0.05%	0.00
A–F	>24	ENE	0.02%	0.02%	-0.01
A–F	>24	E	0.02%	0.02%	0.00
A–F	>24	ESE	0.05%	0.00%	0.05
A–F	>24	SE	0.04%	0.01%	0.03
A–F	>24	SSE	0.04%	0.02%	0.01
A–F	>24	S	0.02%	0.01%	0.01
A–F	>24	SSW	0.00%	0.00%	0.00
A–F	>24	SW	0.00%	0.00%	0.00
A–F	>24	WSW	0.01%	0.01%	-0.01
A–F	>24	W	0.41%	0.44%	-0.03
A–F	>24	WNW	0.52%	0.56%	-0.04
A–F	>24	NW	0.89%	0.56%	0.32

Table 3. Scottsbluff Wind Direction and Wind Speed Joint Frequency Distributions for All Stability Classes Summed					
Class*	Speed (mph)	Direction	15 years (X-axis)	1 year (Y-axis)	Diff** 1 year vs 15 years (pp)
A–F	>24	NNW	0.52%	0.34%	0.18

* The stability classes A–F were summed for each wind speed and wind direction. Calms were distributed by the STAR program within each stability class as described in Section 2.2.3 of the TBD.

** Where 'diff' is the difference in percentage points (pp) calculated between the long- and short-term frequencies. The actual numbers used for the percent point calculations include greater than three significant figures. Therefore, the calculated difference as shown in this table may vary slightly due to rounding.

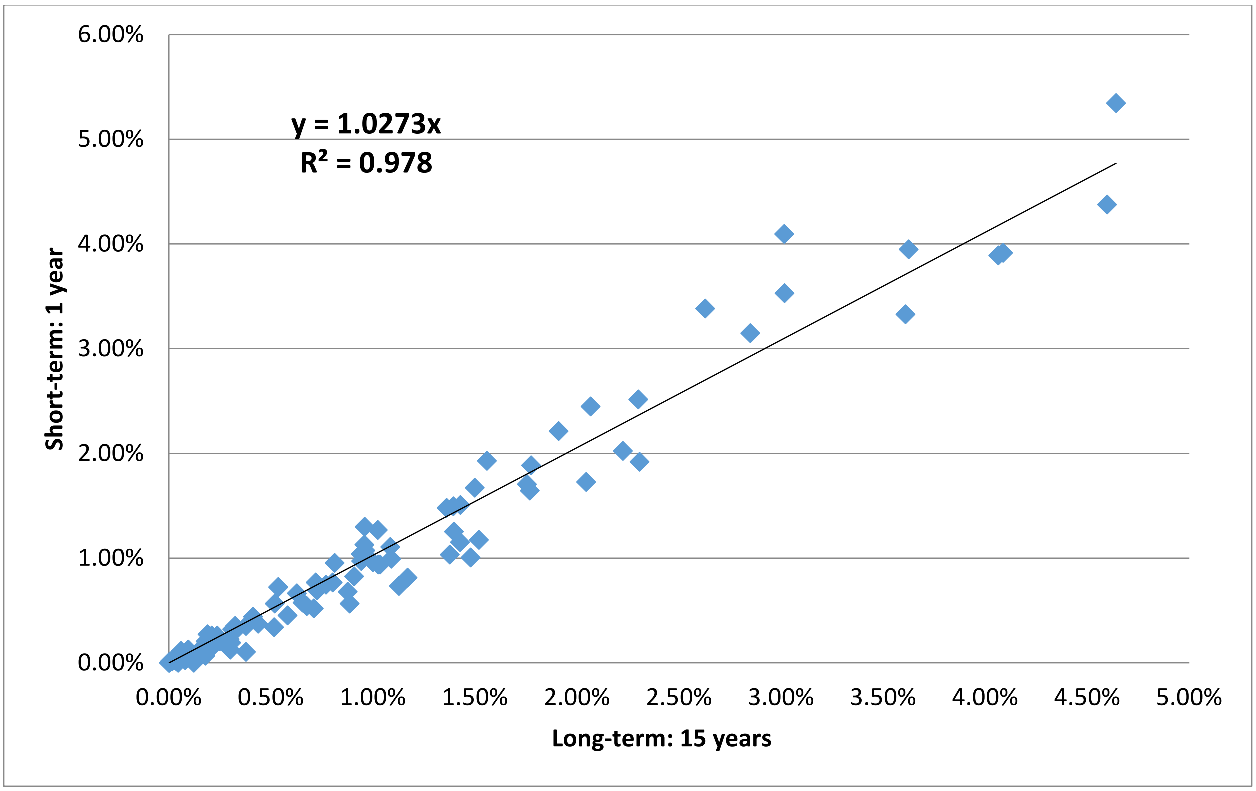

Figure 5. Wind Direction and Wind Speed Joint Frequency Distribution for All Classes: Scottsbluff 1 year vs. 15 years

1.4. WIND DIRECTION AND WIND SPEED JOINT FREQUENCY DISTRIBUTIONS BY ATMOSPHERIC STABILITY CLASS FOR SCOTTSBLUFF AIRPORT

Tables 4–9 contain the Scottsbluff wind direction and wind speed joint frequency distributions (JFDs) data used to create the wind direction and wind speed JFD regression for Classes A, B,C, D,

E, and F depicted in Figures 6–11 respectively.

Class A occurs during the first two wind speed categories (i.e., 1–3 and 4–7 mph) and the linear regression plot only includes those data points. The values for the other wind speed categories are captured as "zeros" in the STAR program; however, these should not be considered as actual values and are excluded from the linear regression analysis. Therefore, the linear regression includes 32 observations which consider two wind speed categories. The other wind categories do not occur thus "NA" (non-applicable) was included for these in the following table.

Table 4. Scottsbluff Wind Direction and Wind Speed Joint Frequency Distributions for Stability Class A

Class	Speed (mph)	Direction	15 years (X-axis)	1 year (Y-axis)	Diff* 1 year vs. 15 years
A	1–3	N	0.06%	0.06%	0.00
A	1–3	NNE	0.03%	0.03%	0.00
A	1–3	NE	0.03%	0.06%	-0.02
A	1–3	ENE	0.04%	0.03%	0.01
A	1–3	E	0.08%	0.07%	0.01
A	1–3	ESE	0.06%	0.04%	0.01
A	1–3	SE	0.06%	0.08%	-0.02
A	1–3	SSE	0.04%	0.14%	-0.10
A	1–3	S	0.06%	0.10%	-0.04
A	1–3	SSW	0.03%	0.01%	0.01
A	1–3	SW	0.03%	0.06%	-0.03
A	1–3	WSW	0.03%	0.03%	0.01
A	1–3	W	0.10%	0.12%	-0.02
A	1–3	WNW	0.07%	0.03%	0.05
A	1–3	NW	0.06%	0.04%	0.02
A	1–3	NNW	0.05%	0.01%	0.04
A	4–7	N	0.03%	0.02%	0.00
A	4–7	NNE	0.01%	0.00%	0.01
A	4–7	NE	0.02%	0.02%	0.00
A	4–7	ENE	0.02%	0.02%	0.00
A	4–7	E	0.05%	0.03%	0.02
A	4–7	ESE	0.03%	0.03%	0.00
A	4–7	SE	0.04%	0.02%	0.01
A	4–7	SSE	0.03%	0.07%	-0.04
A	4–7	S	0.03%	0.03%	0.00
A	4–7	SSW	0.01%	0.01%	0.00
A	4–7	SW	0.02%	0.02%	-0.01
A	4–7	WSW	0.02%	0.02%	-0.01
A	4–7	W	0.05%	0.03%	0.01
A	4–7	WNW	0.04%	0.02%	0.02
A	4–7	NW	0.03%	0.03%	0.00

Table 4. Scottsbluff Wind Direction and Wind Speed Joint Frequency Distributions for Stability Class A					
Class	**Speed (mph)**	**Direction**	**15 years (X-axis)**	**1 year (Y-axis)**	**Diff* 1 year vs. 15 years**
A	**4–7**	**NNW**	0.02%	0.01%	0.01
A	**8–12**	**N**	NA	NA	NA
A	**8–12**	**NNE**	NA	NA	NA
A	**8–12**	**NE**	NA	NA	NA
A	**8–12**	**ENE**	NA	NA	NA
A	**8–12**	**E**	NA	NA	NA
A	**8–12**	**ESE**	NA	NA	NA
A	**8–12**	**SE**	NA	NA	NA
A	**8–12**	**SSE**	NA	NA	NA
A	**8–12**	**S**	NA	NA	NA
A	**8–12**	**SSW**	NA	NA	NA
A	**8–12**	**SW**	NA	NA	NA
A	**8–12**	**WSW**	NA	NA	NA
A	**8–12**	**W**	NA	NA	NA
A	**8–12**	**WNW**	NA	NA	NA
A	**8–12**	**NW**	NA	NA	NA
A	**8–12**	**NNW**	NA	NA	NA
A	**13–18**	**N**	NA	NA	NA
A	**13–18**	**NNE**	NA	NA	NA
A	**13–18**	**NE**	NA	NA	NA
A	**13–18**	**ENE**	NA	NA	NA
A	**13–18**	**E**	NA	NA	NA
A	**13–18**	**ESE**	NA	NA	NA
A	**13–18**	**SE**	NA	NA	NA
A	**13–18**	**SSE**	NA	NA	NA
A	**13–18**	**S**	NA	NA	NA
A	**13–18**	**SSW**	NA	NA	NA
A	**13–18**	**SW**	NA	NA	NA
A	**13–18**	**WSW**	NA	NA	NA
A	**13–18**	**W**	NA	NA	NA
A	**13–18**	**WNW**	NA	NA	NA
A	**13–18**	**NW**	NA	NA	NA
A	**13–18**	**NNW**	NA	NA	NA
A	**19–24**	**N**	NA	NA	NA
A	**19–24**	**NNE**	NA	NA	NA
A	**19–24**	**NE**	NA	NA	NA
A	**19–24**	**ENE**	NA	NA	NA
A	**19–24**	**E**	NA	NA	NA
A	**19–24**	**ESE**	NA	NA	NA
A	**19–24**	**SE**	NA	NA	NA
A	**19–24**	**SSE**	NA	NA	NA
A	**19–24**	**S**	NA	NA	NA
A	**19–24**	**SSW**	NA	NA	NA
A	**19–24**	**SW**	NA	NA	NA

Table 4. Scottsbluff Wind Direction and Wind Speed Joint Frequency Distributions for Stability Class A					
Class	**Speed (mph)**	**Direction**	**15 years (X-axis)**	**1 year (Y-axis)**	**Diff* 1 year vs. 15 years**
A	**19–24**	**WSW**	NA	NA	NA
A	**19–24**	**W**	NA	NA	NA
A	**19–24**	**WNW**	NA	NA	NA
A	**19–24**	**NW**	NA	NA	NA
A	**19–24**	**NNW**	NA	NA	NA
A	**>24**	**N**	NA	NA	NA
A	**>24**	**NNE**	NA	NA	NA
A	**>24**	**NE**	NA	NA	NA
A	**>24**	**ENE**	NA	NA	NA
A	**>24**	**E**	NA	NA	NA
A	**>24**	**ESE**	NA	NA	NA
A	**>24**	**SE**	NA	NA	NA
A	**>24**	**SSE**	NA	NA	NA
A	**>24**	**S**	NA	NA	NA
A	**>24**	**SSW**	NA	NA	NA
A	**>24**	**SW**	NA	NA	NA
A	**>24**	**WSW**	NA	NA	NA
A	**>24**	**W**	NA	NA	NA
A	**>24**	**WNW**	NA	NA	NA
A	**>24**	**NW**	NA	NA	NA
A	**>24**	**NNW**	NA	NA	NA

*Where 'diff' is the difference in percentage points calculated between the long- and short-term frequencies. The actual numbers used for the percent point calculations include greater than three significant figures. Therefore, the calculated difference as shown in this table may vary slightly due to rounding.

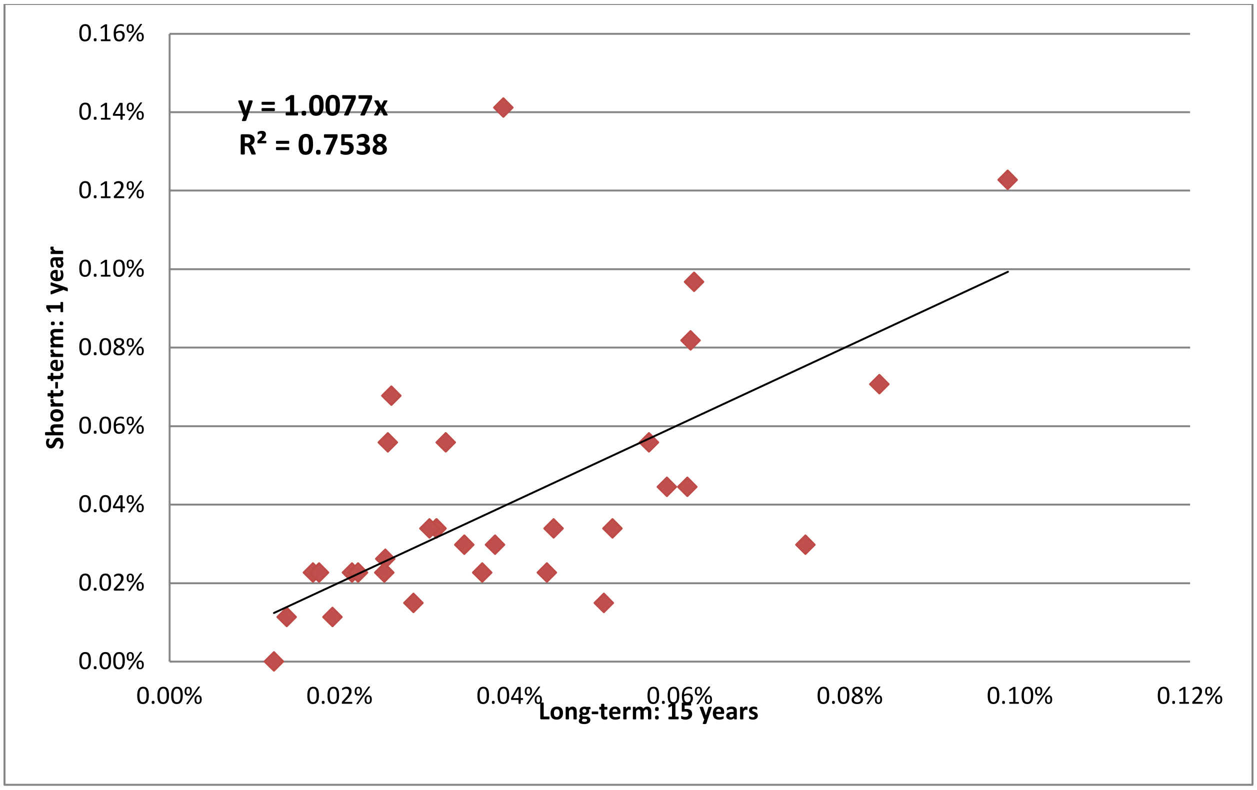

Figure 6. Class A Joint Frequency Distribution: Scottsbluff 1 year vs. 15 years

Class B occurs during the first three wind speed categories (i.e., 1–3, 4–7, and 8–12) mph and the linear regression plot only includes those data points. The values for the other wind speed categories are captured as "zeros" in the STAR program; however, these should not be considered as actual values and are excluded from the linear regression analysis. Therefore, the linear regression includes 48 observations which consider three wind speed categories. The other wind categories do not occur thus "NA" (non-applicable) was included for these in the following table.

Table 5. Scottsbluff Wind Direction and Wind Speed Joint Frequency Distributions for Stability Class B

Class	Speed (mph)	Direction	15 years (X-axis)	1 year (Y-axis)	Diff* 1 year vs. 15 years
B	1–3	N	0.13%	0.09%	0.04
B	1–3	NNE	0.05%	0.04%	0.00
B	1–3	NE	0.07%	0.03%	0.04
B	1–3	ENE	0.08%	0.10%	-0.02
B	1–3	E	0.21%	0.20%	0.01

Table 5. Scottsbluff Wind Direction and Wind Speed Joint Frequency Distributions for Stability Class B					
Class	Speed (mph)	Direction	15 years (X-axis)	1 year (Y-axis)	Diff* 1 year vs. 15 years
B	1–3	ESE	0.21%	0.20%	0.01
B	1–3	SE	0.19%	0.29%	-0.10
B	1–3	SSE	0.13%	0.12%	0.02
B	1–3	S	0.16%	0.20%	-0.04
B	1–3	SSW	0.09%	0.12%	-0.03
B	1–3	SW	0.07%	0.09%	-0.03
B	1–3	WSW	0.08%	0.10%	-0.02
B	1–3	W	0.27%	0.28%	-0.01
B	1–3	WNW	0.27%	0.28%	-0.02
B	1–3	NW	0.21%	0.12%	0.09
B	1–3	NNW	0.15%	0.06%	0.09
B	4–7	N	0.11%	0.08%	0.04
B	4–7	NNE	0.07%	0.08%	-0.01
B	4–7	NE	0.08%	0.02%	0.06
B	4–7	ENE	0.12%	0.14%	-0.01
B	4–7	E	0.27%	0.42%	-0.15
B	4–7	ESE	0.25%	0.23%	0.02
B	4–7	SE	0.22%	0.32%	-0.09
B	4–7	SSE	0.19%	0.23%	-0.04
B	4–7	S	0.21%	0.28%	-0.07
B	4–7	SSW	0.09%	0.09%	0.00
B	4–7	SW	0.08%	0.05%	0.03
B	4–7	WSW	0.08%	0.09%	-0.01
B	4–7	W	0.30%	0.34%	-0.04
B	4–7	WNW	0.30%	0.35%	-0.05
B	4–7	NW	0.24%	0.32%	-0.08
B	4–7	NNW	0.14%	0.16%	-0.01
B	8–12	N	0.07%	0.07%	0.01
B	8–12	NNE	0.03%	0.02%	0.01
B	8–12	NE	0.04%	0.02%	0.02
B	8–12	ENE	0.05%	0.02%	0.03
B	8–12	E	0.21%	0.21%	0.00
B	8–12	ESE	0.18%	0.26%	-0.08
B	8–12	SE	0.19%	0.19%	0.00
B	8–12	SSE	0.13%	0.17%	-0.04
B	8–12	S	0.12%	0.12%	0.00
B	8–12	SSW	0.04%	0.06%	-0.02
B	8–12	SW	0.02%	0.07%	-0.05
B	8–12	WSW	0.04%	0.02%	0.02
B	8–12	W	0.18%	0.21%	-0.04
B	8–12	WNW	0.18%	0.16%	0.02
B	8–12	NW	0.12%	0.23%	-0.10
B	8–12	NNW	0.09%	0.11%	-0.03

Table 5. Scottsbluff Wind Direction and Wind Speed Joint Frequency Distributions for Stability Class B					
Class	**Speed (mph)**	**Direction**	**15 years (X-axis)**	**1 year (Y-axis)**	**Diff* 1 year vs. 15 years**
B	**13–18**	**N**	NA	NA	NA
B	**13–18**	**NNE**	NA	NA	NA
B	**13–18**	**NE**	NA	NA	NA
B	**13–18**	**ENE**	NA	NA	NA
B	**13–18**	**E**	NA	NA	NA
B	**13–18**	**ESE**	NA	NA	NA
B	**13–18**	**SE**	NA	NA	NA
B	**13–18**	**SSE**	NA	NA	NA
B	**13–18**	**S**	NA	NA	NA
B	**13–18**	**SSW**	NA	NA	NA
B	**13–18**	**SW**	NA	NA	NA
B	**13–18**	**WSW**	NA	NA	NA
B	**13–18**	**W**	NA	NA	NA
B	**13–18**	**WNW**	NA	NA	NA
B	**13–18**	**NW**	NA	NA	NA
B	**13–18**	**NNW**	NA	NA	NA
B	**19–24**	**N**	NA	NA	NA
B	**19–24**	**NNE**	NA	NA	NA
B	**19–24**	**NE**	NA	NA	NA
B	**19–24**	**ENE**	NA	NA	NA
B	**19–24**	**E**	NA	NA	NA
B	**19–24**	**ESE**	NA	NA	NA
B	**19–24**	**SE**	NA	NA	NA
B	**19–24**	**SSE**	NA	NA	NA
B	**19–24**	**S**	NA	NA	NA
B	**19–24**	**SSW**	NA	NA	NA
B	**19–24**	**SW**	NA	NA	NA
B	**19–24**	**WSW**	NA	NA	NA
B	**19–24**	**W**	NA	NA	NA
B	**19–24**	**WNW**	NA	NA	NA
B	**19–24**	**NW**	NA	NA	NA
B	**19–24**	**NNW**	NA	NA	NA
B	**>24**	**N**	NA	NA	NA
B	**>24**	**NNE**	NA	NA	NA
B	**>24**	**NE**	NA	NA	NA
B	**>24**	**ENE**	NA	NA	NA
B	**>24**	**E**	NA	NA	NA
B	**>24**	**ESE**	NA	NA	NA
B	**>24**	**SE**	NA	NA	NA
B	**>24**	**SSE**	NA	NA	NA
B	**>24**	**S**	NA	NA	NA
B	**>24**	**SSW**	NA	NA	NA
B	**>24**	**SW**	NA	NA	NA

Table 5. Scottsbluff Wind Direction and Wind Speed Joint Frequency Distributions for Stability Class B					
Class	Speed (mph)	Direction	15 years (X-axis)	1 year (Y-axis)	Diff* 1 year vs. 15 years
B	>24	WSW	NA	NA	NA
B	>24	W	NA	NA	NA
B	>24	WNW	NA	NA	NA
B	>24	NW	NA	NA	NA
B	>24	NNW	NA	NA	NA

*Where 'diff' is the difference in percentage points (pp) calculated between the long- and short-term frequencies. The actual numbers used for the percent point calculations include greater than three significant figures. Therefore, the calculated difference as shown in this table may vary slightly due to rounding.

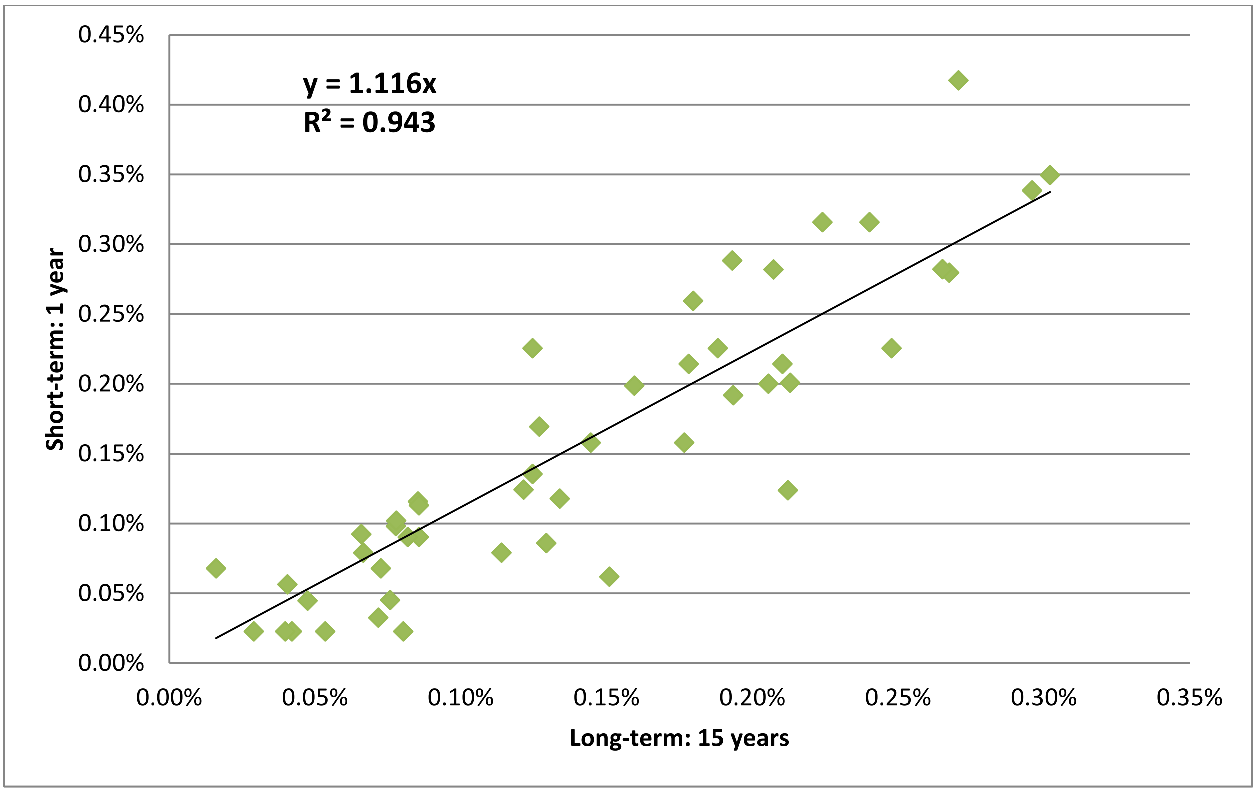

Figure 7. Class B Joint Frequency Distribution: Scottsbluff 1 year vs. 15 years

Class C occurs for all wind speed categories and the linear regression includes those data points. Therefore, the linear regression includes 96 observations which consider all wind speed categories.

Table 6. Scottsbluff Wind Direction and Wind Speed Joint Frequency Distributions for Stability Class C					
Class	Speed (mph)	Direction	15 years (X-axis)	1 year (Y-axis)	Diff* 1 year vs. 15 years
C	1–3	N	0.04%	0.05%	-0.01
C	1–3	NNE	0.02%	0.04%	-0.02
C	1–3	NE	0.02%	0.01%	0.00
C	1–3	ENE	0.03%	0.01%	0.02
C	1–3	E	0.08%	0.08%	0.00
C	1–3	ESE	0.09%	0.06%	0.03
C	1–3	SE	0.07%	0.06%	0.01
C	1–3	SSE	0.04%	0.07%	-0.03
C	1–3	S	0.04%	0.05%	-0.01
C	1–3	SSW	0.02%	0.03%	-0.01
C	1–3	SW	0.02%	0.01%	0.01
C	1–3	WSW	0.02%	0.02%	0.00
C	1–3	W	0.08%	0.08%	0.00
C	1–3	WNW	0.10%	0.11%	-0.01
C	1–3	NW	0.10%	0.06%	0.04
C	1–3	NNW	0.05%	0.05%	0.00
C	4–7	N	0.09%	0.11%	-0.02
C	4–7	NNE	0.05%	0.08%	-0.03
C	4–7	NE	0.06%	0.01%	0.05
C	4–7	ENE	0.06%	0.05%	0.02
C	4–7	E	0.28%	0.20%	0.08
C	4–7	ESE	0.33%	0.26%	0.07
C	4–7	SE	0.29%	0.26%	0.03
C	4–7	SSE	0.18%	0.33%	-0.14
C	4–7	S	0.15%	0.17%	-0.02
C	4–7	SSW	0.07%	0.10%	-0.03
C	4–7	SW	0.06%	0.05%	0.01
C	4–7	WSW	0.07%	0.07%	0.00
C	4–7	W	0.34%	0.29%	0.05
C	4–7	WNW	0.43%	0.41%	0.03
C	4–7	NW	0.37%	0.30%	0.07
C	4–7	NNW	0.15%	0.15%	0.00
C	8–12	N	0.21%	0.16%	0.06
C	8–12	NNE	0.13%	0.12%	0.00
C	8–12	NE	0.10%	0.11%	-0.01
C	8–12	ENE	0.15%	0.16%	-0.01
C	8–12	E	0.51%	0.44%	0.07
C	8–12	ESE	0.77%	0.77%	0.01
C	8–12	SE	0.66%	0.86%	-0.20
C	8–12	SSE	0.38%	0.32%	0.06
C	8–12	S	0.28%	0.28%	-0.01
C	8–12	SSW	0.11%	0.09%	0.02
C	8–12	SW	0.07%	0.11%	-0.05
C	8–12	WSW	0.09%	0.08%	0.01

Table 6. Scottsbluff Wind Direction and Wind Speed Joint Frequency Distributions for Stability Class C					
Class	Speed (mph)	Direction	15 years (X-axis)	1 year (Y-axis)	Diff* 1 year vs. 15 years
C	8–12	W	0.59%	0.59%	0.00
C	8–12	WNW	0.98%	0.77%	0.21
C	8–12	NW	0.62%	0.67%	-0.05
C	8–12	NNW	0.22%	0.23%	0.00
C	13–18	N	0.07%	0.03%	0.03
C	13–18	NNE	0.03%	0.02%	0.00
C	13–18	NE	0.04%	0.05%	-0.01
C	13–18	ENE	0.02%	0.08%	-0.06
C	13–18	E	0.12%	0.14%	-0.02
C	13–18	ESE	0.18%	0.17%	0.01
C	13–18	SE	0.21%	0.18%	0.03
C	13–18	SSE	0.16%	0.16%	0.00
C	13–18	S	0.11%	0.11%	0.00
C	13–18	SSW	0.04%	0.03%	0.00
C	13–18	SW	0.02%	0.01%	0.01
C	13–18	WSW	0.02%	0.05%	-0.03
C	13–18	W	0.12%	0.15%	-0.02
C	13–18	WNW	0.19%	0.16%	0.03
C	13–18	NW	0.10%	0.18%	-0.08
C	13–18	NNW	0.07%	0.05%	0.03
C	19–24	N	0.01%	0.00%	0.01
C	19–24	NNE	0.00%	0.00%	0.00
C	19–24	NE	0.00%	0.00%	0.00
C	19–24	ENE	0.00%	0.01%	-0.01
C	19–24	E	0.00%	0.00%	0.00
C	19–24	ESE	0.02%	0.00%	0.02
C	19–24	SE	0.02%	0.02%	0.00
C	19–24	SSE	0.03%	0.02%	0.00
C	19–24	S	0.02%	0.01%	0.01
C	19–24	SSW	0.01%	0.01%	-0.01
C	19–24	SW	0.00%	0.01%	-0.01
C	19–24	WSW	0.00%	0.00%	0.00
C	19–24	W	0.02%	0.00%	0.02
C	19–24	WNW	0.03%	0.05%	-0.01
C	19–24	NW	0.02%	0.01%	0.01
C	19–24	NNW	0.03%	0.03%	-0.01
C	>24	N	0.00%	0.00%	0.00
C	>24	NNE	0.00%	0.00%	0.00
C	>24	NE	0.00%	0.00%	0.00
C	>24	ENE	0.00%	0.00%	0.00
C	>24	E	0.00%	0.00%	0.00
C	>24	ESE	0.00%	0.00%	0.00
C	>24	SE	0.00%	0.01%	-0.01
C	>24	SSE	0.00%	0.00%	0.00

Table 6. Scottsbluff Wind Direction and Wind Speed Joint Frequency Distributions for Stability Class C					
Class	Speed (mph)	Direction	15 years (X-axis)	1 year (Y-axis)	Diff* 1 year vs. 15 years
C	>24	S	0.00%	0.00%	0.00
C	>24	SSW	0.00%	0.00%	0.00
C	>24	SW	0.00%	0.00%	0.00
C	>24	WSW	0.00%	0.00%	0.00
C	>24	W	0.01%	0.00%	0.01
C	>24	WNW	0.01%	0.02%	-0.01
C	>24	NW	0.02%	0.05%	-0.03
C	>24	NNW	0.01%	0.01%	0.00

*Where 'diff' is the difference in percentage points (pp) calculated between the long- and short-term frequencies. The actual numbers used for the percent point calculations include greater than three significant figures. Therefore, the calculated difference as shown in this table may vary slightly due to rounding.

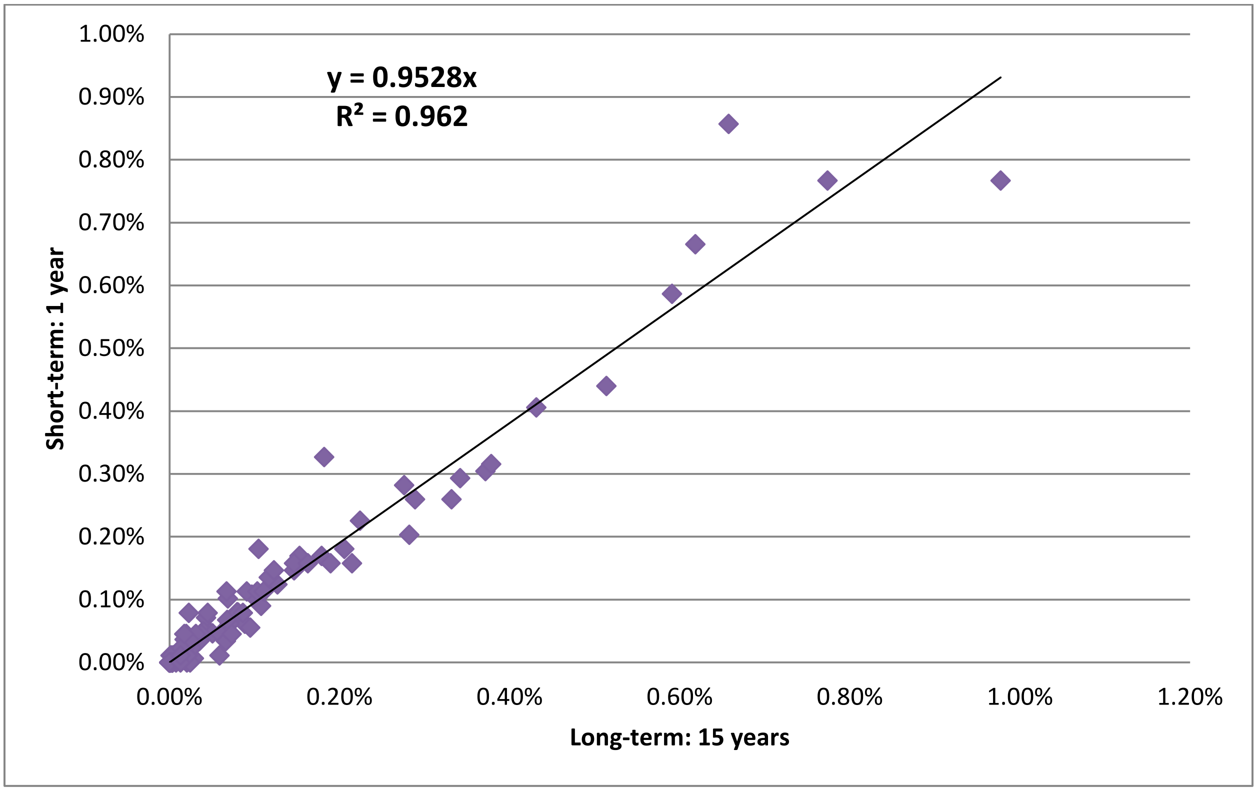

Figure 8. Class C Joint Frequency Distribution: Scottsbluff 1 year vs. 15 years

Class D occurs for all wind speed categories and the linear regression includes those data points. Therefore, the linear regression includes 96 observations which consider all wind speed categories.

Table 7. Scottsbluff Wind Direction and Wind Speed Joint Frequency Distributions for Stability Class D					
Class	Speed (mph)	Direction	15 years (X-axis)	1 year (Y-axis)	Diff* 1 year vs. 15 years
D	1–3	N	0.16%	0.14%	0.02
D	1–3	NNE	0.10%	0.15%	-0.05
D	1–3	NE	0.11%	0.13%	-0.02
D	1–3	ENE	0.12%	0.08%	0.03
D	1–3	E	0.27%	0.18%	0.09
D	1–3	ESE	0.21%	0.26%	-0.04
D	1–3	SE	0.14%	0.10%	0.04
D	1–3	SSE	0.10%	0.08%	0.02
D	1–3	S	0.08%	0.07%	0.02
D	1–3	SSW	0.03%	0.01%	0.02
D	1–3	SW	0.02%	0.02%	0.00
D	1–3	WSW	0.03%	0.04%	-0.01
D	1–3	W	0.12%	0.19%	-0.07
D	1–3	WNW	0.18%	0.23%	-0.05
D	1–3	NW	0.20%	0.20%	0.00
D	1–3	NNW	0.13%	0.12%	0.01
D	4–7	N	0.39%	0.38%	0.00
D	4–7	NNE	0.24%	0.29%	-0.05
D	4–7	NE	0.22%	0.20%	0.01
D	4–7	ENE	0.26%	0.19%	0.07
D	4–7	E	0.63%	0.51%	0.12
D	4–7	ESE	0.52%	0.53%	-0.01
D	4–7	SE	0.37%	0.26%	0.11
D	4–7	SSE	0.21%	0.24%	-0.03
D	4–7	S	0.17%	0.11%	0.06
D	4–7	SSW	0.07%	0.06%	0.01
D	4–7	SW	0.04%	0.01%	0.03
D	4–7	WSW	0.06%	0.01%	0.05
D	4–7	W	0.30%	0.24%	0.07
D	4–7	WNW	0.49%	0.61%	-0.11
D	4–7	NW	0.46%	0.44%	0.02
D	4–7	NNW	0.28%	0.27%	0.01
D	8–12	N	0.76%	0.54%	0.22
D	8–12	NNE	0.52%	0.45%	0.07
D	8–12	NE	0.43%	0.36%	0.07
D	8–12	ENE	0.50%	0.24%	0.26
D	8–12	E	1.05%	1.01%	0.03
D	8–12	ESE	1.44%	1.63%	-0.19
D	8–12	SE	0.87%	0.81%	0.06
D	8–12	SSE	0.32%	0.30%	0.01
D	8–12	S	0.16%	0.19%	-0.03
D	8–12	SSW	0.07%	0.07%	0.00
D	8–12	SW	0.04%	0.05%	0.00
D	8–12	WSW	0.05%	0.05%	0.01

Table 7. Scottsbluff Wind Direction and Wind Speed Joint Frequency Distributions for Stability Class D					
Class	Speed (mph)	Direction	15 years (X-axis)	1 year (Y-axis)	Diff* 1 year vs. 15 years
D	8–12	W	0.47%	0.71%	-0.24
D	8–12	WNW	1.21%	1.31%	-0.10
D	8–12	NW	0.99%	1.16%	-0.17
D	8–12	NNW	0.55%	0.48%	0.07
D	13–18	N	1.10%	0.78%	0.33
D	13–18	NNE	0.65%	0.52%	0.13
D	13–18	NE	0.62%	0.53%	0.09
D	13–18	ENE	0.51%	0.64%	-0.13
D	13–18	E	0.84%	0.99%	-0.15
D	13–18	ESE	2.45%	3.21%	-0.76
D	13–18	SE	1.57%	1.70%	-0.13
D	13–18	SSE	0.86%	0.78%	0.09
D	13–18	S	0.47%	0.34%	0.13
D	13–18	SSW	0.15%	0.17%	-0.02
D	13–18	SW	0.12%	0.09%	0.03
D	13–18	WSW	0.13%	0.07%	0.06
D	13–18	W	1.44%	1.78%	-0.35
D	13–18	WNW	2.83%	3.93%	-1.11
D	13–18	NW	1.96%	2.27%	-0.30
D	13–18	NNW	1.29%	1.43%	-0.14
D	19–24	N	0.37%	0.10%	0.27
D	19–24	NNE	0.20%	0.14%	0.07
D	19–24	NE	0.18%	0.07%	0.11
D	19–24	ENE	0.09%	0.11%	-0.02
D	19–24	E	0.06%	0.11%	-0.05
D	19–24	ESE	0.29%	0.19%	0.10
D	19–24	SE	0.28%	0.10%	0.18
D	19–24	SSE	0.18%	0.24%	-0.05
D	19–24	S	0.08%	0.11%	-0.03
D	19–24	SSW	0.02%	0.01%	0.01
D	19–24	SW	0.02%	0.02%	0.00
D	19–24	WSW	0.04%	0.02%	0.01
D	19–24	W	0.69%	0.52%	0.17
D	19–24	WNW	0.93%	1.03%	-0.09
D	19–24	NW	0.92%	0.96%	-0.04
D	19–24	NNW	0.78%	0.73%	0.05
D	>24	N	0.12%	0.00%	0.12
D	>24	NNE	0.08%	0.02%	0.06
D	>24	NE	0.05%	0.05%	0.00
D	>24	ENE	0.02%	0.02%	-0.01
D	>24	E	0.02%	0.02%	0.00
D	>24	ESE	0.04%	0.00%	0.04
D	>24	SE	0.04%	0.00%	0.04
D	>24	SSE	0.03%	0.02%	0.01

Table 7. Scottsbluff Wind Direction and Wind Speed Joint Frequency Distributions for Stability Class D					
Class	Speed (mph)	Direction	15 years (X-axis)	1 year (Y-axis)	Diff* 1 year vs. 15 years
D	>24	S	0.02%	0.01%	0.00
D	>24	SSW	0.00%	0.00%	0.00
D	>24	SW	0.00%	0.00%	0.00
D	>24	WSW	0.01%	0.01%	-0.01
D	>24	W	0.40%	0.44%	-0.04
D	>24	WNW	0.51%	0.54%	-0.03
D	>24	NW	0.87%	0.52%	0.35
D	>24	NNW	0.50%	0.33%	0.18

*Where 'diff' is the difference in percentage points (pp) calculated between the long- and short-term frequencies. The actual numbers used for the percent point calculations include greater than three significant figures. Therefore, the calculated difference as shown in this table may vary slightly due to rounding.

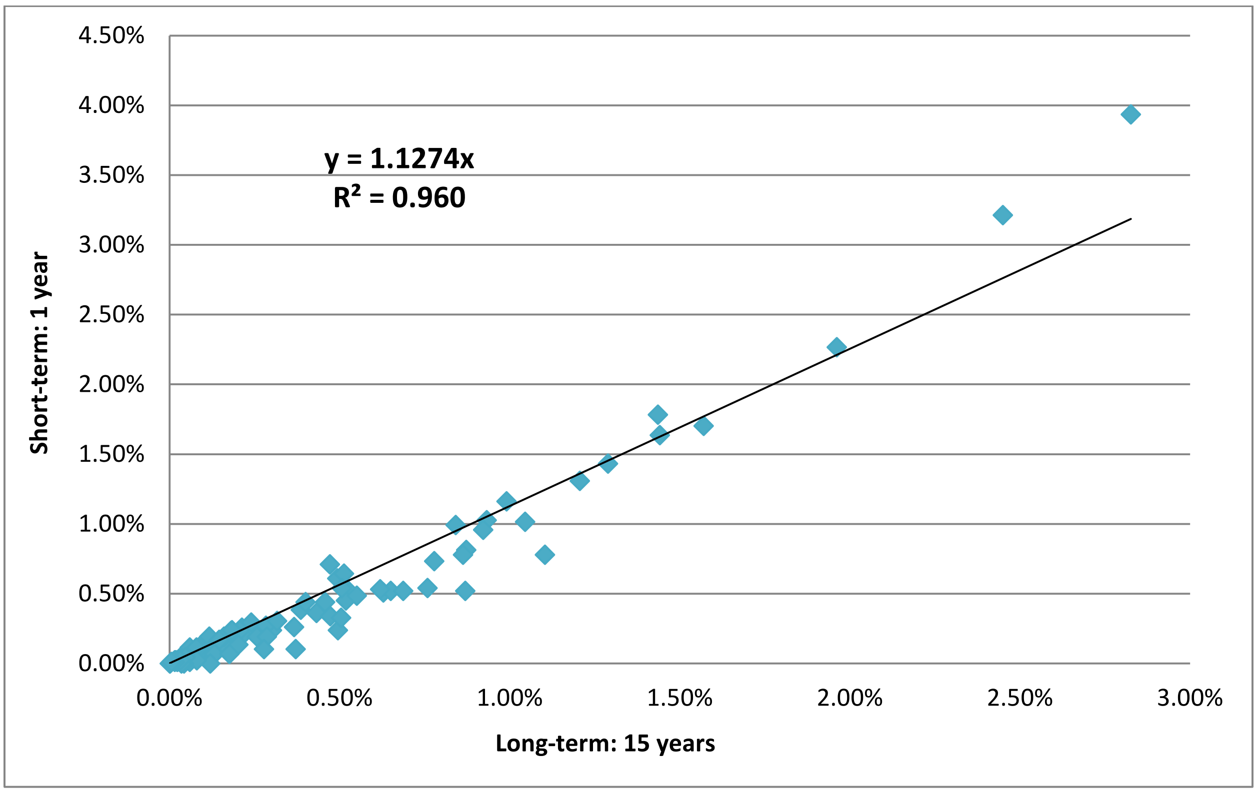

Figure 9. Class D Joint Frequency Distribution: Scottsbluff 1 year vs. 15 years

Class E occurs during wind speed categories 4–7 and 8–12 mph, and the linear regression plot only includes those data points. The values for the other wind speed categories are captured as "zeros" in

the STAR program; however, these should not be considered as actual values and are excluded from the linear regression analysis. Therefore, the linear regression includes 32 observations which consider two wind speed categories.

Table 8. Scottsbluff Wind Direction and Wind Speed Joint Frequency Distributions for Stability Class E

Class	Speed (mph)	Direction	15 years (X-axis)	1 year (Y-axis)	Diff* 1 year vs. 15 years
E	1–3	N	NA	NA	NA
E	1–3	NNE	NA	NA	NA
E	1–3	NE	NA	NA	NA
E	1–3	ENE	NA	NA	NA
E	1–3	E	NA	NA	NA
E	1–3	ESE	NA	NA	NA
E	1–3	SE	NA	NA	NA
E	1–3	SSE	NA	NA	NA
E	1–3	S	NA	NA	NA
E	1–3	SSW	NA	NA	NA
E	1–3	SW	NA	NA	NA
E	1–3	WSW	NA	NA	NA
E	1–3	W	NA	NA	NA
E	1–3	WNW	NA	NA	NA
E	1–3	NW	NA	NA	NA
E	1–3	NNW	NA	NA	NA
E	4–7	N	0.16%	0.19%	-0.03
E	4–7	NNE	0.09%	0.09%	0.00
E	4–7	NE	0.07%	0.02%	0.05
E	4–7	ENE	0.10%	0.08%	0.02
E	4–7	E	0.28%	0.20%	0.08
E	4–7	ESE	0.18%	0.12%	0.06
E	4–7	SE	0.08%	0.14%	-0.05
E	4–7	SSE	0.05%	0.08%	-0.03
E	4–7	S	0.06%	0.08%	-0.02
E	4–7	SSW	0.03%	0.01%	0.02
E	4–7	SW	0.03%	0.02%	0.01
E	4–7	WSW	0.02%	0.02%	0.00
E	4–7	W	0.13%	0.11%	0.02
E	4–7	WNW	0.30%	0.36%	-0.06
E	4–7	NW	0.34%	0.36%	-0.03
E	4–7	NNW	0.17%	0.16%	0.01
E	8–12	N	0.43%	0.24%	0.20
E	8–12	NNE	0.33%	0.36%	-0.04
E	8–12	NE	0.30%	0.18%	0.12
E	8–12	ENE	0.43%	0.32%	0.12
E	8–12	E	2.30%	2.22%	0.07
E	8–12	ESE	2.25%	2.68%	-0.44
E	8–12	SE	0.58%	0.65%	-0.08

Table 8. Scottsbluff Wind Direction and Wind Speed Joint Frequency Distributions for Stability Class E					
Class	**Speed (mph)**	**Direction**	**15 years (X-axis)**	**1 year (Y-axis)**	**Diff* 1 year vs. 15 years**
E	**8–12**	**SSE**	0.21%	0.15%	0.07
E	**8–12**	**S**	0.16%	0.17%	-0.01
E	**8–12**	**SSW**	0.11%	0.14%	-0.02
E	**8–12**	**SW**	0.07%	0.05%	0.02
E	**8–12**	**WSW**	0.07%	0.06%	0.02
E	**8–12**	**W**	0.67%	0.70%	-0.03
E	**8–12**	**WNW**	1.73%	1.68%	0.05
E	**8–12**	**NW**	1.88%	1.27%	0.60
E	**8–12**	**NNW**	0.66%	0.35%	0.31
E	**13–18**	**N**	NA	NA	NA
E	**13–18**	**NNE**	NA	NA	NA
E	**13–18**	**NE**	NA	NA	NA
E	**13–18**	**ENE**	NA	NA	NA
E	**13–18**	**E**	NA	NA	NA
E	**13–18**	**ESE**	NA	NA	NA
E	**13–18**	**SE**	NA	NA	NA
E	**13–18**	**SSE**	NA	NA	NA
E	**13–18**	**S**	NA	NA	NA
E	**13–18**	**SSW**	NA	NA	NA
E	**13–18**	**SW**	NA	NA	NA
E	**13–18**	**WSW**	NA	NA	NA
E	**13–18**	**W**	NA	NA	NA
E	**13–18**	**WNW**	NA	NA	NA
E	**13–18**	**NW**	NA	NA	NA
E	**13–18**	**NNW**	NA	NA	NA
E	**19–24**	**N**	NA	NA	NA
E	**19–24**	**NNE**	NA	NA	NA
E	**19–24**	**NE**	NA	NA	NA
E	**19–24**	**ENE**	NA	NA	NA
E	**19–24**	**E**	NA	NA	NA
E	**19–24**	**ESE**	NA	NA	NA
E	**19–24**	**SE**	NA	NA	NA
E	**19–24**	**SSE**	NA	NA	NA
E	**19–24**	**S**	NA	NA	NA
E	**19–24**	**SSW**	NA	NA	NA
E	**19–24**	**SW**	NA	NA	NA
E	**19–24**	**WSW**	NA	NA	NA
E	**19–24**	**W**	NA	NA	NA
E	**19–24**	**WNW**	NA	NA	NA
E	**19–24**	**NW**	NA	NA	NA
E	**19–24**	**NNW**	NA	NA	NA
E	**>24**	**N**	NA	NA	NA
E	**>24**	**NNE**	NA	NA	NA
E	**>24**	**NE**	NA	NA	NA

Table 8. Scottsbluff Wind Direction and Wind Speed Joint Frequency Distributions for Stability Class E					
Class	**Speed (mph)**	**Direction**	**15 years (X-axis)**	**1 year (Y-axis)**	**Diff* 1 year vs. 15 years**
E	**>24**	**ENE**	NA	NA	NA
E	**>24**	**E**	NA	NA	NA
E	**>24**	**ESE**	NA	NA	NA
E	**>24**	**SE**	NA	NA	NA
E	**>24**	**SSE**	NA	NA	NA
E	**>24**	**S**	NA	NA	NA
E	**>24**	**SSW**	NA	NA	NA
E	**>24**	**SW**	NA	NA	NA
E	**>24**	**WSW**	NA	NA	NA
E	**>24**	**W**	NA	NA	NA
E	**>24**	**WNW**	NA	NA	NA
E	**>24**	**NW**	NA	NA	NA
E	**>24**	**NNW**	NA	NA	NA

*Where 'diff' is the difference in percentage points (pp) calculated between the long- and short-term frequencies. The actual numbers used for the percent point calculations include greater than three significant figures. Therefore, the calculated difference as shown in this table may vary slightly due to rounding.

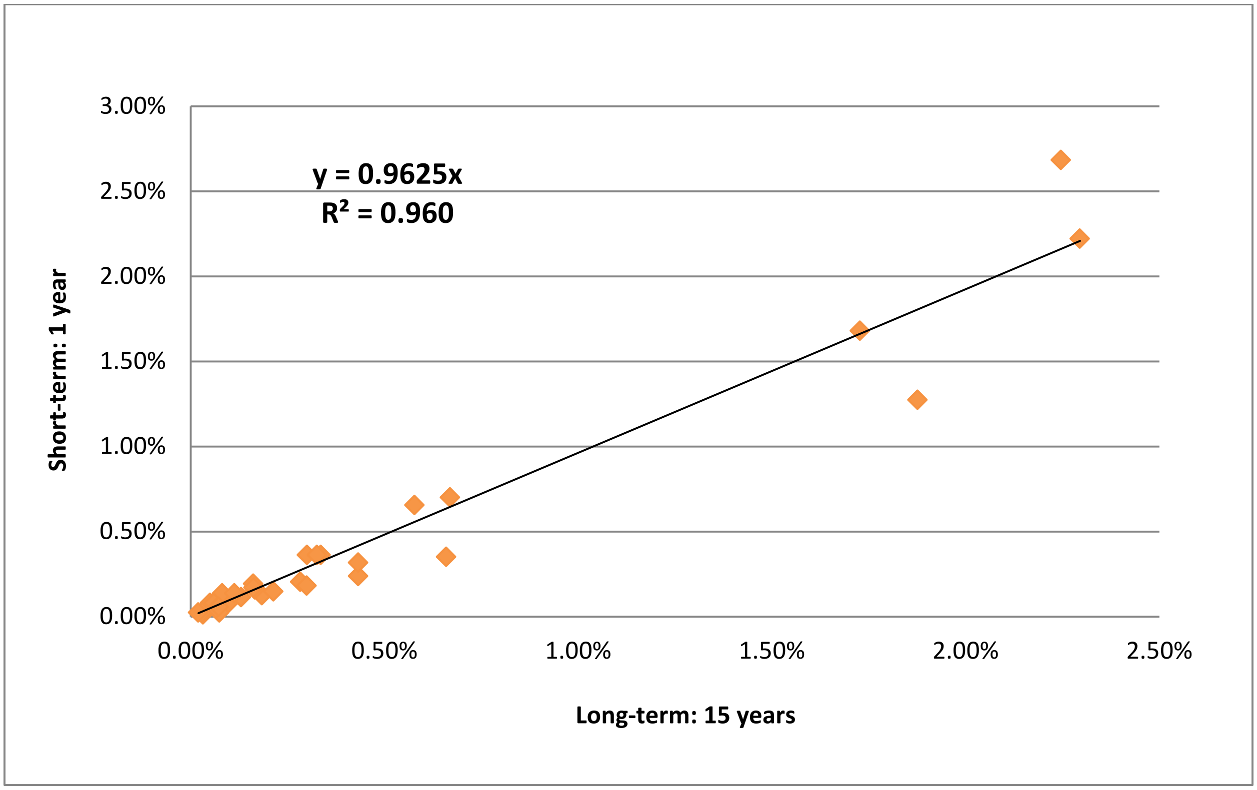

Figure 10. Class E Joint Frequency Distribution: Scottsbluff 1 year vs. 15 years

Class F occurs during wind speed categories 1–3 and 4–7 mph, and the linear regression plot only includes those data points. The values for the other wind speed categories are captured as "zeros" in the STAR program; however, these should not be considered as actual values and are excluded from the linear regression analysis. Therefore, the linear regression includes 32 observations which consider two wind speed categories.

Table 9. Scottsbluff Wind Direction and Wind Speed Joint Frequency Distributions for Stability Class F

Class	Speed (mph)	Direction	15 years (X-axis)	1 year (Y-axis)	Diff* 1 year vs. 15 years
F	1–3	N	1.01%	0.92%	0.09
F	1–3	NNE	0.54%	0.43%	0.10
F	1–3	NE	0.54%	0.51%	0.03
F	1–3	ENE	0.65%	0.61%	0.04
F	1–3	E	1.58%	1.49%	0.09
F	1–3	ESE	0.83%	0.93%	-0.10
F	1–3	SE	0.35%	0.42%	-0.07
F	1–3	SSE	0.23%	0.31%	-0.08
F	1–3	S	0.29%	0.25%	0.03
F	1–3	SSW	0.14%	0.06%	0.08
F	1–3	SW	0.11%	0.09%	0.02
F	1–3	WSW	0.15%	0.12%	0.02
F	1–3	W	0.46%	0.59%	-0.13
F	1–3	WNW	0.81%	0.85%	-0.04
F	1–3	NW	1.21%	1.22%	-0.02
F	1–3	NNW	1.00%	0.79%	0.21
F	4–7	N	1.27%	0.94%	0.33
F	4–7	NNE	0.64%	0.56%	0.07
F	4–7	NE	0.64%	0.71%	-0.07
F	4–7	ENE	0.86%	0.68%	0.19
F	4–7	E	3.08%	3.01%	0.07
F	4–7	ESE	1.53%	1.97%	-0.44
F	4–7	SE	0.50%	0.68%	-0.17
F	4–7	SSE	0.31%	0.36%	-0.05
F	4–7	S	0.32%	0.36%	-0.04
F	4–7	SSW	0.17%	0.10%	0.07
F	4–7	SW	0.11%	0.17%	-0.06
F	4–7	WSW	0.13%	0.14%	0.00
F	4–7	W	0.64%	0.69%	-0.05
F	4–7	WNW	1.45%	1.78%	-0.34
F	4–7	NW	2.19%	2.49%	-0.30
F	4–7	NNW	1.55%	1.17%	0.37
F	8–12	N	NA	NA	NA
F	8–12	NNE	NA	NA	NA
F	8–12	NE	NA	NA	NA
F	8–12	ENE	NA	NA	NA

Table 9. Scottsbluff Wind Direction and Wind Speed Joint Frequency Distributions for Stability Class F					
Class	Speed (mph)	Direction	15 years (X-axis)	1 year (Y-axis)	Diff* 1 year vs. 15 years
F	**8–12**	**E**	NA	NA	NA
F	**8–12**	**ESE**	NA	NA	NA
F	**8–12**	**SE**	NA	NA	NA
F	**8–12**	**SSE**	NA	NA	NA
F	**8–12**	**S**	NA	NA	NA
F	**8–12**	**SSW**	NA	NA	NA
F	**8–12**	**SW**	NA	NA	NA
F	**8–12**	**WSW**	NA	NA	NA
F	**8–12**	**W**	NA	NA	NA
F	**8–12**	**WNW**	NA	NA	NA
F	**8–12**	**NW**	NA	NA	NA
F	**8–12**	**NNW**	NA	NA	NA
F	**13–18**	**N**	NA	NA	NA
F	**13–18**	**NNE**	NA	NA	NA
F	**13–18**	**NE**	NA	NA	NA
F	**13–18**	**ENE**	NA	NA	NA
F	**13–18**	**E**	NA	NA	NA
F	**13–18**	**ESE**	NA	NA	NA
F	**13–18**	**SE**	NA	NA	NA
F	**13–18**	**SSE**	NA	NA	NA
F	**13–18**	**S**	NA	NA	NA
F	**13–18**	**SSW**	NA	NA	NA
F	**13–18**	**SW**	NA	NA	NA
F	**13–18**	**WSW**	NA	NA	NA
F	**13–18**	**W**	NA	NA	NA
F	**13–18**	**WNW**	NA	NA	NA
F	**13–18**	**NW**	NA	NA	NA
F	**13–18**	**NNW**	NA	NA	NA
F	**19–24**	**N**	NA	NA	NA
F	**19–24**	**NNE**	NA	NA	NA
F	**19–24**	**NE**	NA	NA	NA
F	**19–24**	**ENE**	NA	NA	NA
F	**19–24**	**E**	NA	NA	NA
F	**19–24**	**ESE**	NA	NA	NA
F	**19–24**	**SE**	NA	NA	NA
F	**19–24**	**SSE**	NA	NA	NA
F	**19–24**	**S**	NA	NA	NA
F	**19–24**	**SSW**	NA	NA	NA
F	**19–24**	**SW**	NA	NA	NA
F	**19–24**	**WSW**	NA	NA	NA
F	**19–24**	**W**	NA	NA	NA
F	**19–24**	**WNW**	NA	NA	NA
F	**19–24**	**NW**	NA	NA	NA
F	**19–24**	**NNW**	NA	NA	NA

Table 9. Scottsbluff Wind Direction and Wind Speed Joint Frequency Distributions for Stability Class F					
Class	**Speed (mph)**	**Direction**	**15 years (X-axis)**	**1 year (Y-axis)**	**Diff* 1 year vs. 15 years**
F	**>24**	**N**	NA	NA	NA
F	**>24**	**NNE**	NA	NA	NA
F	**>24**	**NE**	NA	NA	NA
F	**>24**	**ENE**	NA	NA	NA
F	**>24**	**E**	NA	NA	NA
F	**>24**	**ESE**	NA	NA	NA
F	**>24**	**SE**	NA	NA	NA
F	**>24**	**SSE**	NA	NA	NA
F	**>24**	**S**	NA	NA	NA
F	**>24**	**SSW**	NA	NA	NA
F	**>24**	**SW**	NA	NA	NA
F	**>24**	**WSW**	NA	NA	NA
F	**>24**	**W**	NA	NA	NA
F	**>24**	**WNW**	NA	NA	NA
F	**>24**	**NW**	NA	NA	NA
F	**>24**	**NNW**	NA	NA	NA

*Where 'diff' is the difference in percentage points calculated between the long- and short-term frequencies. The actual numbers used for the percent point calculations include greater than three significant figures. Therefore, the calculated difference as shown in this table may vary slightly due to rounding.

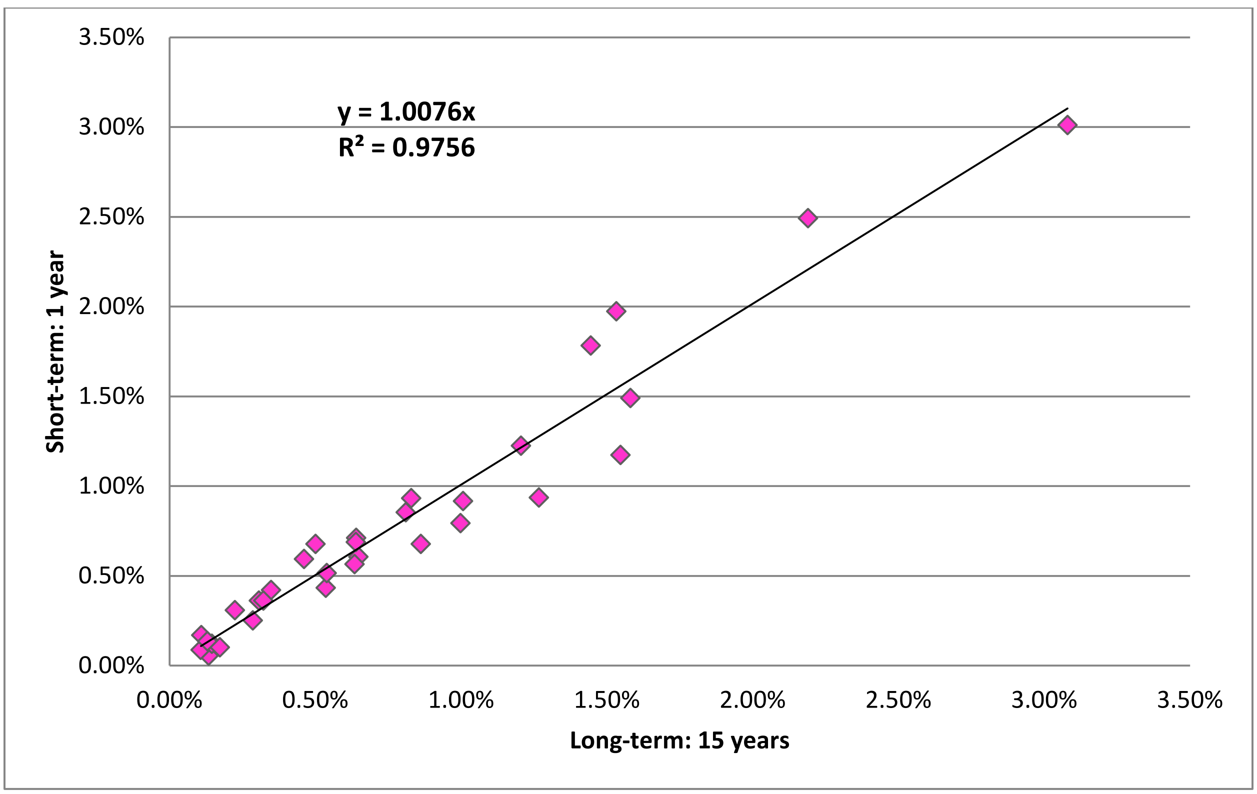

Figure 11. Class F Joint Frequency Distribution: Scottsbluff 1 year vs. 15 years

2. INTRA-SITE COMPARISON: GILLETTE 1 YEAR VS. 15 YEARS

2.1. GILLETTE WIND DIRECTION RELATIVE FREQUENCY DISTRIBUTION

Table 10 contains the Gillette wind direction relative frequency distribution data used to create the wind direction frequency bar chart and regression in Figures 12 and 13.

Table 10. Gillette Wind Direction Relative Frequency Distribution			
Direction	**15 year**	**1 year**	**Diff* 1 year vs. 15 years**
N	7.92%	6.72%	1.20
NNE	2.66%	2.37%	0.29
NE	1.78%	2.06%	-0.28
ENE	1.29%	1.47%	-0.18
E	2.05%	1.71%	0.34
ESE	2.13%	1.49%	0.65
SE	4.22%	2.99%	1.23
SSE	7.68%	8.73%	-1.05
S	13.08%	12.75%	0.33
SSW	5.11%	5.12%	-0.01
SW	8.60%	8.37%	0.23
WSW	5.62%	4.86%	0.76
W	7.83%	8.47%	-0.64
WNW	5.66%	6.35%	-0.68
NW	8.23%	8.08%	0.15
NNW	7.55%	6.98%	0.58
Calms	8.59%	11.49%	-2.89

* Where 'diff' is the difference in percentage points (pp) calculated between the long- and short-term frequencies. The actual numbers used for the percent point calculations include greater than three significant figures. Therefore, the calculated difference as shown in this table may vary slightly due to rounding.

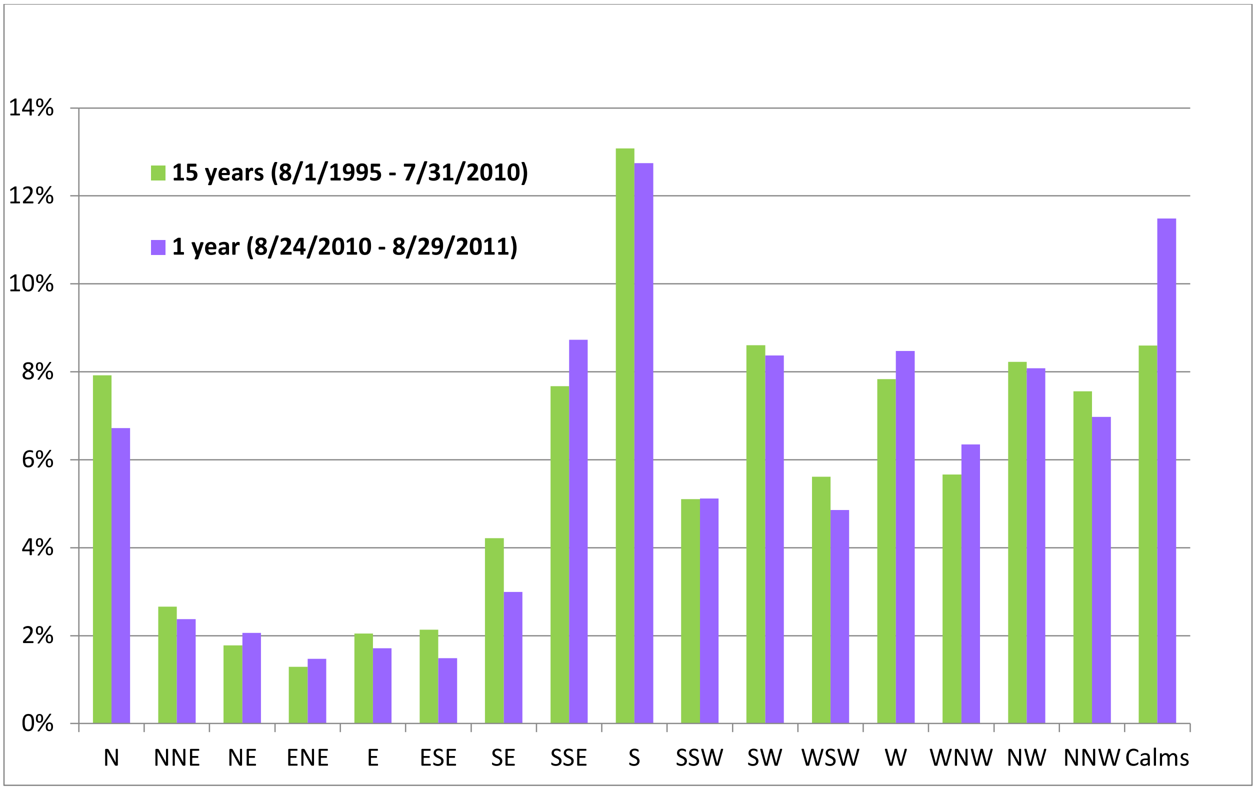

Figure 12. Gillette Wind Direction Relative Frequency Distribution

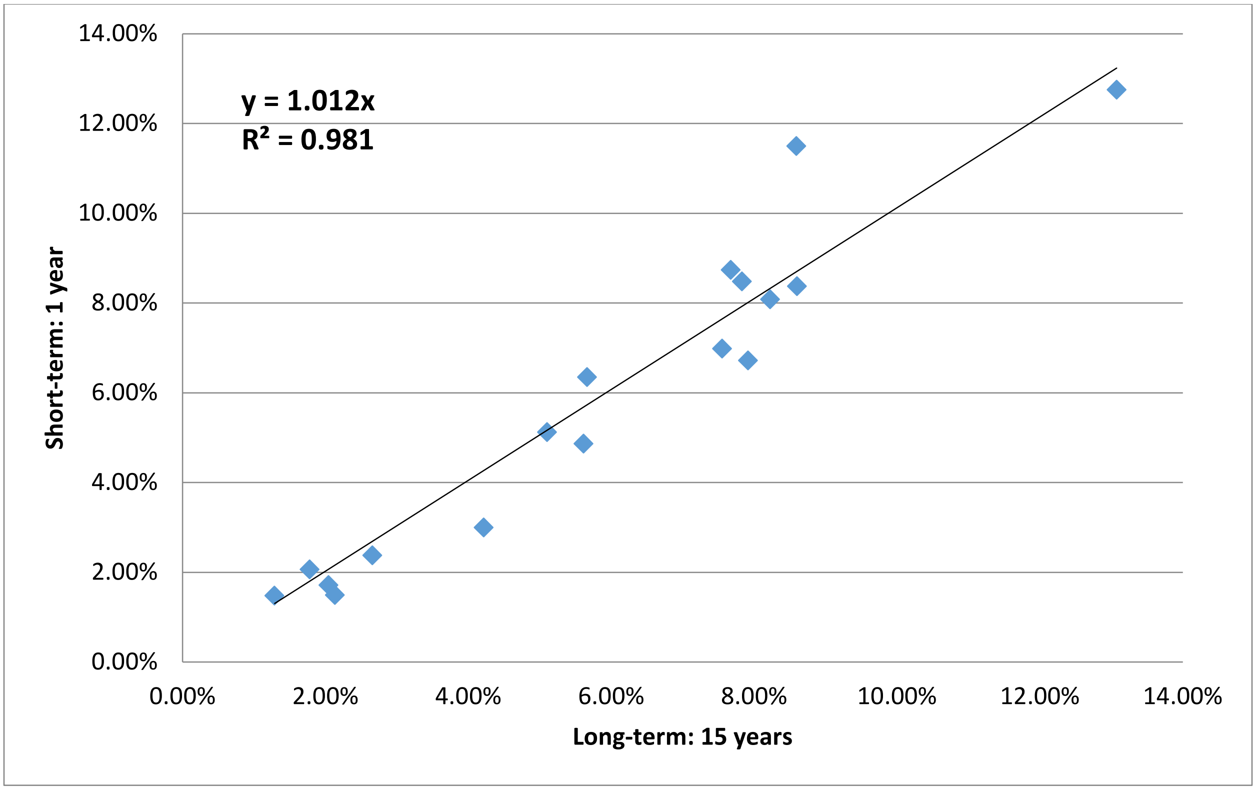

Figure 13. Wind Direction Relative Frequency Distribution: Gillette 1 year vs. 15 years

2.2. GILLETTE WIND SPEED RELATIVE FREQUENCY DISTRIBUTION

Table 11 contains the Gillette wind speed relative frequency distribution data used to create the wind direction relative frequency bar chart and regression in Figures 14 and 15.

Table 11. Gillette Wind Speed Relative Frequency Distribution

Speed (mph)	15 years (X-axis)	1 year (Y-axis)	Diff* 1 year vs. 15 years
1–3	7.21%	5.99%	1.22
4–7	26.15%	25.90%	0.25
8–12	30.86%	30.02%	0.85
13–18	19.75%	18.58%	1.16
19–24	5.93%	6.34%	-0.41
> 24	1.50%	1.69%	-0.19
Calms	8.59%	11.48%	-2.88

* Where 'diff' is the difference in percentage points (pp) calculated between the long- and short-term frequencies.

The actual numbers used for the percent point calculations include greater than three significant figures. Therefore, the calculated difference as shown in this table may vary slightly due to rounding.

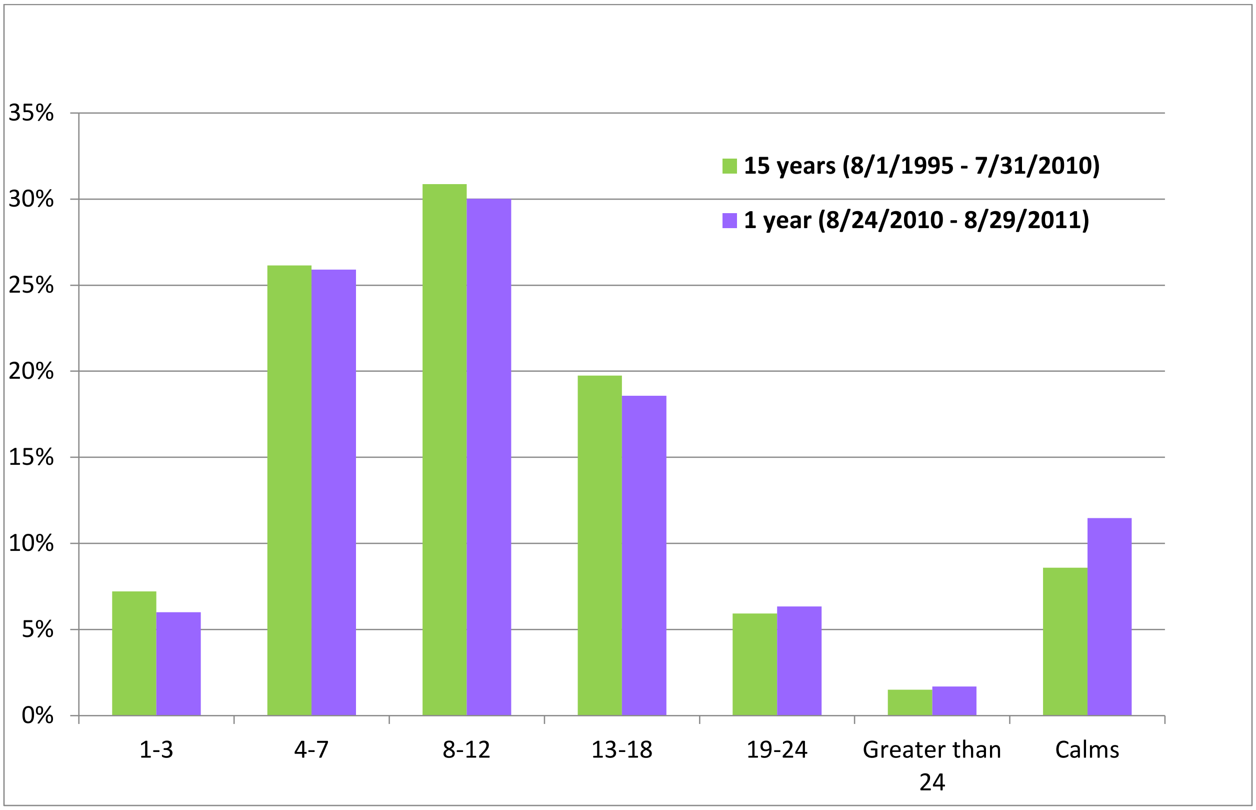

Figure 14. Gillette Wind Speed Relative Frequency Distribution

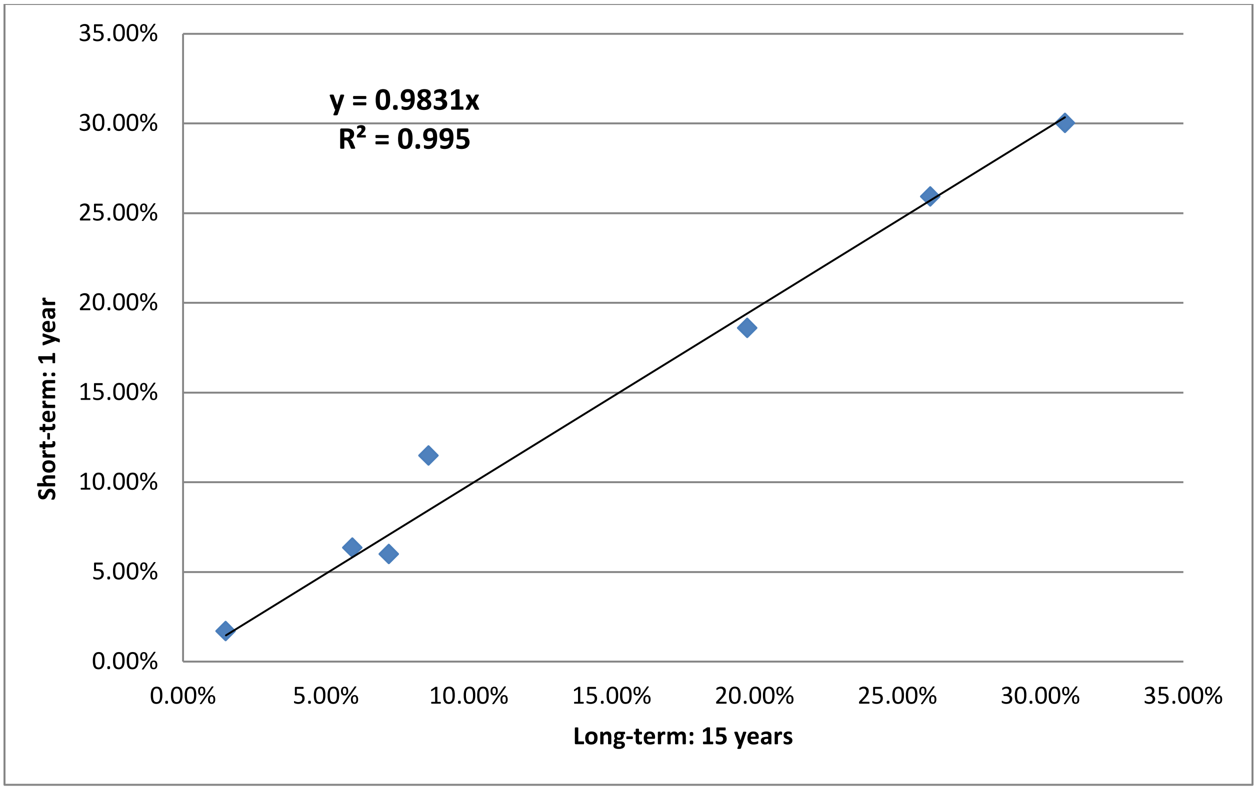

Figure 15. Wind Speed Relative Frequency Distribution: Gillette 1 year vs. 15 years

2.3. ALL STABILITY CLASSES WIND DIRECTION AND WIND SPEED JOINT FREQUENCY DISTRIBUTION FOR GILLETTE AIRPORT

Table 12 contains the Gillette wind direction and wind speed JFDs data used to create the wind direction and wind speed JFD regression for all classes in Figure 16. Table 12 contains 96 data points for each dataset (i.e., short-term and long-term).

Table 12. Gillette Wind Direction and Wind Speed Joint Frequency Distributions for All Stability Classes Summed

Class*	Speed (mph)	Direction	15 years (X-axis)	1 year (Y-axis)	Diff** 1 year vs. 15 years
A–F	1–3	N	1.14%	0.83%	0.31
A–F	1–3	NNE	0.58%	0.55%	0.03
A–F	1–3	NE	0.52%	0.67%	-0.15
A–F	1–3	ENE	0.46%	0.48%	-0.02
A–F	1–3	E	0.80%	0.68%	0.12
A–F	1–3	ESE	0.65%	0.46%	0.20

Table 12. Gillette Wind Direction and Wind Speed Joint Frequency Distributions for All Stability Classes Summed

Class*	Speed (mph)	Direction	15 years (X-axis)	1 year (Y-axis)	Diff** 1 year vs. 15 years
A–F	1–3	SE	0.83%	0.90%	-0.07
A–F	1–3	SSE	1.26%	1.40%	-0.14
A–F	1–3	S	2.65%	3.24%	-0.59
A–F	1–3	SSW	1.37%	1.81%	-0.44
A–F	1–3	SW	1.23%	1.51%	-0.28
A–F	1–3	WSW	1.02%	1.03%	-0.01
A–F	1–3	W	1.28%	1.48%	-0.20
A–F	1–3	WNW	0.68%	0.66%	0.02
A–F	1–3	NW	0.74%	0.72%	0.02
A–F	1–3	NNW	0.83%	1.13%	-0.30
A–F	4–7	N	1.71%	1.44%	0.27
A–F	4–7	NNE	0.75%	0.76%	-0.01
A–F	4–7	NE	0.63%	0.87%	-0.24
A–F	4–7	ENE	0.55%	0.54%	0.01
A–F	4–7	E	0.88%	0.89%	-0.01
A–F	4–7	ESE	0.75%	0.79%	-0.04
A–F	4–7	SE	0.95%	0.83%	0.12
A–F	4–7	SSE	1.47%	1.75%	-0.28
A–F	4–7	S	2.86%	3.10%	-0.24
A–F	4–7	SSW	1.19%	0.96%	0.23
A–F	4–7	SW	1.13%	0.98%	0.15
A–F	4–7	WSW	1.07%	0.96%	0.11
A–F	4–7	W	1.80%	1.67%	0.13
A–F	4–7	WNW	0.97%	1.13%	-0.16
A–F	4–7	NW	1.14%	1.13%	0.00
A–F	4–7	NNW	1.23%	1.20%	0.04
A–F	8–12	N	2.47%	2.28%	0.19
A–F	8–12	NNE	0.93%	0.84%	0.09
A–F	8–12	NE	0.64%	0.78%	-0.13
A–F	8–12	ENE	0.38%	0.56%	-0.18
A–F	8–12	E	0.61%	0.47%	0.14
A–F	8–12	ESE	0.62%	0.36%	0.26
A–F	8–12	SE	1.27%	0.97%	0.30
A–F	8–12	SSE	2.14%	2.46%	-0.32
A–F	8–12	S	3.78%	3.81%	-0.02

Table 12. Gillette Wind Direction and Wind Speed Joint Frequency Distributions for All Stability Classes Summed					
Class*	**Speed (mph)**	**Direction**	**15 years (X-axis)**	**1 year (Y-axis)**	**Diff** 1 year vs. 15 years**
A–F	**8–12**	**SSW**	1.04%	0.94%	0.10
A–F	**8–12**	**SW**	1.79%	1.71%	0.08
A–F	**8–12**	**WSW**	1.95%	1.59%	0.36
A–F	**8–12**	**W**	3.66%	3.85%	-0.19
A–F	**8–12**	**WNW**	2.00%	2.08%	-0.08
A–F	**8–12**	**NW**	1.91%	1.80%	0.11
A–F	**8–12**	**NNW**	1.94%	1.76%	0.18
A–F	**13–18**	**N**	2.09%	1.81%	0.28
A–F	**13–18**	**NNE**	0.62%	0.68%	-0.05
A–F	**13–18**	**NE**	0.25%	0.23%	0.03
A–F	**13–18**	**ENE**	0.13%	0.18%	-0.05
A–F	**13–18**	**E**	0.16%	0.09%	0.07
A–F	**13–18**	**ESE**	0.32%	0.13%	0.20
A–F	**13–18**	**SE**	1.28%	0.65%	0.63
A–F	**13–18**	**SSE**	2.38%	2.83%	-0.44
A–F	**13–18**	**S**	4.13%	4.25%	-0.13
A–F	**13–18**	**SSW**	1.53%	1.54%	-0.02
A–F	**13–18**	**SW**	3.06%	2.92%	0.14
A–F	**13–18**	**WSW**	1.61%	1.49%	0.12
A–F	**13–18**	**W**	1.55%	1.64%	-0.09
A–F	**13–18**	**WNW**	1.75%	1.58%	0.17
A–F	**13–18**	**NW**	2.70%	2.22%	0.49
A–F	**13–18**	**NNW**	2.51%	2.15%	0.36
A–F	**19–24**	**N**	0.43%	0.14%	0.29
A–F	**19–24**	**NNE**	0.08%	0.03%	0.06
A–F	**19–24**	**NE**	0.03%	0.00%	0.03
A–F	**19–24**	**ENE**	0.00%	0.00%	0.00
A–F	**19–24**	**E**	0.01%	0.00%	0.01
A–F	**19–24**	**ESE**	0.10%	0.04%	0.06
A–F	**19–24**	**SE**	0.34%	0.18%	0.16
A–F	**19–24**	**SSE**	0.90%	1.15%	-0.25
A–F	**19–24**	**S**	1.16%	1.25%	-0.09
A–F	**19–24**	**SSW**	0.61%	0.88%	-0.27
A–F	**19–24**	**SW**	1.44%	1.80%	-0.36
A–F	**19–24**	**WSW**	0.39%	0.39%	-0.01

Table 12. Gillette Wind Direction and Wind Speed Joint Frequency Distributions for All Stability Classes Summed

Class*	Speed (mph)	Direction	15 years (X-axis)	1 year (Y-axis)	Diff** 1 year vs. 15 years
A–F	19–24	W	0.18%	0.15%	0.03
A–F	19–24	WNW	0.39%	0.60%	-0.21
A–F	19–24	NW	1.31%	1.43%	-0.11
A–F	19–24	NNW	0.96%	0.92%	0.05
A–F	>24	N	0.08%	0.04%	0.04
A–F	>24	NNE	0.01%	0.00%	0.01
A–F	>24	NE	0.00%	0.00%	0.00
A–F	>24	ENE	0.00%	0.00%	0.00
A–F	>24	E	0.00%	0.00%	0.00
A–F	>24	ESE	0.03%	0.01%	0.02
A–F	>24	SE	0.09%	0.09%	0.00
A–F	>24	SSE	0.34%	0.51%	-0.17
A–F	>24	S	0.28%	0.33%	-0.05
A–F	>24	SSW	0.23%	0.43%	-0.20
A–F	>24	SW	0.82%	1.04%	-0.22
A–F	>24	WSW	0.14%	0.09%	0.06
A–F	>24	W	0.05%	0.04%	0.01
A–F	>24	WNW	0.16%	0.29%	-0.13
A–F	>24	NW	0.71%	0.83%	-0.12
A–F	>24	NNW	0.39%	0.22%	0.18

* The stability classes A–F were summed for each wind speed and wind direction. Calms were distributed by the STAR program within each stability class as described in Section 2.2.3 of the TBD.

** Where 'diff' is the difference in percentage points (pp) calculated between the long- and short-term frequencies. The actual numbers used for the percent point calculations include greater than three significant figures. Therefore, the calculated difference as shown in this table may vary slightly due to rounding.

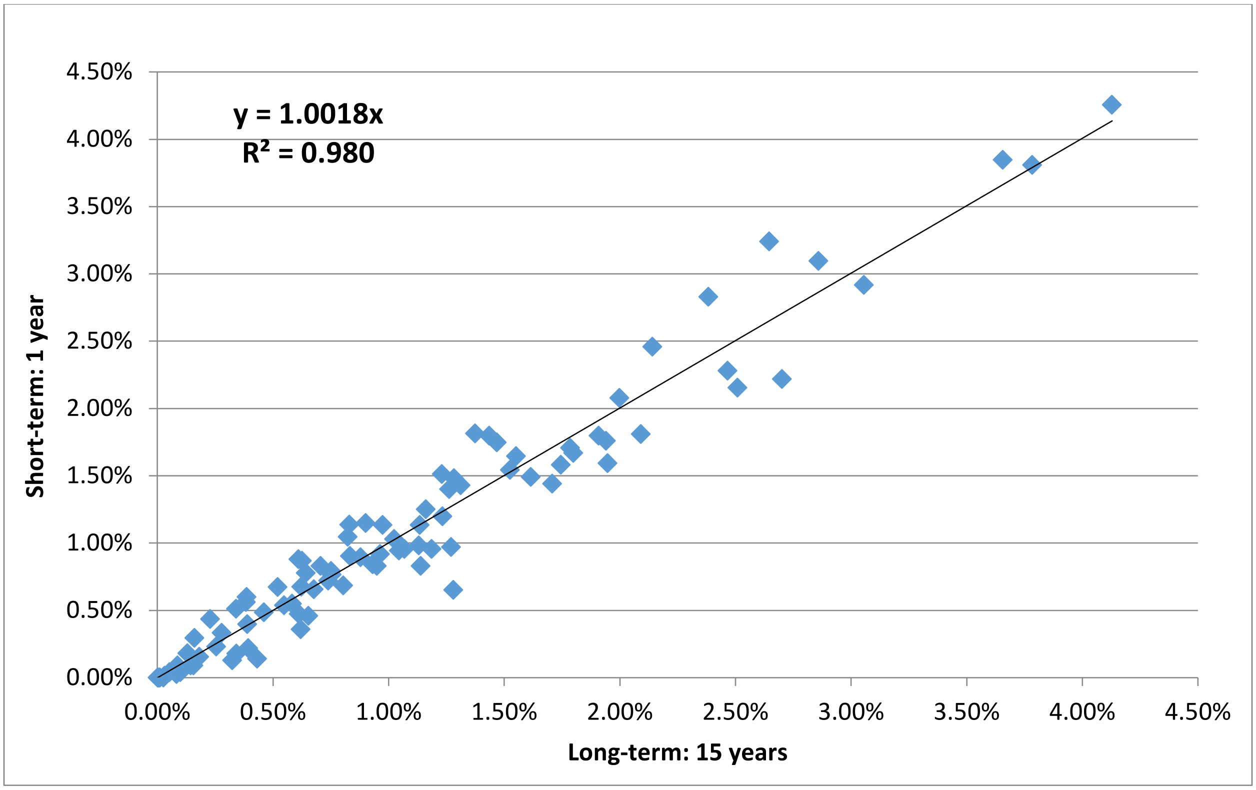

Figure 16. Wind Direction and Wind Speed Joint Frequency Distribution for All Stability Classes: Gillette 1 year vs. 15 years

2.4. Wind Direction and Wind Speed Joint Frequency Distributions by Atmospheric Stability Class for Gillette Airport

Tables 13–18 contain the Gillette wind direction and wind speed JFDs data used to create the wind direction and wind speed JFD regression for Classes A, B, C, D, E, and F depicted in Figures 17–22 respectively.

Class A occurs during the first two wind speed categories (i.e., 1–3 and 4–7 mph) and the linear regression plot only includes those data points. The values for the other wind speed categories are captured as "zeros" in the STAR program; however, these should not be considered as actual values and are excluded from the linear regression analysis. Therefore, the linear regression includes 32 observations which consider two wind speed categories. The other wind categories do not occur thus "NA" (non-applicable) was included for these in the following table.

Table 13. Gillette Wind Direction and Wind Speed Joint Frequency Distributions for Stability Class A

Class	Speed (mph)	Direction	15 years (X-axis)	1 year (Y-axis)	Diff* 1 year vs. 15 years (pp)
A	1–3	N	0.09%	0.09%	-0.01
A	1–3	NNE	0.05%	0.13%	-0.08
A	1–3	NE	0.05%	0.08%	-0.04
A	1–3	ENE	0.04%	0.00%	0.04
A	1–3	E	0.06%	0.05%	0.01
A	1–3	ESE	0.03%	0.02%	0.00
A	1–3	SE	0.03%	0.02%	0.00
A	1–3	SSE	0.05%	0.05%	0.00
A	1–3	S	0.04%	0.11%	-0.06
A	1–3	SSW	0.03%	0.11%	-0.07
A	1–3	SW	0.02%	0.11%	-0.09
A	1–3	WSW	0.03%	0.08%	-0.05
A	1–3	W	0.07%	0.07%	0.00
A	1–3	WNW	0.03%	0.07%	-0.04
A	1–3	NW	0.04%	0.00%	0.04
A	1–3	NNW	0.05%	0.10%	-0.05
A	4–7	N	0.06%	0.05%	0.01
A	4–7	NNE	0.03%	0.05%	-0.02
A	4–7	NE	0.02%	0.03%	-0.01
A	4–7	ENE	0.03%	0.00%	0.03
A	4–7	E	0.04%	0.03%	0.01
A	4–7	ESE	0.02%	0.01%	0.00
A	4–7	SE	0.02%	0.01%	0.00
A	4–7	SSE	0.03%	0.03%	0.00
A	4–7	S	0.02%	0.04%	-0.02
A	4–7	SSW	0.02%	0.04%	-0.02
A	4–7	SW	0.01%	0.04%	-0.03
A	4–7	WSW	0.02%	0.03%	-0.01
A	4–7	W	0.03%	0.00%	0.03
A	4–7	WNW	0.01%	0.04%	-0.02
A	4–7	NW	0.03%	0.00%	0.03
A	4–7	NNW	0.03%	0.01%	0.01
A	8–12	N	NA	NA	NA
A	8–12	NNE	NA	NA	NA
A	8–12	NE	NA	NA	NA

Table 13. Gillette Wind Direction and Wind Speed Joint Frequency Distributions for Stability Class A

Class	Speed (mph)	Direction	15 years (X-axis)	1 year (Y-axis)	Diff* 1 year vs. 15 years (pp)
A	8–12	ENE	NA	NA	NA
A	8–12	E	NA	NA	NA
A	8–12	ESE	NA	NA	NA
A	8–12	SE	NA	NA	NA
A	8–12	SSE	NA	NA	NA
A	8–12	S	NA	NA	NA
A	8–12	SSW	NA	NA	NA
A	8–12	SW	NA	NA	NA
A	8–12	WSW	NA	NA	NA
A	8–12	W	NA	NA	NA
A	8–12	WNW	NA	NA	NA
A	8–12	NW	NA	NA	NA
A	8–12	NNW	NA	NA	NA
A	13–18	N	NA	NA	NA
A	13–18	NNE	NA	NA	NA
A	13–18	NE	NA	NA	NA
A	13–18	ENE	NA	NA	NA
A	13–18	E	NA	NA	NA
A	13–18	ESE	NA	NA	NA
A	13–18	SE	NA	NA	NA
A	13–18	SSE	NA	NA	NA
A	13–18	S	NA	NA	NA
A	13–18	SSW	NA	NA	NA
A	13–18	SW	NA	NA	NA
A	13–18	WSW	NA	NA	NA
A	13–18	W	NA	NA	NA
A	13–18	WNW	NA	NA	NA
A	13–18	NW	NA	NA	NA
A	13–18	NNW	NA	NA	NA
A	19–24	N	NA	NA	NA
A	19–24	NNE	NA	NA	NA
A	19–24	NE	NA	NA	NA
A	19–24	ENE	NA	NA	NA
A	19–24	E	NA	NA	NA
A	19–24	ESE	NA	NA	NA

Table 13. Gillette Wind Direction and Wind Speed Joint Frequency Distributions for Stability Class A					
Class	Speed (mph)	Direction	15 years (X-axis)	1 year (Y-axis)	Diff* 1 year vs. 15 years (pp)
A	19–24	SE	NA	NA	NA
A	19–24	SSE	NA	NA	NA
A	19–24	S	NA	NA	NA
A	19–24	SSW	NA	NA	NA
A	19–24	SW	NA	NA	NA
A	19–24	WSW	NA	NA	NA
A	19–24	W	NA	NA	NA
A	19–24	WNW	NA	NA	NA
A	19–24	NW	NA	NA	NA
A	19–24	NNW	NA	NA	NA
A	>24	N	NA	NA	NA
A	>24	NNE	NA	NA	NA
A	>24	NE	NA	NA	NA
A	>24	ENE	NA	NA	NA
A	>24	E	NA	NA	NA
A	>24	ESE	NA	NA	NA
A	>24	SE	NA	NA	NA
A	>24	SSE	NA	NA	NA
A	>24	S	NA	NA	NA
A	>24	SSW	NA	NA	NA
A	>24	SW	NA	NA	NA
A	>24	WSW	NA	NA	NA
A	>24	W	NA	NA	NA
A	>24	WNW	NA	NA	NA
A	>24	NW	NA	NA	NA
A	>24	NNW	NA	NA	NA

* Where 'diff' is the difference in percentage points (pp) calculated between the long- and short-term frequencies. The actual numbers used for the percent point calculations include greater than three significant figures. Therefore, the calculated difference as shown in this table may vary slightly due to rounding.

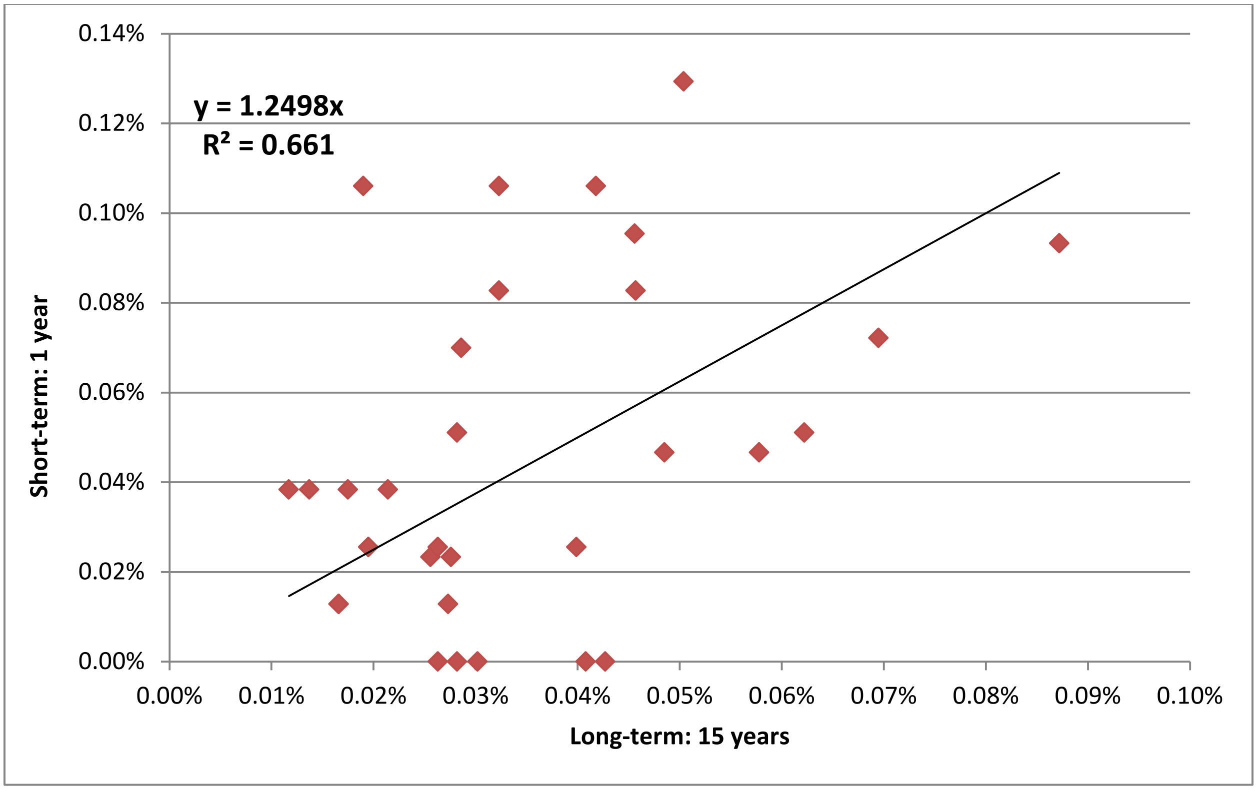

Figure 17. Class A Joint Frequency Distribution: Gillette 1 year vs. 15 years

Class B occurs during the first three wind speed categories (i.e., 1–3, 4–7, and 8–12 mph) and the linear regression plot only includes those data points. The values for the other wind speed categories are captured as "zeros" in the STAR program; however, these should not be considered as actual values and are excluded from the linear regression analysis. Therefore, the linear regression includes 48 observations which consider three wind speed categories. The other wind categories do not occur, thus "NA" (non-applicable) was included for these in the following table.

Table 14. Gillette Wind Direction and Wind Speed Joint Frequency Distributions for Stability Class B

Class	Speed (mph)	Direction	15 years (X-axis)	1 year (Y-axis)	Diff* 1 year vs. 15 years (pp)
B	**1–3**	**N**	0.22%	0.12%	0.10
B	**1–3**	**NNE**	0.16%	0.12%	0.04
B	**1–3**	**NE**	0.12%	0.22%	-0.10
B	**1–3**	**ENE**	0.11%	0.14%	-0.03
B	**1–3**	**E**	0.16%	0.15%	0.01
B	**1–3**	**ESE**	0.12%	0.13%	-0.01
B	**1–3**	**SE**	0.13%	0.20%	-0.07

Table 14. Gillette Wind Direction and Wind Speed Joint Frequency Distributions for Stability Class B					
Class	Speed (mph)	Direction	15 years (X-axis)	1 year (Y-axis)	Diff* 1 year vs. 15 years (pp)
B	1–3	SSE	0.12%	0.20%	-0.08
B	1–3	S	0.19%	0.16%	0.03
B	1–3	SSW	0.09%	0.13%	-0.04
B	1–3	SW	0.12%	0.07%	0.05
B	1–3	WSW	0.10%	0.10%	-0.01
B	1–3	W	0.16%	0.14%	0.02
B	1–3	WNW	0.11%	0.16%	-0.05
B	1–3	NW	0.11%	0.11%	0.01
B	1–3	NNW	0.12%	0.19%	-0.08
B	4–7	N	0.35%	0.32%	0.03
B	4–7	NNE	0.20%	0.18%	0.02
B	4–7	NE	0.14%	0.25%	-0.11
B	4–7	ENE	0.11%	0.14%	-0.03
B	4–7	E	0.17%	0.11%	0.06
B	4–7	ESE	0.12%	0.17%	-0.04
B	4–7	SE	0.15%	0.23%	-0.08
B	4–7	SSE	0.16%	0.19%	-0.03
B	4–7	S	0.20%	0.22%	-0.02
B	4–7	SSW	0.11%	0.18%	-0.07
B	4–7	SW	0.11%	0.09%	0.02
B	4–7	WSW	0.12%	0.08%	0.04
B	4–7	W	0.22%	0.14%	0.08
B	4–7	WNW	0.13%	0.22%	-0.08
B	4–7	NW	0.20%	0.14%	0.06
B	4–7	NNW	0.16%	0.17%	0.00
B	8–12	N	0.18%	0.18%	0.00
B	8–12	NNE	0.10%	0.08%	0.02
B	8–12	NE	0.07%	0.09%	-0.02
B	8–12	ENE	0.05%	0.05%	-0.01
B	8–12	E	0.09%	0.04%	0.05
B	8–12	ESE	0.06%	0.03%	0.03
B	8–12	SE	0.10%	0.08%	0.02
B	8–12	SSE	0.11%	0.09%	0.02
B	8–12	S	0.18%	0.28%	-0.10
B	8–12	SSW	0.07%	0.09%	-0.02

Table 14. Gillette Wind Direction and Wind Speed Joint Frequency Distributions for Stability Class B					
Class	**Speed (mph)**	**Direction**	**15 years (X-axis)**	**1 year (Y-axis)**	**Diff* 1 year vs. 15 years (pp)**
B	**8–12**	**SW**	0.07%	0.19%	-0.12
B	**8–12**	**WSW**	0.07%	0.14%	-0.07
B	**8–12**	**W**	0.09%	0.08%	0.01
B	**8–12**	**WNW**	0.10%	0.13%	-0.03
B	**8–12**	**NW**	0.12%	0.08%	0.04
B	**8–12**	**NNW**	0.12%	0.14%	-0.02
B	**13–18**	**N**	NA	NA	NA
B	**13–18**	**NNE**	NA	NA	NA
B	**13–18**	**NE**	NA	NA	NA
B	**13–18**	**ENE**	NA	NA	NA
B	**13–18**	**E**	NA	NA	NA
B	**13–18**	**ESE**	NA	NA	NA
B	**13–18**	**SE**	NA	NA	NA
B	**13–18**	**SSE**	NA	NA	NA
B	**13–18**	**S**	NA	NA	NA
B	**13–18**	**SSW**	NA	NA	NA
B	**13–18**	**SW**	NA	NA	NA
B	**13–18**	**WSW**	NA	NA	NA
B	**13–18**	**W**	NA	NA	NA
B	**13–18**	**WNW**	NA	NA	NA
B	**13–18**	**NW**	NA	NA	NA
B	**13–18**	**NNW**	NA	NA	NA
B	**19–24**	**N**	NA	NA	NA
B	**19–24**	**NNE**	NA	NA	NA
B	**19–24**	**NE**	NA	NA	NA
B	**19–24**	**ENE**	NA	NA	NA
B	**19–24**	**E**	NA	NA	NA
B	**19–24**	**ESE**	NA	NA	NA
B	**19–24**	**SE**	NA	NA	NA
B	**19–24**	**SSE**	NA	NA	NA
B	**19–24**	**S**	NA	NA	NA
B	**19–24**	**SSW**	NA	NA	NA
B	**19–24**	**SW**	NA	NA	NA
B	**19–24**	**WSW**	NA	NA	NA
B	**19–24**	**W**	NA	NA	NA

Class	Speed (mph)	Direction	15 years (X-axis)	1 year (Y-axis)	Diff* 1 year vs. 15 years (pp)
B	**19–24**	**WNW**	NA	NA	NA
B	**19–24**	**NW**	NA	NA	NA
B	**19–24**	**NNW**	NA	NA	NA
B	**>24**	**N**	NA	NA	NA
B	**>24**	**NNE**	NA	NA	NA
B	**>24**	**NE**	NA	NA	NA
B	**>24**	**ENE**	NA	NA	NA
B	**>24**	**E**	NA	NA	NA
B	**>24**	**ESE**	NA	NA	NA
B	**>24**	**SE**	NA	NA	NA
B	**>24**	**SSE**	NA	NA	NA
B	**>24**	**S**	NA	NA	NA
B	**>24**	**SSW**	NA	NA	NA
B	**>24**	**SW**	NA	NA	NA
B	**>24**	**WSW**	NA	NA	NA
B	**>24**	**W**	NA	NA	NA
B	**>24**	**WNW**	NA	NA	NA
B	**>24**	**NW**	NA	NA	NA
B	**>24**	**NNW**	NA	NA	NA

Table 14. Gillette Wind Direction and Wind Speed Joint Frequency Distributions for Stability Class B

* Where 'diff' is the difference in percentage points (pp) calculated between the long- and short-term frequencies. The actual numbers used for the percent point calculations include greater than three significant figures. Therefore, the calculated difference as shown in this table may vary slightly due to rounding.

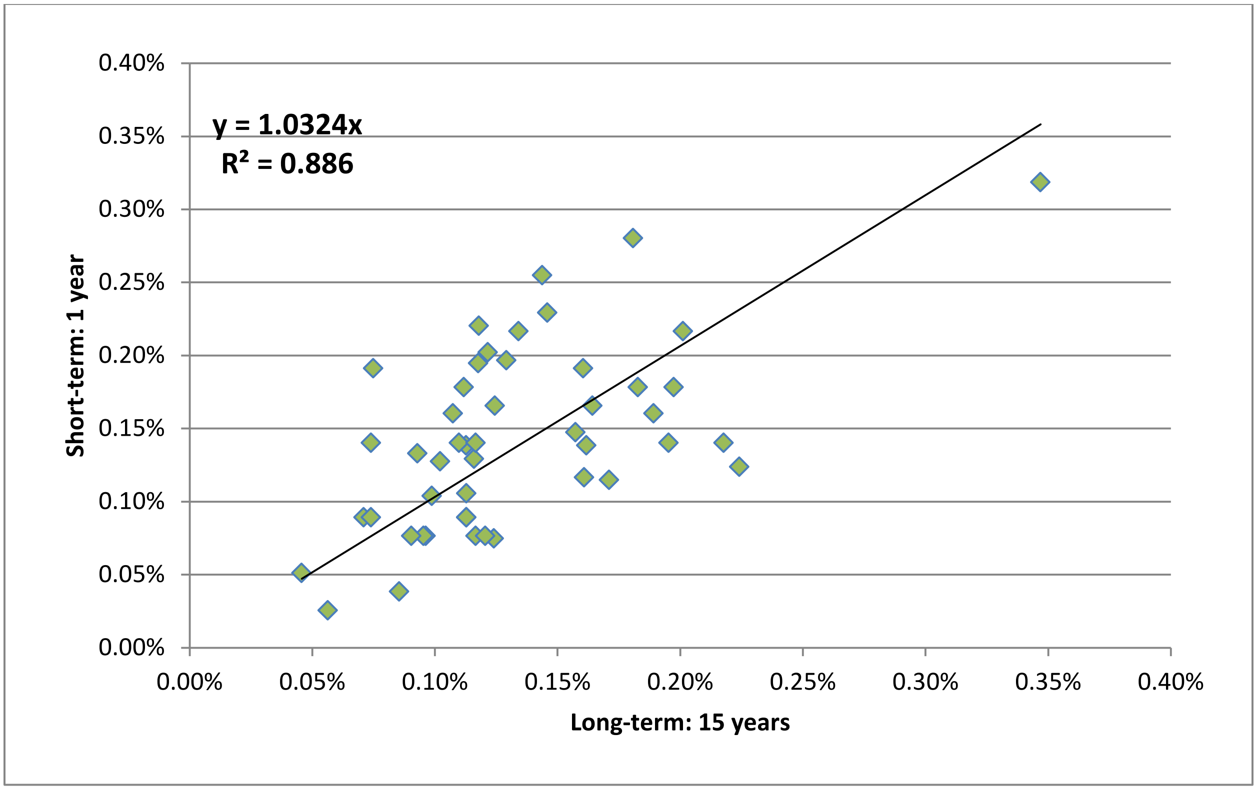

Figure 18. Class B Joint Frequency Distribution: Gillette 1 year vs. 15 years

Class C occurs for all wind speed categories and the linear regression includes those data points. Therefore, the linear regression includes 96 observations which consider all wind speed categories.

Table 15. Gillette Wind Direction and Wind Speed Joint Frequency Distributions for Stability Class C

Class	Speed (mph)	Direction	15 years (X-axis)	1 year (Y-axis)	Diff* 1 year vs. 15 years (pp)
C	1–3	N	0.08%	0.08%	0.01
C	1–3	NNE	0.05%	0.01%	0.03
C	1–3	NE	0.04%	0.04%	0.00
C	1–3	ENE	0.04%	0.04%	0.00
C	1–3	E	0.07%	0.04%	0.03
C	1–3	ESE	0.05%	0.04%	0.01
C	1–3	SE	0.05%	0.01%	0.03
C	1–3	SSE	0.07%	0.06%	0.00
C	1–3	S	0.11%	0.05%	0.06
C	1–3	SSW	0.05%	0.02%	0.04

Table 15. Gillette Wind Direction and Wind Speed Joint Frequency Distributions for Stability Class C

Class	Speed (mph)	Direction	15 years (X-axis)	1 year (Y-axis)	Diff* 1 year vs. 15 years (pp)
C	**1–3**	**SW**	0.06%	0.03%	0.02
C	**1–3**	**WSW**	0.06%	0.04%	0.02
C	**1–3**	**W**	0.08%	0.06%	0.02
C	**1–3**	**WNW**	0.05%	0.03%	0.02
C	**1–3**	**NW**	0.05%	0.04%	0.01
C	**1–3**	**NNW**	0.06%	0.03%	0.02
C	**4–7**	**N**	0.24%	0.25%	-0.02
C	**4–7**	**NNE**	0.14%	0.11%	0.02
C	**4–7**	**NE**	0.10%	0.11%	-0.02
C	**4–7**	**ENE**	0.08%	0.10%	-0.02
C	**4–7**	**E**	0.14%	0.20%	-0.07
C	**4–7**	**ESE**	0.13%	0.20%	-0.08
C	**4–7**	**SE**	0.12%	0.11%	0.01
C	**4–7**	**SSE**	0.19%	0.25%	-0.06
C	**4–7**	**S**	0.25%	0.25%	0.00
C	**4–7**	**SSW**	0.13%	0.13%	0.00
C	**4–7**	**SW**	0.17%	0.14%	0.03
C	**4–7**	**WSW**	0.18%	0.22%	-0.04
C	**4–7**	**W**	0.28%	0.25%	0.02
C	**4–7**	**WNW**	0.15%	0.22%	-0.06
C	**4–7**	**NW**	0.16%	0.23%	-0.07
C	**4–7**	**NNW**	0.14%	0.14%	0.00
C	**8–12**	**N**	0.69%	0.64%	0.05
C	**8–12**	**NNE**	0.27%	0.20%	0.06
C	**8–12**	**NE**	0.20%	0.20%	-0.01
C	**8–12**	**ENE**	0.13%	0.27%	-0.13
C	**8–12**	**E**	0.21%	0.13%	0.08
C	**8–12**	**ESE**	0.18%	0.11%	0.07
C	**8–12**	**SE**	0.27%	0.25%	0.02
C	**8–12**	**SSE**	0.47%	0.46%	0.01
C	**8–12**	**S**	0.70%	0.82%	-0.11
C	**8–12**	**SSW**	0.34%	0.34%	0.00
C	**8–12**	**SW**	0.43%	0.39%	0.04
C	**8–12**	**WSW**	0.42%	0.37%	0.05
C	**8–12**	**W**	0.54%	0.43%	0.11

Table 15. Gillette Wind Direction and Wind Speed Joint Frequency Distributions for Stability Class C					
Class	**Speed (mph)**	**Direction**	**15 years (X-axis)**	**1 year (Y-axis)**	**Diff* 1 year vs. 15 years (pp)**
C	**8–12**	**WNW**	0.43%	0.46%	-0.03
C	**8–12**	**NW**	0.43%	0.50%	-0.06
C	**8–12**	**NNW**	0.44%	0.33%	0.11
C	**13–18**	**N**	0.15%	0.17%	-0.02
C	**13–18**	**NNE**	0.07%	0.10%	-0.03
C	**13–18**	**NE**	0.03%	0.04%	-0.01
C	**13–18**	**ENE**	0.02%	0.01%	0.01
C	**13–18**	**E**	0.02%	0.00%	0.02
C	**13–18**	**ESE**	0.03%	0.00%	0.03
C	**13–18**	**SE**	0.11%	0.05%	0.06
C	**13–18**	**SSE**	0.15%	0.13%	0.03
C	**13–18**	**S**	0.19%	0.25%	-0.06
C	**13–18**	**SSW**	0.08%	0.05%	0.03
C	**13–18**	**SW**	0.07%	0.08%	-0.01
C	**13–18**	**WSW**	0.05%	0.04%	0.02
C	**13–18**	**W**	0.04%	0.06%	-0.02
C	**13–18**	**WNW**	0.08%	0.06%	0.02
C	**13–18**	**NW**	0.15%	0.08%	0.07
C	**13–18**	**NNW**	0.14%	0.08%	0.06
C	**19–24**	**N**	0.01%	0.00%	0.01
C	**19–24**	**NNE**	0.00%	0.00%	0.00
C	**19–24**	**NE**	0.00%	0.00%	0.00
C	**19–24**	**ENE**	0.00%	0.00%	0.00
C	**19–24**	**E**	0.00%	0.00%	0.00
C	**19–24**	**ESE**	0.00%	0.00%	0.00
C	**19–24**	**SE**	0.01%	0.00%	0.01
C	**19–24**	**SSE**	0.04%	0.03%	0.01
C	**19–24**	**S**	0.02%	0.03%	0.00
C	**19–24**	**SSW**	0.01%	0.00%	0.01
C	**19–24**	**SW**	0.01%	0.01%	0.00
C	**19–24**	**WSW**	0.00%	0.05%	-0.05
C	**19–24**	**W**	0.00%	0.00%	0.00
C	**19–24**	**WNW**	0.01%	0.00%	0.01
C	**19–24**	**NW**	0.03%	0.01%	0.02
C	**19–24**	**NNW**	0.03%	0.00%	0.03

Table 15. Gillette Wind Direction and Wind Speed Joint Frequency Distributions for Stability Class C

Class	Speed (mph)	Direction	15 years (X-axis)	1 year (Y-axis)	Diff* 1 year vs. 15 years (pp)
C	>24	N	0.00%	0.00%	0.00
C	>24	NNE	0.00%	0.00%	0.00
C	>24	NE	0.00%	0.00%	0.00
C	>24	ENE	0.00%	0.00%	0.00
C	>24	E	0.00%	0.00%	0.00
C	>24	ESE	0.00%	0.00%	0.00
C	>24	SE	0.01%	0.01%	-0.01
C	>24	SSE	0.01%	0.05%	-0.04
C	>24	S	0.00%	0.04%	-0.03
C	>24	SSW	0.00%	0.01%	-0.01
C	>24	SW	0.00%	0.08%	-0.07
C	>24	WSW	0.00%	0.00%	0.00
C	>24	W	0.00%	0.00%	0.00
C	>24	WNW	0.00%	0.00%	0.00
C	>24	NW	0.01%	0.01%	-0.01
C	>24	NNW	0.00%	0.00%	0.00

* Where 'diff' is the difference in percentage points (pp) calculated between the long- and short-term frequencies. The actual numbers used for the percent point calculations include greater than three significant figures. Therefore, the calculated difference as shown in this table may vary slightly due to rounding.

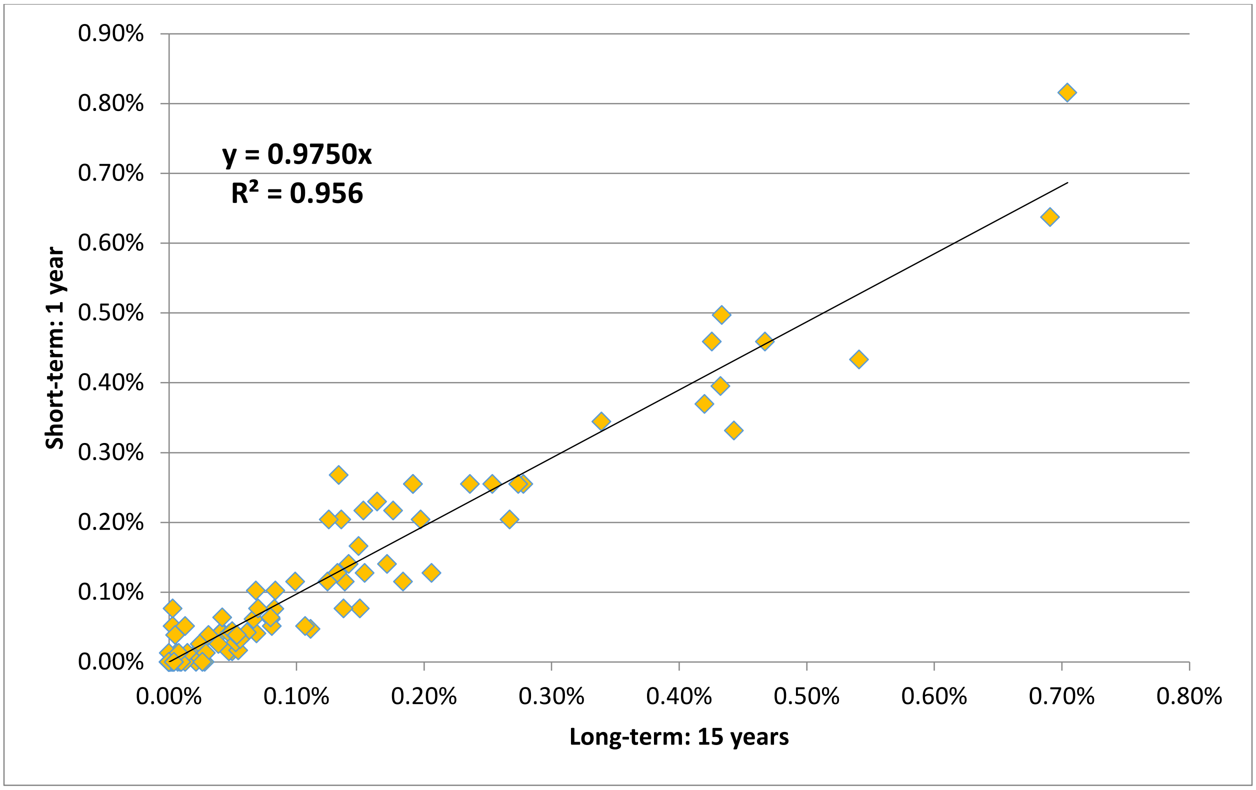

Figure 19. Class C Joint Frequency Distribution: Gillette 1 year vs. 15 years

Class D occurs for all wind speed categories and the linear regression includes those data points. Therefore, the linear regression includes 96 observations which consider all wind speed categories.

Table 16. Gillette Wind Direction and Wind Speed Joint Frequency Distributions for Stability Class D

Class	Speed (mph)	Direction	15 years (X-axis)	1 year (Y-axis)	Diff* 1 year vs. 15 years (pp)
D	1–3	N	0.29%	0.28%	0.01
D	1–3	NNE	0.10%	0.16%	-0.06
D	1–3	NE	0.09%	0.25%	-0.16
D	1–3	ENE	0.07%	0.13%	-0.06
D	1–3	E	0.11%	0.20%	-0.09
D	1–3	ESE	0.07%	0.08%	-0.01
D	1–3	SE	0.08%	0.10%	-0.02
D	1–3	SSE	0.08%	0.09%	-0.01
D	1–3	S	0.14%	0.12%	0.02
D	1–3	SSW	0.05%	0.02%	0.03
D	1–3	SW	0.05%	0.03%	0.01

Table 16. Gillette Wind Direction and Wind Speed Joint Frequency Distributions for Stability Class D					
Class	Speed (mph)	Direction	15 years (X-axis)	1 year (Y-axis)	Diff* 1 year vs. 15 years (pp)
D	1–3	WSW	0.06%	0.06%	0.00
D	1–3	W	0.13%	0.20%	-0.07
D	1–3	WNW	0.10%	0.18%	-0.08
D	1–3	NW	0.13%	0.14%	-0.01
D	1–3	NNW	0.17%	0.30%	-0.13
D	4–7	N	0.64%	0.61%	0.03
D	4–7	NNE	0.22%	0.34%	-0.12
D	4–7	NE	0.18%	0.37%	-0.19
D	4–7	ENE	0.16%	0.15%	0.01
D	4–7	E	0.20%	0.29%	-0.09
D	4–7	ESE	0.16%	0.14%	0.02
D	4–7	SE	0.18%	0.10%	0.07
D	4–7	SSE	0.20%	0.18%	0.02
D	4–7	S	0.26%	0.33%	-0.07
D	4–7	SSW	0.11%	0.06%	0.05
D	4–7	SW	0.13%	0.05%	0.07
D	4–7	WSW	0.12%	0.14%	-0.02
D	4–7	W	0.32%	0.36%	-0.04
D	4–7	WNW	0.26%	0.31%	-0.05
D	4–7	NW	0.29%	0.33%	-0.04
D	4–7	NNW	0.41%	0.51%	-0.10
D	8–12	N	1.32%	1.41%	-0.10
D	8–12	NNE	0.43%	0.53%	-0.10
D	8–12	NE	0.26%	0.48%	-0.23
D	8–12	ENE	0.13%	0.24%	-0.11
D	8–12	E	0.20%	0.31%	-0.11
D	8–12	ESE	0.21%	0.20%	0.01
D	8–12	SE	0.34%	0.52%	-0.18
D	8–12	SSE	0.49%	1.46%	-0.97
D	8–12	S	0.65%	1.97%	-1.32
D	8–12	SSW	0.23%	0.41%	-0.18
D	8–12	SW	0.38%	0.83%	-0.45
D	8–12	WSW	0.55%	0.97%	-0.42
D	8–12	W	1.13%	3.02%	-1.89
D	8–12	WNW	0.81%	1.35%	-0.54

Table 16. Gillette Wind Direction and Wind Speed Joint Frequency Distributions for Stability Class D

Class	Speed (mph)	Direction	15 years (X-axis)	1 year (Y-axis)	Diff* 1 year vs. 15 years (pp)
D	8–12	NW	0.91%	1.07%	-0.16
D	8–12	NNW	0.99%	1.17%	-0.18
D	13–18	N	1.94%	1.64%	0.30
D	13–18	NNE	0.55%	0.57%	-0.02
D	13–18	NE	0.22%	0.19%	0.03
D	13–18	ENE	0.11%	0.17%	-0.06
D	13–18	E	0.14%	0.09%	0.05
D	13–18	ESE	0.30%	0.13%	0.17
D	13–18	SE	1.17%	0.60%	0.58
D	13–18	SSE	2.23%	2.70%	-0.47
D	13–18	S	3.94%	4.00%	-0.06
D	13–18	SSW	1.44%	1.49%	-0.05
D	13–18	SW	2.99%	2.84%	0.15
D	13–18	WSW	1.56%	1.45%	0.11
D	13–18	W	1.51%	1.58%	-0.07
D	13–18	WNW	1.67%	1.52%	0.15
D	13–18	NW	2.55%	2.14%	0.41
D	13–18	NNW	2.37%	2.08%	0.30
D	19–24	N	0.42%	0.14%	0.28
D	19–24	NNE	0.08%	0.03%	0.06
D	19–24	NE	0.03%	0.00%	0.03
D	19–24	ENE	0.00%	0.00%	0.00
D	19–24	E	0.01%	0.00%	0.01
D	19–24	ESE	0.10%	0.04%	0.06
D	19–24	SE	0.33%	0.18%	0.16
D	19–24	SSE	0.86%	1.12%	-0.26
D	19–24	S	1.14%	1.22%	-0.09
D	19–24	SSW	0.60%	0.88%	-0.28
D	19–24	SW	1.42%	1.78%	-0.36
D	19–24	WSW	0.39%	0.34%	0.04
D	19–24	W	0.18%	0.15%	0.03
D	19–24	WNW	0.38%	0.60%	-0.22
D	19–24	NW	1.28%	1.41%	-0.13
D	19–24	NNW	0.94%	0.92%	0.02
D	>24	N	0.07%	0.04%	0.03

Table 16. Gillette Wind Direction and Wind Speed Joint Frequency Distributions for Stability Class D					
Class	**Speed (mph)**	**Direction**	**15 years (X-axis)**	**1 year (Y-axis)**	**Diff* 1 year vs. 15 years (pp)**
D	**>24**	**NNE**	0.01%	0.00%	0.01
D	**>24**	**NE**	0.00%	0.00%	0.00
D	**>24**	**ENE**	0.00%	0.00%	0.00
D	**>24**	**E**	0.00%	0.00%	0.00
D	**>24**	**ESE**	0.03%	0.01%	0.02
D	**>24**	**SE**	0.08%	0.08%	0.01
D	**>24**	**SSE**	0.33%	0.46%	-0.13
D	**>24**	**S**	0.27%	0.29%	-0.02
D	**>24**	**SSW**	0.23%	0.42%	-0.19
D	**>24**	**SW**	0.82%	0.97%	-0.15
D	**>24**	**WSW**	0.14%	0.09%	0.05
D	**>24**	**W**	0.05%	0.04%	0.01
D	**>24**	**WNW**	0.16%	0.29%	-0.14
D	**>24**	**NW**	0.70%	0.82%	-0.12
D	**>24**	**NNW**	0.39%	0.22%	0.17

* Where ‘diff’ is the difference in percentage points (pp) calculated between the long- and short-term frequencies. The actual numbers used for the percent point calculations include greater than three significant figures. Therefore, the calculated difference as shown in this table may vary slightly due to rounding.

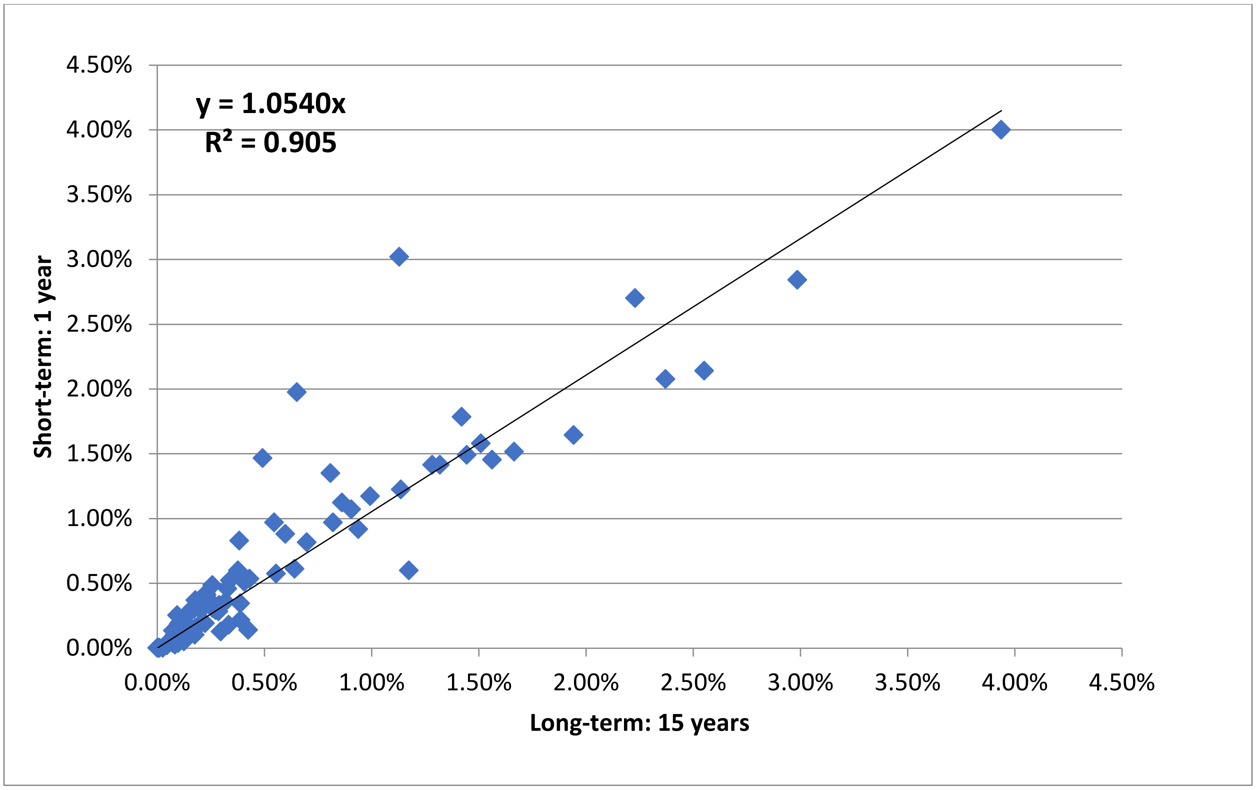

Figure 20. Class D Joint Frequency Distribution: Gillette 1 year vs. 15 years

Class E occurs during wind speed categories 4–7 and 8–12 mph, and the linear regression plot only includes those data points. The values for the other wind speed categories are captured as "zeros" in the STAR program; however, these should not be considered as actual values and are excluded from the linear regression analysis. Therefore, the linear regression includes 32 observations which consider two wind speed categories. The other wind categories do not occur, thus "NA" (non-applicable) was included for these in the following table.

Table 17. Gillette Wind Direction and Wind Speed Joint Frequency Distributions for Stability Class E

Class	Speed (mph)	Direction	15 years (X-axis)	1 year (Y-axis)	Diff* 1 year vs. 15 years (pp)
E	**1–3**	**N**	NA	NA	NA
E	**1–3**	**NNE**	NA	NA	NA
E	**1–3**	**NE**	NA	NA	NA
E	**1–3**	**ENE**	NA	NA	NA
E	**1–3**	**E**	NA	NA	NA
E	**1–3**	**ESE**	NA	NA	NA

Table 17. Gillette Wind Direction and Wind Speed Joint Frequency Distributions for Stability Class E					
Class	**Speed (mph)**	**Direction**	**15 years (X-axis)**	**1 year (Y-axis)**	**Diff* 1 year vs. 15 years (pp)**
E	**1–3**	**SE**	NA	NA	NA
E	**1–3**	**SSE**	NA	NA	NA
E	**1–3**	**S**	NA	NA	NA
E	**1–3**	**SSW**	NA	NA	NA
E	**1–3**	**SW**	NA	NA	NA
E	**1–3**	**WSW**	NA	NA	NA
E	**1–3**	**W**	NA	NA	NA
E	**1–3**	**WNW**	NA	NA	NA
E	**1–3**	**NW**	NA	NA	NA
E	**1–3**	**NNW**	NA	NA	NA
E	**4–7**	**N**	0.11%	0.15%	-0.04
E	**4–7**	**NNE**	0.02%	0.06%	-0.04
E	**4–7**	**NE**	0.04%	0.09%	-0.05
E	**4–7**	**ENE**	0.03%	0.11%	-0.08
E	**4–7**	**E**	0.04%	0.23%	-0.19
E	**4–7**	**ESE**	0.03%	0.23%	-0.20
E	**4–7**	**SE**	0.04%	0.27%	-0.23
E	**4–7**	**SSE**	0.06%	0.70%	-0.64
E	**4–7**	**S**	0.13%	1.32%	-1.20
E	**4–7**	**SSW**	0.05%	0.33%	-0.28
E	**4–7**	**SW**	0.06%	0.39%	-0.33
E	**4–7**	**WSW**	0.06%	0.34%	-0.28
E	**4–7**	**W**	0.15%	0.70%	-0.55
E	**4–7**	**WNW**	0.08%	0.29%	-0.21
E	**4–7**	**NW**	0.08%	0.31%	-0.22
E	**4–7**	**NNW**	0.12%	0.24%	-0.12
E	**8–12**	**N**	0.27%	0.05%	0.22
E	**8–12**	**NNE**	0.14%	0.03%	0.11
E	**8–12**	**NE**	0.12%	0.00%	0.12
E	**8–12**	**ENE**	0.07%	0.00%	0.07
E	**8–12**	**E**	0.12%	0.00%	0.12
E	**8–12**	**ESE**	0.17%	0.01%	0.15
E	**8–12**	**SE**	0.56%	0.11%	0.45
E	**8–12**	**SSE**	1.07%	0.45%	0.62
E	**8–12**	**S**	2.25%	0.74%	1.51

Table 17. Gillette Wind Direction and Wind Speed Joint Frequency Distributions for Stability Class E

Class	Speed (mph)	Direction	15 years (X-axis)	1 year (Y-axis)	Diff* 1 year vs. 15 years (pp)
E	8–12	SSW	0.40%	0.10%	0.30
E	8–12	SW	0.89%	0.29%	0.60
E	8–12	WSW	0.91%	0.11%	0.79
E	8–12	W	1.90%	0.32%	1.58
E	8–12	WNW	0.66%	0.14%	0.52
E	8–12	NW	0.45%	0.15%	0.30
E	8–12	NNW	0.39%	0.11%	0.27
E	13–18	N	NA	NA	NA
E	13–18	NNE	NA	NA	NA
E	13–18	NE	NA	NA	NA
E	13–18	ENE	NA	NA	NA
E	13–18	E	NA	NA	NA
E	13–18	ESE	NA	NA	NA
E	13–18	SE	NA	NA	NA
E	13–18	SSE	NA	NA	NA
E	13–18	S	NA	NA	NA
E	13–18	SSW	NA	NA	NA
E	13–18	SW	NA	NA	NA
E	13–18	WSW	NA	NA	NA
E	13–18	W	NA	NA	NA
E	13–18	WNW	NA	NA	NA
E	13–18	NW	NA	NA	NA
E	13–18	NNW	NA	NA	NA
E	19–24	N	NA	NA	NA
E	19–24	NNE	NA	NA	NA
E	19–24	NE	NA	NA	NA
E	19–24	ENE	NA	NA	NA
E	19–24	E	NA	NA	NA
E	19–24	ESE	NA	NA	NA
E	19–24	SE	NA	NA	NA
E	19–24	SSE	NA	NA	NA
E	19–24	S	NA	NA	NA
E	19–24	SSW	NA	NA	NA
E	19–24	SW	NA	NA	NA
E	19–24	WSW	NA	NA	NA

Table 17. Gillette Wind Direction and Wind Speed Joint Frequency Distributions for Stability Class E					
Class	**Speed (mph)**	**Direction**	**15 years (X-axis)**	**1 year (Y-axis)**	**Diff* 1 year vs. 15 years (pp)**
E	**19–24**	**W**	NA	NA	NA
E	**19–24**	**WNW**	NA	NA	NA
E	**19–24**	**NW**	NA	NA	NA
E	**19–24**	**NNW**	NA	NA	NA
E	**>24**	**N**	NA	NA	NA
E	**>24**	**NNE**	NA	NA	NA
E	**>24**	**NE**	NA	NA	NA
E	**>24**	**ENE**	NA	NA	NA
E	**>24**	**E**	NA	NA	NA
E	**>24**	**ESE**	NA	NA	NA
E	**>24**	**SE**	NA	NA	NA
E	**>24**	**SSE**	NA	NA	NA
E	**>24**	**S**	NA	NA	NA
E	**>24**	**SSW**	NA	NA	NA
E	**>24**	**SW**	NA	NA	NA
E	**>24**	**WSW**	NA	NA	NA
E	**>24**	**W**	NA	NA	NA
E	**>24**	**WNW**	NA	NA	NA
E	**>24**	**NW**	NA	NA	NA
E	**>24**	**NNW**	NA	NA	NA

* Where 'diff' is the difference in percentage points (pp) calculated between the long- and short-term frequencies. The actual numbers used for the percent point calculations include greater than three significant figures. Therefore, the calculated difference as shown in this table may vary slightly due to rounding.

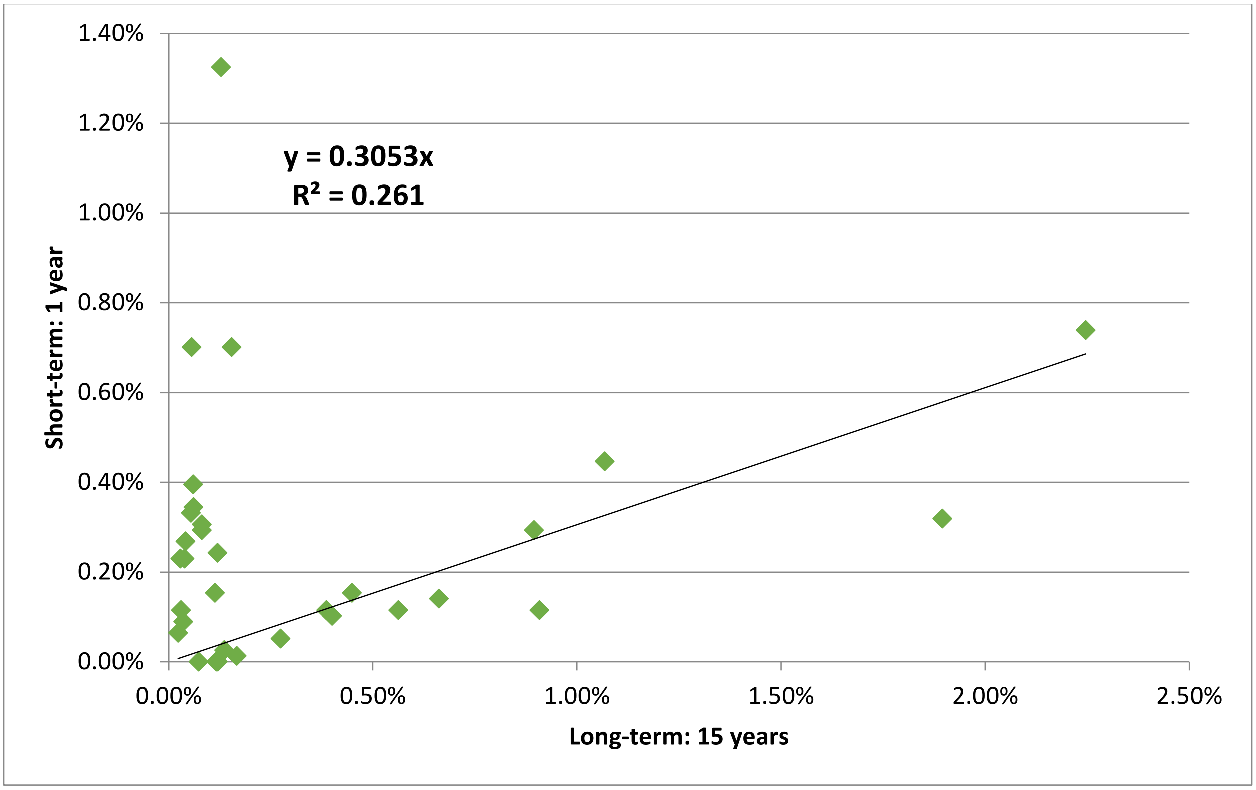

Figure 21. Class E Joint Frequency Distribution: Gillette 1 year vs. 15 years

Class F occurs during wind speed categories 1–3 and 4–7 mph, and the linear regression plot only includes those data points. The values for the other wind speed categories are captured as "zeros" in the STAR program; however, these should not be considered as actual values and are excluded from the linear regression analysis. Therefore, the linear regression includes 32 observations which consider two wind speed categories. The other wind categories do not occur, thus "NA" (non-applicable) was included for these in the following table.

Table 18. Gillette Wind Direction and Wind Speed Joint Frequency Distributions for Stability Class F

Class	Speed (mph)	Direction	15 years (X-axis)	1 year (Y-axis)	Diff* 1 year vs. 15 years (pp)
F	1–3	N	0.46%	0.26%	0.20
F	1–3	NNE	0.22%	0.13%	0.10
F	1–3	NE	0.22%	0.07%	0.15
F	1–3	ENE	0.19%	0.17%	0.02
F	1–3	E	0.41%	0.25%	0.16
F	1–3	ESE	0.39%	0.18%	0.21

Table 18. Gillette Wind Direction and Wind Speed Joint Frequency Distributions for Stability Class F					
Class	**Speed (mph)**	**Direction**	**15 years (X-axis)**	**1 year (Y-axis)**	**Diff* 1 year vs. 15 years (pp)**
F	**1–3**	**SE**	0.55%	0.57%	-0.02
F	**1–3**	**SSE**	0.94%	1.00%	-0.06
F	**1–3**	**S**	2.17%	2.80%	-0.64
F	**1–3**	**SSW**	1.15%	1.54%	-0.39
F	**1–3**	**SW**	0.98%	1.26%	-0.28
F	**1–3**	**WSW**	0.77%	0.74%	0.03
F	**1–3**	**W**	0.84%	1.01%	-0.17
F	**1–3**	**WNW**	0.39%	0.21%	0.17
F	**1–3**	**NW**	0.41%	0.43%	-0.02
F	**1–3**	**NNW**	0.44%	0.51%	-0.07
F	**4–7**	**N**	0.31%	0.05%	0.26
F	**4–7**	**NNE**	0.15%	0.01%	0.13
F	**4–7**	**NE**	0.15%	0.01%	0.14
F	**4–7**	**ENE**	0.14%	0.03%	0.11
F	**4–7**	**E**	0.29%	0.03%	0.26
F	**4–7**	**ESE**	0.30%	0.04%	0.26
F	**4–7**	**SE**	0.45%	0.10%	0.34
F	**4–7**	**SSE**	0.84%	0.39%	0.44
F	**4–7**	**S**	1.99%	0.93%	1.06
F	**4–7**	**SSW**	0.76%	0.22%	0.54
F	**4–7**	**SW**	0.65%	0.27%	0.38
F	**4–7**	**WSW**	0.57%	0.15%	0.42
F	**4–7**	**W**	0.80%	0.22%	0.58
F	**4–7**	**WNW**	0.33%	0.06%	0.27
F	**4–7**	**NW**	0.38%	0.13%	0.25
F	**4–7**	**NNW**	0.37%	0.13%	0.25
F	**8–12**	**N**	NA	NA	NA
F	**8–12**	**NNE**	NA	NA	NA
F	**8–12**	**NE**	NA	NA	NA
F	**8–12**	**ENE**	NA	NA	NA
F	**8–12**	**E**	NA	NA	NA
F	**8–12**	**ESE**	NA	NA	NA
F	**8–12**	**SE**	NA	NA	NA
F	**8–12**	**SSE**	NA	NA	NA
F	**8–12**	**S**	NA	NA	NA

Table 18. Gillette Wind Direction and Wind Speed Joint Frequency Distributions for Stability Class F

Class	Speed (mph)	Direction	15 years (X-axis)	1 year (Y-axis)	Diff* 1 year vs. 15 years (pp)
F	**8–12**	**SSW**	NA	NA	NA
F	**8–12**	**SW**	NA	NA	NA
F	**8–12**	**WSW**	NA	NA	NA
F	**8–12**	**W**	NA	NA	NA
F	**8–12**	**WNW**	NA	NA	NA
F	**8–12**	**NW**	NA	NA	NA
F	**8–12**	**NNW**	NA	NA	NA
F	**13–18**	**N**	NA	NA	NA
F	**13–18**	**NNE**	NA	NA	NA
F	**13–18**	**NE**	NA	NA	NA
F	**13–18**	**ENE**	NA	NA	NA
F	**13–18**	**E**	NA	NA	NA
F	**13–18**	**ESE**	NA	NA	NA
F	**13–18**	**SE**	NA	NA	NA
F	**13–18**	**SSE**	NA	NA	NA
F	**13–18**	**S**	NA	NA	NA
F	**13–18**	**SSW**	NA	NA	NA
F	**13–18**	**SW**	NA	NA	NA
F	**13–18**	**WSW**	NA	NA	NA
F	**13–18**	**W**	NA	NA	NA
F	**13–18**	**WNW**	NA	NA	NA
F	**13–18**	**NW**	NA	NA	NA
F	**13–18**	**NNW**	NA	NA	NA
F	**19–24**	**N**	NA	NA	NA
F	**19–24**	**NNE**	NA	NA	NA
F	**19–24**	**NE**	NA	NA	NA
F	**19–24**	**ENE**	NA	NA	NA
F	**19–24**	**E**	NA	NA	NA
F	**19–24**	**ESE**	NA	NA	NA
F	**19–24**	**SE**	NA	NA	NA
F	**19–24**	**SSE**	NA	NA	NA
F	**19–24**	**S**	NA	NA	NA
F	**19–24**	**SSW**	NA	NA	NA
F	**19–24**	**SW**	NA	NA	NA
F	**19–24**	**WSW**	NA	NA	NA

Table 18. Gillette Wind Direction and Wind Speed Joint Frequency Distributions for Stability Class F					
Class	Speed (mph)	Direction	15 years (X-axis)	1 year (Y-axis)	Diff* 1 year vs. 15 years (pp)
F	**19–24**	**W**	NA	NA	NA
F	**19–24**	**WNW**	NA	NA	NA
F	**19–24**	**NW**	NA	NA	NA
F	**19–24**	**NNW**	NA	NA	NA
F	**>24**	**N**	NA	NA	NA
F	**>24**	**NNE**	NA	NA	NA
F	**>24**	**NE**	NA	NA	NA
F	**>24**	**ENE**	NA	NA	NA
F	**>24**	**E**	NA	NA	NA
F	**>24**	**ESE**	NA	NA	NA
F	**>24**	**SE**	NA	NA	NA
F	**>24**	**SSE**	NA	NA	NA
F	**>24**	**S**	NA	NA	NA
F	**>24**	**SSW**	NA	NA	NA
F	**>24**	**SW**	NA	NA	NA
F	**>24**	**WSW**	NA	NA	NA
F	**>24**	**W**	NA	NA	NA
F	**>24**	**WNW**	NA	NA	NA
F	**>24**	**NW**	NA	NA	NA
F	**>24**	**NNW**	NA	NA	NA

* Where 'diff' is the difference in percentage points (pp) calculated between the long- and short-term frequencies. The actual numbers used for the percent point calculations include greater than three significant figures. Therefore, the calculated difference as shown in this table may vary slightly due to rounding.

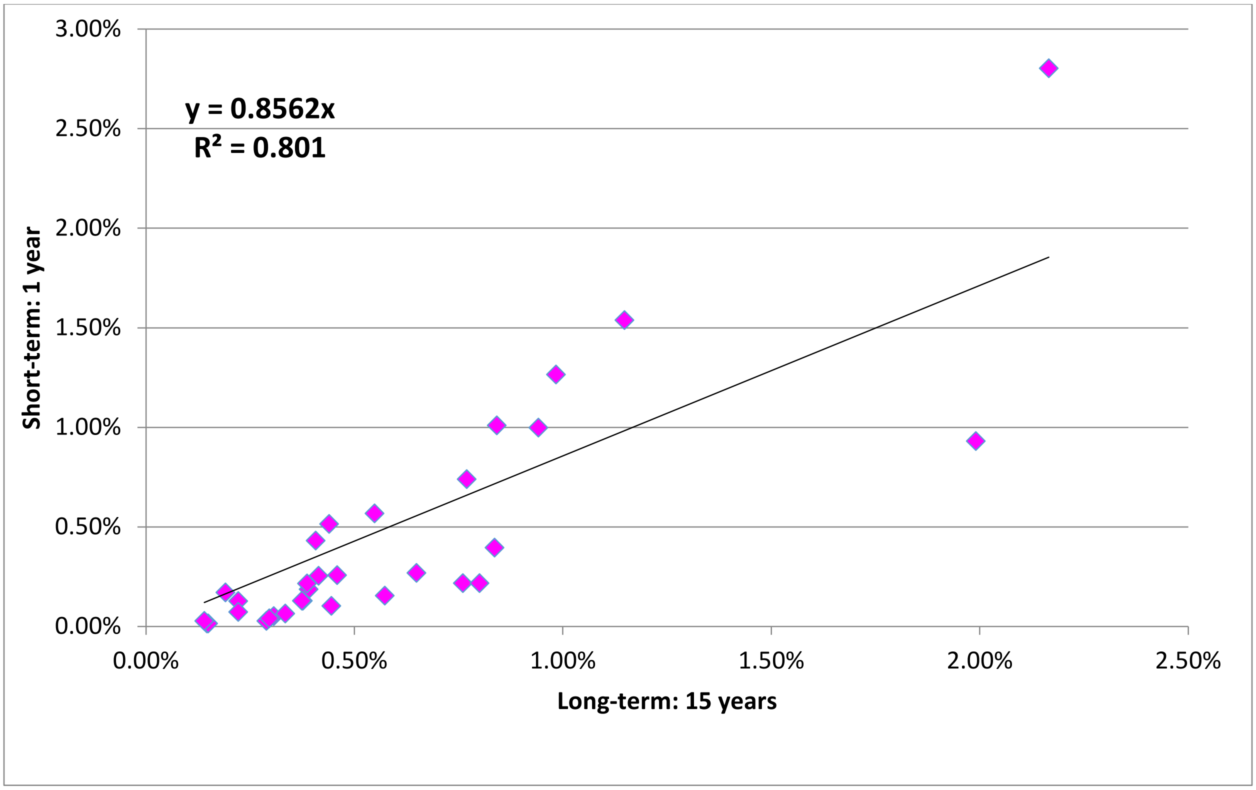

Figure 22. Class F Joint Frequency Distribution: Gillette 1 year vs. 15 years

3. INTER-SITE COMPARISON: SCOTTSBLUFF 1 YEAR VS. GILLETTE 15 YEARS

3.1. SCOTTSBLUFF 1 YEAR AND GILLETTE 15 YEARS WIND DIRECTION RELATIVE FREQUENCY DISTRIBUTION

Table 19 contains the Gillette wind direction relative frequency distribution data used to create the wind direction frequency bar chart and regression in Figures 23 and 24.

Table 19. Scottsbluff 1 year and Gillette15 years Wind Direction Relative Frequency Distribution

Direction	Gillette 15 years (X-axis)	Scottsbluff 1 year (Y-axis)	Diff* 1 year vs. 15 years
N	7.92%	4.69%	3.23
NNE	2.66%	3.10%	-0.44
NE	1.78%	2.72%	-0.94
ENE	1.29%	3.17%	-1.88
E	2.05%	10.25%	-8.21

Table 19. Scottsbluff 1 year and Gillette15 years Wind Direction Relative Frequency Distribution			
Direction	**Gillette 15 years (X-axis)**	**Scottsbluff 1 year (Y-axis)**	**Diff* 1 year vs. 15 years**
ESE	2.13%	12.61%	-10.48
SE	4.22%	6.63%	-2.41
SSE	7.68%	3.73%	3.94
S	13.08%	2.70%	10.38
SSW	5.11%	1.06%	4.05
SW	8.60%	0.84%	7.76
WSW	5.62%	0.88%	4.74
W	7.83%	7.45%	0.38
WNW	5.66%	13.73%	-8.06
NW	8.23%	11.80%	-3.58
NNW	7.55%	6.13%	1.43
Calms	8.59%	8.50%	0.10

* Where 'diff' is the difference in percentage points (pp) calculated between the long- and short-term frequencies. The actual numbers used for the percent point calculations include greater than three significant figures. Therefore, the calculated difference as shown in this table may vary slightly due to rounding.

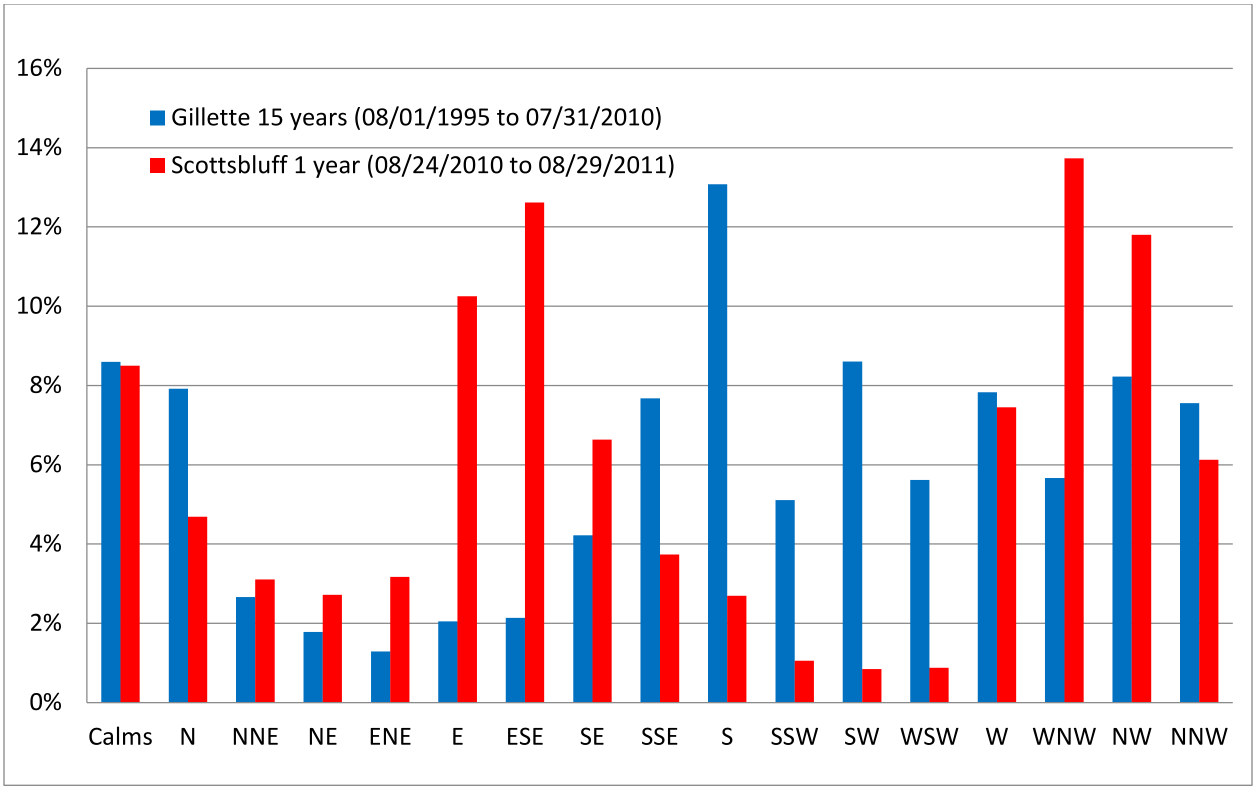

Figure 23. Inter-site Comparison of Wind Direction Relative Frequency Distribution: Scottsbluff 1 year vs. Gillette 15 years

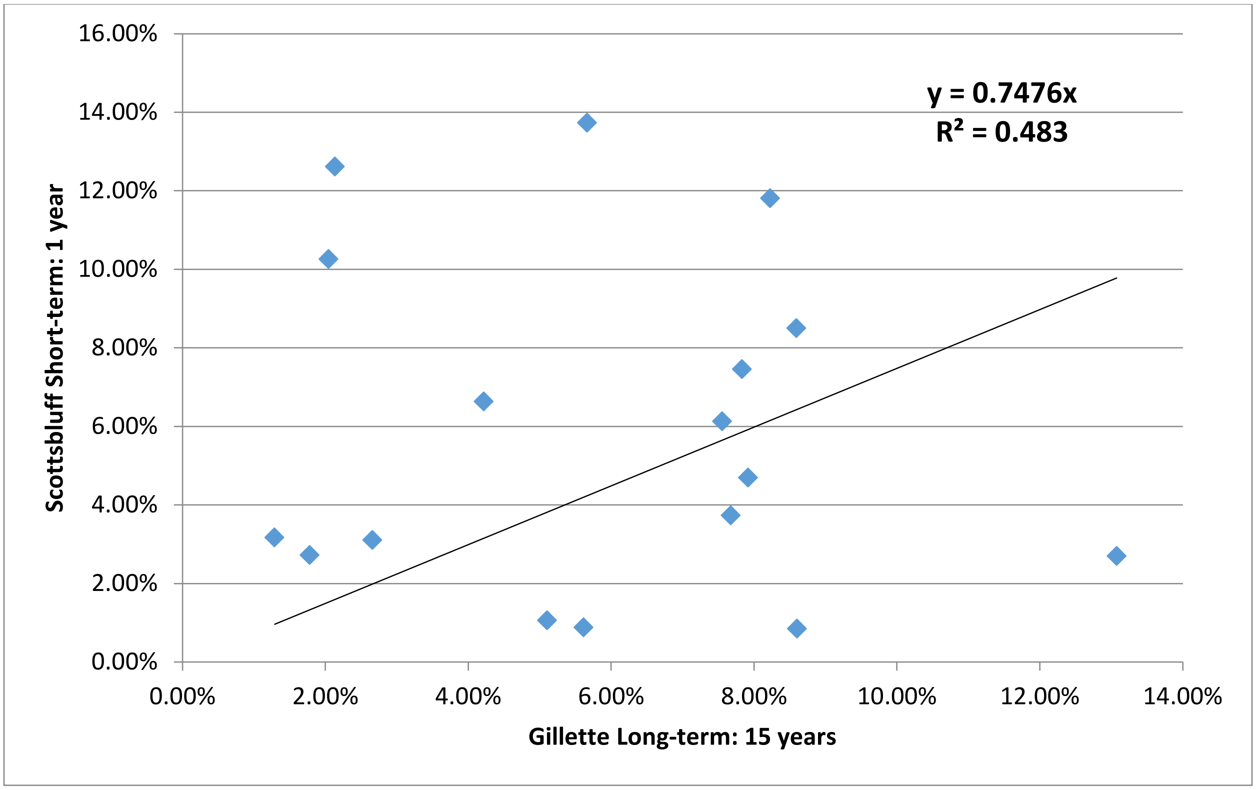

Figure 24. Inter-site Comparison of Wind Direction Relative Frequency Distribution: Scottsbluff 1 year vs. Gillette 15 years

3.2. Scottsbluff 1 year and Gillette 15 years Wind Speed Frequency Distribution

Table 20 contains the Gillette wind speed relative frequency distribution data used to create the wind direction relative frequency bar chart and regression in Figures 25 and 26.

Table 20. Scottsbluff 1 year and Gillette15 years Wind Speed Relative Frequency Distribution

Speed (mph)	Gillette 15 years (X-axis)	Scottsbluff 1 year (Y-axis)	Diff* 1 year vs. 15 years
1–3	7.21%	7.21%	0.01
4–7	26.15%	28.67%	-2.52
8–12	30.86%	28.20%	2.67
13–18	19.75%	20.73%	-0.98
19–24	5.93%	4.63%	1.30
> 24	1.50%	2.07%	-0.57
Calms	8.59%	8.50%	0.10

* Where 'diff' is the difference in percentage points (pp) calculated between the long- and short-term frequencies. The actual numbers used for the percent point calculations include greater than three significant figures. Therefore, the calculated difference as shown in this table may vary slightly due to rounding.

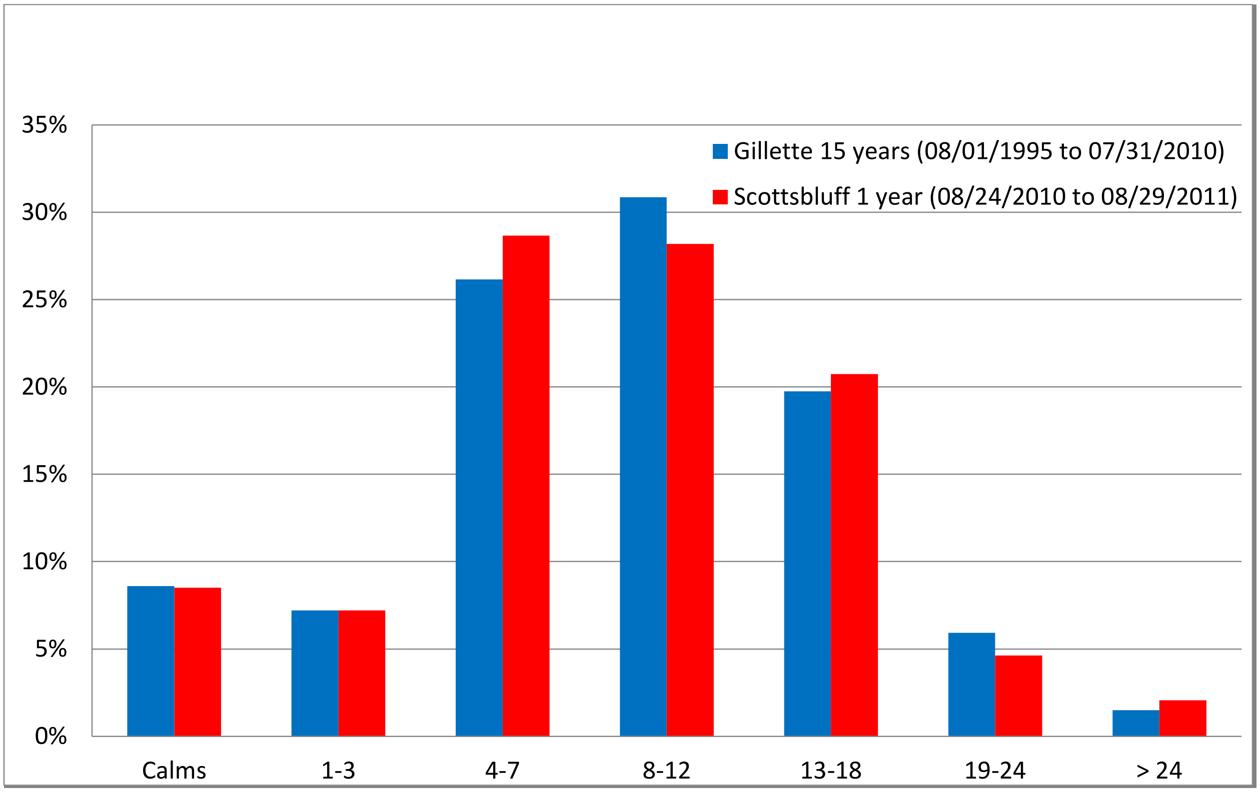

Figure 25. Inter-site Comparison of Wind Speed Relative Frequency Distribution: Scottsbluff 1 year and Gillette 15 years

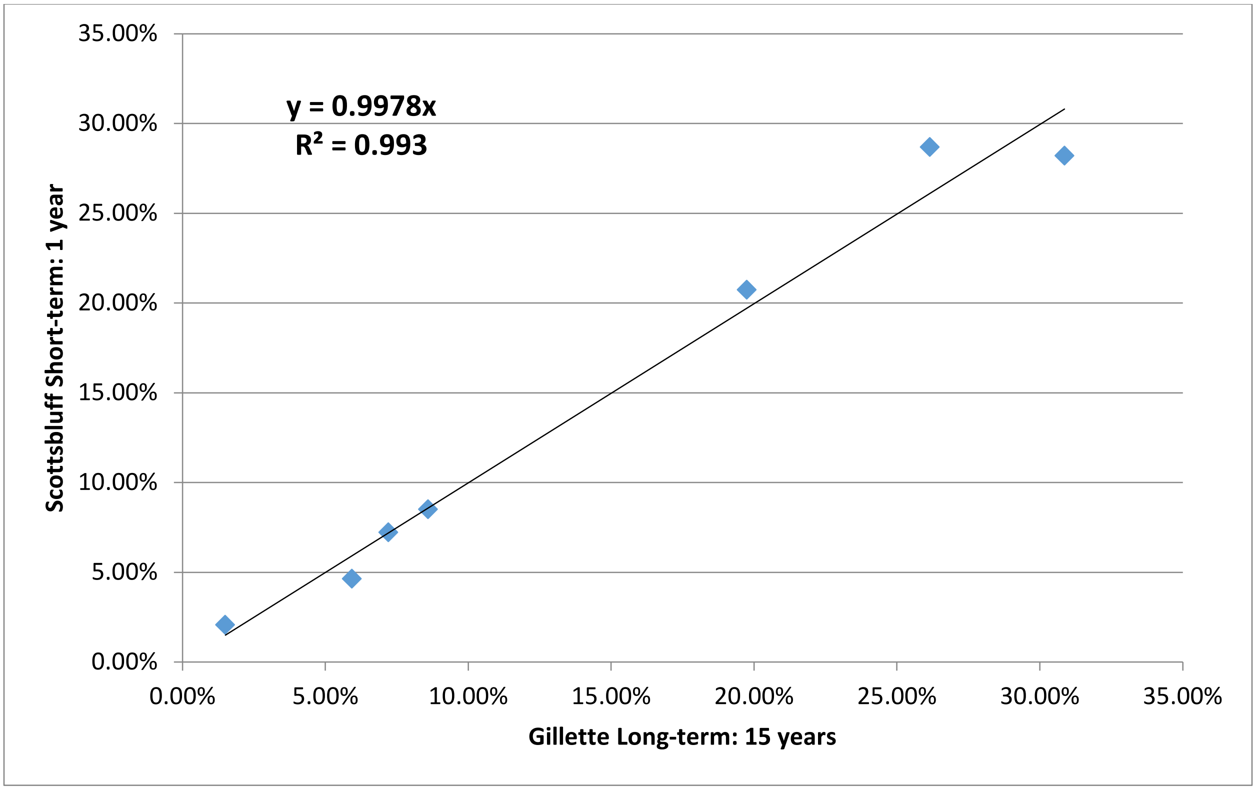

Figure 26. Inter-site Comparison of Wind Speed Relative Frequency Distribution: Scottsbluff 1 year vs. Gillette 15 years

3.3. ALL STABILITY CLASSES WIND DIRECTION AND WIND SPEED JOINT FREQUENCY DISTRIBUTION FOR SCOTTSBLUFF AND GILLETTE AIRPORTS

The inter-site comparison is performed with the JFD data from Scottsbluff and Gillette using linear regression analysis. Table 21 contains the Scottsbluff and Gillette wind direction and wind speed JFDs data used to create the wind direction and wind speed JFD regression for all classes in Figure 27.

Table 21. Scottsbluff 1 year and Gillette 15 years Wind Direction and Wind Speed Joint Frequency Distributions for All Stability Classes Summed

Class*	Speed (mph)	Direction	Gillette 15 years (X-axis)	Scottsbluff 1 year (Y-axis)	Diff** 1 year vs. 15 years
A–F	1–3	N	1.14%	1.25%	-0.11
A–F	1–3	NNE	0.58%	0.69%	-0.11
A–F	1–3	NE	0.52%	0.75%	-0.22

Table 21. Scottsbluff 1 year and Gillette 15 years Wind Direction and Wind Speed Joint Frequency Distributions for All Stability Classes Summed

Class*	Speed (mph)	Direction	Gillette 15 years (X-axis)	Scottsbluff 1 year (Y-axis)	Diff** 1 year vs. 15 years
A–F	**1–3**	**ENE**	0.46%	0.82%	-0.36
A–F	**1–3**	**E**	0.80%	2.02%	-1.22
A–F	**1–3**	**ESE**	0.65%	1.49%	-0.84
A–F	**1–3**	**SE**	0.83%	0.95%	-0.12
A–F	**1–3**	**SSE**	1.26%	0.72%	0.54
A–F	**1–3**	**S**	2.65%	0.66%	1.98
A–F	**1–3**	**SSW**	1.37%	0.23%	1.15
A–F	**1–3**	**SW**	1.23%	0.26%	0.97
A–F	**1–3**	**WSW**	1.02%	0.32%	0.70
A–F	**1–3**	**W**	1.28%	1.27%	0.02
A–F	**1–3**	**WNW**	0.68%	1.51%	-0.83
A–F	**1–3**	**NW**	0.74%	1.64%	-0.90
A–F	**1–3**	**NNW**	0.83%	1.03%	-0.20
A–F	**4–7**	**N**	1.71%	1.73%	-0.02
A–F	**4–7**	**NNE**	0.75%	1.11%	-0.35
A–F	**4–7**	**NE**	0.63%	0.99%	-0.37
A–F	**4–7**	**ENE**	0.55%	1.15%	-0.60
A–F	**4–7**	**E**	0.88%	4.37%	-3.50
A–F	**4–7**	**ESE**	0.75%	3.15%	-2.39
A–F	**4–7**	**SE**	0.95%	1.67%	-0.72
A–F	**4–7**	**SSE**	1.47%	1.30%	0.17
A–F	**4–7**	**S**	2.86%	1.04%	1.82
A–F	**4–7**	**SSW**	1.19%	0.37%	0.81
A–F	**4–7**	**SW**	1.13%	0.32%	0.81
A–F	**4–7**	**WSW**	1.07%	0.35%	0.72
A–F	**4–7**	**W**	1.80%	1.70%	0.10
A–F	**4–7**	**WNW**	0.97%	3.53%	-2.55
A–F	**4–7**	**NW**	1.14%	3.95%	-2.81
A–F	**4–7**	**NNW**	1.23%	1.92%	-0.68
A–F	**8–12**	**N**	2.47%	1.00%	1.46
A–F	**8–12**	**NNE**	0.93%	0.96%	-0.03
A–F	**8–12**	**NE**	0.64%	0.68%	-0.03
A–F	**8–12**	**ENE**	0.38%	0.73%	-0.35
A–F	**8–12**	**E**	0.61%	3.89%	-3.28
A–F	**8–12**	**ESE**	0.62%	5.34%	-4.72

Table 21. Scottsbluff 1 year and Gillette 15 years Wind Direction and Wind Speed Joint Frequency Distributions for All Stability Classes Summed					
Class*	Speed (mph)	Direction	Gillette 15 years (X-axis)	Scottsbluff 1 year (Y-axis)	Diff** 1 year vs. 15 years
A–F	**8–12**	**SE**	1.27%	2.51%	-1.24
A–F	**8–12**	**SSE**	2.14%	0.94%	1.21
A–F	**8–12**	**S**	3.78%	0.77%	3.02
A–F	**8–12**	**SSW**	1.04%	0.35%	0.70
A–F	**8–12**	**SW**	1.79%	0.27%	1.51
A–F	**8–12**	**WSW**	1.95%	0.20%	1.74
A–F	**8–12**	**W**	3.66%	2.21%	1.45
A–F	**8–12**	**WNW**	2.00%	3.91%	-1.91
A–F	**8–12**	**NW**	1.91%	3.33%	-1.42
A–F	**8–12**	**NNW**	1.94%	1.17%	0.77
A–F	**13–18**	**N**	2.09%	0.81%	1.28
A–F	**13–18**	**NNE**	0.62%	0.54%	0.08
A–F	**13–18**	**NE**	0.25%	0.58%	-0.32
A–F	**13–18**	**ENE**	0.13%	0.72%	-0.59
A–F	**13–18**	**E**	0.16%	1.13%	-0.97
A–F	**13–18**	**ESE**	0.32%	3.38%	-3.06
A–F	**13–18**	**SE**	1.28%	1.88%	-0.60
A–F	**13–18**	**SSE**	2.38%	0.94%	1.45
A–F	**13–18**	**S**	4.13%	0.45%	3.68
A–F	**13–18**	**SSW**	1.53%	0.20%	1.32
A–F	**13–18**	**SW**	3.06%	0.10%	2.95
A–F	**13–18**	**WSW**	1.61%	0.11%	1.50
A–F	**13–18**	**W**	1.55%	1.93%	-0.38
A–F	**13–18**	**WNW**	1.75%	4.09%	-2.35
A–F	**13–18**	**NW**	2.70%	2.45%	0.25
A–F	**13–18**	**NNW**	2.51%	1.48%	1.03
A–F	**19–24**	**N**	0.43%	0.10%	0.33
A–F	**19–24**	**NNE**	0.08%	0.14%	-0.05
A–F	**19–24**	**NE**	0.03%	0.07%	-0.04
A–F	**19–24**	**ENE**	0.00%	0.12%	-0.12
A–F	**19–24**	**E**	0.01%	0.11%	-0.10
A–F	**19–24**	**ESE**	0.10%	0.19%	-0.09
A–F	**19–24**	**SE**	0.34%	0.12%	0.22
A–F	**19–24**	**SSE**	0.90%	0.26%	0.64
A–F	**19–24**	**S**	1.16%	0.12%	1.04

Table 21. Scottsbluff 1 year and Gillette 15 years Wind Direction and Wind Speed Joint Frequency Distributions for All Stability Classes Summed

Class*	Speed (mph)	Direction	Gillette 15 years (X-axis)	Scottsbluff 1 year (Y-axis)	Diff** 1 year vs. 15 years
A–F	**19–24**	**SSW**	0.61%	0.02%	0.59
A–F	**19–24**	**SW**	1.44%	0.03%	1.40
A–F	**19–24**	**WSW**	0.39%	0.02%	0.37
A–F	**19–24**	**W**	0.18%	0.52%	-0.34
A–F	**19–24**	**WNW**	0.39%	1.07%	-0.68
A–F	**19–24**	**NW**	1.31%	0.97%	0.34
A–F	**19–24**	**NNW**	0.96%	0.77%	0.20
A–F	**>24**	**N**	0.08%	0.00%	0.08
A–F	**>24**	**NNE**	0.01%	0.02%	-0.01
A–F	**>24**	**NE**	0.00%	0.05%	-0.04
A–F	**>24**	**ENE**	0.00%	0.02%	-0.02
A–F	**>24**	**E**	0.00%	0.02%	-0.02
A–F	**>24**	**ESE**	0.03%	0.00%	0.03
A–F	**>24**	**SE**	0.09%	0.01%	0.08
A–F	**>24**	**SSE**	0.34%	0.02%	0.32
A–F	**>24**	**S**	0.28%	0.01%	0.27
A–F	**>24**	**SSW**	0.23%	0.00%	0.23
A–F	**>24**	**SW**	0.82%	0.00%	0.82
A–F	**>24**	**WSW**	0.14%	0.01%	0.13
A–F	**>24**	**W**	0.05%	0.44%	-0.39
A–F	**>24**	**WNW**	0.16%	0.56%	-0.40
A–F	**>24**	**NW**	0.71%	0.56%	0.14
A–F	**>24**	**NNW**	0.39%	0.34%	0.05

* The stability classes A-F were summed for each wind speed and wind direction. Calms were distributed by the STAR program within each stability class as described in Section 2.2.3 of the TBD.

** Where 'diff' is the difference in percentage points (pp) calculated between the long- and short-term frequencies. The actual numbers used for the percent point calculations include greater than three significant figures. Therefore, the calculated difference as shown in this table may vary slightly due to rounding.

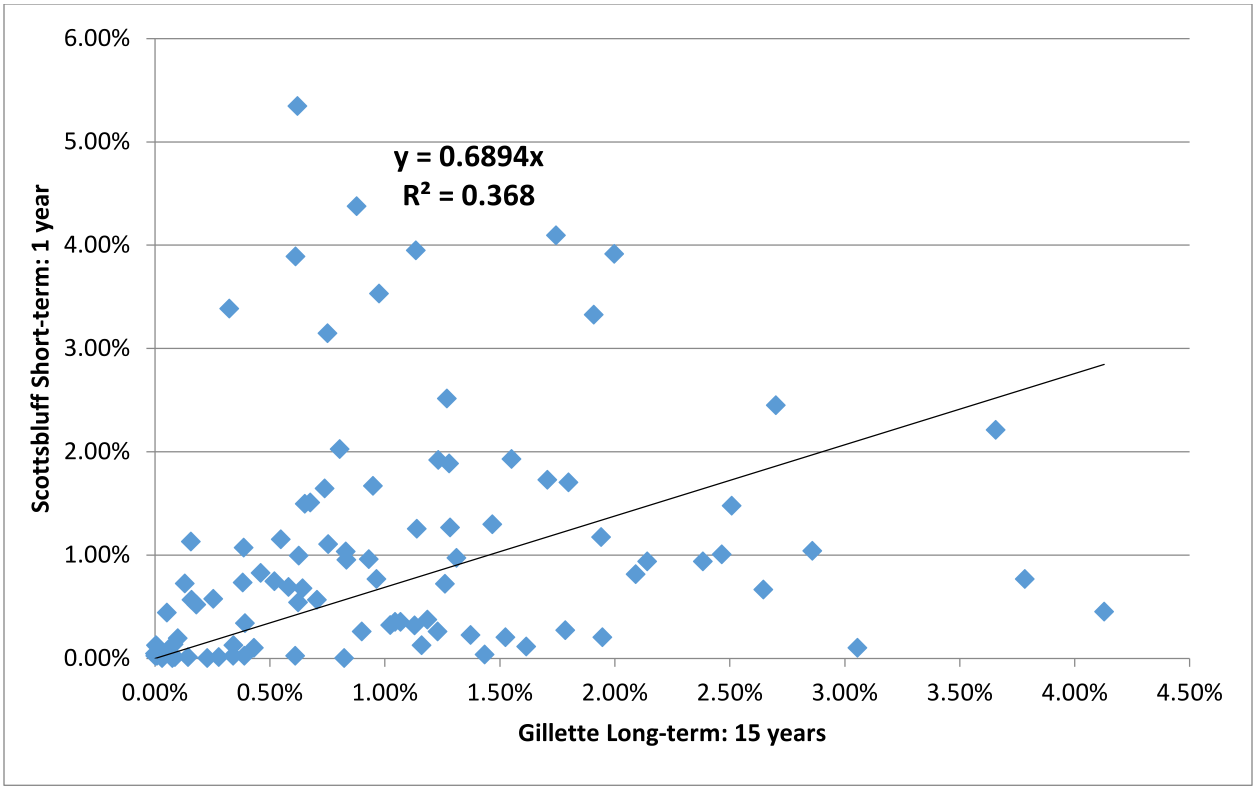

Figure 27. Wind Direction and Wind Speed Joint Frequency Distribution for All Stability Classes Summed: Scottsbluff 1 year vs. Gillette 15 years

3.4. Wind Direction and Wind Speed Joint Frequency Distributions by Atmospheric Stability Class for Gillette and Scottsbluff Airports

Tables 22–27 contain the Scottsbluff 1 year and Gillette 15 years wind direction and wind speed JFDs data used to create the wind direction and wind speed JFD regression for Classes A, B,C, D, E, and F depicted in Figures 28–33 respectively.

Class A occurs during the first two wind speed categories (i.e., 1–3 and 4–7 mph) and the linear regression plot only includes those data points. The values for the other wind speed categories are captured as "zeros" in the STAR program; however, these should not be considered as actual values and are excluded from the linear regression analysis. Therefore, the linear regression includes 32 observations which consider two wind speed categories. The other wind categories do not occur, thus "NA" (non-applicable) was included for these in the following table.

Table 22. Scottsbluff 1 year and Gillette 15 years Wind Direction and Wind Speed Joint Frequency Distributions for Stability Class A					
Class	**Speed (mph)**	**Direction**	**15 years (X-axis)**	**1 year (Y-axis)**	**Diff* 1 year vs. 15 years (pp)**
A	**1–3**	**N**	0.09%	0.06%	0.03
A	**1–3**	**NNE**	0.05%	0.03%	0.02
A	**1–3**	**NE**	0.05%	0.06%	-0.01
A	**1–3**	**ENE**	0.04%	0.03%	0.01
A	**1–3**	**E**	0.06%	0.07%	-0.01
A	**1–3**	**ESE**	0.03%	0.04%	-0.02
A	**1–3**	**SE**	0.03%	0.08%	-0.05
A	**1–3**	**SSE**	0.05%	0.14%	-0.09
A	**1–3**	**S**	0.04%	0.10%	-0.05
A	**1–3**	**SSW**	0.03%	0.01%	0.02
A	**1–3**	**SW**	0.02%	0.06%	-0.04
A	**1–3**	**WSW**	0.03%	0.03%	0.00
A	**1–3**	**W**	0.07%	0.12%	-0.05
A	**1–3**	**WNW**	0.03%	0.03%	0.00
A	**1–3**	**NW**	0.04%	0.04%	0.00
A	**1–3**	**NNW**	0.05%	0.01%	0.03
A	**4–7**	**N**	0.06%	0.02%	0.04
A	**4–7**	**NNE**	0.03%	0.00%	0.03
A	**4–7**	**NE**	0.02%	0.02%	0.00
A	**4–7**	**ENE**	0.03%	0.02%	0.00
A	**4–7**	**E**	0.04%	0.03%	0.01
A	**4–7**	**ESE**	0.02%	0.03%	-0.02
A	**4–7**	**SE**	0.02%	0.02%	-0.01
A	**4–7**	**SSE**	0.03%	0.07%	-0.04
A	**4–7**	**S**	0.02%	0.03%	-0.01
A	**4–7**	**SSW**	0.02%	0.01%	0.01
A	**4–7**	**SW**	0.01%	0.02%	-0.01
A	**4–7**	**WSW**	0.02%	0.02%	0.00
A	**4–7**	**W**	0.03%	0.03%	0.00
A	**4–7**	**WNW**	0.01%	0.02%	-0.01
A	**4–7**	**NW**	0.03%	0.03%	-0.01
A	**4–7**	**NNW**	0.03%	0.01%	0.02
A	**8–12**	**N**	NA	NA	NA
A	**8–12**	**NNE**	NA	NA	NA
A	**8–12**	**NE**	NA	NA	NA

Table 22. Scottsbluff 1 year and Gillette 15 years Wind Direction and Wind Speed Joint Frequency Distributions for Stability Class A					
Class	Speed (mph)	Direction	15 years (X-axis)	1 year (Y-axis)	Diff* 1 year vs. 15 years (pp)
A	8–12	ENE	NA	NA	NA
A	8–12	E	NA	NA	NA
A	8–12	ESE	NA	NA	NA
A	8–12	SE	NA	NA	NA
A	8–12	SSE	NA	NA	NA
A	8–12	S	NA	NA	NA
A	8–12	SSW	NA	NA	NA
A	8–12	SW	NA	NA	NA
A	8–12	WSW	NA	NA	NA
A	8–12	W	NA	NA	NA
A	8–12	WNW	NA	NA	NA
A	8–12	NW	NA	NA	NA
A	8–12	NNW	NA	NA	NA
A	13–18	N	NA	NA	NA
A	13–18	NNE	NA	NA	NA
A	13–18	NE	NA	NA	NA
A	13–18	ENE	NA	NA	NA
A	13–18	E	NA	NA	NA
A	13–18	ESE	NA	NA	NA
A	13–18	SE	NA	NA	NA
A	13–18	SSE	NA	NA	NA
A	13–18	S	NA	NA	NA
A	13–18	SSW	NA	NA	NA
A	13–18	SW	NA	NA	NA
A	13–18	WSW	NA	NA	NA
A	13–18	W	NA	NA	NA
A	13–18	WNW	NA	NA	NA
A	13–18	NW	NA	NA	NA
A	13–18	NNW	NA	NA	NA
A	19–24	N	NA	NA	NA
A	19–24	NNE	NA	NA	NA
A	19–24	NE	NA	NA	NA
A	19–24	ENE	NA	NA	NA
A	19–24	E	NA	NA	NA
A	19–24	ESE	NA	NA	NA

Table 22. Scottsbluff 1 year and Gillette 15 years Wind Direction and Wind Speed Joint Frequency Distributions for Stability Class A					
Class	**Speed (mph)**	**Direction**	**15 years (X-axis)**	**1 year (Y-axis)**	**Diff* 1 year vs. 15 years (pp)**
A	**19–24**	**SE**	NA	NA	NA
A	**19–24**	**SSE**	NA	NA	NA
A	**19–24**	**S**	NA	NA	NA
A	**19–24**	**SSW**	NA	NA	NA
A	**19–24**	**SW**	NA	NA	NA
A	**19–24**	**WSW**	NA	NA	NA
A	**19–24**	**W**	NA	NA	NA
A	**19–24**	**WNW**	NA	NA	NA
A	**19–24**	**NW**	NA	NA	NA
A	**19–24**	**NNW**	NA	NA	NA
A	**>24**	**N**	NA	NA	NA
A	**>24**	**NNE**	NA	NA	NA
A	**>24**	**NE**	NA	NA	NA
A	**>24**	**ENE**	NA	NA	NA
A	**>24**	**E**	NA	NA	NA
A	**>24**	**ESE**	NA	NA	NA
A	**>24**	**SE**	NA	NA	NA
A	**>24**	**SSE**	NA	NA	NA
A	**>24**	**S**	NA	NA	NA
A	**>24**	**SSW**	NA	NA	NA
A	**>24**	**SW**	NA	NA	NA
A	**>24**	**WSW**	NA	NA	NA
A	**>24**	**W**	NA	NA	NA
A	**>24**	**WNW**	NA	NA	NA
A	**>24**	**NW**	NA	NA	NA
A	**>24**	**NNW**	NA	NA	NA

* Where 'diff' is the difference in percentage points (pp) calculated between the long- and short-term frequencies. The actual numbers used for the percent point calculations include greater than three significant figures. Therefore, the calculated difference as shown in this table may vary slightly due to rounding.

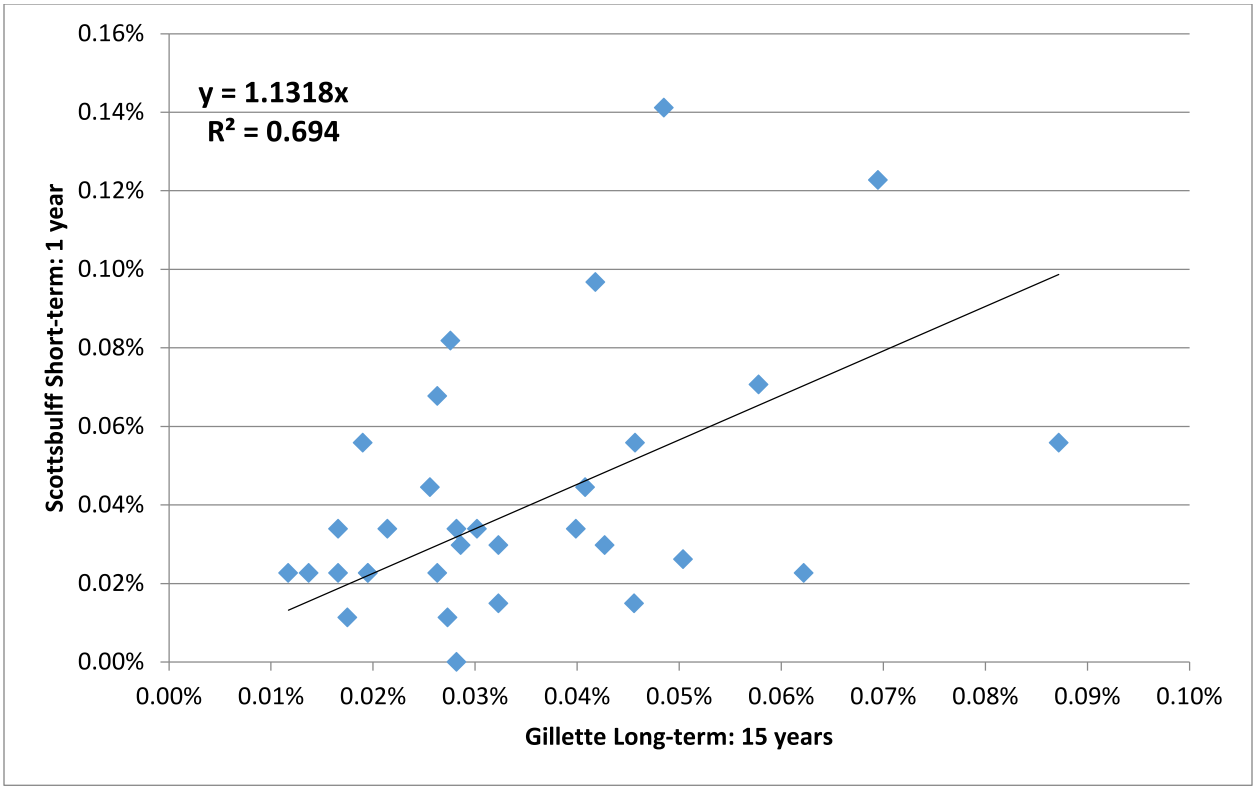

Figure 28. Class A Joint Frequency Distribution: Scottsbluff 1 year vs. Gillette 15 years

Class B occurs during the first three wind speed categories (i.e., 1–3, 4–7, and 8–12 mph) and the linear regression plot only includes those data points. The values for the other wind speed categories are captured as "zeros" in the STAR program; however, these should not be considered as actual values and are excluded from the linear regression analysis. Therefore, the linear regression includes 48 observations which consider three wind speed categories. The other wind categories do not occur, thus "NA" (non-applicable) was included for these in the following table.

Table 23. Scottsbluff 1 year and Gillette 15 years Wind Direction and Wind Speed Joint Frequency Distributions for Stability Class B

Class	Speed (mph)	Direction	15 years (X-axis)	1 year (Y-axis)	Diff* 1 year vs. 15 years
B	**1–3**	**N**	0.22%	0.09%	0.14
B	**1–3**	**NNE**	0.16%	0.04%	0.12
B	**1–3**	**NE**	0.12%	0.03%	0.09
B	**1–3**	**ENE**	0.11%	0.10%	0.01
B	**1–3**	**E**	0.16%	0.20%	-0.04
B	**1–3**	**ESE**	0.12%	0.20%	-0.08
B	**1–3**	**SE**	0.13%	0.29%	-0.16

Table 23. Scottsbluff 1 year and Gillette 15 years Wind Direction and Wind Speed Joint Frequency Distributions for Stability Class B					
Class	**Speed (mph)**	**Direction**	**15 years (X-axis)**	**1 year (Y-axis)**	**Diff* 1 year vs. 15 years**
B	**1–3**	**SSE**	0.12%	0.12%	0.00
B	**1–3**	**S**	0.19%	0.20%	-0.01
B	**1–3**	**SSW**	0.09%	0.12%	-0.02
B	**1–3**	**SW**	0.12%	0.09%	0.03
B	**1–3**	**WSW**	0.10%	0.10%	0.00
B	**1–3**	**W**	0.16%	0.28%	-0.12
B	**1–3**	**WNW**	0.11%	0.28%	-0.17
B	**1–3**	**NW**	0.11%	0.12%	-0.01
B	**1–3**	**NNW**	0.12%	0.06%	0.06
B	**4–7**	**N**	0.35%	0.08%	0.27
B	**4–7**	**NNE**	0.20%	0.08%	0.12
B	**4–7**	**NE**	0.14%	0.02%	0.12
B	**4–7**	**ENE**	0.11%	0.14%	-0.03
B	**4–7**	**E**	0.17%	0.42%	-0.25
B	**4–7**	**ESE**	0.12%	0.23%	-0.10
B	**4–7**	**SE**	0.15%	0.32%	-0.17
B	**4–7**	**SSE**	0.16%	0.23%	-0.07
B	**4–7**	**S**	0.20%	0.28%	-0.08
B	**4–7**	**SSW**	0.11%	0.09%	0.02
B	**4–7**	**SW**	0.11%	0.05%	0.07
B	**4–7**	**WSW**	0.12%	0.09%	0.03
B	**4–7**	**W**	0.22%	0.34%	-0.12
B	**4–7**	**WNW**	0.13%	0.35%	-0.22
B	**4–7**	**NW**	0.20%	0.32%	-0.12
B	**4–7**	**NNW**	0.16%	0.16%	0.01
B	**8–12**	**N**	0.18%	0.07%	0.12
B	**8–12**	**NNE**	0.10%	0.02%	0.07
B	**8–12**	**NE**	0.07%	0.02%	0.05
B	**8–12**	**ENE**	0.05%	0.02%	0.02
B	**8–12**	**E**	0.09%	0.21%	-0.13
B	**8–12**	**ESE**	0.06%	0.26%	-0.20
B	**8–12**	**SE**	0.10%	0.19%	-0.10
B	**8–12**	**SSE**	0.11%	0.17%	-0.06
B	**8–12**	**S**	0.18%	0.12%	0.06
B	**8–12**	**SSW**	0.07%	0.06%	0.02

Class	Speed (mph)	Direction	15 years (X-axis)	1 year (Y-axis)	Diff* 1 year vs. 15 years
B	**8–12**	**SW**	0.07%	0.07%	0.01
B	**8–12**	**WSW**	0.07%	0.02%	0.05
B	**8–12**	**W**	0.09%	0.21%	-0.12
B	**8–12**	**WNW**	0.10%	0.16%	-0.06
B	**8–12**	**NW**	0.12%	0.23%	-0.11
B	**8–12**	**NNW**	0.12%	0.11%	0.00
B	**13–18**	**N**	NA	NA	NA
B	**13–18**	**NNE**	NA	NA	NA
B	**13–18**	**NE**	NA	NA	NA
B	**13–18**	**ENE**	NA	NA	NA
B	**13–18**	**E**	NA	NA	NA
B	**13–18**	**ESE**	NA	NA	NA
B	**13–18**	**SE**	NA	NA	NA
B	**13–18**	**SSE**	NA	NA	NA
B	**13–18**	**S**	NA	NA	NA
B	**13–18**	**SSW**	NA	NA	NA
B	**13–18**	**SW**	NA	NA	NA
B	**13–18**	**WSW**	NA	NA	NA
B	**13–18**	**W**	NA	NA	NA
B	**13–18**	**WNW**	NA	NA	NA
B	**13–18**	**NW**	NA	NA	NA
B	**13–18**	**NNW**	NA	NA	NA
B	**19–24**	**N**	NA	NA	NA
B	**19–24**	**NNE**	NA	NA	NA
B	**19–24**	**NE**	NA	NA	NA
B	**19–24**	**ENE**	NA	NA	NA
B	**19–24**	**E**	NA	NA	NA
B	**19–24**	**ESE**	NA	NA	NA
B	**19–24**	**SE**	NA	NA	NA
B	**19–24**	**SSE**	NA	NA	NA
B	**19–24**	**S**	NA	NA	NA
B	**19–24**	**SSW**	NA	NA	NA
B	**19–24**	**SW**	NA	NA	NA
B	**19–24**	**WSW**	NA	NA	NA
B	**19–24**	**W**	NA	NA	NA

Table 23. Scottsbluff 1 year and Gillette 15 years Wind Direction and Wind Speed Joint Frequency Distributions for Stability Class B					
Class	Speed (mph)	Direction	15 years (X-axis)	1 year (Y-axis)	Diff* 1 year vs. 15 years
B	19–24	WNW	NA	NA	NA
B	19–24	NW	NA	NA	NA
B	19–24	NNW	NA	NA	NA
B	>24	N	NA	NA	NA
B	>24	NNE	NA	NA	NA
B	>24	NE	NA	NA	NA
B	>24	ENE	NA	NA	NA
B	>24	E	NA	NA	NA
B	>24	ESE	NA	NA	NA
B	>24	SE	NA	NA	NA
B	>24	SSE	NA	NA	NA
B	>24	S	NA	NA	NA
B	>24	SSW	NA	NA	NA
B	>24	SW	NA	NA	NA
B	>24	WSW	NA	NA	NA
B	>24	W	NA	NA	NA
B	>24	WNW	NA	NA	NA
B	>24	NW	NA	NA	NA
B	>24	NNW	NA	NA	NA

* Where 'diff' is the difference in percentage points (pp) calculated between the long- and short-term frequencies. The actual numbers used for the percent point calculations include greater than three significant figures. Therefore, the calculated difference as shown in this table may vary slightly due to rounding.

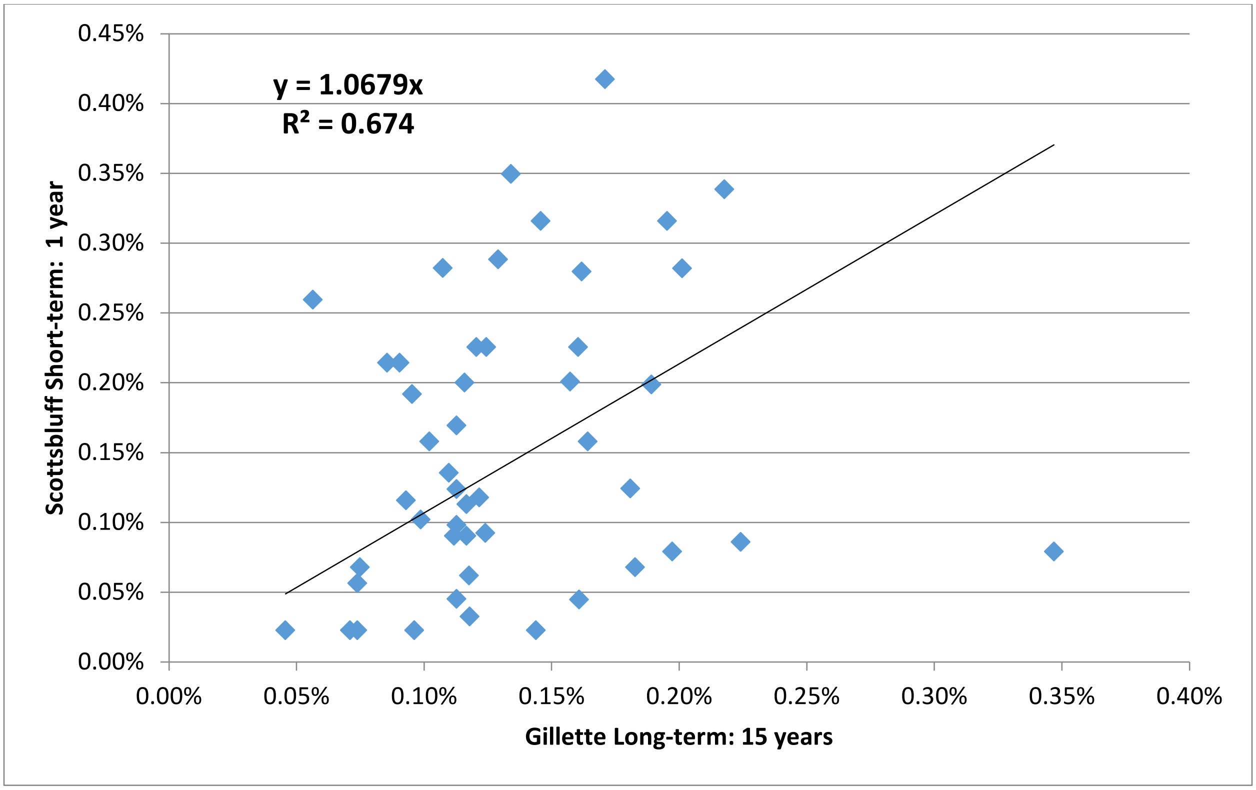

Figure 29. Class B Joint Frequency Distribution: Scottsbluff 1 year vs. Gillette 15 years

Class C occurs for all wind speed categories and the linear regression includes those data points. Therefore, the linear regression includes 96 observations which consider all wind speed categories.

Table 24. Scottsbluff 1 year and Gillette 15 years Wind Direction and Wind Speed Joint Frequency Distributions for Stability Class C					
Class	Speed (mph)	Direction	15 years (X-axis)	1 year (Y-axis)	Diff* 1 year vs. 15 years
C	1–3	N	0.08%	0.05%	0.03
C	1–3	NNE	0.05%	0.04%	0.01
C	1–3	NE	0.04%	0.01%	0.03
C	1–3	ENE	0.04%	0.01%	0.03
C	1–3	E	0.07%	0.08%	-0.01
C	1–3	ESE	0.05%	0.06%	-0.01
C	1–3	SE	0.05%	0.06%	-0.01
C	1–3	SSE	0.07%	0.07%	0.00
C	1–3	S	0.11%	0.05%	0.06
C	1–3	SSW	0.05%	0.03%	0.03
C	1–3	SW	0.06%	0.01%	0.05
C	1–3	WSW	0.06%	0.02%	0.04

Table 24. Scottsbluff 1 year and Gillette 15 years Wind Direction and Wind Speed Joint Frequency Distributions for Stability Class C

Class	Speed (mph)	Direction	15 years (X-axis)	1 year (Y-axis)	Diff* 1 year vs. 15 years
C	1–3	W	0.08%	0.08%	0.00
C	1–3	WNW	0.05%	0.11%	-0.06
C	1–3	NW	0.05%	0.06%	-0.01
C	1–3	NNW	0.06%	0.05%	0.01
C	4–7	N	0.24%	0.11%	0.12
C	4–7	NNE	0.14%	0.08%	0.06
C	4–7	NE	0.10%	0.01%	0.09
C	4–7	ENE	0.08%	0.05%	0.04
C	4–7	E	0.14%	0.20%	-0.07
C	4–7	ESE	0.13%	0.26%	-0.13
C	4–7	SE	0.12%	0.26%	-0.14
C	4–7	SSE	0.19%	0.33%	-0.14
C	4–7	S	0.25%	0.17%	0.08
C	4–7	SSW	0.13%	0.10%	0.03
C	4–7	SW	0.17%	0.05%	0.13
C	4–7	WSW	0.18%	0.07%	0.11
C	4–7	W	0.28%	0.29%	-0.02
C	4–7	WNW	0.15%	0.41%	-0.25
C	4–7	NW	0.16%	0.30%	-0.14
C	4–7	NNW	0.14%	0.15%	-0.01
C	8–12	N	0.69%	0.16%	0.53
C	8–12	NNE	0.27%	0.12%	0.14
C	8–12	NE	0.20%	0.11%	0.08
C	8–12	ENE	0.13%	0.16%	-0.02
C	8–12	E	0.21%	0.44%	-0.23
C	8–12	ESE	0.18%	0.77%	-0.58
C	8–12	SE	0.27%	0.86%	-0.58
C	8–12	SSE	0.47%	0.32%	0.15
C	8–12	S	0.70%	0.28%	0.42
C	8–12	SSW	0.34%	0.09%	0.25
C	8–12	SW	0.43%	0.11%	0.32
C	8–12	WSW	0.42%	0.08%	0.34
C	8–12	W	0.54%	0.59%	-0.05
C	8–12	WNW	0.43%	0.77%	-0.34
C	8–12	NW	0.43%	0.67%	-0.23

Table 24. Scottsbluff 1 year and Gillette 15 years Wind Direction and Wind Speed Joint Frequency Distributions for Stability Class C					
Class	**Speed (mph)**	**Direction**	**15 years (X-axis)**	**1 year (Y-axis)**	**Diff* 1 year vs. 15 years**
C	**8–12**	**NNW**	0.44%	0.23%	0.22
C	**13–18**	**N**	0.15%	0.03%	0.11
C	**13–18**	**NNE**	0.07%	0.02%	0.05
C	**13–18**	**NE**	0.03%	0.05%	-0.01
C	**13–18**	**ENE**	0.02%	0.08%	-0.06
C	**13–18**	**E**	0.02%	0.14%	-0.11
C	**13–18**	**ESE**	0.03%	0.17%	-0.14
C	**13–18**	**SE**	0.11%	0.18%	-0.07
C	**13–18**	**SSE**	0.15%	0.16%	0.00
C	**13–18**	**S**	0.19%	0.11%	0.08
C	**13–18**	**SSW**	0.08%	0.03%	0.05
C	**13–18**	**SW**	0.07%	0.01%	0.06
C	**13–18**	**WSW**	0.05%	0.05%	0.01
C	**13–18**	**W**	0.04%	0.15%	-0.10
C	**13–18**	**WNW**	0.08%	0.16%	-0.08
C	**13–18**	**NW**	0.15%	0.18%	-0.03
C	**13–18**	**NNW**	0.14%	0.05%	0.09
C	**19–24**	**N**	0.01%	0.00%	0.01
C	**19–24**	**NNE**	0.00%	0.00%	0.00
C	**19–24**	**NE**	0.00%	0.00%	0.00
C	**19–24**	**ENE**	0.00%	0.01%	-0.01
C	**19–24**	**E**	0.00%	0.00%	0.00
C	**19–24**	**ESE**	0.00%	0.00%	0.00
C	**19–24**	**SE**	0.01%	0.02%	-0.01
C	**19–24**	**SSE**	0.04%	0.02%	0.02
C	**19–24**	**S**	0.02%	0.01%	0.01
C	**19–24**	**SSW**	0.01%	0.01%	0.00
C	**19–24**	**SW**	0.01%	0.01%	0.00
C	**19–24**	**WSW**	0.00%	0.00%	0.00
C	**19–24**	**W**	0.00%	0.00%	0.00
C	**19–24**	**WNW**	0.01%	0.05%	-0.04
C	**19–24**	**NW**	0.03%	0.01%	0.02
C	**19–24**	**NNW**	0.03%	0.03%	-0.01
C	**>24**	**N**	0.00%	0.00%	0.00
C	**>24**	**NNE**	0.00%	0.00%	0.00

Table 24. Scottsbluff 1 year and Gillette 15 years Wind Direction and Wind Speed Joint Frequency Distributions for Stability Class C					
Class	**Speed (mph)**	**Direction**	**15 years (X-axis)**	**1 year (Y-axis)**	**Diff* 1 year vs. 15 years**
C	**>24**	**NE**	0.00%	0.00%	0.00
C	**>24**	**ENE**	0.00%	0.00%	0.00
C	**>24**	**E**	0.00%	0.00%	0.00
C	**>24**	**ESE**	0.00%	0.00%	0.00
C	**>24**	**SE**	0.01%	0.01%	-0.01
C	**>24**	**SSE**	0.01%	0.00%	0.01
C	**>24**	**S**	0.00%	0.00%	0.00
C	**>24**	**SSW**	0.00%	0.00%	0.00
C	**>24**	**SW**	0.00%	0.00%	0.00
C	**>24**	**WSW**	0.00%	0.00%	0.00
C	**>24**	**W**	0.00%	0.00%	0.00
C	**>24**	**WNW**	0.00%	0.02%	-0.02
C	**>24**	**NW**	0.01%	0.05%	-0.04
C	**>24**	**NNW**	0.00%	0.01%	-0.01

* Where 'diff' is the difference in percentage points (pp) calculated between the long- and short-term frequencies. The actual numbers used for the percent point calculations include greater than three significant figures. Therefore, the calculated difference as shown in this table may vary slightly due to rounding.

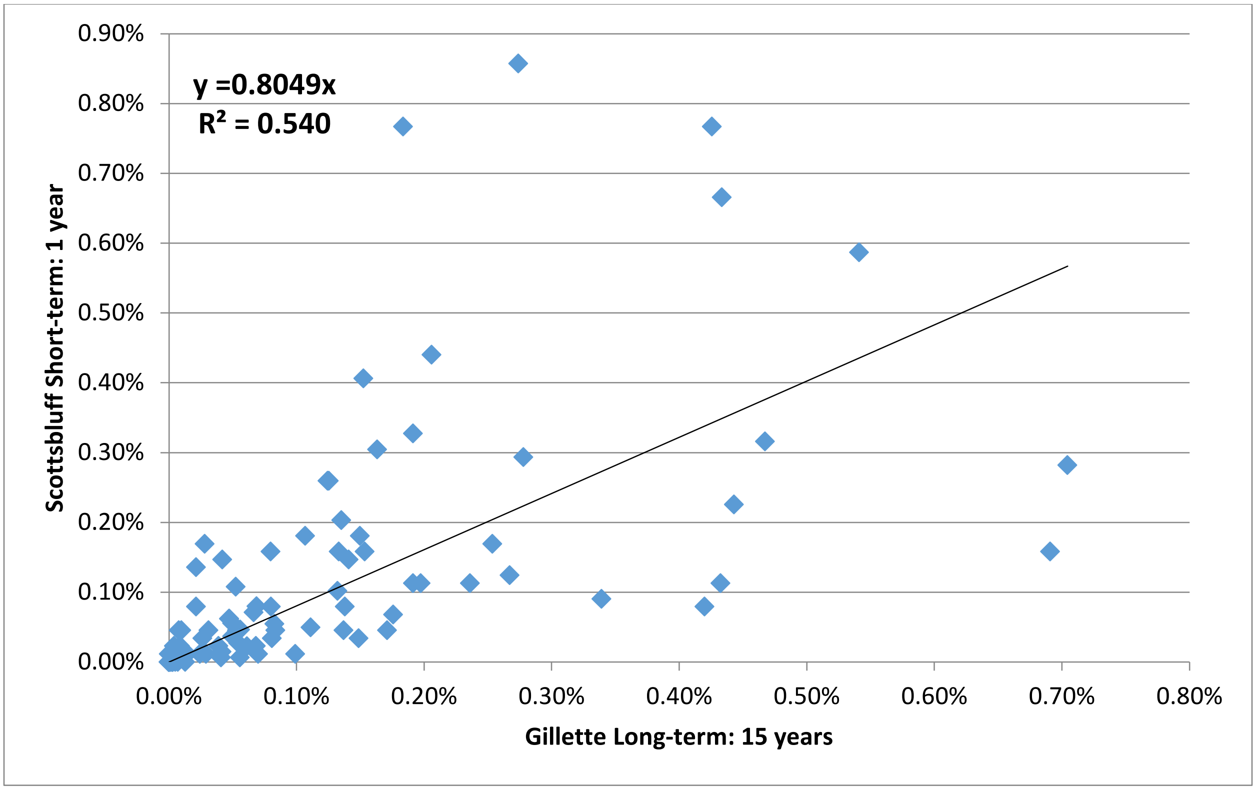

Figure 30. Class C Joint Frequency Distribution: Scottsbluff 1 year vs. Gillette 15 years

Class D occurs for all wind speed categories and the linear regression includes those data points. Therefore, the linear regression includes 96 observations which consider all wind speed categories.

Table 25. Scottsbluff 1 year and Gillette 15 years Wind Direction and Wind Speed Joint Frequency Distributions for Stability Class D

Class	Speed (mph)	Direction	15 years (X-axis)	1 year (Y-axis)	Diff* 1 year vs. 15 years (pp)
D	1–3	N	0.29%	0.14%	0.15
D	1–3	NNE	0.10%	0.15%	-0.05
D	1–3	NE	0.09%	0.13%	-0.03
D	1–3	ENE	0.07%	0.08%	-0.01
D	1–3	E	0.11%	0.18%	-0.08
D	1–3	ESE	0.07%	0.26%	-0.18
D	1–3	SE	0.08%	0.10%	-0.02
D	1–3	SSE	0.08%	0.08%	0.00
D	1–3	S	0.14%	0.07%	0.07
D	1–3	SSW	0.05%	0.01%	0.03
D	1–3	SW	0.05%	0.02%	0.03
D	1–3	WSW	0.06%	0.04%	0.02

Table 25. Scottsbluff 1 year and Gillette 15 years Wind Direction and Wind Speed Joint Frequency Distributions for Stability Class D

Class	Speed (mph)	Direction	15 years (X-axis)	1 year (Y-axis)	Diff* 1 year vs. 15 years (pp)
D	1–3	W	0.13%	0.19%	-0.06
D	1–3	WNW	0.10%	0.23%	-0.13
D	1–3	NW	0.13%	0.20%	-0.07
D	1–3	NNW	0.17%	0.12%	0.06
D	4–7	N	0.64%	0.38%	0.26
D	4–7	NNE	0.22%	0.29%	-0.07
D	4–7	NE	0.18%	0.20%	-0.03
D	4–7	ENE	0.16%	0.19%	-0.03
D	4–7	E	0.20%	0.51%	-0.30
D	4–7	ESE	0.16%	0.53%	-0.37
D	4–7	SE	0.18%	0.26%	-0.08
D	4–7	SSE	0.20%	0.24%	-0.04
D	4–7	S	0.26%	0.11%	0.15
D	4–7	SSW	0.11%	0.06%	0.05
D	4–7	SW	0.13%	0.01%	0.11
D	4–7	WSW	0.12%	0.01%	0.11
D	4–7	W	0.32%	0.24%	0.08
D	4–7	WNW	0.26%	0.61%	-0.35
D	4–7	NW	0.29%	0.44%	-0.15
D	4–7	NNW	0.41%	0.27%	0.14
D	8–12	N	1.32%	0.54%	0.78
D	8–12	NNE	0.43%	0.45%	-0.02
D	8–12	NE	0.26%	0.36%	-0.10
D	8–12	ENE	0.13%	0.24%	-0.11
D	8–12	E	0.20%	1.01%	-0.81
D	8–12	ESE	0.21%	1.63%	-1.42
D	8–12	SE	0.34%	0.81%	-0.47
D	8–12	SSE	0.49%	0.30%	0.19
D	8–12	S	0.65%	0.19%	0.46
D	8–12	SSW	0.23%	0.07%	0.16
D	8–12	SW	0.38%	0.05%	0.34
D	8–12	WSW	0.55%	0.05%	0.50
D	8–12	W	1.13%	0.71%	0.42
D	8–12	WNW	0.81%	1.31%	-0.50
D	8–12	NW	0.91%	1.16%	-0.26

Table 25. Scottsbluff 1 year and Gillette 15 years Wind Direction and Wind Speed Joint Frequency Distributions for Stability Class D					
Class	Speed (mph)	Direction	15 years (X-axis)	1 year (Y-axis)	Diff* 1 year vs. 15 years (pp)
D	8–12	NNW	0.99%	0.48%	0.51
D	13–18	N	1.94%	0.78%	1.16
D	13–18	NNE	0.55%	0.52%	0.04
D	13–18	NE	0.22%	0.53%	-0.31
D	13–18	ENE	0.11%	0.64%	-0.53
D	13–18	E	0.14%	0.99%	-0.86
D	13–18	ESE	0.30%	3.21%	-2.92
D	13–18	SE	1.17%	1.70%	-0.53
D	13–18	SSE	2.23%	0.78%	1.45
D	13–18	S	3.94%	0.34%	3.60
D	13–18	SSW	1.44%	0.17%	1.28
D	13–18	SW	2.99%	0.09%	2.90
D	13–18	WSW	1.56%	0.07%	1.49
D	13–18	W	1.51%	1.78%	-0.27
D	13–18	WNW	1.67%	3.93%	-2.27
D	13–18	NW	2.55%	2.27%	0.29
D	13–18	NNW	2.37%	1.43%	0.94
D	19–24	N	0.42%	0.10%	0.32
D	19–24	NNE	0.08%	0.14%	-0.05
D	19–24	NE	0.03%	0.07%	-0.04
D	19–24	ENE	0.00%	0.11%	-0.11
D	19–24	E	0.01%	0.11%	-0.10
D	19–24	ESE	0.10%	0.19%	-0.09
D	19–24	SE	0.33%	0.10%	0.23
D	19–24	SSE	0.86%	0.24%	0.63
D	19–24	S	1.14%	0.11%	1.02
D	19–24	SSW	0.60%	0.01%	0.59
D	19–24	SW	1.42%	0.02%	1.40
D	19–24	WSW	0.39%	0.02%	0.36
D	19–24	W	0.18%	0.52%	-0.34
D	19–24	WNW	0.38%	1.03%	-0.65
D	19–24	NW	1.28%	0.96%	0.33
D	19–24	NNW	0.94%	0.73%	0.20
D	>24	N	0.07%	0.00%	0.07
D	>24	NNE	0.01%	0.02%	-0.01

Table 25. Scottsbluff 1 year and Gillette 15 years Wind Direction and Wind Speed Joint Frequency Distributions for Stability Class D

Class	Speed (mph)	Direction	15 years (X-axis)	1 year (Y-axis)	Diff* 1 year vs. 15 years (pp)
D	>24	NE	0.00%	0.05%	-0.04
D	>24	ENE	0.00%	0.02%	-0.02
D	>24	E	0.00%	0.02%	-0.02
D	>24	ESE	0.03%	0.00%	0.03
D	>24	SE	0.08%	0.00%	0.08
D	>24	SSE	0.33%	0.02%	0.30
D	>24	S	0.27%	0.01%	0.26
D	>24	SSW	0.23%	0.00%	0.23
D	>24	SW	0.82%	0.00%	0.82
D	>24	WSW	0.14%	0.01%	0.13
D	>24	W	0.05%	0.44%	-0.39
D	>24	WNW	0.16%	0.54%	-0.38
D	>24	NW	0.70%	0.52%	0.18
D	>24	NNW	0.39%	0.33%	0.06

* Where 'diff' is the difference in percentage points (pp) calculated between the long- and short-term frequencies. The actual numbers used for the percent point calculations include greater than three significant figures. Therefore, the calculated difference as shown in this table may vary slightly due to rounding.

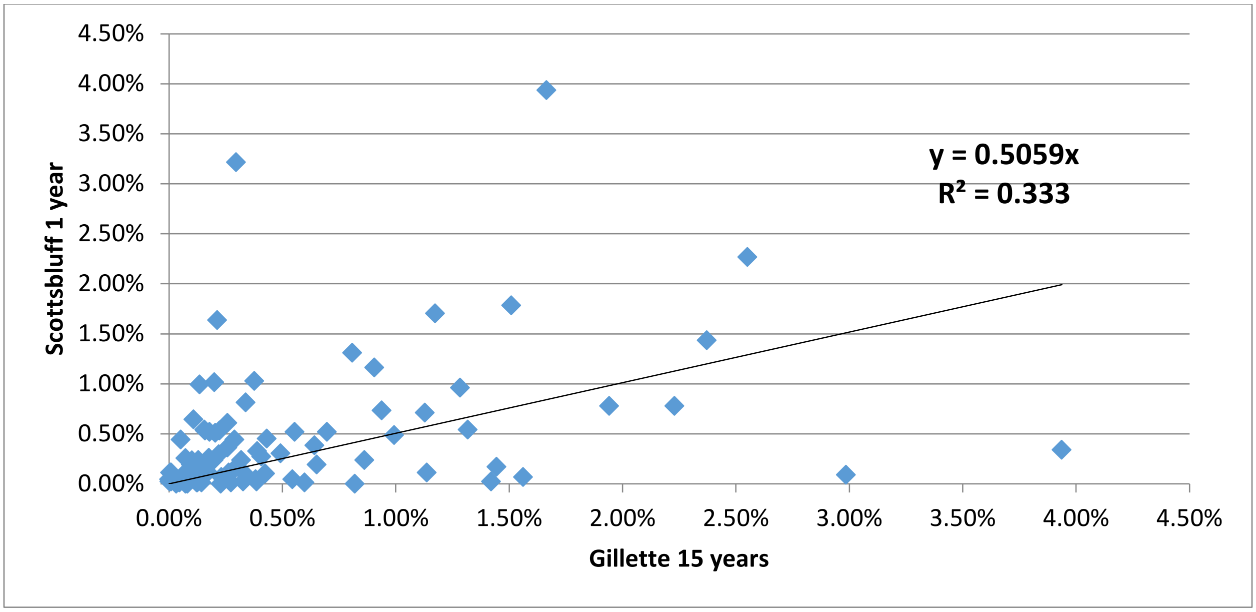

Figure 31. Class D Joint Frequency Distribution: Scottsbluff 1 year vs. Gillette 15 years

Class E occurs during wind speed categories 4–7 and 8–12 mph, and the linear regression plot only includes those data points. The values for the other wind speed categories are captured as "zeros" in the STAR program; however, these should not be considered as actual values and are excluded from the linear regression analysis. Therefore, the linear regression includes 32 observations which consider two wind speed categories. The other wind categories do not occur, thus "NA" (non-applicable) was included for these in the following table.

Table 26. Scottsbluff 1 year and Gillette 15 years Wind Direction and Wind Speed Joint Frequency Distributions for Stability Class E

Class	Speed (mph)	Direction	15 years (X-axis)	1 year (Y-axis)	Diff* 1 year vs. 15 years (pp)
E	1–3	N	NA	NA	NA
E	1–3	NNE	NA	NA	NA
E	1–3	NE	NA	NA	NA
E	1–3	ENE	NA	NA	NA
E	1–3	E	NA	NA	NA
E	1–3	ESE	NA	NA	NA
E	1–3	SE	NA	NA	NA
E	1–3	SSE	NA	NA	NA
E	1–3	S	NA	NA	NA
E	1–3	SSW	NA	NA	NA
E	1–3	SW	NA	NA	NA
E	1–3	WSW	NA	NA	NA
E	1–3	W	NA	NA	NA
E	1–3	WNW	NA	NA	NA
E	1–3	NW	NA	NA	NA
E	1–3	NNW	NA	NA	NA
E	4–7	N	0.11%	0.19%	-0.08
E	4–7	NNE	0.02%	0.09%	-0.07
E	4–7	NE	0.04%	0.02%	0.01
E	4–7	ENE	0.03%	0.08%	-0.05
E	4–7	E	0.04%	0.20%	-0.16
E	4–7	ESE	0.03%	0.12%	-0.09
E	4–7	SE	0.04%	0.14%	-0.09
E	4–7	SSE	0.06%	0.08%	-0.02
E	4–7	S	0.13%	0.08%	0.05
E	4–7	SSW	0.05%	0.01%	0.04
E	4–7	SW	0.06%	0.02%	0.04

Table 26. Scottsbluff 1 year and Gillette 15 years Wind Direction and Wind Speed Joint Frequency Distributions for Stability Class E					
Class	**Speed (mph)**	**Direction**	**15 years (X-axis)**	**1 year (Y-axis)**	**Diff* 1 year vs. 15 years (pp)**
E	**4–7**	**WSW**	0.06%	0.02%	0.04
E	**4–7**	**W**	0.15%	0.11%	0.04
E	**4–7**	**WNW**	0.08%	0.36%	-0.28
E	**4–7**	**NW**	0.08%	0.36%	-0.28
E	**4–7**	**NNW**	0.12%	0.16%	-0.04
E	**8–12**	**N**	0.27%	0.24%	0.04
E	**8–12**	**NNE**	0.14%	0.36%	-0.22
E	**8–12**	**NE**	0.12%	0.18%	-0.06
E	**8–12**	**ENE**	0.07%	0.32%	-0.24
E	**8–12**	**E**	0.12%	2.22%	-2.10
E	**8–12**	**ESE**	0.17%	2.68%	-2.52
E	**8–12**	**SE**	0.56%	0.65%	-0.09
E	**8–12**	**SSE**	1.07%	0.15%	0.92
E	**8–12**	**S**	2.25%	0.17%	2.08
E	**8–12**	**SSW**	0.40%	0.14%	0.27
E	**8–12**	**SW**	0.89%	0.05%	0.85
E	**8–12**	**WSW**	0.91%	0.06%	0.85
E	**8–12**	**W**	1.90%	0.70%	1.20
E	**8–12**	**WNW**	0.66%	1.68%	-1.02
E	**8–12**	**NW**	0.45%	1.27%	-0.83
E	**8–12**	**NNW**	0.39%	0.35%	0.04
E	**13–18**	**N**	NA	NA	NA
E	**13–18**	**NNE**	NA	NA	NA
E	**13–18**	**NE**	NA	NA	NA
E	**13–18**	**ENE**	NA	NA	NA
E	**13–18**	**E**	NA	NA	NA
E	**13–18**	**ESE**	NA	NA	NA
E	**13–18**	**SE**	NA	NA	NA
E	**13–18**	**SSE**	NA	NA	NA
E	**13–18**	**S**	NA	NA	NA
E	**13–18**	**SSW**	NA	NA	NA
E	**13–18**	**SW**	NA	NA	NA
E	**13–18**	**WSW**	NA	NA	NA
E	**13–18**	**W**	NA	NA	NA
E	**13–18**	**WNW**	NA	NA	NA

Table 26. Scottsbluff 1 year and Gillette 15 years Wind Direction and Wind Speed Joint Frequency Distributions for Stability Class E					
Class	Speed (mph)	Direction	15 years (X-axis)	1 year (Y-axis)	Diff* 1 year vs. 15 years (pp)
E	**13–18**	**NW**	NA	NA	NA
E	**13–18**	**NNW**	NA	NA	NA
E	**19–24**	**N**	NA	NA	NA
E	**19–24**	**NNE**	NA	NA	NA
E	**19–24**	**NE**	NA	NA	NA
E	**19–24**	**ENE**	NA	NA	NA
E	**19–24**	**E**	NA	NA	NA
E	**19–24**	**ESE**	NA	NA	NA
E	**19–24**	**SE**	NA	NA	NA
E	**19–24**	**SSE**	NA	NA	NA
E	**19–24**	**S**	NA	NA	NA
E	**19–24**	**SSW**	NA	NA	NA
E	**19–24**	**SW**	NA	NA	NA
E	**19–24**	**WSW**	NA	NA	NA
E	**19–24**	**W**	NA	NA	NA
E	**19–24**	**WNW**	NA	NA	NA
E	**19–24**	**NW**	NA	NA	NA
E	**19–24**	**NNW**	NA	NA	NA
E	**>24**	**N**	NA	NA	NA
E	**>24**	**NNE**	NA	NA	NA
E	**>24**	**NE**	NA	NA	NA
E	**>24**	**ENE**	NA	NA	NA
E	**>24**	**E**	NA	NA	NA
E	**>24**	**ESE**	NA	NA	NA
E	**>24**	**SE**	NA	NA	NA
E	**>24**	**SSE**	NA	NA	NA
E	**>24**	**S**	NA	NA	NA
E	**>24**	**SSW**	NA	NA	NA
E	**>24**	**SW**	NA	NA	NA
E	**>24**	**WSW**	NA	NA	NA
E	**>24**	**W**	NA	NA	NA
E	**>24**	**WNW**	NA	NA	NA
E	**>24**	**NW**	NA	NA	NA
E	**>24**	**NNW**	NA	NA	NA

*Where 'diff' is the difference in percentage points (pp) calculated between the long- and short-term frequencies. The actual numbers used for the percent point calculations include greater than three significant figures. Therefore,

the calculated difference as shown in this table may vary slightly due to rounding.

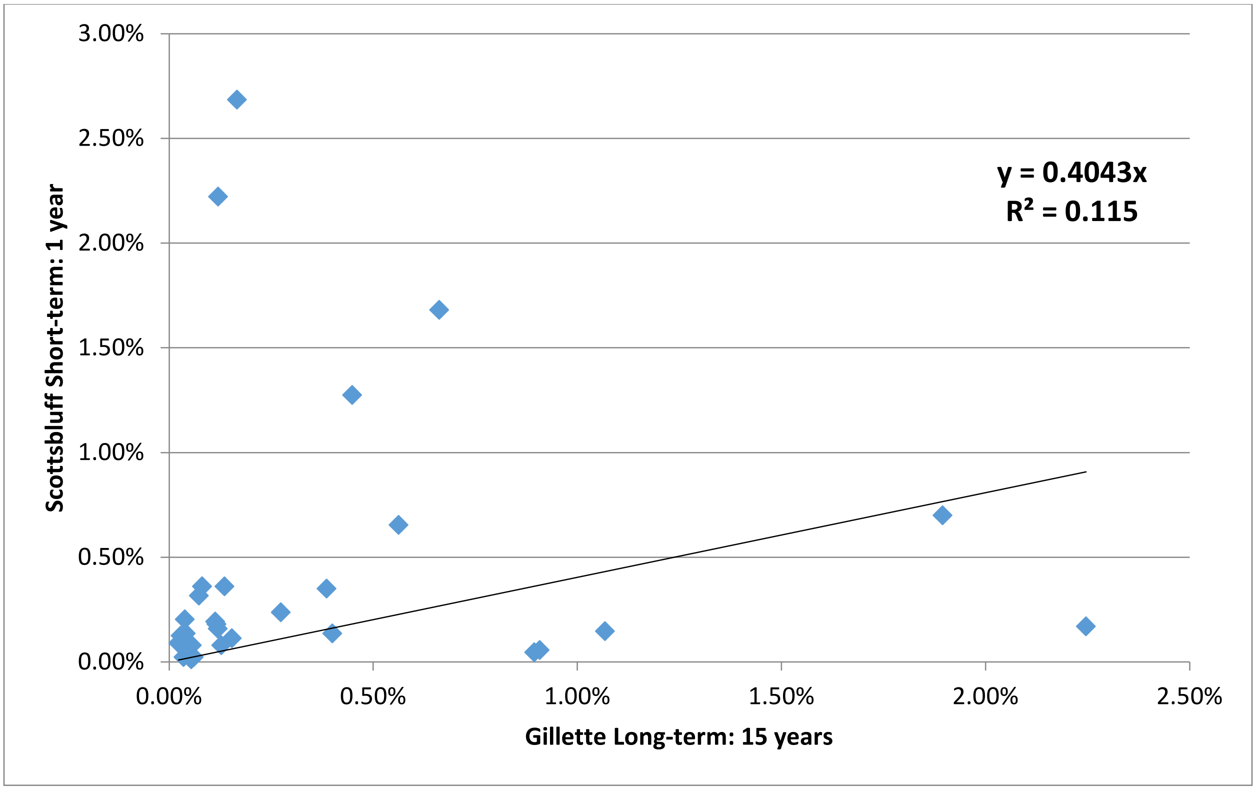

Figure 32. Class E Joint Frequency Distribution: Scottsbluff 1 year vs. Gillette 15 years

Class F occurs during wind speed categories 1–3 and 4–7 mph, and the linear regression plot only includes those data points. The values for the other wind speed categories are captured as "zeros" in the STAR program; however, these should not be considered as actual values and are excluded from the linear regression analysis. Therefore, the linear regression includes 32 observations which consider two wind speed categories. The other wind categories do not occur, thus "NA" (non-applicable) was included for these in the following table.

Table 27. Scottsbluff 1 year and Gillette 15 years Wind Direction and Wind Speed Joint Frequency Distributions for Stability Class F

Class	Speed (mph)	Direction	15 years (X-axis)	1 year (Y-axis)	Diff* 1 year vs. 15 years
F	1–3	N	0.46%	0.92%	-0.46
F	1–3	NNE	0.22%	0.43%	-0.21
F	1–3	NE	0.22%	0.51%	-0.29
F	1–3	ENE	0.19%	0.61%	-0.41
F	1–3	E	0.41%	1.49%	-1.07

Table 27. Scottsbluff 1 year and Gillette 15 years Wind Direction and Wind Speed Joint Frequency Distributions for Stability Class F					
Class	**Speed (mph)**	**Direction**	**15 years (X-axis)**	**1 year (Y-axis)**	**Diff* 1 year vs. 15 years**
F	**1–3**	**ESE**	0.39%	0.93%	-0.54
F	**1–3**	**SE**	0.55%	0.42%	0.13
F	**1–3**	**SSE**	0.94%	0.31%	0.63
F	**1–3**	**S**	2.17%	0.25%	1.91
F	**1–3**	**SSW**	1.15%	0.06%	1.09
F	**1–3**	**SW**	0.98%	0.09%	0.90
F	**1–3**	**WSW**	0.77%	0.12%	0.65
F	**1–3**	**W**	0.84%	0.59%	0.25
F	**1–3**	**WNW**	0.39%	0.85%	-0.47
F	**1–3**	**NW**	0.41%	1.22%	-0.82
F	**1–3**	**NNW**	0.44%	0.79%	-0.35
F	**4–7**	**N**	0.31%	0.94%	-0.63
F	**4–7**	**NNE**	0.15%	0.56%	-0.42
F	**4–7**	**NE**	0.15%	0.71%	-0.56
F	**4–7**	**ENE**	0.14%	0.68%	-0.54
F	**4–7**	**E**	0.29%	3.01%	-2.72
F	**4–7**	**ESE**	0.30%	1.97%	-1.68
F	**4–7**	**SE**	0.45%	0.68%	-0.23
F	**4–7**	**SSE**	0.84%	0.36%	0.48
F	**4–7**	**S**	1.99%	0.36%	1.63
F	**4–7**	**SSW**	0.76%	0.10%	0.66
F	**4–7**	**SW**	0.65%	0.17%	0.48
F	**4–7**	**WSW**	0.57%	0.14%	0.44
F	**4–7**	**W**	0.80%	0.69%	0.11
F	**4–7**	**WNW**	0.33%	1.78%	-1.45
F	**4–7**	**NW**	0.38%	2.49%	-2.11
F	**4–7**	**NNW**	0.37%	1.17%	-0.80
F	**8–12**	**N**	NA	NA	NA
F	**8–12**	**NNE**	NA	NA	NA
F	**8–12**	**NE**	NA	NA	NA
F	**8–12**	**ENE**	NA	NA	NA
F	**8–12**	**E**	NA	NA	NA
F	**8–12**	**ESE**	NA	NA	NA
F	**8–12**	**SE**	NA	NA	NA
F	**8–12**	**SSE**	NA	NA	NA

Table 27. Scottsbluff 1 year and Gillette 15 years Wind Direction and Wind Speed Joint Frequency Distributions for Stability Class F					
Class	Speed (mph)	Direction	15 years (X-axis)	1 year (Y-axis)	Diff* 1 year vs. 15 years
F	8–12	S	NA	NA	NA
F	8–12	SSW	NA	NA	NA
F	8–12	SW	NA	NA	NA
F	8–12	WSW	NA	NA	NA
F	8–12	W	NA	NA	NA
F	8–12	WNW	NA	NA	NA
F	8–12	NW	NA	NA	NA
F	8–12	NNW	NA	NA	NA
F	13–18	N	NA	NA	NA
F	13–18	NNE	NA	NA	NA
F	13–18	NE	NA	NA	NA
F	13–18	ENE	NA	NA	NA
F	13–18	E	NA	NA	NA
F	13–18	ESE	NA	NA	NA
F	13–18	SE	NA	NA	NA
F	13–18	SSE	NA	NA	NA
F	13–18	S	NA	NA	NA
F	13–18	SSW	NA	NA	NA
F	13–18	SW	NA	NA	NA
F	13–18	WSW	NA	NA	NA
F	13–18	W	NA	NA	NA
F	13–18	WNW	NA	NA	NA
F	13–18	NW	NA	NA	NA
F	13–18	NNW	NA	NA	NA
F	19–24	N	NA	NA	NA
F	19–24	NNE	NA	NA	NA
F	19–24	NE	NA	NA	NA
F	19–24	ENE	NA	NA	NA
F	19–24	E	NA	NA	NA
F	19–24	ESE	NA	NA	NA
F	19–24	SE	NA	NA	NA
F	19–24	SSE	NA	NA	NA
F	19–24	S	NA	NA	NA
F	19–24	SSW	NA	NA	NA
F	19–24	SW	NA	NA	NA

Table 27. Scottsbluff 1 year and Gillette 15 years Wind Direction and Wind Speed Joint Frequency Distributions for Stability Class F					
Class	**Speed (mph)**	**Direction**	**15 years (X-axis)**	**1 year (Y-axis)**	**Diff* 1 year vs. 15 years**
F	**19–24**	**WSW**	NA	NA	NA
F	**19–24**	**W**	NA	NA	NA
F	**19–24**	**WNW**	NA	NA	NA
F	**19–24**	**NW**	NA	NA	NA
F	**19–24**	**NNW**	NA	NA	NA
F	**>24**	**N**	NA	NA	NA
F	**>24**	**NNE**	NA	NA	NA
F	**>24**	**NE**	NA	NA	NA
F	**>24**	**ENE**	NA	NA	NA
F	**>24**	**E**	NA	NA	NA
F	**>24**	**ESE**	NA	NA	NA
F	**>24**	**SE**	NA	NA	NA
F	**>24**	**SSE**	NA	NA	NA
F	**>24**	**S**	NA	NA	NA
F	**>24**	**SSW**	NA	NA	NA
F	**>24**	**SW**	NA	NA	NA
F	**>24**	**WSW**	NA	NA	NA
F	**>24**	**W**	NA	NA	NA
F	**>24**	**WNW**	NA	NA	NA
F	**>24**	**NW**	NA	NA	NA
F	**>24**	**NNW**	NA	NA	NA

* Where 'diff' is the difference in percentage points (pp) calculated between the long- and short-term frequencies. The actual numbers used for the percent point calculations include greater than three significant figures. Therefore, the calculated difference as shown in this table may vary slightly due to rounding.

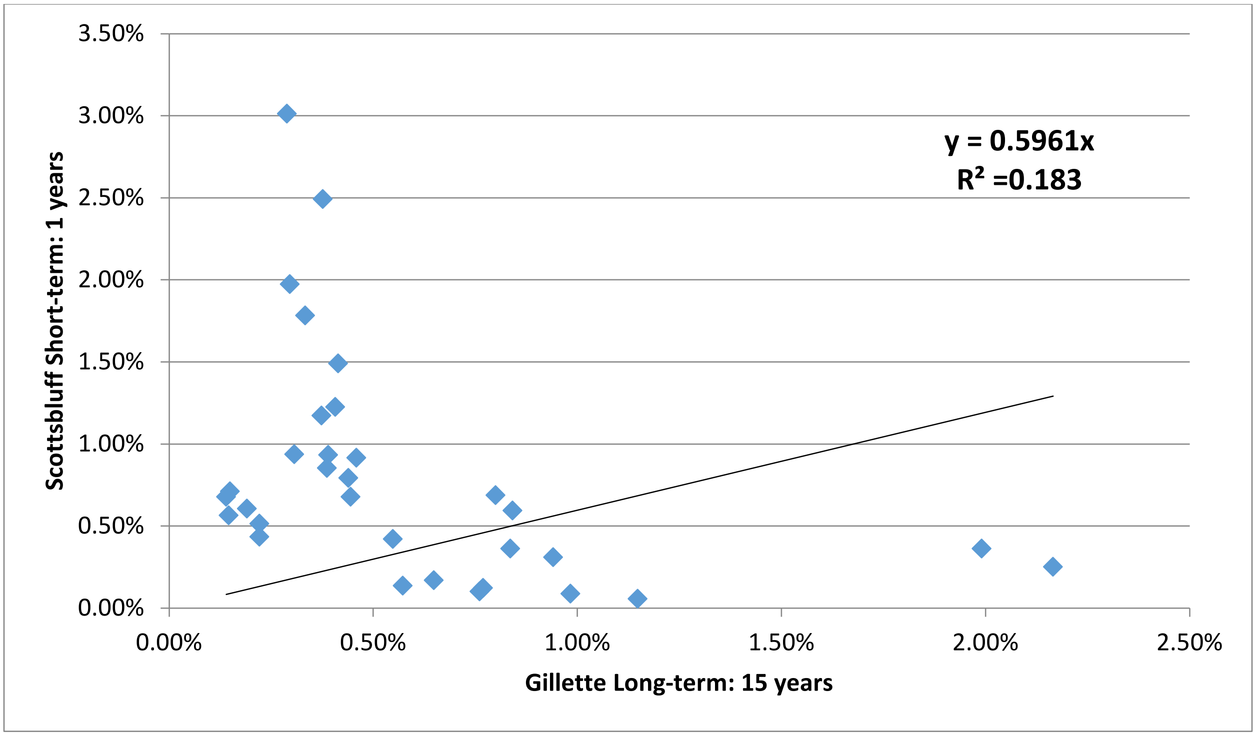

Figure 33. Class F Joint Frequency Distribution: Scottsbluff 1 year vs. Gillette 15 years

APPENDIX C
ACCEPTABLE EVALUATION PROCESS FOR DEMONSTRATING REPRESENTATIVENESS OF OFFSITE METEOROLOGICAL STATION DATA

APPENDIX C

Acceptable Evaluation Process for Demonstrating Representativeness of Offsite Meteorological Station (e.g., NWS) Data (i.e., Wind Speed, Wind Direction, and Stability Class)

Note: This evaluation process is based on the limited collection of data sets that were assessed for the technical basis document (TBD). As this technique is more broadly applied, refinements may become necessary as the number of comparative populations is expanded.

1. Acquire and prepare NCEI meteorological data following the general steps in Figure 1.

Step 1.1
Acquire/download the necessary meteorological NWS data from the NCEI website[1] which includes station number, wind direction, wind speed, ceiling height, sky cover, air temperature, dew point temperature, station barometric pressure, and relative humidity. Then transfer the data into a Microsoft Excel workbook. This is the primary workbook.
↓
Step 1.2
Filter and prepare/screen the data for the STAR program (to be used in Step 4 to determine joint frequency distributions by stability class) and save as a separate file (secondary workbook). Establish the secondary workbook by selecting the parameters needed for the CD-144 format in the appropriate units and resolution. This STAR-specific format differs from the NCEI data format. The secondary workbook includes all the data points (e.g., 30 years of meteorological data) to be used as input to the STAR program in Step 4. A copy of this secondary workbook will be used in Steps 2 and 3 for further qualitative analyses.
↓
Step 1.3
Make a copy of the secondary workbook, and extract the short-term (baseline, e.g., 1 year), and long-term (e.g., 15 and 30 years) data from the entire dataset. Place each dataset (e.g., 1-yr, 15-yr, and 30-yr) into a separate Microsoft Excel worksheet within the workbook. Ensure that the long-term data period does not include the baseline data period (i.e., use non-overlapping data).

Figure 1. NCEI Data Acquisition and Preparation

[1] The NCEI website (as of November 23, 2015) to obtain the meteorological data is: http://www7.ncdc.noaa.gov/CDO/cdopoemain.cmd?datasetabbv=DS3505&countryabbv=&georegionabbv=&resolution=40. There are two options to choose from; i.e., simplified and advanced. For further guidance on obtaining the data contact NCEI.

2. Determine the relative frequency distribution for wind speed and wind direction (stability class has not been calculated at this stage) following the general steps in Figure 2.

Step 2.1
On the copy of the secondary workbook, calculate the number of occurrences (frequency) of wind speed and wind direction for the short- and long-term data.
⬇
Step 2.2
When calculating the number of occurrences for wind speed, make sure any non-integer values are rounded upward. NWS wind directions are given to the nearest 10 degrees azimuth. Hence some sectors will have wind from three directions placed into them, while others will have wind from only two directions.
⬇
Step 2.3
The number of occurrences calculated for each wind direction and speed need to be allocated in the bins or ranges based on what is needed for the STAR program (i.e., there should be 16 direction bins plus calm, the directions centered on 0 degrees and each 22.5 degrees thereafter, and the speed ranges should be consistent with those used for the STAR program).
⬇
Step 2.4
Calculate the total number of occurrences and then normalize by dividing the number of occurrences in each wind direction and wind speed range by the total number of occurrences to obtain the relative frequency distributions. The data are then ready for qualitative and quantitative analyses.

Figure 2. Calculate Relative Frequency Distribution to Perform the Data Analyses

3. Perform a qualitative (i.e., visual) comparison of the wind direction and wind speed relative frequency distributions by following the general steps in Figure 3.

Step 3.1
Perform the qualitative comparison by using wind roses, radar plots, and histograms constructed from offsite short- and long-term NWS data.
⬇
Step 3.2
Parameters should be compared separately (e.g., wind speed separate from wind direction and compared short-term to long-term).

Figure 3. Perform Qualitative Analyses of the Wind Direction and Wind Speed

4. Run STAR to determine the full three-dimensional joint frequency distributions (JFDs) by stability class, wind speed, and wind direction, providing output files that will correspond to the short- and long-term datasets. Create Microsoft Excel workbooks from these JFDs for analyses following the general steps in Figure 4.

Step 4.1
Generate separate STAR files that will correspond to the short-and long-term datasets. The joint frequency distribution data (with calms redistributed) from these files should be imported into a tertiary Microsoft Excel workbook. The data imported to this workbook should include the wind speed and wind direction joint frequency distribution by stability class.
↓
Step 4.2
Sum the wind direction and wind speed joint frequency distribution data for all stability classes (A–F) to analyze the classes together. Perform this step for the short- and long-term datasets. The data for all classes is ready for quantitative analyses (by linear regression as described in the TBD and Appendix A).
↓
Step 4.3
Take the wind direction and wind speed joint frequency distribution data for stability Classes E and F, and analyze individually for the short- and long-term datasets. The data for each individual class is ready for quantitative analyses (i.e., linear regression analyses as described in the TBD and Appendix A).

Figure 3. Prepare JFD Data Generated by STAR for Quantitative Analyses

5. Perform a quantitative comparison using linear regression. A step-by-step process is not provided because there are numerous valid statistical programs that perform linear regression. General analysis guidance is provided in Appendix A (i.e., X-axis for long-term and Y-axis for short-term; regression line forced through the origin). The following regression analyses in Figure 5 should be performed:

Step 5.1
Evaluate the combined frequency distributions of wind speed and wind direction independent of stability class (i.e., wind speed and wind direction for all stability classes [A–F] summed).
↓
Step 5.2
Evaluate JFDs of wind speed and wind direction for stability Classes E and F only.
↓

Step 5.3
Use the information below for the interpretation of the linear regression analysis for 5.1 and 5.2 above: a. R^2 should be ≥ 0.90 for the combined frequency distribution; and, b. R^2 should be ≥ 0.95 for the linear regressions Class E and F. c. If a and b are satisfied and supported by the qualitative evidence, then no further analyses should be necessary and the data can be considered temporally representative.

Figure 5. Perform Regression Analyses

APPENDIX D
ADDITIONAL EVALUATION TO DETERMINE DIFFERENCES IN DOSE USING MILDOS-AREA

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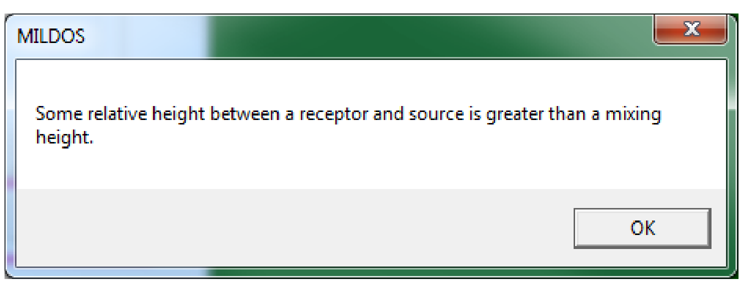
APPENDIX D. ADDITIONAL EVALUATION TO DETERMINE DIFFERENCES IN DOSE USING MILDOS-AREA

In order to perform the MILDOS evaluation using Scottsbluff, Nebraska and Gillette, Wyoming airport data, a real MILDOS-AREA scenario was selected from Marsland Expansion Area (MEA) Crow Butte Resources, Inc., in Crawford, Nebraska. From all of MEA MILDOS-AREA scenarios included in Appendix M of MEA original technical report (May 2012), the scenario for mine units (MU) 1–5 was selected for performing the check. This check is not intended to be a complete dose analysis. The purpose is to evaluate the differences between short-term and long-term airport datasets if inconclusive results are obtained from the statistical analyses. The steps that ORAU followed are below:

STEP 1

The MEA MU1-5 scenario was recreated, using MEA inputs. However, ORAU noticed discrepancies between the actual inputs shown in the report and the inputs provided in Tables 2 and 3 of Appendix M of MEA original technical report (May 2012). The discrepancies were noticed in the locations for sources (MU-4, MU-5) and receptors (Harrison, Minatare, Van Tassell, Residence 4, and Residence 5).

Note that Version 3.1, an improved version of MILDOS-AREA, was used to reproduce the MEA run. The MEA run was originally done using an older version of MILDOS (02/97) that did not have the "checks" that the Version 3.1 has. Issues were encountered when attempting to run MEA MU 1–5 with a "Z" value of 633 m for Harrison (receptor). This value is greater than the mixing height of 100 m used as input for morning and afternoon. Therefore, the code would not run and displayed the following message:



Argonne National Laboratory (ANL) was contacted about this issue, it was explained by ANL that the older version of MILDOS did not have input checks in place and running the code with a receptor above the mixing height will give invalid results because the model assumes atmospheric transport below the mixing height. That is why Version 3.1, which has some checks in place, will not run (and should not be run with those inputs).

Based on the fact that the code would not run using a "Z" value of 633 m for Harrison, and a mixing height of 100 m, the "Z" value was lowered arbitrarily to 50 m in order to allow it to run.

After the run was completed, the dose results for the population and individual receptors were compared with the results in MEA's MILDOS report to ensure similar dose results were obtained.

Results for Step 1

The results of ORAU's run show meaningful differences for the population doses compared to the original MEA run. At this time, it is uncertain as to why the population doses obtained with MILDOS-AREA Version 3.1 are higher than the population doses obtained with the older version (02/97) of MILDOS. However, the 40 CFR 190 annual dose commitments were 0 mrem/yr for all the individual receptors as in the original MEA run and the total annual dose commitments for the individual receptors were very similar.

Figure 1 shows the locations for MEA mine units 1–5 and individual receptors. The figure illustrates the location of the MEA's individual receptors used in ORAU's run. Tables 1 and 2 have the results for MEA (original) run and ORAU's run.

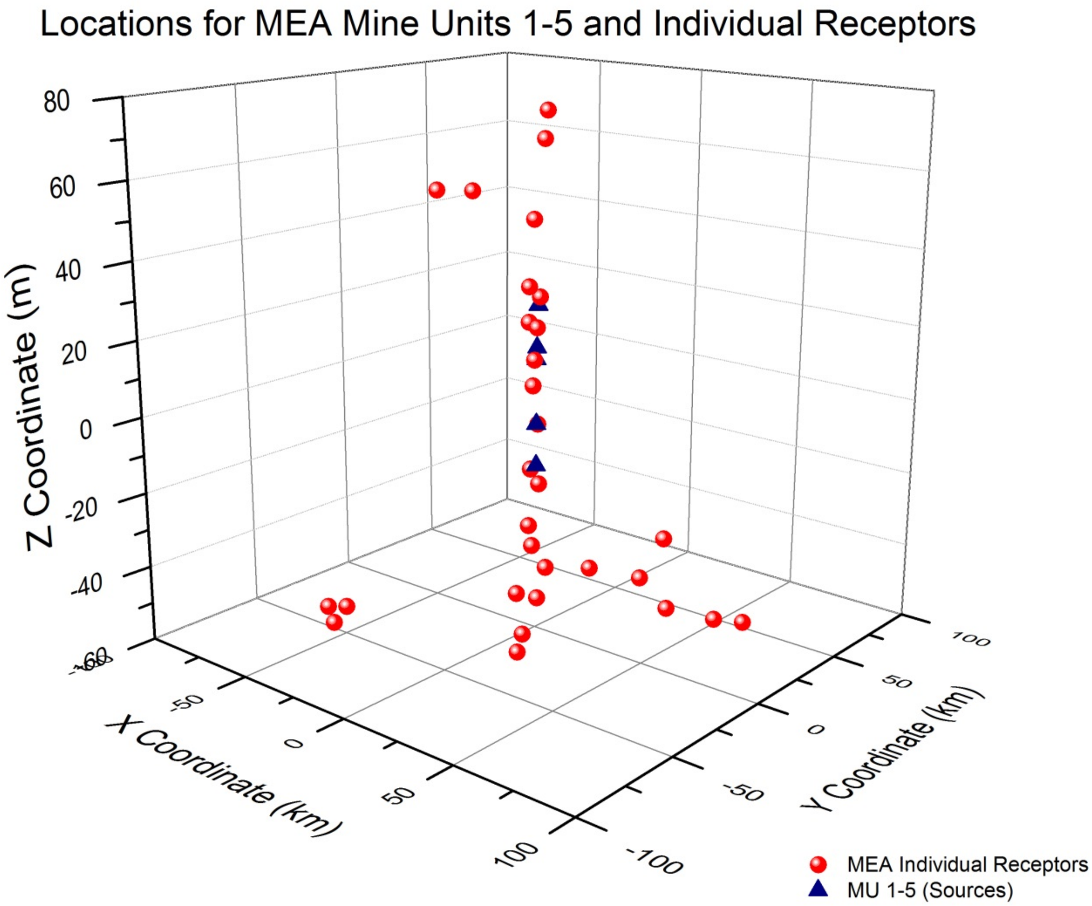


Figure 1. Location of MEA Mine Units 1–5 and Individual Receptors

Table 1. MILDOS Results from Output Reports for Annual Population Dose Commitments		
Population	**MEA (original) Total-Effective (Person-rem per year)**	**ORAU's MEA Total-Effective (Person-rem per year)**
Doses received by people within 80 kilometers	1.547E+00	3.337E+00
Doses received by people beyond 80 kilometers	0.000E+00	7.846E+01
Total doses computed over all populations	1.547E+00	8.180E+01

Table 2. MILDOS Results from Output Reports for Total Annual Dose Commitments		
Individual Receptors	**MEA MU 1–5 Adult-Effective (mrem/yr)**	**ORAU's MEA MU 1–5 Adult-Effective (mrem/yr)**
Alliance	3.44E-01	3.44E-01
Berea	4.87E-01	4.87E-01
Chadron	2.78E-01	2.78E-01
Clinton	1.39E-01	1.39E-01
Crawford	5.61E-01	5.61E-01
Harrison	2.11E-01	2.11E-01
Hay Springs	2. 30E-01	2.30E-01
Hemmingford	9.19E-01	9.19E-01
Marsland	1.11E+00	1.11E+00
Minatare	1.44E-01	1.44E-01
Mitchell	1.02E-01	1.02E-01
Oelrichs	1.64E-01	1.64E-01
Rushville	1.61E-01	1.61E-01
Scottsbluff	1.13E-01	1.13E-01
Van Tassell	1.53E-01	1.53E-01
Whitney	4.17E-01	4.17E-01
Residence 1	1.58E+01	1.58E+01
Residence 2	4.45E+01	4.48E+01
Residence 3	6.86E+00	6.86E+00
Residence 4	4.16E+00	4.16E+00
Residence 5	4.85E+00	4.85E+00
Residence 6	3.45E+00	3.45E+00
Residence 7	6.17E+00	6.17E+00
Residence 8	2.13E+00	2.13E+00
Unoccupied 1	7.50E+01	7.60E+01
Unoccupied 2	8.61E+00	8.61E+00
North boundary	3.91E+01	3.89E+01
East boundary	1.67E+01	1.67E+01
South boundary	3.50E+01	3.49E+01
West boundary	2.41E+01	2.40E+01

Note: 40 CFR 190 annual dose commitments were 0 mrem/yr for all the receptors; therefore, these results were not included in the table.

STEP 2

The MU1–5 scenario was run with all of MEA parameters (e.g., sources, receptors) except for the meteorological data. Three runs were performed using Scottsbluff, Nebraska airport meteorological data for 1 year, 15 years and 30 years respectively. The same three runs we repeated with Gillette, Wyoming airport data.

Results for Step 2

Results for Scottsbluff are provided in Tables 3 and 4 and illustrated in Figures 2 and 3. Results for Gillette are provided in Tables 5 and 6 and illustrated in Figures 4 and 5.

Table 3. MILDOS Results from Output Reports for Annual Population Dose Commitments (using Scottsbluff Meteorological Data)

Population	Scottsbluff 1 year Total-Effective (Person-rem per year)	Scottsbluff 15 year Total-Effective (Person-rem per year)	Scottsbluff 30 year Total-Effective (Person-rem per year)	Percent Difference 1 year vs. 15 years	Percent Difference 1 year vs. 30 years	Percent Difference 15 year vs. 30 years
Doses received by people within 80 kilometers	3.019E+00	3.167E+00	2.655E+00	4.8%	-12.8%	-17.6%
Doses received by people beyond 80 kilometers	7.951E+01	7.967E+01	7.796E+01	0.2%	-2.0%	-2.2%
Total doses computed over all populations	8.253E+01	8.283E+01	8.062E+01	0.4%	-2.3%	-2.7%

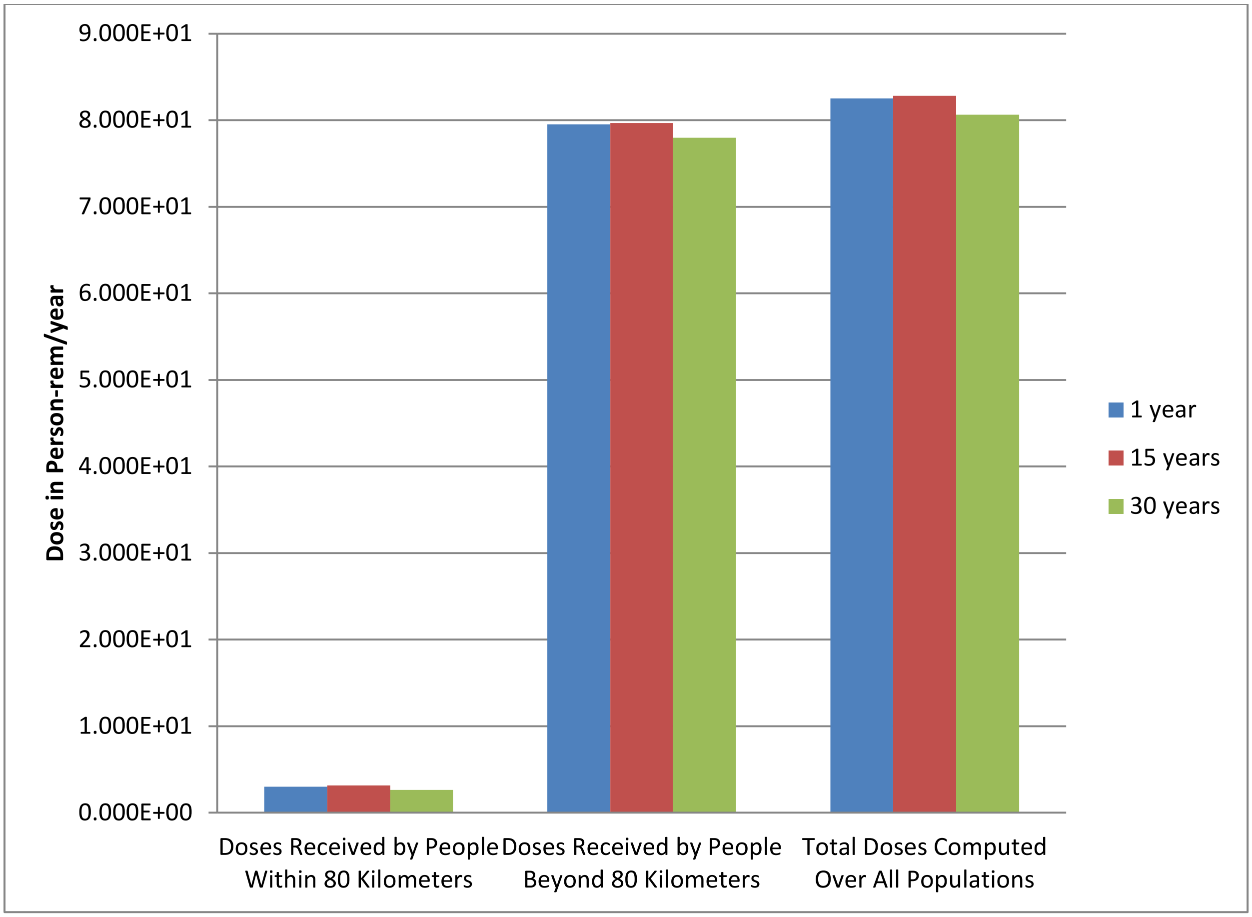


Figure 2. MEA MU 1–5 MILDOS-AREA Population Doses using Scottsbluff Meteorological Data

Table 4. MILDOS Results from Output Reports for Total Annual Dose Commitments (using Scottsbluff Meteorological Data)

Individual Receptors	Scottsbluff 1 year MU 1–5 Scenario Adult-Effective (mrem/yr)	Scottsbluff 15 years MU 1–5 Scenario Adult-Effective (mrem/yr)	Scottsbluff 30 years MU 1–5 Scenario Adult-Effective (mrem/yr)	Percent Difference 1 year vs. 15 years	Percent Difference 1 year vs. 30 years	Percent Difference 15 year vs. 30 years
Alliance	3.180E-01	3.51E-01	2.87E-01	9.9%	-10.2%	-20.1%
Berea	4.48E-01	4.95E-01	4.05E-01	10.0%	-10.1%	-20.0%
Chadron	6.780E-02	7.27E-02	6.55E-02	7.0%	-3.5%	-10.4%
Clinton	6.100E-02	5.78E-02	4.93E-02	-5.4%	-21.2%	-15.9%
Crawford	4.780E-01	4.14E-01	3.62E-01	-14.3%	-27.6%	-13.4%
Harrison	4.570E-01	4.11E-01	3.17E-01	-10.6%	-36.2%	-25.8%
Hay Springs	7.510E-02	7.37E-02	6.32E-02	-1.9%	-17.2%	-15.3%

ORAU

Table 4. MILDOS Results from Output Reports for Total Annual Dose Commitments (using Scottsbluff Meteorological Data)						
Individual Receptors	**Scottsbluff 1 year MU 1–5 Scenario Adult-Effective (mrem/yr)**	**Scottsbluff 15 years MU 1–5 Scenario Adult-Effective (mrem/yr)**	**Scottsbluff 30 years MU 1–5 Scenario Adult-Effective (mrem/yr)**	**Percent Difference 1 year vs. 15 years**	**Percent Difference 1 year vs. 30 years**	**Percent Difference 15 year vs. 30 years**
Hemmingford	9.420E-01	1.03E+00	8.32E-01	8.9%	-12.4%	-21.3%
Marsland	9.740E-01	1.01E+00	1.02E+00	3.6%	4.6%	1.0%
Minatare	1.140E-01	1.25E-01	1.17E-01	9.2%	2.6%	-6.6%
Mitchell	9.570E-02	1.03E-01	1.03E-01	7.3%	7.3%	0.0%
Oelrichs	8.970E-02	8.64E-02	9.73E-02	-3.7%	8.1%	11.9%
Rushville	8.040E-02	7.52E-02	6.40E-02	-6.7%	-22.7%	-16.1%
Scottsbluff	9.580E-02	9.97E-02	1.00E-01	4.0%	4.3%	0.3%
Van Tassell	3.620E-01	3.43E-01	2.73E-01	-5.4%	-28.0%	-22.7%
Whitney	2.360E-01	2.26E-01	2.57E-01	-4.3%	8.5%	12.8%
Residence 1	2.060E+01	2.29E+01	2.09E+01	10.6%	1.4%	-9.1%
Residence 2	2.850E+01	2.81E+01	2.54E+01	-1.4%	-11.5%	-10.1%
Residence 3	6.010E+00	6.72E+00	6.14E+00	11.2%	2.1%	-9.0%
Residence 4	3.240E+00	3.74E+00	3.28E+00	14.3%	1.2%	-13.1%
Residence 5	2.950E+00	3.68E+00	2.85E+00	22.0%	-3.4%	-25.4%
Residence 6	1.000E+01	1.01E+01	8.05E+00	1.0%	-21.6%	-22.6%
Residence 7	1.280E+00	1.45E+00	1.23E+00	12.5%	-4.0%	-16.4%
Residence 8	3.070E+00	3.17E+00	2.69E+00	3.2%	-13.2%	-16.4%
Unoccupied 1	7.460E+01	7.34E+01	7.06E+01	-1.6%	-5.5%	-3.9%
Unoccupied 2	2.930E+00	2.96E+00	2.49E+00	1.0%	-16.2%	-17.2%
North boundary	9.200E+00	1.00E+01	9.20E+00	8.3%	0.0%	-8.3%
East boundary	1.310E+01	1.26E+01	1.17E+01	-3.9%	-11.3%	-7.4%
South boundary	4.500E+01	4.98E+01	4.21E+01	10.1%	-6.7%	-16.8%
West boundary	3.65E+01	3.91E+01	3.29E+01	6.9%	-10.4%	-17.2%

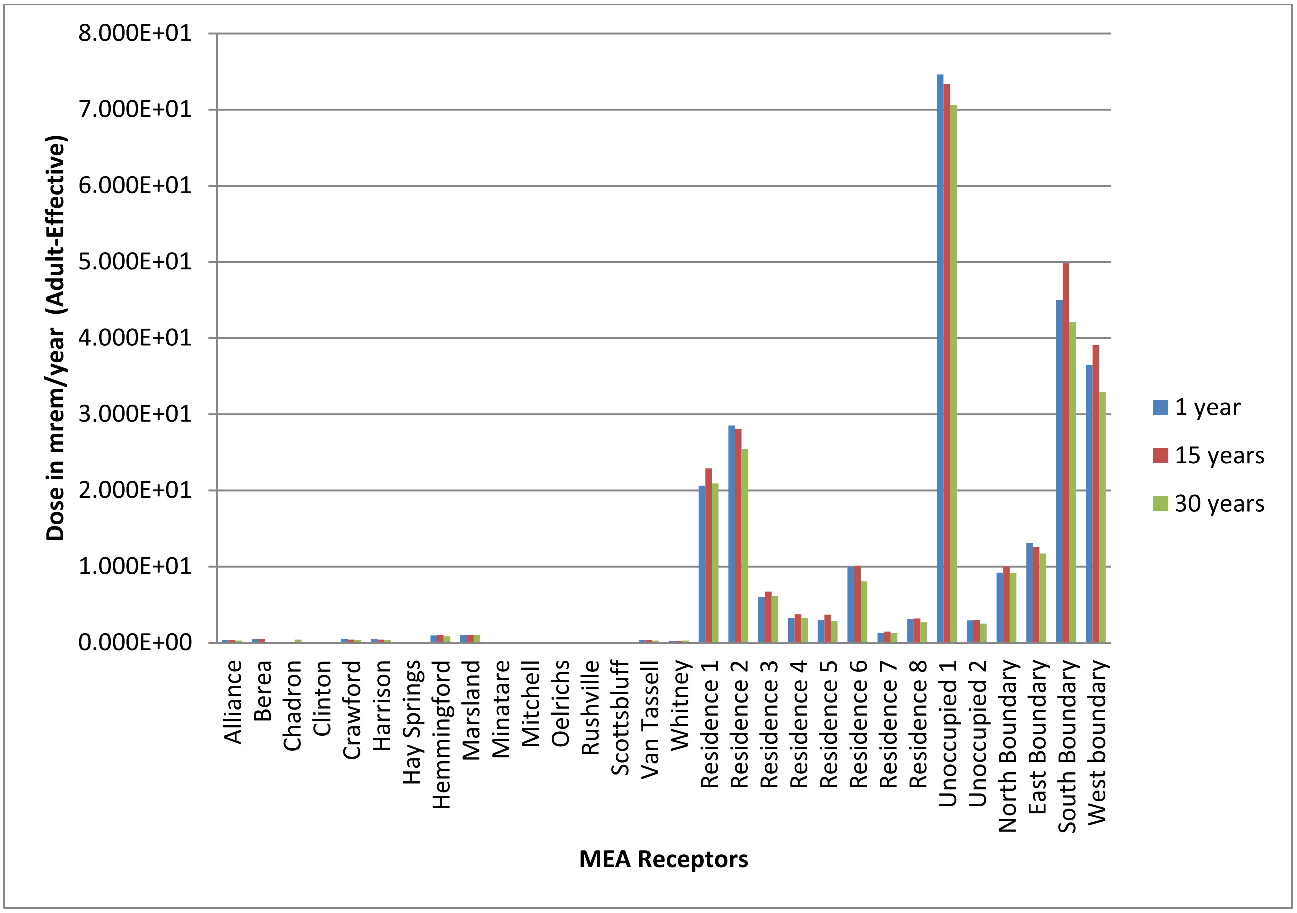


Figure 3. MEA MU 1–5 MILDOS-AREA Doses by Receptors using Scottsbluff Meteorological Data

Table 5. MILDOS Results from Output Reports for Annual Population Dose Commitments (using Gillette Meteorological Data)			
Population	**Gillette 1 year Total-Effective (Person-rem per year)**	**Gillette 15 year Total-Effective (Person-rem per year)**	**Percent Difference 1 year vs. 15 years**
Doses received by people within 80 kilometers	3.435E+00	3.179E+00	-7.7%
Doses received by people beyond 80 kilometers	8.019E+01	7.948E+01	-0.9%
Total doses computed over all populations	8.363E+01	8.266E+01	-1.2%

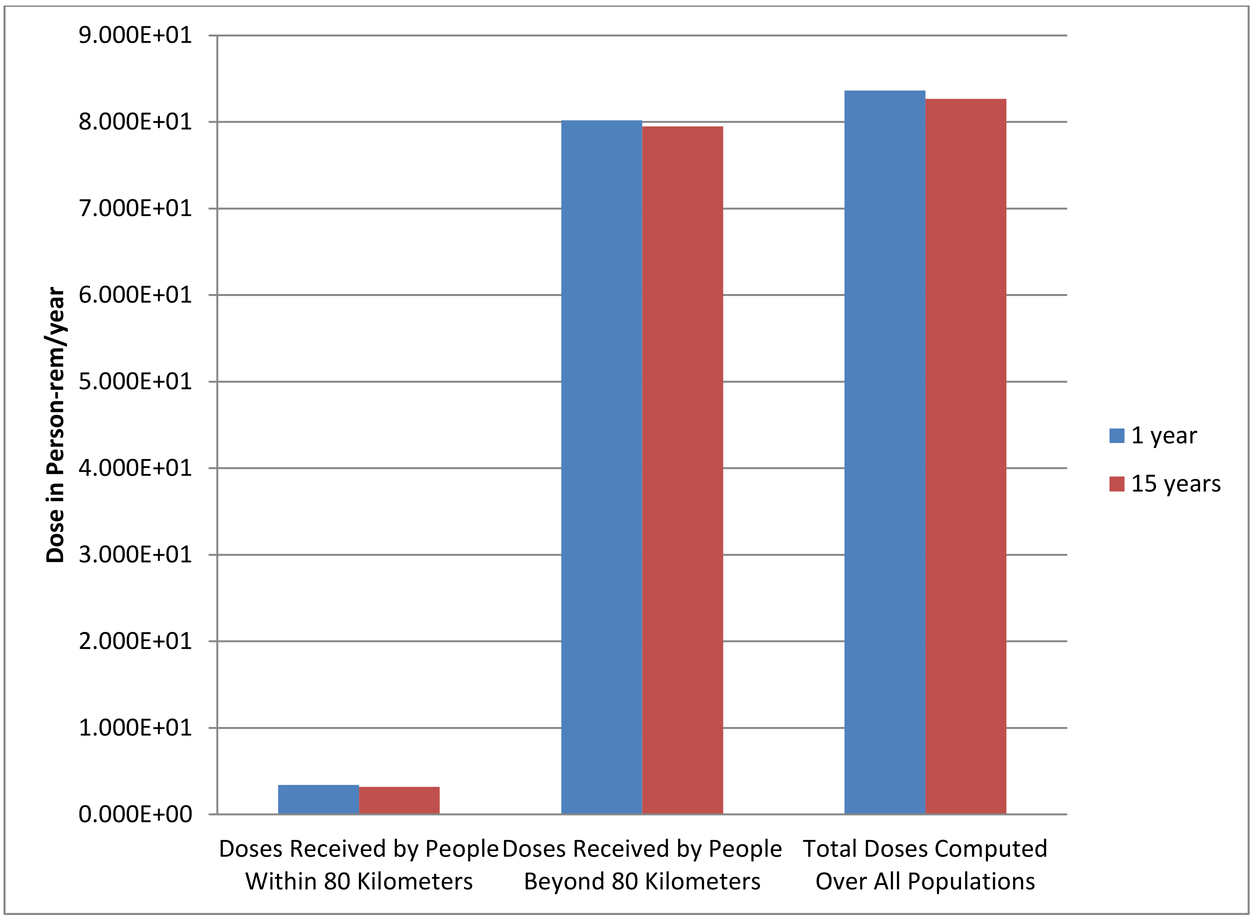


Figure 4. MEA MU 1-5 MILDOS-AREA Doses by Receptors using Gillette Meteorological Data

Table 6. MILDOS Results from Output Reports for Total Annual Dose Commitments (using Gillette Meteorological Data)			
Individual Receptors	**Gillette 1 year MU 1-5 Scenario Adult-Effective (mrem/yr)**	**Gillette 15 years MU 1-5 Scenario Adult-Effective (mrem/yr)**	**Percent Difference 1 year vs. 15 years**
Alliance	2.370E-01	2.25E-01	-5.2%
Berea	3.32E-01	3.14E-01	-5.6%
Chadron	3.90E-01	3.43E-01	-12.8%
Clinton	1.470E-01	1.47E-01	0.0%
Crawford	6.29E-01	5.73E-01	-9.3%
Harrison	9.90E-02	1.36E-01	31.5%
Hay Springs	2.250E-01	2.31E-01	2.6%
Hemmingford	5.840E-01	5.62E-01	-3.8%
Marsland	8.420E-01	8.07E-01	-4.2%
Minatare	1.05E-01	1.17E-01	10.8%
Mitchell	9.53E-02	7.64E-02	-22.0%
Oelrichs	3.82E-01	3.34E-01	-13.4%
Rushville	1.76E-01	1.75E-01	-0.6%
Scottsbluff	8.69E-02	8.38E-02	-3.6%
Van Tassell	8.37E-02	1.08E-01	25.4%
Whitney	1.03E+00	9.00E-01	-13.5%
Residence 1	7.680E+00	9.59E+00	22.1%
Residence 2	6.190E+01	6.01E+01	-3.0%
Residence 3	3.660E+00	4.42E+00	18.8%
Residence 4	2.480E+00	3.09E+00	21.9%
Residence 5	2.750E+00	2.59E+00	-6.0%
Residence 6	1.960E+00	2.72E+00	32.5%
Residence 7	8.420E+00	7.93E+00	-6.0%
Residence 8	1.630E+00	1.64E+00	0.6%
Unoccupied 1	5.190E+01	5.47E+01	5.3%
Unoccupied 2	1.190E+01	1.13E+01	-5.2%
North Boundary	6.280E+01	5.82E+01	-7.6%
East Boundary	2.360E+01	2.19E+01	-7.5%
South Boundary	1.640E+01	1.98E+01	18.8%
West boundary	1.13E+01	1.52E+01	29.4%

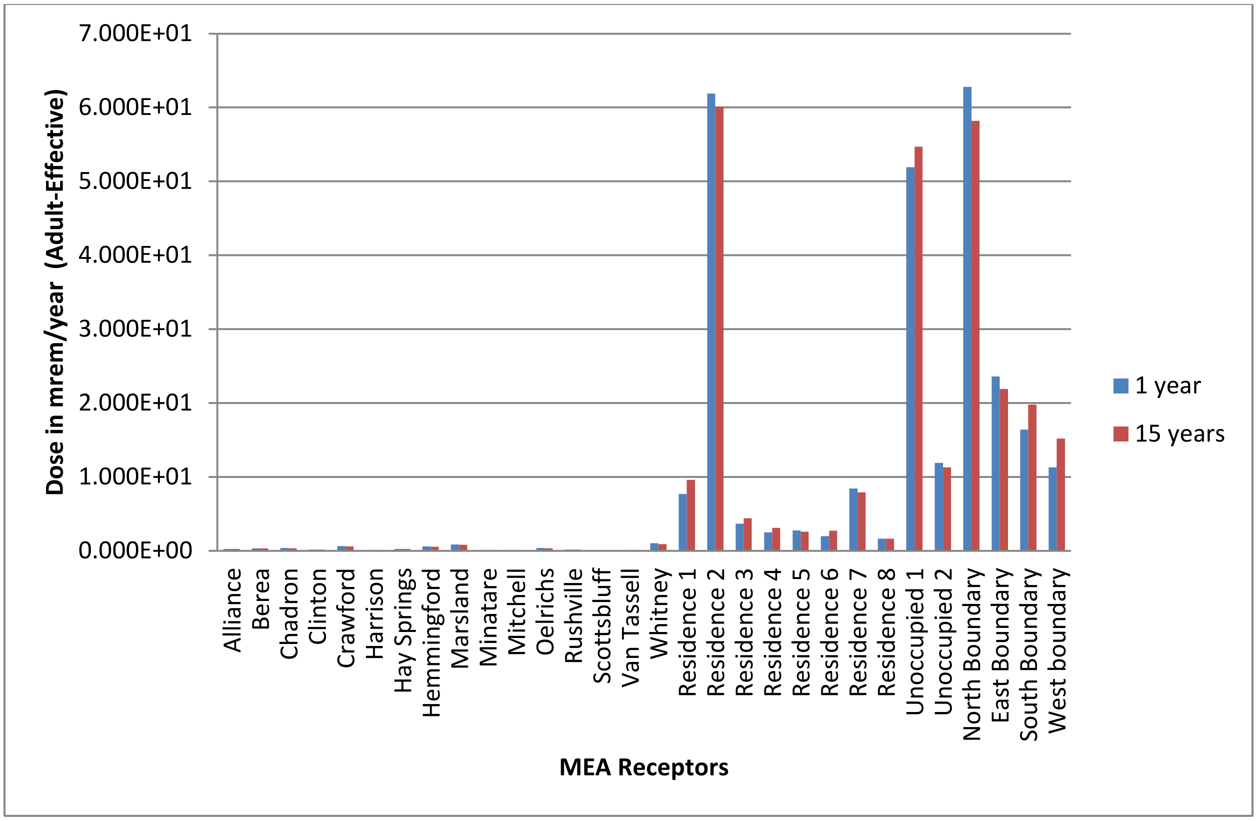


Figure 5. MEA MU 1–5 MILDOS-AREA Doses by Receptors using Gillette Meteorological Data

STEP 3A

The MU 1–5 scenario was run with Scottsbluff data again (1, 15, and 30 years), but the MEA receptors are not used in this scenario. Instead this scenario includes receptors at 16 sectors (N, NNE, NE…), at 2 km radius and at Z=0 m. It is important to note that the receptors affected by wind from a given sector are in the sector opposite in direction from the source. The wind blows from the source toward the receptors. This scenario was also done using Gillette data.

Results for Step 3a

Figure 6 shows the location of hypothetical receptors around MU 1–5. Tables 7 and 8 include the results using Scottsbluff data. These results are illustrated in Figures 7 and 8. Tables 9 and 10 include the results using Gillette data. These results are illustrated in Figures 9 and 10.

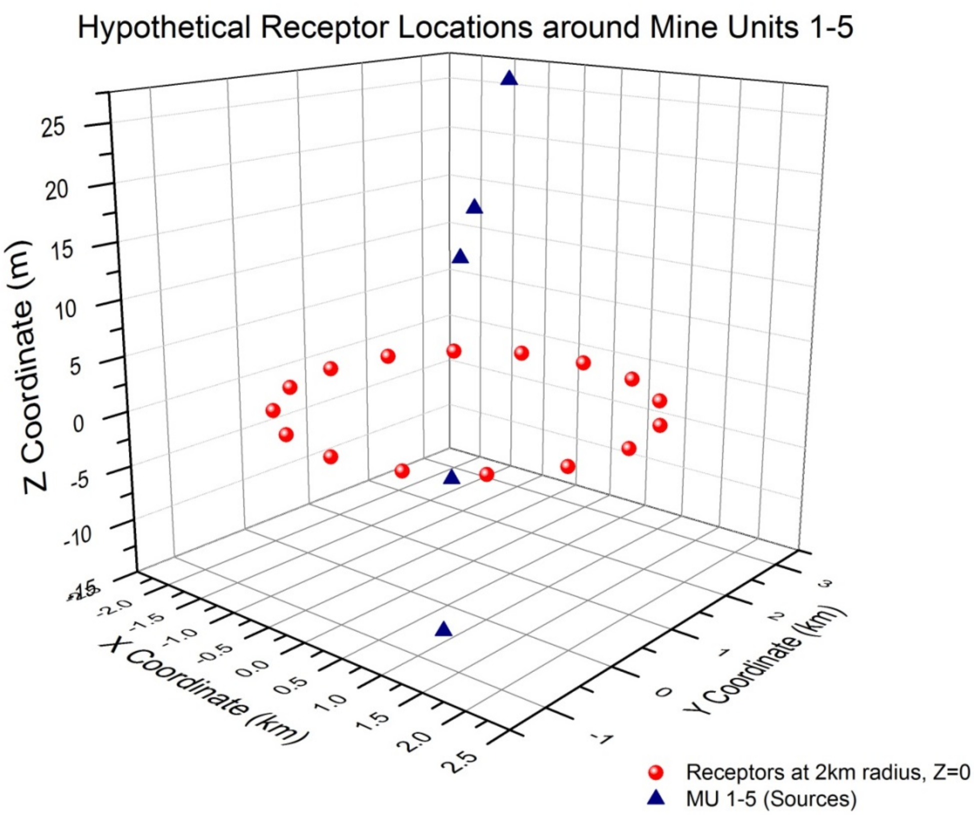


Figure 6. Illustrates Hypothetical Receptor Locations around Mine Units 1–5 (Z=0 m)

Table 7. MILDOS Results from Output Reports for Annual Population Dose Commitments (using Scottsbluff Meteorological Data)						
Population	**Scottsbluff 1 year Total-Effective (Person-rem per year)**	**Scottsbluff 15 year Total-Effective (Person-rem per year)**	**Scottsbluff 30 year Total-Effective (Person-rem per year)**	**Percent Difference 1 year vs. 15 years**	**Percent Difference 1 year vs. 30 years**	**Percent Difference 15 year vs. 30 years**
Doses received by people within 80 kilometers	3.019E+00	3.167E+00	2.655E+00	4.8%	-12.8%	-17.6%
Doses received by people beyond 80 kilometers	7.951E+01	7.967E+01	7.796E+01	0.2%	-2.0%	-2.2%
Total doses Computed over all populations	8.253E+01	8.283E+01	8.062E+01	0.4%	-2.3%	-2.7%

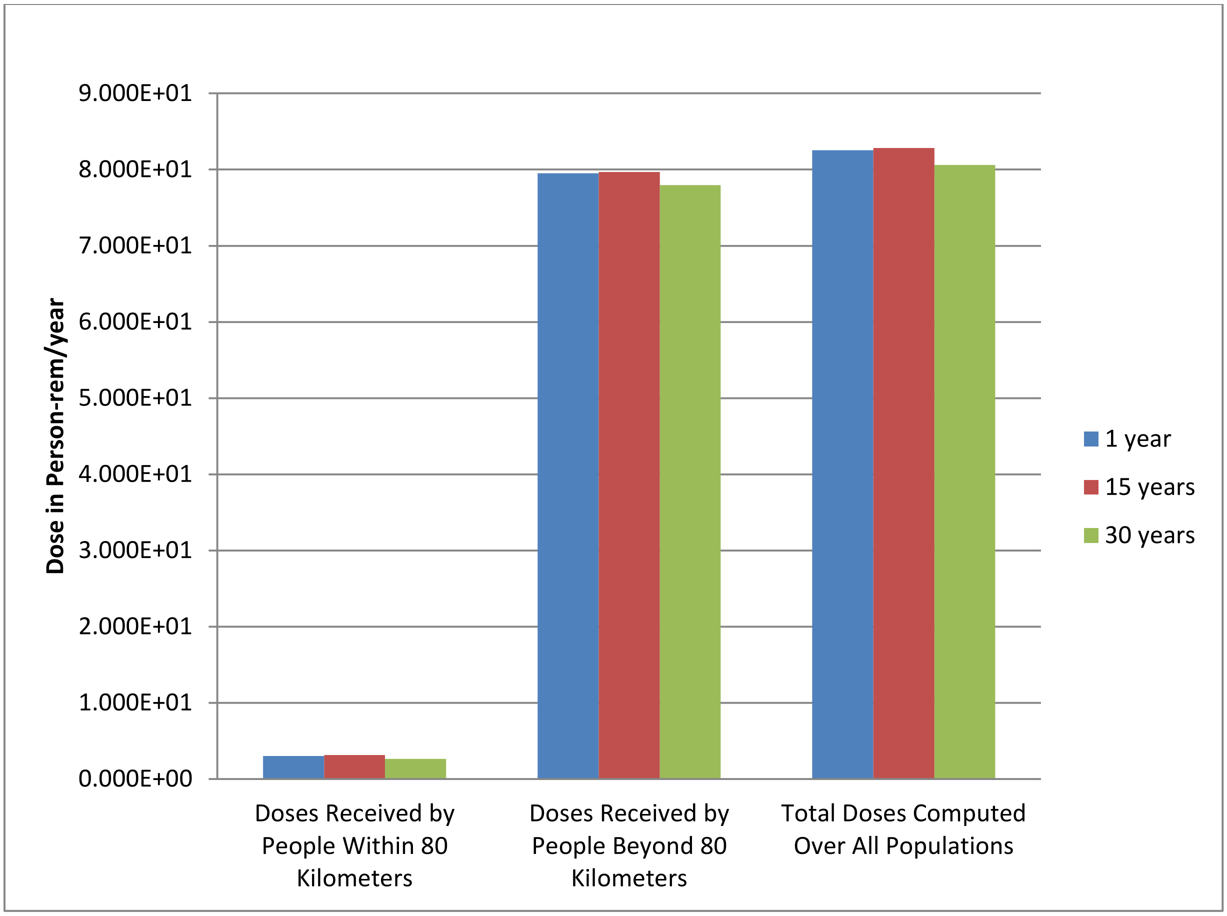


Figure 7. MEA MU 1–5 Population Doses using Scottsbluff Meteorological Data

Table 8. MILDOS Results from Output Reports for Total Annual Dose Commitments (using Scottsbluff Meteorological Data, hypothetical receptors at 16 sectors, 2 km radius, and Z=0 m for all)						
Receptor Location	**Scottsbluff 1 year MU 1–5 Scenario Adult-Effective (mrem/yr)**	**Scottsbluff 15 years MU 1–5 Scenario Adult-Effective (mrem/yr)**	**Scottsbluff 30 years MU 1–5 Scenario Adult-Effective (mrem/yr)**	**Percent Difference 1 year vs. 15 years**	**Percent Difference 1 year vs. 30 years**	**Percent Difference 15 year vs. 30 years**
N	4.18E+00	4.43E+00	4.450E+00	5.8%	6.3%	0.5%
NNE	3.190E+00	3.43E+00	3.35E+00	7.3%	4.9%	-2.4%
NE	4.890E+00	4.76E+00	4.11E+00	-2.7%	-17.3%	-14.7%
ENE	7.250E+00	6.67E+00	6.12E+00	-8.3%	-16.9%	-8.6%
E	9.980E+00	9.210E+00	8.93E+00	-8.0%	-11.1%	-3.1%
ESE	1.730E+01	1.590E+01	1.45E+01	-8.4%	-17.6%	-9.2%
SE	5.010E+01	4.600E+01	4.20E+01	-8.5%	-17.6%	-9.1%
SSE	4.270E+01	5.070E+01	4.13E+01	17.1%	-3.3%	-20.4%
S	1.630E+01	1.870E+01	1.67E+01	13.7%	2.4%	-11.3%
SSW	1.270E+01	1.420E+01	1.32E+01	11.2%	3.9%	-7.3%
SW	1.270E+01	1.380E+01	1.27E+01	8.3%	0.0%	-8.3%
WSW	1.510E+01	1.590E+01	1.40E+01	5.2%	-7.6%	-12.7%
W	1.670E+01	1.690E+01	1.49E+01	1.2%	-11.4%	-12.6%
WNW	2.280E+01	2.290E+01	1.95E+01	0.4%	-15.6%	-16.0%
NW	2.040E+01	1.920E+01	1.63E+01	-6.1%	-22.3%	-16.3%
NNW	1.040E+01	9.110E+00	8.95E+00	-13.2%	-15.0%	-1.8%

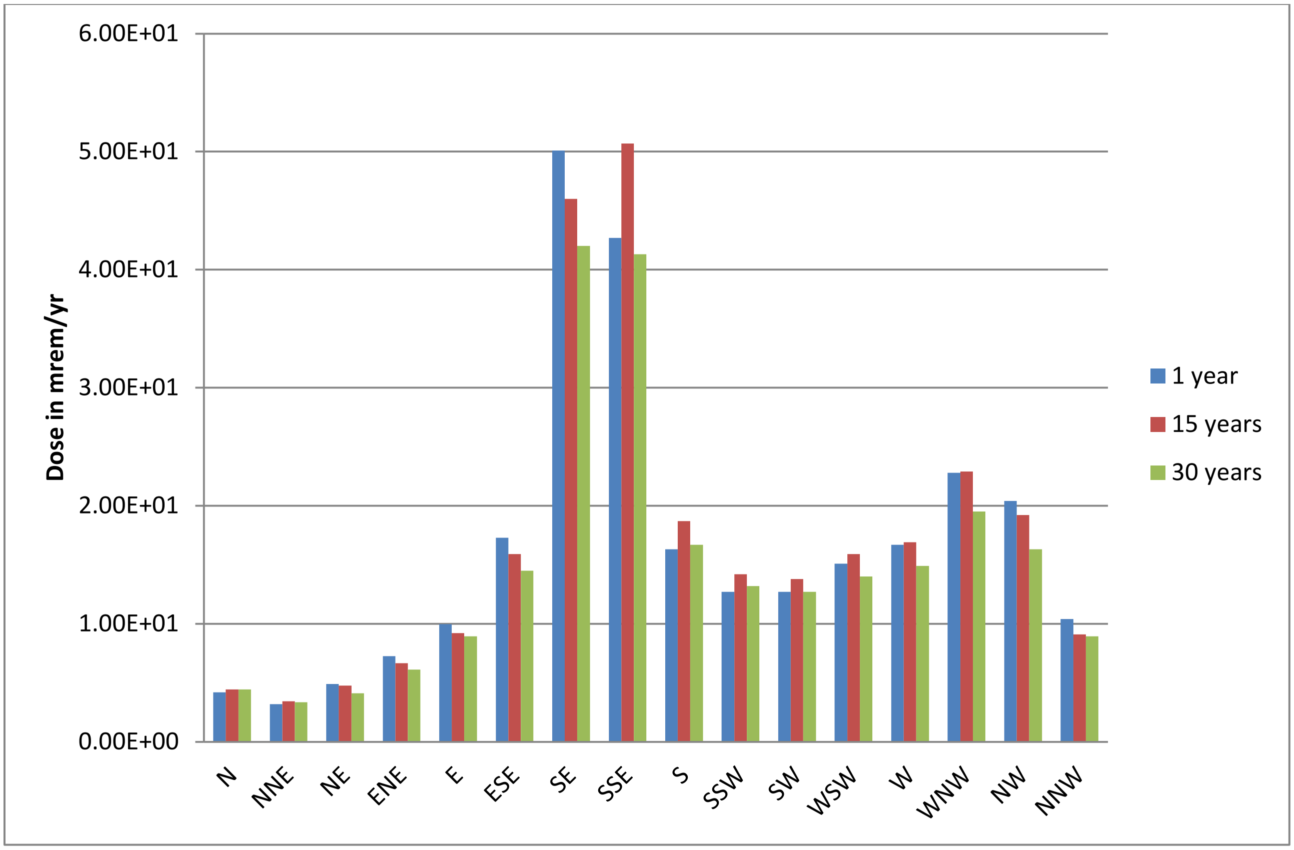


Figure 8. MEA MU 1–5 MILDOS-AREA Doses by Receptors at 16 sectors and at Z=0 m using Scottsbluff Meteorological Data

Table 9. MILDOS Results from Output Reports for Annual Population Dose Commitments (using Gillette Meteorological Data)

Population	Gillette 1 year Total-Effective (Person-rem per year)	Gillette 15 year Total-Effective (Person-rem per year)	Percent Difference 1 year vs. 15 years
Doses received by people within 80 kilometers	3.435E+00	3.179E+00	-7.7%
Doses received by people beyond 80 kilometers	8.019E+01	7.948E+01	-0.9%
Total doses computed over all populations	8.363E+01	8.266E+01	-1.2%

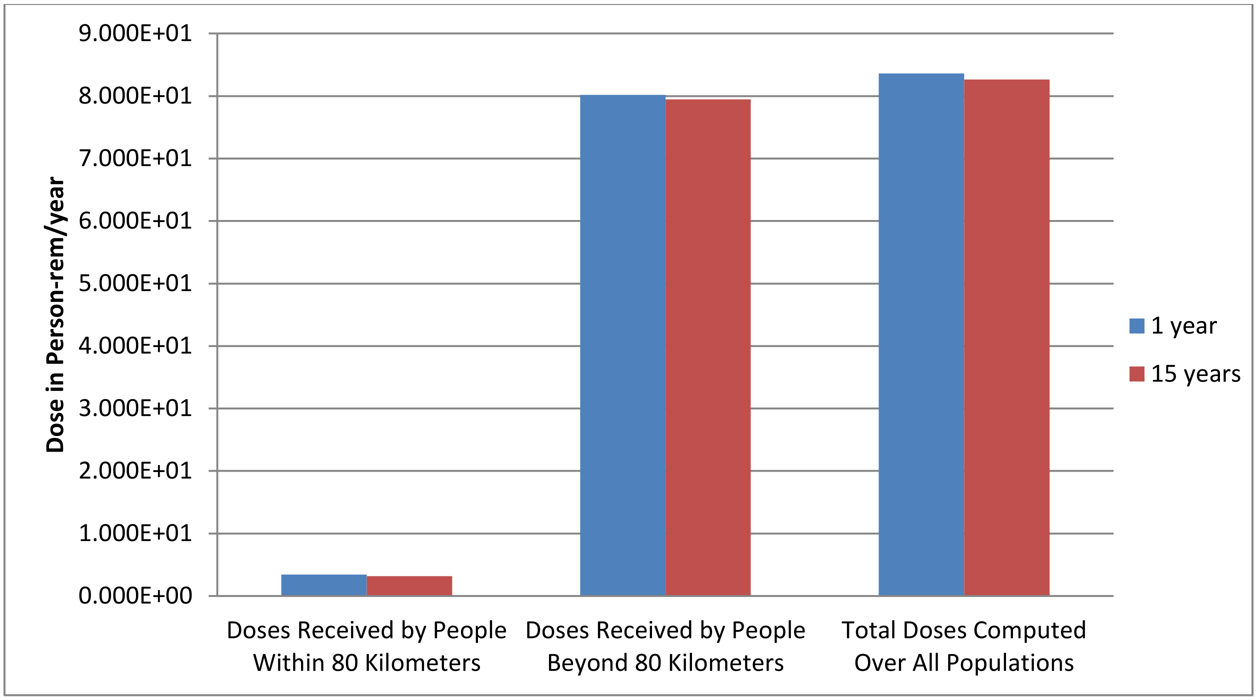


Figure 9. MEA MU 1-5 Population Doses using Gillette Meteorological Data

Table 10. MILDOS Results from Output Reports for Total Annual Dose Commitments (using Gillette Meteorological Data, Hypothetical Receptors at 16 Sectors, 2 km Radius, and Z=0 m for All)

Receptor Location	Gillette 1 year MU 1–5 Scenario Adult-Effective (mrem/yr)	Gillette 15 years MU 1–5 Scenario Adult-Effective (mrem/yr)	Percent Difference 1 year vs. 15 years
N	2.56E+01	2.25E+01	-12.9%
NNE	2.07E+01	1.88E+01	-9.6%
NE	1.64E+01	1.51E+01	-8.3%
ENE	1.47E+01	1.37E+01	-7.0%
E	1.39E+01	1.37E+01	-1.4%
ESE	1.82E+01	1.82E+01	0.0%
SE	3.28E+01	3.31E+01	0.9%
SSE	2.54E+01	3.05E+01	18.2%
S	8.80E+00	1.04E+01	16.7%
SSW	5.93E+00	7.29E+00	20.6%
SW	4.50E+00	5.26E+00	15.6%
WSW	4.56E+00	5.30E+00	15.0%
W	4.75E+00	5.53E+00	15.2%
WNW	6.17E+00	7.45E+00	18.8%

Table 10. MILDOS Results from Output Reports for Total Annual Dose Commitments (using Gillette Meteorological Data, Hypothetical Receptors at 16 Sectors, 2 km Radius, and Z=0 m for All)

Receptor Location	Gillette 1 year MU 1–5 Scenario Adult-Effective (mrem/yr)	Gillette 15 years MU 1–5 Scenario Adult-Effective (mrem/yr)	Percent Difference 1 year vs. 15 years
NW	1.050E+01	1.14E+01	8.2%
NNW	2.90E+01	2.50E+01	-14.8%

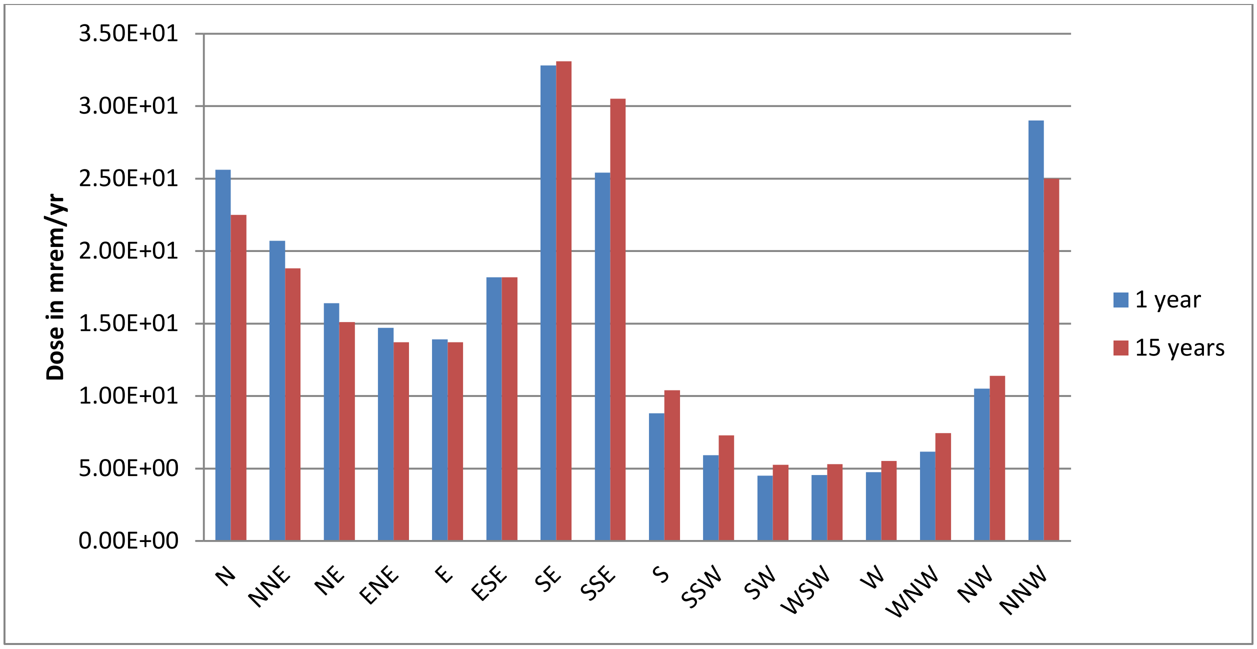


Figure 10. MEA MU 1–5 MILDOS-AREA Doses by Receptors at 16 Sectors and at Z=0 m using Gillette Meteorological Data

STEP 3B

The MU 1–5 scenario was run with Scottsbluff data again (1, 15, and 30 years), but the MEA receptors are not used in this scenario. Instead this scenario includes receptors at 16 sectors (N, NNE, NE…) at 2 km radius and at Z=10 m. It is important to note that the receptors affected by wind from a given sector are in the sector opposite in direction from the source. The wind blows from the source toward the receptors. This scenario was also done using Gillette data.

Results for Step 3b

Figure 11 shows the location of hypothetical receptors around MU 1–5. Table 11 and 12 include the results using Scottsbluff data. These results are illustrated in Figures 12 and 13. Tables 13 and 14 include the results using Gillette data. These results are illustrated in Figures 14 and 15.

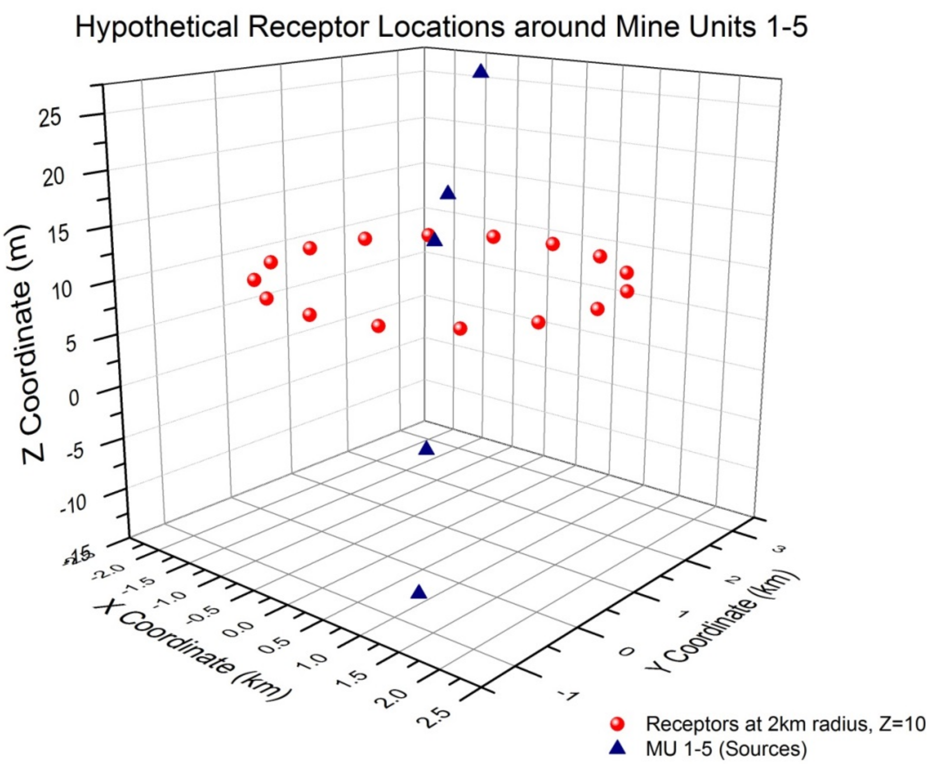


Figure 11. Illustrates Hypothetical Receptor Locations around Mine Units 1–5 (Z=10 m)

Table 11. MILDOS Results from Output Reports for Annual Population Dose Commitments (using Scottsbluff Meteorological Data)						
Population	**Scottsbluff 1 year Total-Effective (Person-rem per year)**	**Scottsbluff 15 year Total-Effective (Person-rem per year)**	**Scottsbluff 30 year Total-Effective (Person-rem per year)**	**Percent Difference 1 year vs. 15 years**	**Percent Difference 1 year vs. 30 years**	**Percent Difference 15 year vs. 30 years**
Doses received by people within 80 kilometers	3.019E+00	3.167E+00	2.655E+00	4.8%	-12.8%	-17.6%
Doses received by people beyond 80 kilometers	7.951E+01	7.967E+01	7.796E+01	0.2%	-2.0%	-2.2%
Total doses computed over all populations	8.253E+01	8.283E+01	8.062E+01	0.4%	-2.3%	-2.7%

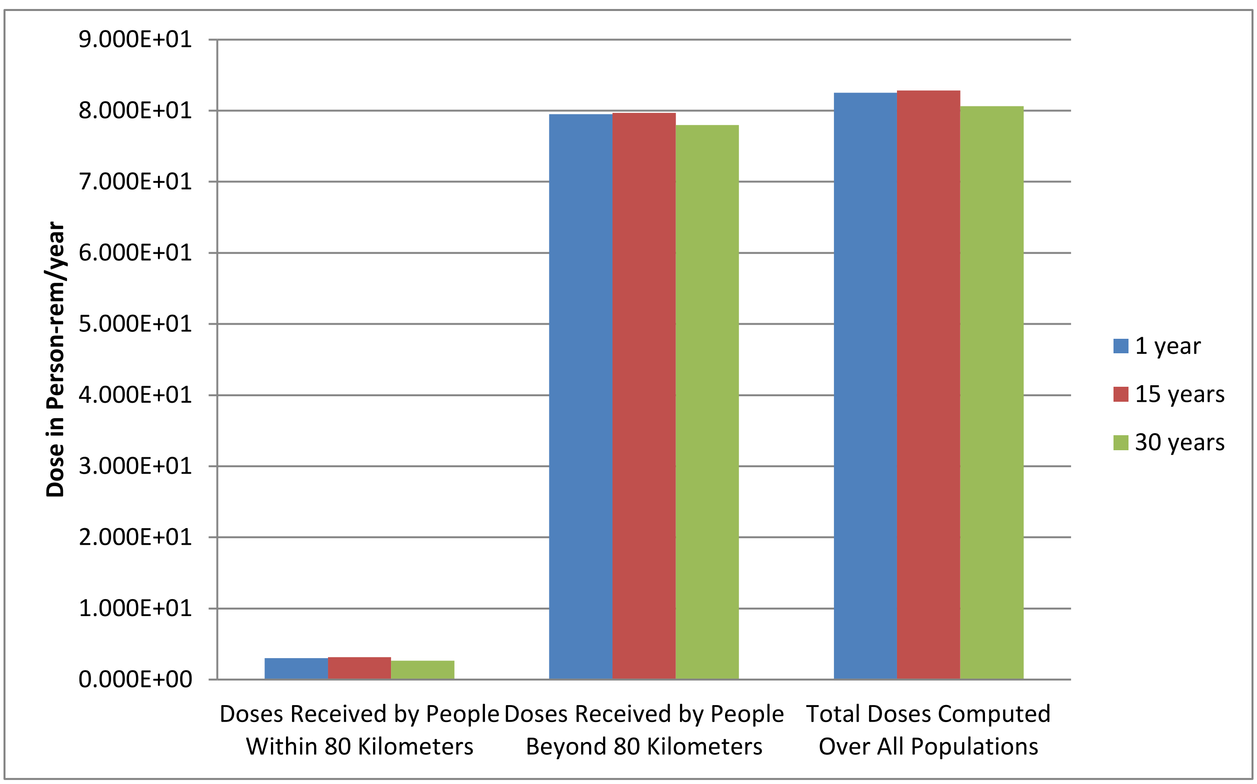


Figure 12. MEA MU 1–5 Population Doses using Scottsbluff Meteorological Data

Table 12. MILDOS Results from Output Reports for Total Annual Dose Commitments (using Scottsbluff Meteorological Data, hypothetical receptors at 16 sectors, 2 km radius, and Z=10 m for all)						
Receptor Location	**Scottsbluff 1 year MU 1–5 Scenario Adult-Effective (mrem/yr)**	**Scottsbluff 15 years MU 1–5 Scenario Adult-Effective (mrem/yr)**	**Scottsbluff 30 years MU 1–5 Scenario Adult-Effective (mrem/yr)**	**Percent Difference 1 year vs. 15 years**	**Percent Difference 1 year vs. 30 years**	**Percent Difference 15 year vs. 30 years**
N	5.000E+00	5.53E+00	5.42E+00	10.1%	8.1%	-2.0%
NNE	3.650E+00	3.97E+00	3.78E+00	8.4%	3.5%	-4.9%
NE	5.790E+00	5.53E+00	4.72E+00	-4.6%	-20.4%	-15.8%
ENE	8.360E+00	7.64E+00	6.98E+00	-9.0%	-18.0%	-9.0%
E	1.130E+01	1.04E+01	1.00E+01	-8.3%	-12.2%	-3.9%
ESE	1.870E+01	1.72E+01	1.57E+01	-8.4%	-17.4%	-9.1%
SE	5.110E+01	4.71E+01	4.28E+01	-8.1%	-17.7%	-9.6%
SSE	4.330E+01	5.15E+01	4.18E+01	17.3%	-3.5%	-20.8%
S	1.730E+01	1.99E+01	1.77E+01	14.0%	2.3%	-11.7%
SSW	1.360E+01	1.52E+01	1.40E+01	11.1%	2.9%	-8.2%
SW	1.350E+01	1.47E+01	1.35E+01	8.5%	0.0%	-8.5%
WSW	1.630E+01	1.72E+01	1.52E+01	5.4%	-7.0%	-12.3%
W	1.890E+01	1.93E+01	1.71E+01	2.1%	-10.0%	-12.1%
WNW	2.92E+01	2.96E+01	2.52E+01	1.4%	-14.7%	-16.1%
NW	3.40E+01	3.25E+01	2.67E+01	-4.5%	-24.1%	-19.6%
NNW	1.49E+01	1.32E+01	1.30E+01	-12.1%	-13.6%	-1.5%

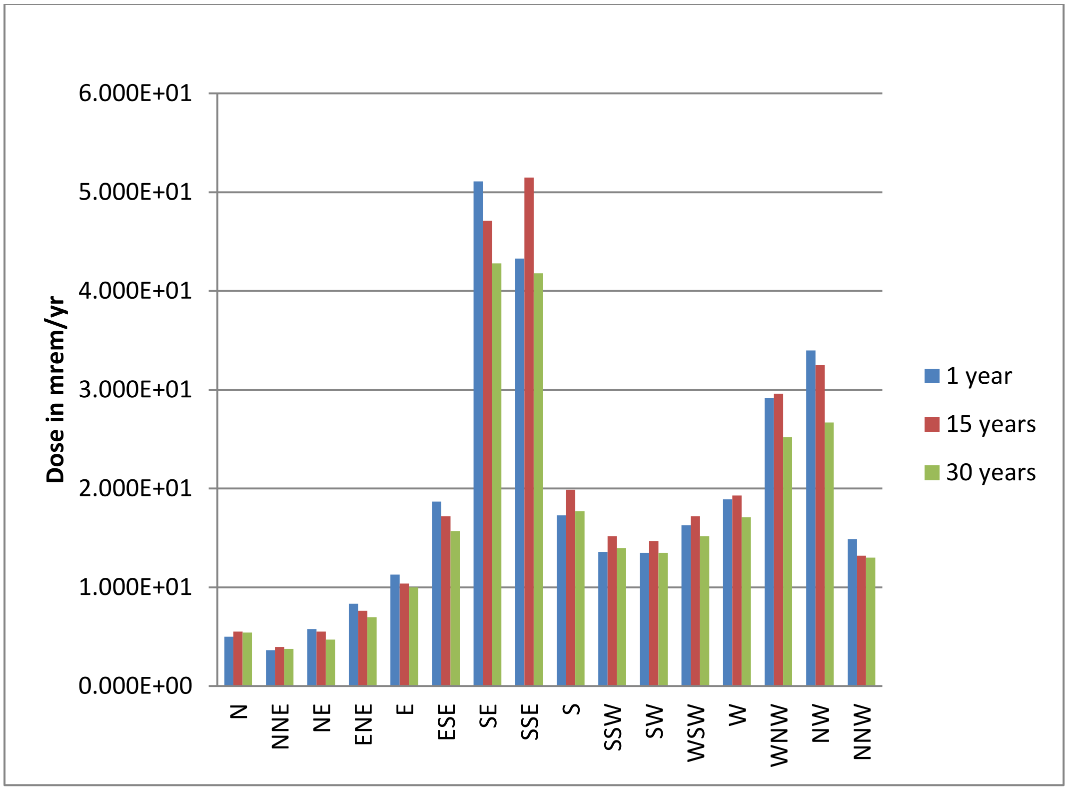


Figure 13. MEA MU 1–5 MILDOS-AREA Doses by Receptors at 16 Sectors and at Z=10 m using Scottsbluff Meteorological Data

Table 13. MILDOS Results from Output Reports for Annual Population Dose Commitments (using Gillette Meteorological Data)			
Population	**Gillette 1 year Total-Effective (Person-rem per year)**	**Gillette 15 year Total-Effective (Person-rem per year)**	**Percent Difference 1 year vs. 15 years**
Doses received by people within 80 kilometers	3.435E+00	3.179E+00	-7.7%
Doses received by people beyond 80 kilometers	8.019E+01	7.948E+01	-0.9%
Total doses computed over all populations	8.363E+01	8.266E+01	-1.2%

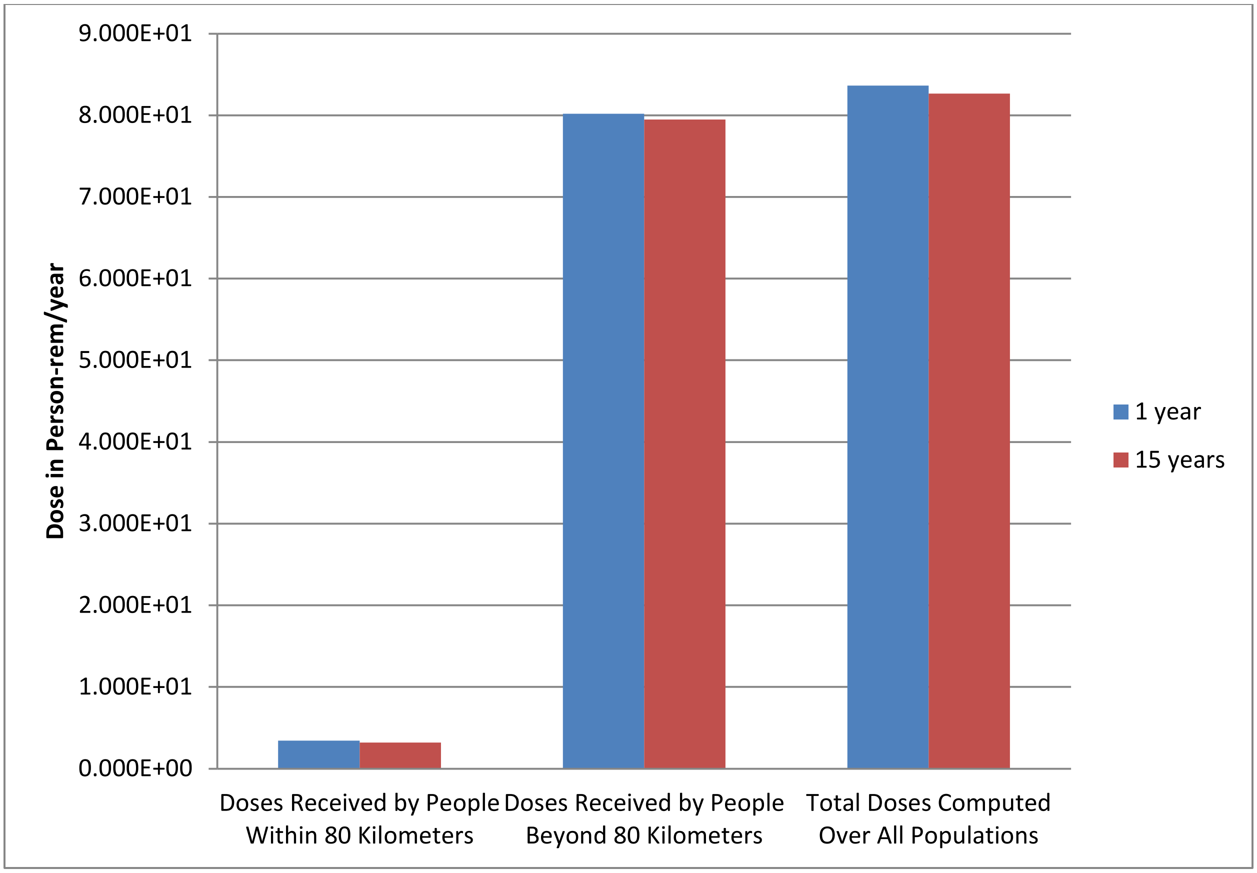


Figure 14. MEA MU 1–5 Population Doses using Gillette Meteorological Data

Table 14. MILDOS Results from Output Reports for Total Annual Dose Commitments (using Gillette Meteorological Data, Hypothetical Receptors at 16 Sectors, 2 km Radius, and Z=10 m for All)			
Receptor Location	**Gillette 1 year MU 1–5 Scenario Adult-Effective (mrem/yr)**	**Gillette 15 years MU 1–5 Scenario Adult-Effective (mrem/yr)**	**Percent Difference 1 year vs. 15 years**
N	3.55E+01	3.11E+01	-13.2%
NNE	2.39E+01	2.20E+01	-8.3%
NE	1.83E+01	1.70E+01	-7.4%
ENE	1.58E+01	1.49E+01	-5.9%
E	1.46E+01	1.45E+01	-0.7%
ESE	1.85E+01	1.87E+01	1.1%
SE	3.33E+01	3.35E+01	0.6%
SSE	2.56E+01	3.07E+01	18.1%
S	9.19E+00	1.10E+01	17.9%
SSW	6.19E+00	7.75E+00	22.4%
SW	4.71E+00	5.63E+00	17.8%
WSW	4.81E+00	5.74E+00	17.6%
W	5.16E+00	6.21E+00	18.5%
WNW	7.20E+00	8.99E+00	22.1%
NW	1.39E+01	1.59E+01	13.4%
NNW	4.54E+01	3.97E+01	-13.4%

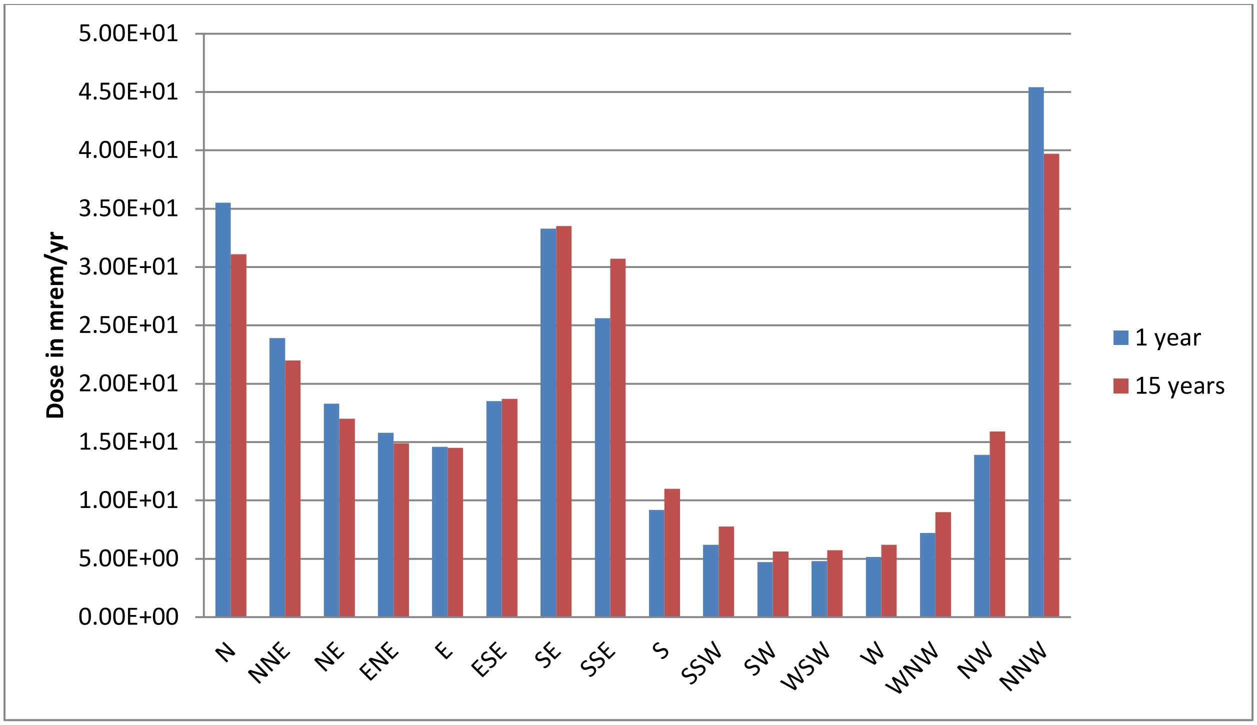


Figure 15. MEA MU 1–5 MILDOS-AREA Doses by Receptors at 16 Sectors and at Z=10 m using Gillette Meteorological Data

STEP 3C

This step is to compare Scottsbluff and Gillette, two different sites that are not expected to be representative. The dose results show large differences in many of the individual receptors. Appendix B of this technical basis document has the statistical comparison for Gillette and Scottsbluff.

Results for Step 3c

Figures 15, 16, and 17 show the MILDOS results from output reports.

Table 15. MILDOS Results from Output Reports for Total Annual Dose Commitments for Individual Receptors (Scottsbluff vs. Gillette)

Individual Receptors	Scottsbluff 1 year MU 1–5 Scenario Adult-Effective (mrem/yr)	Scottsbluff 15 years MU 1–5 Scenario Adult-Effective (mrem/yr)	Gillette 1 year MU 1–5 Scenario Adult-Effective (mrem/yr)	Gillette 15 years MU 1–5 Scenario Adult-Effective (mrem/yr)	Percent Difference Scottsbluff 1 year vs. Gillette 15 years	Percent Difference Gillette 1 year vs. Scottsbluff 15 years
Alliance	3.180E-01	3.51E-01	2.37E-01	2.25E-01	-34.3%	-38.8%
Berea	4.48E-01	4.95E-01	3.32E-01	3.14E-01	-35.2%	-39.4%
Chadron	6.780E-02	7.27E-02	3.90E-01	3.43E-01	134.0%	137.2%
Clinton	6.100E-02	5.78E-02	1.47E-01	1.47E-01	82.7%	87.1%
Crawford	4.780E-01	4.14E-01	6.29E-01	5.73E-01	18.1%	41.2%
Harrison	4.570E-01	4.11E-01	9.90E-02	1.36E-01	-108.3%	-122.4%
Hay Springs	7.510E-02	7.37E-02	2.25E-01	2.31E-01	101.9%	101.3%
Hemmingford	9.420E-01	1.03E+00	5.84E-01	5.62E-01	-50.5%	-55.3%
Marsland	9.740E-01	1.01E+00	8.42E-01	8.07E-01	-18.8%	-18.1%
Minatare	1.140E-01	1.25E-01	1.05E-01	1.17E-01	2.6%	-17.4%
Mitchell	9.570E-02	1.03E-01	9.53E-02	7.64E-02	-22.4%	-7.8%
Oelrichs	8.970E-02	8.64E-02	3.82E-01	3.34E-01	115.3%	126.2%
Rushville	8.040E-02	7.52E-02	1.76E-01	1.75E-01	74.1%	80.3%
Scottsbluff	9.580E-02	9.97E-02	8.69E-02	8.38E-02	-13.4%	-13.7%
Van Tassell	3.620E-01	3.43E-01	8.37E-02	1.08E-01	-108.1%	-121.5%
Whitney	2.360E-01	2.26E-01	1.03E+00	9.00E-01	116.9%	128.0%
Residence 1	2.060E+01	2.29E+01	7.68E+00	9.59E+00	-72.9%	-99.5%
Residence 2	2.850E+01	2.81E+01	6.19E+01	6.01E+01	71.3%	75.1%
Residence 3	6.010E+00	6.72E+00	3.66E+00	4.42E+00	-30.5%	-59.0%
Residence 4	3.240E+00	3.74E+00	2.48E+00	3.09E+00	-4.7%	-40.5%
Residence 5	2.950E+00	3.68E+00	2.75E+00	2.59E+00	-13.0%	-28.9%
Residence 6	1.000E+01	1.01E+01	1.96E+00	2.72E+00	-114.5%	-135.0%
Residence 7	1.280E+00	1.45E+00	8.42E+00	7.93E+00	144.4%	141.2%
Residence 8	3.070E+00	3.17E+00	1.63E+00	1.64E+00	-60.7%	-64.2%
Unoccupied 1	7.460E+01	7.34E+01	5.19E+01	5.47E+01	-30.8%	-34.3%
Unoccupied 2	2.930E+00	2.96E+00	1.19E+01	1.13E+01	117.6%	120.3%
N. Boundary	9.200E+00	1.00E+01	6.28E+01	5.82E+01	145.4%	145.1%
East Boundary	1.310E+01	1.26E+01	2.36E+01	2.19E+01	50.3%	60.8%
South Boundary	4.500E+01	4.98E+01	1.64E+01	1.98E+01	-77.8%	-100.9%
West boundary	3.65E+01	3.91E+01	1.13E+01	1.52E+01	-82.4%	-110.3%

Table 16. MILDOS Results from Output Reports for Total Annual Dose Commitments (Scottsbluff vs. Gillette, Hypothetical Receptors at 16 Sectors, 2 km Radius, and Z=0 m for All)						
Receptor Location	**Scottsbluff 1 year MU 1–5 Scenario Adult-Effective (mrem/yr)**	**Scottsbluff 15 years MU 1–5 Scenario Adult-Effective (mrem/yr)**	**Gillette 1 year MU 1–5 Scenario Adult-Effective (mrem/yr)**	**Gillette 15 years MU 1–5 Scenario Adult-Effective (mrem/yr)**	**Percent Difference Scottsbluff 1 year vs. Gillette 15 years**	**Percent Difference Gillette 1 year vs. Scottsbluff 15 years**
N	4.19E+00	4.43E+00	2.56E+01	2.25E+01	137.2%	141.0%
NNE	3.19E+00	3.43E+00	2.07E+01	1.88E+01	142.0%	143.1%
NE	4.89E+00	4.76E+00	1.64E+01	1.51E+01	102.2%	110.0%
ENE	7.25E+00	6.67E+00	1.47E+01	1.37E+01	61.6%	75.2%
E	9.98E+00	9.21E+00	1.39E+01	1.37E+01	31.4%	40.6%
ESE	1.73E+01	1.59E+01	1.82E+01	1.82E+01	5.1%	13.5%
SE	5.01E+01	4.60E+01	3.28E+01	3.31E+01	-40.9%	-33.5%
SSE	4.27E+01	5.07E+01	2.54E+01	3.05E+01	-33.3%	-66.5%
S	1.63E+01	1.87E+01	8.80E+00	1.04E+01	-44.2%	-72.0%
SSW	1.27E+01	1.42E+01	5.93E+00	7.29E+00	-54.1%	-82.2%
SW	1.27E+01	1.38E+01	4.50E+00	5.26E+00	-82.9%	-101.6%
WSW	1.51E+01	1.59E+01	4.56E+00	5.30E+00	-96.1%	-110.9%
W	1.67E+01	1.69E+01	4.75E+00	5.53E+00	-100.5%	-112.2%
WNW	2.28E+01	2.29E+01	6.17E+00	7.45E+00	-101.5%	-115.1%
NW	2.04E+01	1.92E+01	1.050E+01	1.14E+01	-56.6%	-58.6%
NNW	1.04E+01	9.11E+00	2.90E+01	2.50E+01	82.5%	104.4%

Table 17. MILDOS Results from Output Reports for Total Annual Dose Commitments (Scottsbluff vs. Gillette, Hypothetical Receptors at 16 Sectors, 2 km Radius, and Z=10 m for All)						
Receptor Location	**Scottsbluff 1 year MU 1–5 Scenario Adult-Effective (mrem/yr)**	**Scottsbluff 15 years MU 1–5 Scenario Adult-Effective (mrem/yr)**	**Gillette 1 year MU 1–5 Scenario Adult-Effective (mrem/yr)**	**Gillette 15 years MU 1–5 Scenario Adult-Effective (mrem/yr)**	**Percent Difference Scottsbluff 1 year vs. Gillette 15 years**	**Percent Difference Gillette 1 year vs. Scottsbluff 15 years**
N	5.000E+00	5.53E+00	3.55E+01	3.11E+01	144.6%	146.1%
NNE	3.650E+00	3.97E+00	2.39E+01	2.20E+01	143.1%	143.0%
NE	5.790E+00	5.53E+00	1.83E+01	1.70E+01	98.4%	107.2%
ENE	8.360E+00	7.64E+00	1.58E+01	1.49E+01	56.2%	69.6%
E	1.130E+01	1.04E+01	1.46E+01	1.45E+01	24.8%	33.6%

Table 17. MILDOS Results from Output Reports for Total Annual Dose Commitments (Scottsbluff vs. Gillette, Hypothetical Receptors at 16 Sectors, 2 km Radius, and Z=10 m for All)						
Receptor Location	**Scottsbluff 1 year MU 1–5 Scenario Adult-Effective (mrem/yr)**	**Scottsbluff 15 years MU 1–5 Scenario Adult-Effective (mrem/yr)**	**Gillette 1 year MU 1–5 Scenario Adult-Effective (mrem/yr)**	**Gillette 15 years MU 1–5 Scenario Adult-Effective (mrem/yr)**	**Percent Difference Scottsbluff 1 year vs. Gillette 15 years**	**Percent Difference Gillette 1 year vs. Scottsbluff 15 years**
ESE	1.870E+01	1.72E+01	1.85E+01	1.87E+01	0.0%	7.3%
SE	5.110E+01	4.71E+01	3.33E+01	3.35E+01	-41.6%	-34.3%
SSE	4.330E+01	5.15E+01	2.56E+01	3.07E+01	-34.1%	-67.2%
S	1.730E+01	1.99E+01	9.19E+00	1.10E+01	-44.5%	-73.6%
SSW	1.360E+01	1.52E+01	6.19E+00	7.75E+00	-54.8%	-84.2%
SW	1.350E+01	1.47E+01	4.71E+00	5.63E+00	-82.3%	-102.9%
WSW	1.630E+01	1.72E+01	4.81E+00	5.74E+00	-95.8%	-112.6%
W	1.890E+01	1.93E+01	5.16E+00	6.21E+00	-101.1%	-115.6%
WNW	2.92E+01	2.96E+01	7.20E+00	8.99E+00	-105.8%	-121.7%
NW	3.40E+01	3.25E+01	1.39E+01	1.59E+01	-72.5%	-80.2%
NNW	1.49E+01	1.32E+01	4.54E+01	3.97E+01	90.8%	109.9%

SUMMARY

Steps 1–3b: Scottsbluff vs. Scottsbluff and Gillette vs. Gillette

In this evaluation, the differences between the dose results for Scottsbluff short-term versus long-term are considered minor. ORAU performed a comparison of dose results in order to establish differences between runs using Scottsbluff data. This was not a complete dose analysis.

Step 3c: Scottsbluff vs. Gillette and Gillette vs. Scottsbluff

The dose results for the inter-site comparison show meaningful differences for many of the individual receptors.

ORAU

APPENDIX E
COMPARISON OF SCOTTSBLUFF, NEBRASKA 15-YEAR AND 30-YEAR LONG-TERM DATASET CANDIDATES

APPENDIX E
COMPARISON OF SCOTTSBLUFF, NEBRASKA 15-YEAR AND 30-YEAR LONG-TERM DATASET CANDIDATES

There have been questions as to whether 15 years of historical data would be adequate to demonstrate baseline year representativeness if the recommended 30 years of historical data are unavailable. Therefore, ORAU performed qualitative (radar plot and bar charts) and quantitative (linear-regression) analysis of data from the National Weather Service site at Scottsbluff, Nebraska. Methodology on how to manage the data is included in Section 2 of this technical basis document (TBD). A discussion of results is included in this appendix.

1. STATISTICAL ANALYSES OF WIND-DIRECTION FREQUENCY DISTRIBUTIONS, WIND-SPEED FREQUENCY DISTRIBUTIONS, AND JFDs FOR VARIOUS DATA PERIODS

1.1 WIND-DIRECTION FREQUENCY DISTRIBUTION COMPARISON

Figure 1 (figures and tables are in the attachment to Appendix E) shows a radar plot comparing the relative frequency distribution of wind direction for the 1-year, 15-year, and 30-year datasets. Figure 2 presents a bar chart of the wind direction frequencies for the 1-year, 15-year, and 30-year datasets, while Table 1 lists wind direction frequencies and the differences in percentage points (pp) among these datasets. Although Table 1 shows differences as high as 3.76 pp for non-calm categories, visual examination of Figures 1 and 2 may lead to a conclusion that despite these differences the datasets appear overall to have similar characteristics. Quantitative analysis will then be required to determine whether sufficient difference exists to affect licensing decisions.

1.2 WIND-SPEED FREQUENCY DISTRIBUTION COMPARISON

Figure 3 presents a bar chart of the relative frequencies of wind speed for the 1-year, 15-year, and 30-year datasets, while Table 2 shows wind speed frequencies and the differences in pp among these datasets. The maximum is 3.50 pp. Visual examination of this figure and table may lead to a conclusion like that for wind direction frequency distributions. There are differences, but overall these datasets appear to have similar characteristics. However, Table 2 reveals a 2.57 pp difference between the 1-year and 30-year relative frequency in the calms category. This may be an important finding since calm wind provides the weakest atmospheric dilution and hence the strongest maximum dose. The calm category thus has a disproportionately strong influence on how well the baseline year's distribution of wind speed could serve in estimating the long-term dose to sensitive receptors. The quantitative analysis in this case potentially includes running a dispersion model such as MILDOS-AREA to evaluate the reliability of a long-term dose assessment based on the wind-speed distribution derived from the Scottsbluff data for the baseline year.

1.3 Wind Speed and Wind Direction JFDs[1] Compared for All Stability Classes

Figures 4 and 5 present the linear regression comparison between 1-year vs. 15-year datasets (R^2= 0.978) and 1-year vs. 30-year datasets (R^2= 0.943) for the wind speed and wind direction joint frequency distributions (JFDs) for all classes, again highlighting an important statistical difference in the amount of baseline year variation explained between the two long-term dataset candidates. Figure 6 shows a linear regression comparison between the 15-year vs. 30-year datasets (R^2= 0.961). Table 4 lists frequencies of stability classes and differences in pp among these datasets.

1.4 Wind Speed and Wind Direction JFDs Comparison for E and F Stability Classes

In order to determine whether stability class plays a meaningful role in representativeness demonstrations, Figures 7 through 10 present the linear regression comparison between 1-year vs. 15-year datasets and 1-year vs. 30-year datasets for the combined wind speed and wind direction distribution for the E and F stability classes. Examination of these figures reveals that there are notable differences in stability class E (stable) between the 15-year and 30-year datasets. The differences in the E and F stability classes are noteworthy as these classes represent poor horizontal and vertical diffusion. Tables 5 and 6 include the JFD data for E and F stability classes.

2. RESULTS AND CONCLUSIONS

2.1 Length of Dataset

It should be noted that a 30-year dataset is recommended for long-term data representativeness purposes in Regulatory Guide 3.63. It is also the climatological standard normal established by the World Meteorological Organization (WMO) (Trewin, 2007) and is the U.S. climatic normal published every 10 years by the National Oceanic and Atmospheric Administration's (NOAA's) National Centers for Environmental Information (NCEI). In general, a climate normal needs to have long enough averages to capture longer-term (decadal) climatic oscillations (Karl, 1988); however, the averages also need to be short enough to reflect climatic trends for predictive purposes. The 30-year standard reflects the current consensus. Therefore, the 30-year standard should remain the recommended period for long-term data.

2.2 Interpretation of Statistical Analyses

The approach recommended in Appendix A and B to evaluate meteorological data was applied in this appendix. Linear regression was used as the statistical method to analyze the data. In this particular study, it was found that the one-year baseline data for Scottsbluff more closely correlated with the data for the 15-year than with the 30-year historical period. Longer-term decadal climatic oscillations are demonstrated in that the correlation between 15 and 30 years is not as strong as the correlation of the one-year with the 15-year dataset. These results are supportive of the WMO recommendation of a 30-year period to represent long-term climate (refer to Recommendation A in Section 3.1.2).

[1] Summed for all stability classes (A–F)

The JFDs for all classes combined were also evaluated first to determine if the R^2 is 0.90 or greater. Then, Classes E and F were evaluated to determine if the R^2 for each class is 0.95 or greater. In general, the example used in this study produced values of R^2 in the acceptable range for both the 15-year and the 30-year datasets at Scottsbluff. The exception is the 30-year dataset in Class E for which R^2 dipped below 0.95, the acceptability threshold for Classes E and F presented in Appendices A and B. These classes, as noted previously, have disproportionate influence on the dose due to their limited dilution and diffusion. Further analysis such as with MILDOS-AREA, as discussed below, may or may not result in a finding of acceptable representativeness for this case. However, this result illustrates the potential trouble in using a 15-yr dataset to represent the long term when significant fluctuations in climate are known to occur on decadal scales. With a shorter period than the standard 30 years, there is a possibility of bias toward representativeness simply because a single year is more likely to represent the most recent preceding 15 years than it will the full 30 years. It is recommended that the standard be 30 years, consistent with the current climatological practice, unless an applicant can show that 30 years of data are unobtainable.

3. ADDITIONAL ANALYSES OF SCOTTSBLUFF DATA USING MILDOS-AREA TO COMPARE DOSE RESULTS

MILDOS-AREA (Yuan et al. 1989) code was executed for the 1-year, 15-year, and 30-year Scottsbluff, Nebraska datasets to determine whether the individual and population doses are substantively different between the 1-year vs. 15-year run comparison and the 1-year vs. 30-year run comparison. The results showed there were no meaningful differences in the estimated doses. Appendix D of the TBD contains the additional evaluations performed using MILDOS-AREA to examine the differences among datasets.

4. REFERENCES

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ATTACHMENT OF APPENDIX E: TABLES AND FIGURES

1. SCOTTSBLUFF WIND DIRECTION RELATIVE FREQUENCY DISTRIBUTION

Table 1 contains the Scottsbluff, Nebraska Airport wind direction relative frequency distributions data used to create the wind direction radar plot, and bar chart in Figures 1 and 2 respectively.

Table 1. Scottsbluff Wind Direction Frequency Distribution

Direction	30 years	15 years	1 year	Diff* 1 year vs. 30 years (pp)	Diff* 1 year vs. 15 years (pp)	Diff* 15 years vs. 30 years (pp)
N	5.65%	6.45%	4.69%	0.96	1.76	-0.80
NNE	3.29%	3.41%	3.10%	0.19	0.31	-0.12
NE	3.72%	3.24%	2.72%	1.00	0.52	0.48
ENE	4.80%	3.63%	3.17%	1.63	0.46	1.17
E	10.89%	10.55%	10.25%	0.64	0.29	0.34
ESE	9.72%	11.03%	12.61%	-2.90	-1.58	-1.31
SE	6.04%	6.27%	6.63%	-0.60	-0.36	-0.24
SSE	3.74%	3.51%	3.73%	0.00	-0.22	0.23
S	3.50%	2.67%	2.70%	0.80	-0.03	0.83
SSW	1.10%	1.13%	1.06%	0.04	0.07	-0.03
SW	0.81%	0.81%	0.84%	-0.03	-0.03	0.00
WSW	1.01%	0.99%	0.88%	0.13	0.12	0.02
W	6.58%	6.82%	7.45%	-0.87	-0.63	-0.23
WNW	15.94%	12.18%	13.73%	2.21	-1.55	3.76
NW	11.44%	11.85%	11.80%	-0.37	0.05	-0.42
NNW	5.83%	7.14%	6.13%	-0.30	1.02	-1.32
Calms	5.94%	8.31%	8.50%	-2.56	-0.19	-2.37

*Where 'diff' is the difference in percentage points (pp) calculated between the long- and short-term relative frequencies. The actual numbers used for the percent point calculations include greater than three significant figures. Therefore, the calculated difference as shown in this table may vary slightly due to rounding.

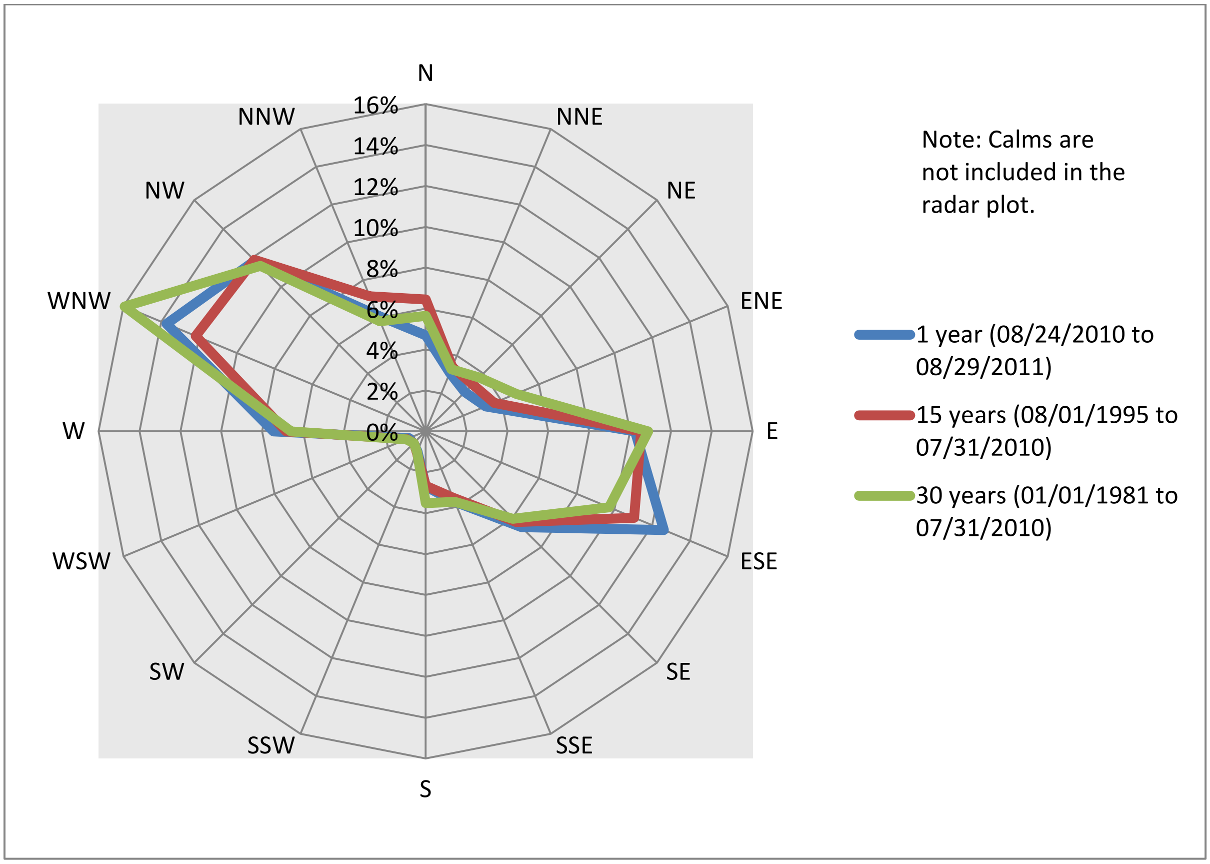

Figure 1. Wind Direction Frequency Distributions for Scottsbluff Airport

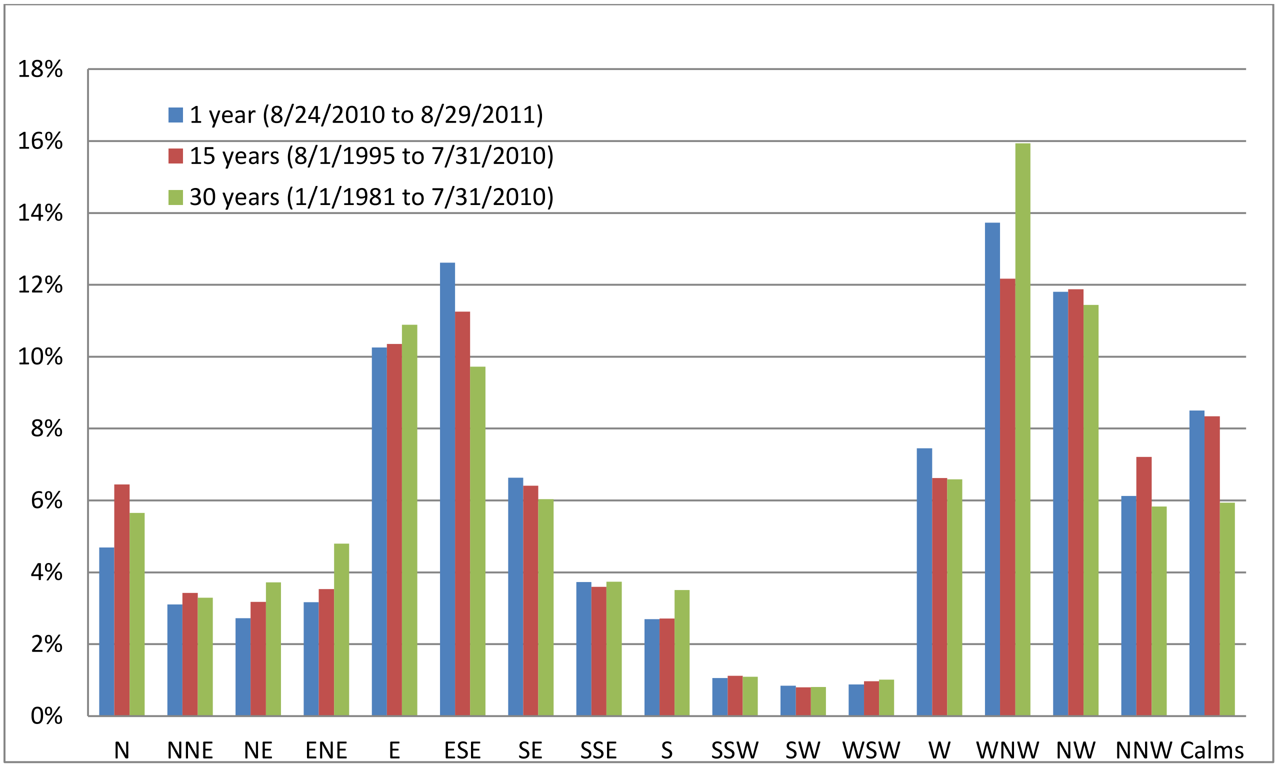

Figure 2. Scottsbluff Wind Direction Frequency Distribution

2. SCOTTSBLUFF WIND SPEED RELATIVE FREQUENCY DISTRIBUTION

Table 2 contains the Scottsbluff, Nebraska Airport wind speed relative frequency distributions data used to create the wind speed bar chart in Figure 3.

Table 2. Wind Speed Relative Frequency Distribution

Speed (mph)	30 years	15 years	1 year	Diff* 1 year vs. 30 years	Diff* 1 year vs. 15 years	Diff* 15 year vs. 30 years
1–3	5.94%	6.99%	7.21%	-1.27	-0.21	-1.06
4–7	27.35%	28.97%	28.67%	-1.32	0.30	-1.62
8–12	31.70%	29.13%	28.20%	3.50	0.93	2.57
13–18	20.64%	18.48%	20.73%	-0.09	-2.25	2.16
19–24	5.75%	5.35%	4.63%	1.11	0.72	0.40
>24	2.69%	2.78%	2.07%	0.63	0.71	-0.08
Calms	5.94%	8.31%	8.50%	-2.56	-0.19	-2.37

*Where 'diff' is the difference in percentage points (pp) calculated between the long- and short-term relative frequencies. The actual numbers used for the percent point calculations include greater than three significant figures. Therefore, the calculated difference as shown in this table may vary slightly due to rounding.

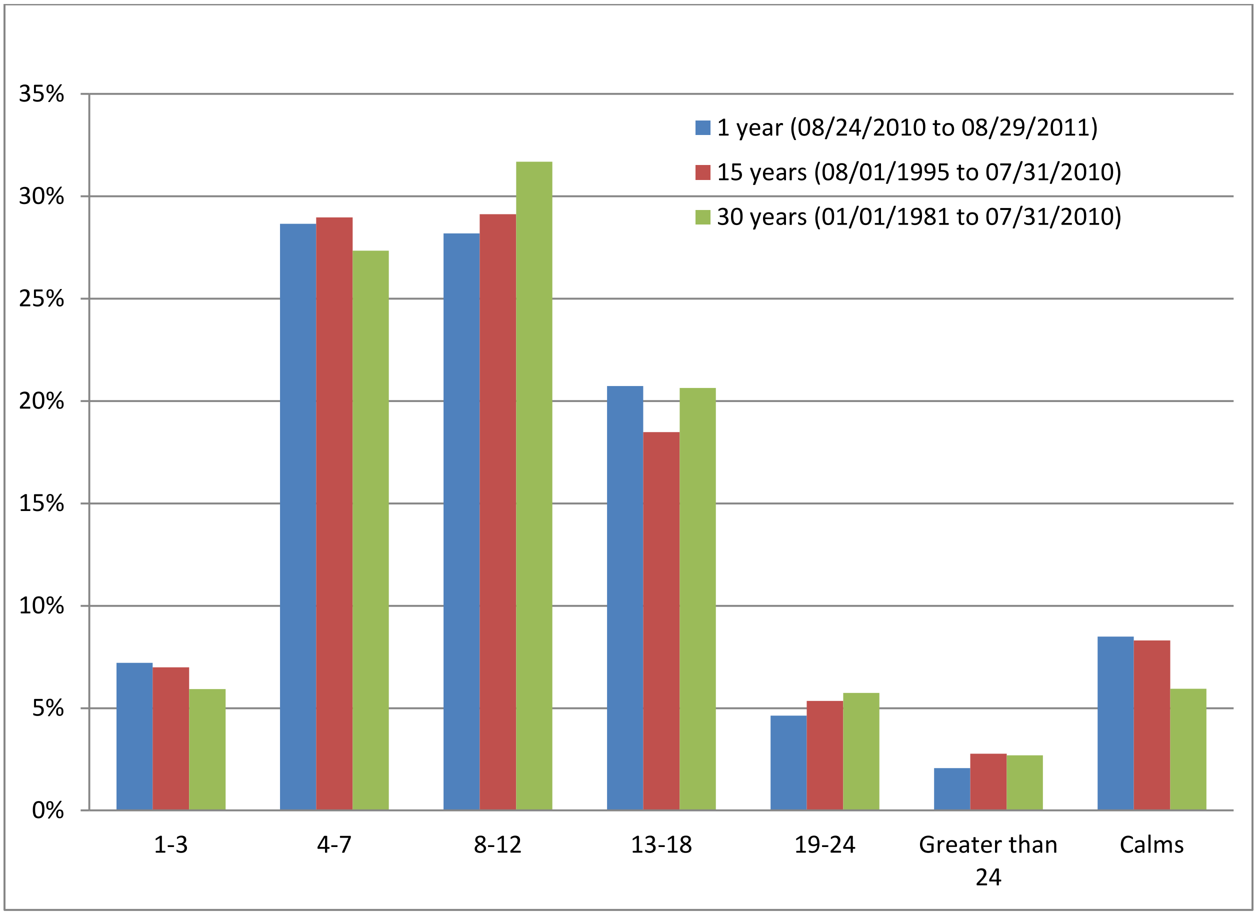

Figure 3. Scottsbluff Wind Speed Relative Frequency Distribution

3. ALL STABILITY CLASSES WIND DIRECTION AND WIND SPEED JOINT FREQUENCY DISTRIBUTION FOR SCOTTSBLUFF AIRPORT

Table 3 contains the Scottsbluff wind direction and wind speed JFDs data used to create the wind direction and wind speed JFD regressions for all classes (A–F) in Figures 4 through 6.

Table 3. Scottsbluff Wind Direction and Wind Speed Joint Frequency Distributions for All Stability Classes Summed

Class*	Speed (mph)	Direction	15 years	30 years	1 year	Diff** 1 year vs. 30 years (pp)	Diff** 1 year vs. 15 years (pp)	Diff** 15 year vs. 30 years (pp)
A–F	1–3	N	1.40%	1.08%	1.25%	-0.17	0.15	-0.32
A–F	1–3	NNE	0.73%	0.63%	0.69%	-0.06	0.04	-0.10
A–F	1–3	NE	0.77%	0.71%	0.75%	-0.03	0.03	-0.06
A–F	1–3	ENE	0.91%	0.96%	0.82%	0.13	0.09	0.05
A–F	1–3	E	2.23%	1.64%	2.02%	-0.38	0.20	-0.58
A–F	1–3	ESE	1.40%	0.97%	1.49%	-0.52	-0.10	-0.42
A–F	1–3	SE	0.81%	0.61%	0.95%	-0.35	-0.14	-0.21
A–F	1–3	SSE	0.54%	0.45%	0.72%	-0.27	-0.18	-0.09
A–F	1–3	S	0.63%	0.68%	0.66%	0.01	-0.03	0.05
A–F	1–3	SSW	0.30%	0.25%	0.23%	0.03	0.07	-0.05
A–F	1–3	SW	0.24%	0.21%	0.26%	-0.05	-0.02	-0.03
A–F	1–3	WSW	0.31%	0.25%	0.32%	-0.07	-0.01	-0.07
A–F	1–3	W	1.03%	0.77%	1.27%	-0.50	-0.24	-0.26
A–F	1–3	WNW	1.43%	1.33%	1.51%	-0.17	-0.0	-0.09
A–F	1–3	NW	1.77%	1.37%	1.64%	-0.28	0.13	-0.41
A–F	1–3	NNW	1.38%	1.01%	1.03%	-0.03	0.35	-0.37
A–F	4–7	N	2.05%	1.87%	1.73%	0.14	0.32	-0.18
A–F	4–7	NNE	1.09%	1.19%	1.11%	0.09	-0.02	0.10
A–F	4–7	NE	1.09%	1.16%	0.99%	0.17	0.10	0.07
A–F	4–7	ENE	1.43%	1.88%	1.15%	0.73	0.28	0.45
A–F	4–7	E	4.60%	3.87%	4.37%	-0.50	0.22	-0.72
A–F	4–7	ESE	2.85%	2.20%	3.15%	-0.94	-0.30	-0.65
A–F	4–7	SE	1.50%	1.28%	1.67%	-0.38	-0.17	-0.22
A–F	4–7	SSE	0.96%	0.95%	1.30%	-0.35	-0.34	-0.01
A–F	4–7	S	0.94%	1.19%	1.04%	0.15	-0.10	0.25
A–F	4–7	SSW	0.44%	0.42%	0.37%	0.05	0.07	-0.02
A–F	4–7	SW	0.33%	0.34%	0.32%	0.03	0.02	0.01
A–F	4–7	WSW	0.38%	0.37%	0.35%	0.02	0.03	-0.01
A–F	4–7	W	1.76%	1.56%	1.70%	-0.14	0.05	-0.20
A–F	4–7	WNW	3.02%	3.44%	3.53%	-0.09	-0.51	0.42
A–F	4–7	NW	3.63%	3.24%	3.95%	-0.70	-0.32	-0.38
A–F	4–7	NNW	2.31%	1.87%	1.92%	-0.05	0.39	-0.44
A–F	8–12	N	1.48%	1.56%	1.00%	0.55	0.48	0.08
A–F	8–12	NNE	1.00%	1.26%	0.96%	0.30	0.04	0.26

Table 3. Scottsbluff Wind Direction and Wind Speed Joint Frequency Distributions for All Stability Classes Summed								
Class*	**Speed (mph)**	**Direction**	**15 years**	**30 years**	**1 year**	**Diff** 1 year vs. 30 years (pp)**	**Diff** 1 year vs. 15 years (pp)**	**Diff** 15 year vs. 30 years (pp)**
A–F	**8–12**	**NE**	0.88%	1.04%	0.68%	0.36	0.20	0.16
A–F	**8–12**	**ENE**	1.13%	1.80%	0.73%	1.06	0.40	0.67
A–F	**8–12**	**E**	4.07%	4.71%	3.89%	0.82	0.18	0.64
A–F	**8–12**	**ESE**	4.64%	3.87%	5.34%	-1.48	-0.70	-0.77
A–F	**8–12**	**SE**	2.30%	2.05%	2.51%	-0.46	-0.21	-0.25
A–F	**8–12**	**SSE**	1.04%	1.09%	0.94%	0.16	0.10	0.06
A–F	**8–12**	**S**	0.72%	0.89%	0.77%	0.13	-0.05	0.17
A–F	**8–12**	**SSW**	0.33%	0.31%	0.35%	-0.04	-0.02	-0.02
A–F	**8–12**	**SW**	0.19%	0.19%	0.27%	-0.08	-0.08	0.00
A–F	**8–12**	**WSW**	0.25%	0.25%	0.20%	0.05	0.05	0.00
A–F	**8–12**	**W**	1.91%	1.88%	2.21%	-0.33	-0.30	-0.03
A–F	**8–12**	**WNW**	4.09%	5.62%	3.91%	1.70	0.18	1.53
A–F	**8–12**	**NW**	3.61%	3.46%	3.33%	0.14	0.28	-0.15
A–F	**8–12**	**NNW**	1.52%	1.35%	1.17%	0.17	0.35	-0.17
A–F	**13–18**	**N**	1.17%	1.14%	0.81%	0.33	0.36	-0.03
A–F	**13–18**	**NNE**	0.68%	0.88%	0.54%	0.33	0.14	0.20
A–F	**13–18**	**NE**	0.66%	0.78%	0.58%	0.21	0.08	0.12
A–F	**13–18**	**ENE**	0.54%	0.81%	0.72%	0.09	-0.18	0.28
A–F	**13–18**	**E**	0.96%	1.49%	1.13%	0.37	-0.17	0.53
A–F	**13–18**	**ESE**	2.63%	2.57%	3.38%	-0.81	-0.75	-0.06
A–F	**13–18**	**SE**	1.78%	1.77%	1.88%	-0.11	-0.11	-0.01
A–F	**13–18**	**SSE**	1.03%	1.09%	0.94%	0.15	0.09	0.06
A–F	**13–18**	**S**	0.58%	0.72%	0.45%	0.27	0.13	0.14
A–F	**13–18**	**SSW**	0.18%	0.17%	0.20%	-0.04	-0.02	-0.02
A–F	**13–18**	**SW**	0.14%	0.12%	0.10%	0.02	0.04	-0.03
A–F	**13–18**	**WSW**	0.15%	0.14%	0.11%	0.02	0.04	-0.02
A–F	**13–18**	**W**	1.56%	1.51%	1.93%	-0.41	-0.37	-0.05
A–F	**13–18**	**WNW**	3.02%	4.09%	4.09%	0.00	-1.08	1.08
A–F	**13–18**	**NW**	2.07%	2.07%	2.45%	-0.38	-0.38	0.00
A–F	**13–18**	**NNW**	1.36%	1.18%	1.48%	-0.29	-0.11	-0.18
A–F	**19–24**	**N**	0.38%	0.33%	0.10%	0.23	0.28	-0.05
A–F	**19–24**	**NNE**	0.21%	0.23%	0.14%	0.09	0.07	0.02
A–F	**19–24**	**NE**	0.18%	0.22%	0.07%	0.15	0.11	0.04
A–F	**19–24**	**ENE**	0.09%	0.17%	0.12%	0.04	-0.03	0.07
A–F	**19–24**	**E**	0.06%	0.15%	0.11%	0.03	-0.05	0.08
A–F	**19–24**	**ESE**	0.31%	0.33%	0.19%	0.14	0.12	0.03
A–F	**19–24**	**SE**	0.30%	0.30%	0.12%	0.17	0.18	0.00
A–F	**19–24**	**SSE**	0.21%	0.23%	0.26%	-0.03	-0.05	0.02
A–F	**19–24**	**S**	0.10%	0.14%	0.12%	0.02	-0.03	0.04
A–F	**19–24**	**SSW**	0.03%	0.03%	0.02%	0.01	0.01	0.00
A–F	**19–24**	**SW**	0.02%	0.02%	0.03%	-0.01	-0.01	0.00
A–F	**19–24**	**WSW**	0.04%	0.04%	0.02%	0.01	0.02	0.00

Table 3. Scottsbluff Wind Direction and Wind Speed Joint Frequency Distributions for All Stability Classes Summed								
Class*	Speed (mph)	Direction	15 years	30 years	1 year	Diff** 1 year vs. 30 years (pp)	Diff** 1 year vs. 15 years (pp)	Diff** 15 year vs. 30 years (pp)
A–F	19–24	W	0.71%	0.62%	0.52%	0.10	0.19	-0.09
A–F	19–24	WNW	0.96%	1.30%	1.07%	0.23	-0.11	0.33
A–F	19–24	NW	0.94%	1.01%	0.97%	0.04	-0.03	0.06
A–F	19–24	NNW	0.80%	0.64%	0.77%	-0.13	0.04	-0.17
A–F	>24	N	0.12%	0.11%	0.00%	0.11	0.12	-0.02
A–F	>24	NNE	0.08%	0.08%	0.02%	0.06	0.06	0.00
A–F	>24	NE	0.05%	0.05%	0.05%	0.01	0.00	0.01
A–F	>24	ENE	0.02%	0.05%	0.02%	0.03	-0.01	0.03
A–F	>24	E	0.02%	0.03%	0.02%	0.00	0.00	0.01
A–F	>24	ESE	0.05%	0.05%	0.00%	0.05	0.05	0.00
A–F	>24	SE	0.04%	0.04%	0.01%	0.03	0.03	0.00
A–F	>24	SSE	0.04%	0.04%	0.02%	0.02	0.01	0.00
A–F	>24	S	0.02%	0.03%	0.01%	0.02	0.01	0.01
A–F	>24	SSW	0.00%	0.00%	0.00%	0.00	0.00	0.00
A–F	>24	SW	0.00%	0.01%	0.00%	0.01	0.00	0.00
A–F	>24	WSW	0.01%	0.00%	0.01%	-0.01	-0.01	0.00
A–F	>24	W	0.41%	0.38%	0.44%	-0.06	-0.03	-0.04
A–F	>24	WNW	0.52%	0.65%	0.56%	0.09	-0.04	0.13
A–F	>24	NW	0.89%	0.79%	0.56%	0.22	0.32	-0.10
A–F	>24	NNW	0.52%	0.36%	0.34%	0.03	0.18	-0.15

* The stability classes A-F were summed for each wind speed and wind direction.
**Where 'diff' is the difference in percentage points (pp) calculated between the long- and short-term relative frequencies. The actual numbers used for the percent point calculations include greater than three significant figures. Therefore, the calculated difference as shown in this table may vary slightly due to rounding.

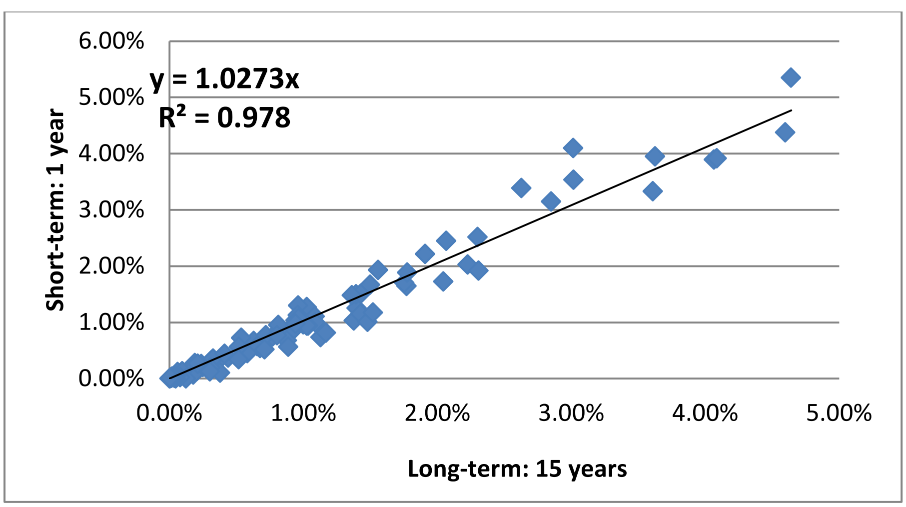

Figure 4. Wind Direction and Wind Speed Joint Frequency Distribution for All Classes: Scottsbluff 1 year vs. 15 years

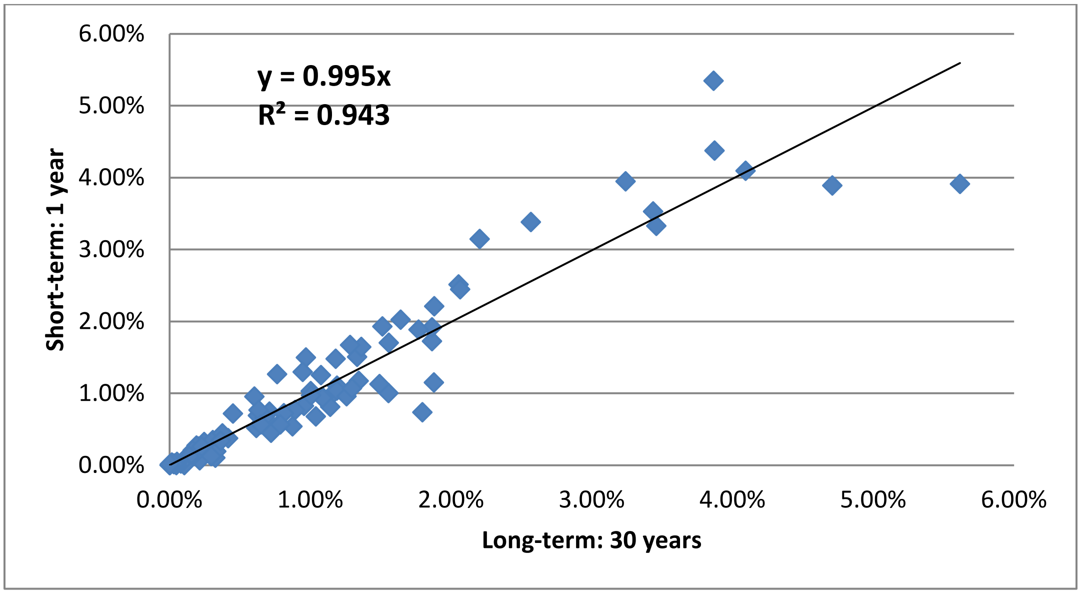

Figure 5. Wind Direction and Wind Speed Joint Frequency Distribution for All Classes: Scottsbluff 1 year vs. 30 years

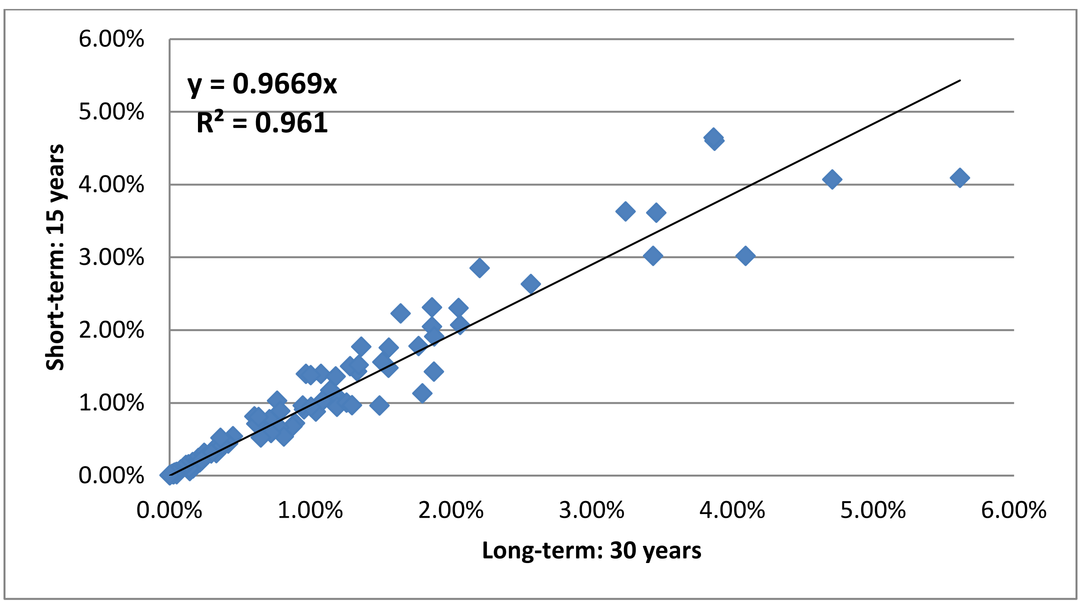

Figure 6. Wind Direction and Wind Speed Joint Frequency Distribution for All Stability Classes: Scottsbluff 15 years vs. 30 years

Table 4 provides the frequency of occurrence of each stability class for all wind speeds and directions JFDs from the one-year, 15-year, and 30-year datasets. Also presented are percent points (pp) differences between pairs of results from the three datasets.

Table 4. Frequency of Stability Classes						
Class	**30 years**	**15 years**	**1 year**	**Diff* 1 year vs. 30 years (pp)**	**Diff* 1 year vs. 15 years (pp)**	**Diff* 15 years vs. 30 years (pp)**
A	1.01%	1.28%	1.33%	-0.32%	-0.05	-0.27
B	6.37%	6.80%	7.44%	-1.07%	-0.64	-0.43
C	11.33%	11.46%	11.18%	0.15%	0.28	-0.13
D	45.10%	40.96%	41.40%	3.70%	-0.44	4.14
E	15.33%	14.26%	13.26%	2.07%	1.00	1.07
F	20.88%	25.26%	25.40%	-4.52%	-0.14	-4.38

*Where 'diff' is the difference in percentage points (pp) calculated between the long- and short-term relative frequencies. The actual numbers used for the percent point calculations include greater than three significant figures. Therefore, the calculated difference as shown in this table may vary slightly due to rounding.

Stability classes are defined as follows:
A Extremely unstable
B Unstable
C Slightly unstable
D Neutral
E Slightly stable
F Stable

4. SCOTTSBLUFF AIRPORT WIND DIRECTION AND WIND SPEED JOINT FREQUENCY DISTRIBUTION FOR CLASSES E AND F

Class E Wind Direction and Wind Speed Joint Frequency Distribution

Table 5 contains the Scottsbluff wind direction and wind speed JFDs data used to create the wind direction and wind speed JFD regression for stability Class E in Figures 7 and 8.

Table 5. Scottsbluff Wind Direction and Wind Speed Joint Frequency Distributions for Stability Class E

Class	Speed (mph)	Direction	15 years	30 years	1 year	Diff* 1 year vs. 30 years (pp)	Diff* 1 year vs. 15 years (pp)	Diff* 15 year vs. 30 years (pp)
E	1–3	N	NA	NA	NA	NA	NA	NA
E	1–3	NNE	NA	NA	NA	NA	NA	NA
E	1–3	NE	NA	NA	NA	NA	NA	NA
E	1–3	ENE	NA	NA	NA	NA	NA	NA
E	1–3	E	NA	NA	NA	NA	NA	NA
E	1–3	ESE	NA	NA	NA	NA	NA	NA
E	1–3	SE	NA	NA	NA	NA	NA	NA
E	1–3	SSE	NA	NA	NA	NA	NA	NA
E	1–3	S	NA	NA	NA	NA	NA	NA
E	1–3	SSW	NA	NA	NA	NA	NA	NA
E	1–3	SW	NA	NA	NA	NA	NA	NA
E	1–3	WSW	NA	NA	NA	NA	NA	NA
E	1–3	W	NA	NA	NA	NA	NA	NA
E	1–3	WNW	NA	NA	NA	NA	NA	NA
E	1–3	NW	NA	NA	NA	NA	NA	NA
E	1–3	NNW	NA	NA	NA	NA	NA	NA
E	4–7	N	0.16%	0.27%	0.19%	0.08	-0.03	0.11
E	4–7	NNE	0.09%	0.18%	0.09%	0.09	0.00	0.09
E	4–7	NE	0.07%	0.16%	0.02%	0.14	0.05	0.08
E	4–7	ENE	0.10%	0.30%	0.08%	0.23	0.02	0.21
E	4–7	E	0.28%	0.43%	0.20%	0.23	0.08	0.15
E	4–7	ESE	0.18%	0.22%	0.12%	0.10	0.06	0.04
E	4–7	SE	0.08%	0.13%	0.14%	-0.01	-0.05	0.05
E	4–7	SSE	0.05%	0.10%	0.08%	0.02	-0.03	0.05
E	4–7	S	0.06%	0.16%	0.08%	0.08	-0.02	0.10
E	4–7	SSW	0.03%	0.06%	0.01%	0.04	0.02	0.02
E	4–7	SW	0.03%	0.04%	0.02%	0.02	0.01	0.01
E	4–7	WSW	0.02%	0.04%	0.02%	0.02	0.00	0.02
E	4–7	W	0.13%	0.17%	0.11%	0.06	0.02	0.04
E	4–7	WNW	0.30%	0.50%	0.36%	0.14	-0.06	0.20
E	4–7	NW	0.34%	0.42%	0.36%	0.06	-0.03	0.08

Table 5. Scottsbluff Wind Direction and Wind Speed Joint Frequency Distributions for Stability Class E								
Class	**Speed (mph)**	**Direction**	**15 years**	**30 years**	**1 year**	**Diff* 1 year vs. 30 years (pp)**	**Diff* 1 year vs. 15 years (pp)**	**Diff* 15 year vs. 30 years (pp)**
E	**4–7**	**NNW**	0.17%	0.21%	0.16%	0.05	0.01	0.04
E	**8–12**	**N**	0.43%	0.48%	0.24%	0.24	0.20	0.05
E	**8–12**	**NNE**	0.33%	0.40%	0.36%	0.04	-0.04	0.07
E	**8–12**	**NE**	0.30%	0.34%	0.18%	0.16	0.12	0.04
E	**8–12**	**ENE**	0.43%	0.69%	0.32%	0.37	0.12	0.26
E	**8–12**	**E**	2.30%	2.38%	2.22%	0.16	0.07	0.09
E	**8–12**	**ESE**	2.25%	1.64%	2.68%	-1.05	-0.44	-0.61
E	**8–12**	**SE**	0.58%	0.48%	0.65%	-0.18	-0.08	-0.10
E	**8–12**	**SSE**	0.21%	0.22%	0.15%	0.08	0.07	0.01
E	**8–12**	**S**	0.16%	0.20%	0.17%	0.03	-0.01	0.03
E	**8–12**	**SSW**	0.11%	0.09%	0.14%	-0.04	-0.02	-0.02
E	**8–12**	**SW**	0.07%	0.05%	0.05%	0.01	0.02	-0.02
E	**8–12**	**WSW**	0.07%	0.06%	0.06%	0.00	0.02	-0.01
E	**8–12**	**W**	0.67%	0.56%	0.70%	-0.14	-0.03	-0.11
E	**8–12**	**WNW**	1.73%	2.11%	1.68%	0.43	0.05	0.39
E	**8–12**	**NW**	1.88%	1.69%	1.27%	0.42	0.60	-0.18
E	**8–12**	**NNW**	0.66%	0.55%	0.35%	0.20	0.31	-0.11
E	**13–18**	**N**	NA	NA	NA	NA	NA	NA
E	**13–18**	**NNE**	NA	NA	NA	NA	NA	NA
E	**13–18**	**NE**	NA	NA	NA	NA	NA	NA
E	**13–18**	**ENE**	NA	NA	NA	NA	NA	NA
E	**13–18**	**E**	NA	NA	NA	NA	NA	NA
E	**13–18**	**ESE**	NA	NA	NA	NA	NA	NA
E	**13–18**	**SE**	NA	NA	NA	NA	NA	NA
E	**13–18**	**SSE**	NA	NA	NA	NA	NA	NA
E	**13–18**	**S**	NA	NA	NA	NA	NA	NA
E	**13–18**	**SSW**	NA	NA	NA	NA	NA	NA
E	**13–18**	**SW**	NA	NA	NA	NA	NA	NA
E	**13–18**	**WSW**	NA	NA	NA	NA	NA	NA
E	**13–18**	**W**	NA	NA	NA	NA	NA	NA
E	**13–18**	**WNW**	NA	NA	NA	NA	NA	NA
E	**13–18**	**NW**	NA	NA	NA	NA	NA	NA
E	**13–18**	**NNW**	NA	NA	NA	NA	NA	NA
E	**19–24**	**N**	NA	NA	NA	NA	NA	NA
E	**19–24**	**NNE**	NA	NA	NA	NA	NA	NA
E	**19–24**	**NE**	NA	NA	NA	NA	NA	NA
E	**19–24**	**ENE**	NA	NA	NA	NA	NA	NA
E	**19–24**	**E**	NA	NA	NA	NA	NA	NA
E	**19–24**	**ESE**	NA	NA	NA	NA	NA	NA
E	**19–24**	**SE**	NA	NA	NA	NA	NA	NA
E	**19–24**	**SSE**	NA	NA	NA	NA	NA	NA
E	**19–24**	**S**	NA	NA	NA	NA	NA	NA

Table 5. Scottsbluff Wind Direction and Wind Speed Joint Frequency Distributions for Stability Class E								
Class	**Speed (mph)**	**Direction**	**15 years**	**30 years**	**1 year**	**Diff* 1 year vs. 30 years (pp)**	**Diff* 1 year vs. 15 years (pp)**	**Diff* 15 year vs. 30 years (pp)**
E	**19–24**	**SSW**	NA	NA	NA	NA	NA	NA
E	**19–24**	**SW**	NA	NA	NA	NA	NA	NA
E	**19–24**	**WSW**	NA	NA	NA	NA	NA	NA
E	**19–24**	**W**	NA	NA	NA	NA	NA	NA
E	**19–24**	**WNW**	NA	NA	NA	NA	NA	NA
E	**19–24**	**NW**	NA	NA	NA	NA	NA	NA
E	**19–24**	**NNW**	NA	NA	NA	NA	NA	NA
E	**>24**	**N**	NA	NA	NA	NA	NA	NA
E	**>24**	**NNE**	NA	NA	NA	NA	NA	NA
E	**>24**	**NE**	NA	NA	NA	NA	NA	NA
E	**>24**	**ENE**	NA	NA	NA	NA	NA	NA
E	**>24**	**E**	NA	NA	NA	NA	NA	NA
E	**>24**	**ESE**	NA	NA	NA	NA	NA	NA
E	**>24**	**SE**	NA	NA	NA	NA	NA	NA
E	**>24**	**SSE**	NA	NA	NA	NA	NA	NA
E	**>24**	**S**	NA	NA	NA	NA	NA	NA
E	**>24**	**SSW**	NA	NA	NA	NA	NA	NA
E	**>24**	**SW**	NA	NA	NA	NA	NA	NA
E	**>24**	**WSW**	NA	NA	NA	NA	NA	NA
E	**>24**	**W**	NA	NA	NA	NA	NA	NA
E	**>24**	**WNW**	NA	NA	NA	NA	NA	NA
E	**>24**	**NW**	NA	NA	NA	NA	NA	NA
E	**>24**	**NNW**	NA	NA	NA	NA	NA	NA

* Where 'diff' is the difference in percentage points (pp) calculated between the long- and short-term relative frequencies. The actual numbers used for the percent point calculations include greater than three significant figures. Therefore, the calculated difference as shown in this table may vary slightly due to rounding.

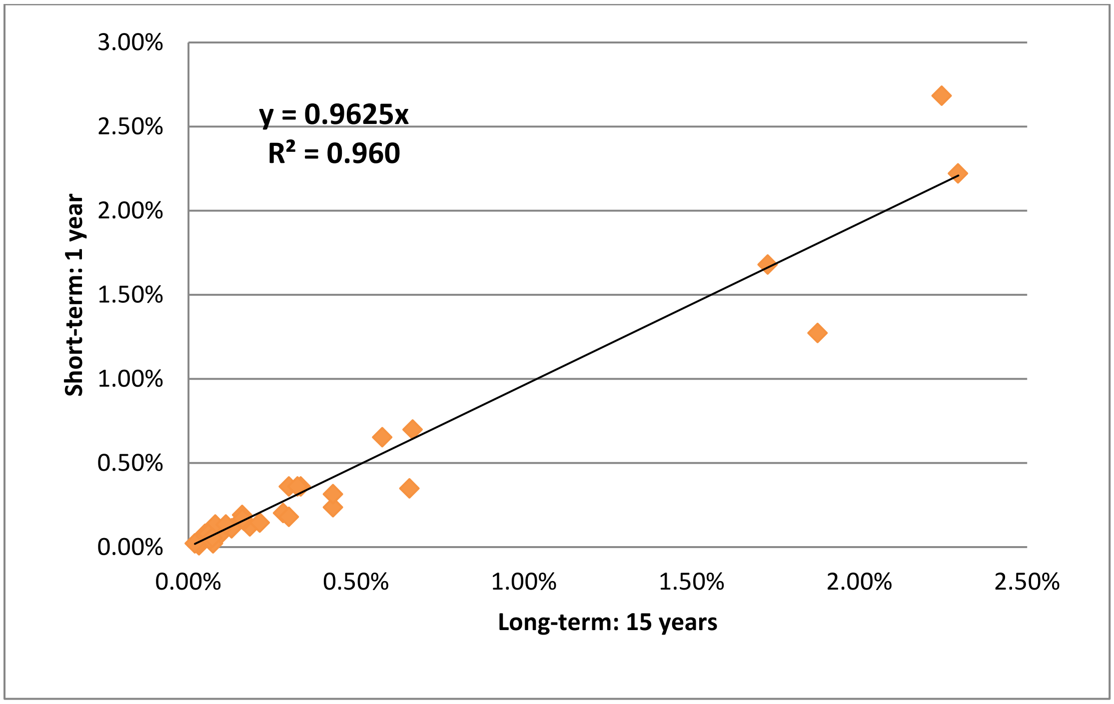

Figure 7. Class E Joint Frequency Distribution: Scottsbluff 1 year vs. 15 years

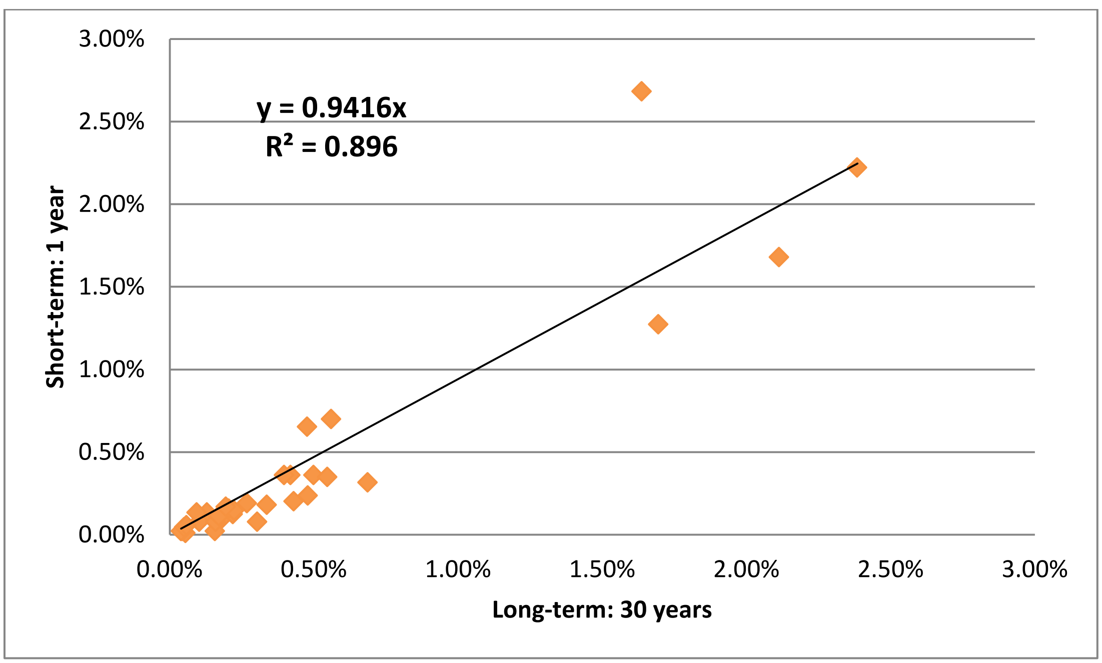

Figure 8. Class E Joint Frequency Distribution: Scottsbluff 1 year vs. 30 years

Class F Wind Direction and Wind Speed Joint Frequency Distribution

Table 6 contains the Scottsbluff wind direction and wind speed JFDs data used to create the wind direction and wind speed JFD regression for stability Class F in Figures 9 and 10.

Table 6. Scottsbluff Wind Direction and Wind Speed Joint Frequency Distributions for Stability Class F

Class	Speed (mph)	Direction	15 years	30 years	1 year	Diff* 1 year vs. 30 years (pp)	Diff* 1 year vs. 15 years (pp)	Diff* 15 year vs. 30 years (pp)
F	1–3	N	1.01%	0.78%	0.92%	-0.14	0.09	-0.23
F	1–3	NNE	0.54%	0.43%	0.43%	0.00	0.10	-0.10
F	1–3	NE	0.54%	0.48%	0.51%	-0.03	0.03	-0.06
F	1–3	ENE	0.65%	0.66%	0.61%	0.05	0.04	0.01
F	1–3	E	1.58%	1.15%	1.49%	-0.34	0.09	-0.43
F	1–3	ESE	0.83%	0.57%	0.93%	-0.36	-0.10	-0.26
F	1–3	SE	0.35%	0.28%	0.42%	-0.14	-0.07	-0.07
F	1–3	SSE	0.23%	0.21%	0.31%	-0.10	-0.08	-0.01
F	1–3	S	0.29%	0.31%	0.25%	0.06	0.03	0.03
F	1–3	SSW	0.14%	0.11%	0.06%	0.06	0.08	-0.02
F	1–3	SW	0.11%	0.09%	0.09%	0.00	0.02	-0.02
F	1–3	WSW	0.15%	0.11%	0.12%	-0.01	0.02	-0.04
F	1–3	W	0.46%	0.35%	0.59%	-0.25	-0.13	-0.11
F	1–3	WNW	0.81%	0.77%	0.85%	-0.09	-0.04	-0.04
F	1–3	NW	1.21%	0.93%	1.22%	-0.30	-0.02	-0.28
F	1–3	NNW	1.00%	0.71%	0.79%	-0.08	0.21	-0.29
F	4–7	N	1.27%	1.03%	0.94%	0.10	0.33	-0.24
F	4–7	NNE	0.64%	0.60%	0.56%	0.03	0.07	-0.04
F	4–7	NE	0.64%	0.60%	0.71%	-0.11	-0.07	-0.04
F	4–7	ENE	0.86%	0.97%	0.68%	0.30	0.19	0.11
F	4–7	E	3.08%	2.32%	3.01%	-0.69	0.07	-0.76
F	4–7	ESE	1.53%	1.10%	1.97%	-0.87	-0.44	-0.43
F	4–7	SE	0.50%	0.40%	0.68%	-0.28	-0.17	-0.10
F	4–7	SSE	0.31%	0.27%	0.36%	-0.09	-0.05	-0.03
F	4–7	S	0.32%	0.36%	0.36%	0.00	-0.04	0.04
F	4–7	SSW	0.17%	0.13%	0.10%	0.03	0.07	-0.04
F	4–7	SW	0.11%	0.10%	0.17%	-0.07	-0.06	-0.01
F	4–7	WSW	0.13%	0.10%	0.14%	-0.03	0.00	-0.03
F	4–7	W	0.64%	0.51%	0.69%	-0.18	-0.05	-0.13
F	4–7	WNW	1.45%	1.48%	1.78%	-0.30	-0.34	0.04
F	4–7	NW	2.19%	1.83%	2.49%	-0.66	-0.30	-0.36
F	4–7	NNW	1.55%	1.14%	1.17%	-0.03	0.37	-0.41
F	8–12	N	NA	NA	NA	NA	NA	NA
F	8–12	NNE	NA	NA	NA	NA	NA	NA
F	8–12	NE	NA	NA	NA	NA	NA	NA
F	8–12	ENE	NA	NA	NA	NA	NA	NA

Table 6. Scottsbluff Wind Direction and Wind Speed Joint Frequency Distributions for Stability Class F								
Class	Speed (mph)	Direction	15 years	30 years	1 year	Diff* 1 year vs. 30 years (pp)	Diff* 1 year vs. 15 years (pp)	Diff* 15 year vs. 30 years (pp)
F	8–12	E	NA	NA	NA	NA	NA	NA
F	8–12	ESE	NA	NA	NA	NA	NA	NA
F	8–12	SE	NA	NA	NA	NA	NA	NA
F	8–12	SSE	NA	NA	NA	NA	NA	NA
F	8–12	S	NA	NA	NA	NA	NA	NA
F	8–12	SSW	NA	NA	NA	NA	NA	NA
F	8–12	SW	NA	NA	NA	NA	NA	NA
F	8–12	WSW	NA	NA	NA	NA	NA	NA
F	8–12	W	NA	NA	NA	NA	NA	NA
F	8–12	WNW	NA	NA	NA	NA	NA	NA
F	8–12	NW	NA	NA	NA	NA	NA	NA
F	8–12	NNW	NA	NA	NA	NA	NA	NA
F	13–18	N	NA	NA	NA	NA	NA	NA
F	13–18	NNE	NA	NA	NA	NA	NA	NA
F	13–18	NE	NA	NA	NA	NA	NA	NA
F	13–18	ENE	NA	NA	NA	NA	NA	NA
F	13–18	E	NA	NA	NA	NA	NA	NA
F	13–18	ESE	NA	NA	NA	NA	NA	NA
F	13–18	SE	NA	NA	NA	NA	NA	NA
F	13–18	SSE	NA	NA	NA	NA	NA	NA
F	13–18	S	NA	NA	NA	NA	NA	NA
F	13–18	SSW	NA	NA	NA	NA	NA	NA
F	13–18	SW	NA	NA	NA	NA	NA	NA
F	13–18	WSW	NA	NA	NA	NA	NA	NA
F	13–18	W	NA	NA	NA	NA	NA	NA
F	13–18	WNW	NA	NA	NA	NA	NA	NA
F	13–18	NW	NA	NA	NA	NA	NA	NA
F	13–18	NNW	NA	NA	NA	NA	NA	NA
F	19–24	N	NA	NA	NA	NA	NA	NA
F	19–24	NNE	NA	NA	NA	NA	NA	NA
F	19–24	NE	NA	NA	NA	NA	NA	NA
F	19–24	ENE	NA	NA	NA	NA	NA	NA
F	19–24	E	NA	NA	NA	NA	NA	NA
F	19–24	ESE	NA	NA	NA	NA	NA	NA
F	19–24	SE	NA	NA	NA	NA	NA	NA
F	19–24	SSE	NA	NA	NA	NA	NA	NA
F	19–24	S	NA	NA	NA	NA	NA	NA
F	19–24	SSW	NA	NA	NA	NA	NA	NA
F	19–24	SW	NA	NA	NA	NA	NA	NA
F	19–24	WSW	NA	NA	NA	NA	NA	NA
F	19–24	W	NA	NA	NA	NA	NA	NA
F	19–24	WNW	NA	NA	NA	NA	NA	NA

Table 6. Scottsbluff Wind Direction and Wind Speed Joint Frequency Distributions for Stability Class F

Class	Speed (mph)	Direction	15 years	30 years	1 year	Diff* 1 year vs. 30 years (pp)	Diff* 1 year vs. 15 years (pp)	Diff* 15 year vs. 30 years (pp)
F	**19–24**	**NW**	NA	NA	NA	NA	NA	NA
F	**19–24**	**NNW**	NA	NA	NA	NA	NA	NA
F	**>24**	**N**	NA	NA	NA	NA	NA	NA
F	**>24**	**NNE**	NA	NA	NA	NA	NA	NA
F	**>24**	**NE**	NA	NA	NA	NA	NA	NA
F	**>24**	**ENE**	NA	NA	NA	NA	NA	NA
F	**>24**	**E**	NA	NA	NA	NA	NA	NA
F	**>24**	**ESE**	NA	NA	NA	NA	NA	NA
F	**>24**	**SE**	NA	NA	NA	NA	NA	NA
F	**>24**	**SSE**	NA	NA	NA	NA	NA	NA
F	**>24**	**S**	NA	NA	NA	NA	NA	NA
F	**>24**	**SSW**	NA	NA	NA	NA	NA	NA
F	**>24**	**SW**	NA	NA	NA	NA	NA	NA
F	**>24**	**WSW**	NA	NA	NA	NA	NA	NA
F	**>24**	**W**	NA	NA	NA	NA	NA	NA
F	**>24**	**WNW**	NA	NA	NA	NA	NA	NA
F	**>24**	**NW**	NA	NA	NA	NA	NA	NA
F	**>24**	**NNW**	NA	NA	NA	NA	NA	NA

* Where 'diff' is the difference in percentage points (pp) calculated between the long- and short-term relative frequencies. The actual numbers used for the percent point calculations include greater than three significant figures. Therefore, the calculated difference as shown in this table may vary slightly due to rounding.

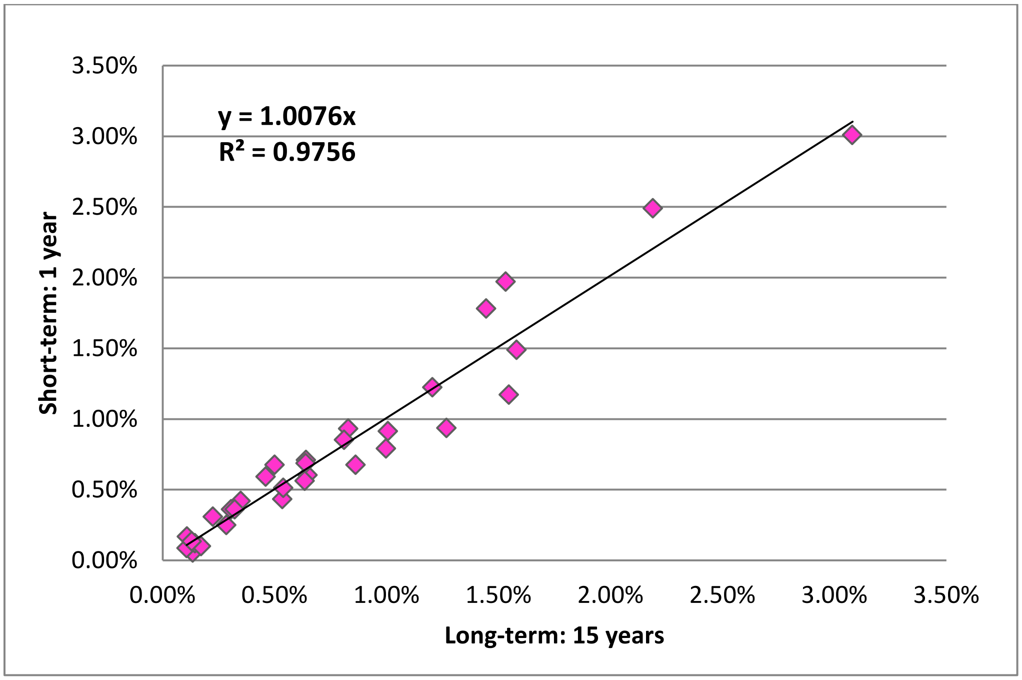

Figure 9. Class F Joint Frequency Distribution: Scottsbluff 1 year vs. 15 years

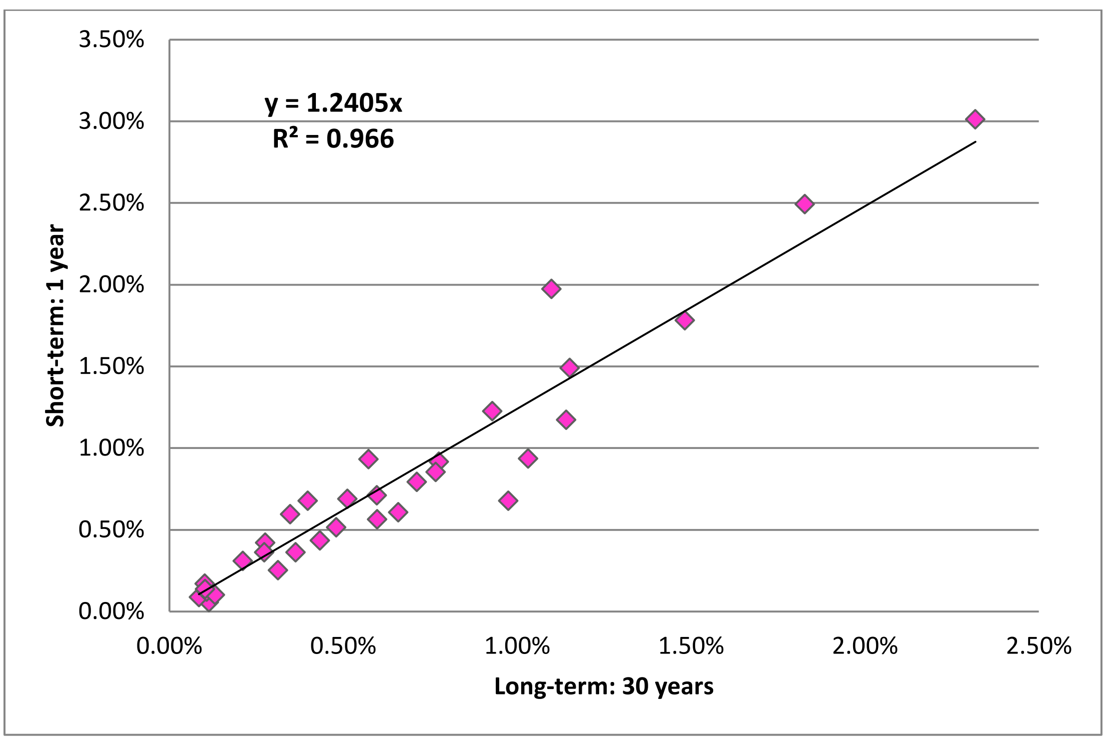

Figure 10. Class F Joint Frequency Distribution: Scottsbluff 1 year vs. 30 years

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APPENDIX F
METEOROLOGICAL PARAMETERS

Appendix F
Table 1. Importance of Meteorological Parameters by Particulate Sources

Sources	Wind Speed	Wind Direction	Stability Class	Precipitation	Evaporation	Temperature	Relative Humidity	Weather NPHs	Mixing Height[5]	Net Radiation
Conventional Mills										
Ore handling	High[1]	High[1]	High[1]	Low[4]	Low[4]	Medium[3]	Medium[3]	Medium[3]	Low[4]	Low[4]
Ore storage	High[1]	High[1]	High[1]	Low[4]	Low[4]	Medium[3]	Medium[3]	Medium[3]	Low[4]	Low[4]
Ore crushing and grinding	High[1]	High[1]	High[1]	Low[4]	Low[4]	Medium[3]	Medium[3]	Medium[3]	Low[4]	Low[4]
Ore conveying	High[1]	High[1]	High[1]	Low[4]	Low[4]	Medium[3]	Medium[3]	Medium[3]	Low[4]	Low[4]
Ore feed system	High[1]	High[1]	High[1]	Low[4]	Low[4]	Medium[3]	Medium[3]	Medium[3]	Low[4]	Low[4]
Yellowcake drying and packaging	High[1]	High[1]	High[1]	Low[4]	Low[4]	Medium[3]	Medium[3]	Medium[3]	Low[4]	Low[4]
Tailings piles	High[1]	High[1]	High[1]	High[1,2]	High[1,2]	Medium[3]	Medium[3]	Medium[3]	Low[4]	Low[4]
Heap Leach										
Ore crushing	High[1]	High[1]	High[1]	Low[4]	Low[4]	Medium[3]	Medium[3]	Medium[3]	Low[4]	Low[4]
Active heap piles	High[1]	High[1]	High[1]	Low[4]	Low[4]	Medium[3]	Medium[3]	Medium[3]	Low[4]	Low[4]
Spent heap piles	High[1]	High[1]	High[1]	Low[4]	Low[4]	Medium[3]	Medium[3]	Medium[3]	Low[4]	Low[4]
Yellowcake drying and packaging.	High[1]	High[1]	High[1]	Low[4]	Low[4]	Medium[3]	Medium[3]	Medium[3]	Low[4]	Low[4]
In-Situ Recovery										
Yellowcake drying and packaging	High[1]	High[1]	High[1]	Low[4]	Low[4]	Medium[3]	Medium[3]	Medium[3]	Low[4]	Low[4]

Notes:

[1] High importance is assigned to meteorological parameters for which it is necessary to demonstrate representativeness, because the parameter is required for the nuclear safety analyses.
[2] High importance is assigned to precipitation and evaporation. The importance would be high importance for uranium recovery facilities where tailing impoundments, evaporation ponds and settlement basins are part of the design and operation for nuclear safety. If precipitation is common, wet deposition of radionuclides to the surface (plume washout) may become important.
[3] Medium importance is assigned to meteorological parameters associated with facility design, but that are not considered to impact nuclear safety.
[4] Low importance is assigned to meteorological parameters associated with characterization of the environment.
[5] The 100-m default mixing height (MILDOS-AREA) is a recommended conservative value. If a greater mixing height is required to achieve acceptable dose, this parameter should be considered of high importance because of the potential significance to nuclear safety.

Appendix F
Table 2. Importance of Meteorological Parameters by Radon Sources

Sources	Wind Speed	Wind Direction	Stability Class	Mixing Height[5]	Temperature	Precipitation	Relative Humidity	Evaporation	Net Radiation	Weather NPHs
Conventional Mills										
Ore storage	High[1]	High[1]	High[1]	Low[4]	Medium[3]	Low[4]	Medium[3]	Low[4]	Low[4]	Medium[3]
Ore crushing and grinding	High[1]	High[1]	High[1]	Low[4]	Medium[3]	Low[4]	Medium[3]	Low[4]	Low[4]	Medium[3]
Ore feed system	High[1]	High[1]	High[1]	Low[4]	Medium[3]	Low[4]	Medium[3]	Low[4]	Low[4]	Medium[3]
Evaporation ponds	High[1]	High[1]	High[1]	Low[4]	Medium[3]	High[1,2]	Medium[3]	High[1,2]	Low[4]	Medium[3]
Mill tailings disposal site	High[1]	High[1]	High[1]	Low[4]	Medium[3]	High[1,2]	Medium[3]	High[1,2]	Low[4]	Medium[3]
Heap Leach										
Process ponds	High[1]	High[1]	High[1]	Low[4]	Medium[3]	High[1,2]	Medium[3]	High[1,2]	Low[4]	Medium[3]
Active heap piles	High[1]	High[1]	High[1]	Low[4]	Medium[3]	Low[4]	Medium[3]	Low[4]	Low[4]	Medium[3]
Spent heap piles	High[1]	High[1]	High[1]	Low[4]	Medium[3]	Low[4]	Medium[3]	Low[4]	Low[4]	Medium[3]
Evaporation ponds	High[1]	High[1]	High[1]	Low[4]	Medium[3]	High[1,2]	Medium[3]	High[1,2]	Low[4]	Medium[3]
In-Situ Recovery										
Wellfield operations	High[1]	High[1]	High[1]	Low[4]	Medium[3]	Low[4]	Medium[3]	Low[4]	Low[4]	Medium[3]
Central plant operations	High[1]	High[1]	High[1]	Low[4]	Medium[3]	Low[4]	Medium[3]	Low[4]	Low[4]	Medium[3]
Resin transfer operations	High[1]	High[1]	High[1]	Low[4]	Medium[3]	Low[4]	Medium[3]	Low[4]	Low[4]	Medium[3]
Aquifer restoration activities	High[1]	High[1]	High[1]	Low[4]	Medium[3]	Low[4]	Medium[3]	Low[4]	Low[4]	Medium[3]
Evaporation ponds	High[1]	High[1]	High[1]	Low[4]	Medium[3]	High[1,2]	Medium[3]	High[1,2]	Low[4]	Medium[3]

Notes:

[1] High importance is assigned to meteorological parameters for which it is necessary to demonstrate representativeness, because the parameter is required for the nuclear safety analyses.
[2] High importance is assigned to precipitation and evaporation. The importance would be high for uranium recovery facilities where tailing impoundments, evaporation ponds and settlement basins are part of the design and operation for nuclear safety. If precipitation is common, wet deposition of radionuclides to the surface (plume washout) may become important.
[3] Medium importance is assigned to meteorological parameters associated with facility design, but that are not considered to impact nuclear safety.
[4] Low importance is assigned to meteorological parameters associated with characterization of the environment.
[5] The 100-m default mixing height (MILDOS-AREA) is a recommended conservative value. If a greater mixing height is required to achieve acceptable dose, this parameter should be considered of high importance because of the potential significance to nuclear safety.