BSC

Design Calculation or Analysis Cover Sheet

Complete only applicable items.

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1: Description of Microsoft Excel File Containing the Input Data, Calculations, and Wind Hazard Curve Plots	3 pages and 1 CD

RECORD OF REVISIONS

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DISCLAIMER

CONTENTS

FIGURES

Page

TABLES

Page

ACRONYMS

ASHRAE	American Society of Heating, Refrigerating & Air-Conditioning Engineers
HVAC	heating, ventilation, and air-conditioning

1. PURPOSE

The primary purpose of this analysis is to produce straight wind hazard curves showing the probability of occurrences per year of maximum three-second gusts and one-minute average wind speeds. The analysis includes identifying the maximum annual three-second gust straight (non-tornado) wind speed associated with a 10^{-6} per year probability of occurrence.

A secondary purpose of the analysis is to investigate a wind velocity requirement used in heating, ventilation, and air-conditioning (HVAC) calculations using data from the on-site measurement program.

The analysis scope includes identifying appropriate methods to develop the products, obtaining the appropriate input data, and producing the products. The analysis is based on straight wind information, that is, it does not include tornado or other circular storm winds that might apply to the site.

2. REFERENCES

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2.2.16 ASCE/SEI 7-05. 2006. *Minimum Design Loads for Buildings and Other Structures.* Including Supplement No. 1. Reston, Virginia: American Society of Civil Engineers. TIC: 258057. (DIRS 176248)

2.2.17 Regulatory Guide 1.23, Rev. 0, 1972. *Onsite Meteorological Programs.* Washington, D.C.: U.S. Atomic Energy Commission. TIC: 2937. (DIRS 103640)

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2.3 ANALYSIS CONSTRAINTS

None

2.4 ANALYSIS OUTPUTS

2.4.1 Straight wind hazard curves, based on three-second and one-minute average wind speeds. Occurrences range from 10^{-1} to 10^{-6} per year.

2.4.2 Maximum annual three-second gust straight (non-tornado) wind speed associated with a 10^{-6} per year probability of occurrence.

2.4.3 Calculated sustained wind speeds over 40 mph based on Site 1 data.

3. ASSUMPTIONS

3.1 ASSUMPTIONS REQUIRING VERIFICATION

This analysis does not contain any assumptions requiring verification.

3.2 ASSUMPTIONS NOT REQUIRING VERIFICATION

3.2.1 Wind Data from Site 1

The wind data collected from the ten-meter above ground level (agl) instruments at Site 1 are appropriate for the purposes of this analysis.

Rationale–The proposed surface facilities would be located at the North Portal Area, which is approximately one kilometer north of Site 1, at a similar elevation and topographic exposure as Site 1. As such, Site 1 is representative of the proposed area of the surface facilities area for purposes of this analysis according to TWP-MGR-MM-000001, *Technical Work Plan for: Meteorological Monitoring and Data Analysis* (Reference 2.2.1, Addendum A, Section A2, p. 17). Furthermore, ASCE/SEI 7-05, *Minimum Design Loads for Buildings and Other*

Structures (Reference 2.2.16, Section 6.5.4, p. 25) bases this type of analysis on wind data collected at the ten-meter level. The data files used for this analysis include the maximum three-second gust and one-minute average speeds that were recorded in both ten-minute and daily time periods. The hourly average values and maximum one-minute values recorded during ten-minute and daily periods were used to estimate the occurrences of sustained winds of 40 mph for the HVAC requirement comparison. The data archiving methods were based on ASTM D 5741-96, *Standard Practice for Characterizing Surface Wind Using a Wind Vane and Rotating Anemometer* (Reference 2.2.4, Section 4.3).

3.2.2 Sustained Wind Speed

Two related assumptions were made to analyze the wind velocity criterion relevant to HVAC building leakage requirements of 000-3DG-GEHV-00100-000-00A, *Discipline Design Guide and Standards for Surface Facilities HVAC Systems* (Reference 2.2.20, Section 2.1.2, p. 8). First, hourly average wind speed data from Site 1, rather than maximum three-second gust or one-minute average, are the most relevant data to investigate the extreme 1% data used as the basis for the criterion. Second, calculated probabilities and actual occurrences of maximum one-minute average wind speeds at least 40 mph can be used to compare on-site data to the sustained wind speed criterion.

Rationale (hourly average)–The basis of the HVAC wind velocity criterion is the upper 1% extreme of the routine wind speed observations for Mercury, Nevada, as published by the American Society of Heating, Refrigerating & Air-Conditioning Engineers (ASHRAE) in *2001 ASHRAE Handbook, Fundamentals* (Reference 2.2.21, pp. 27.3 and 27.14). The design wind speed in this publication was produced for the design of smoke management systems. As such, this speed is not the same as the gust (three-second average) basic wind speed used for structural design (Reference 2.2.16, p. 21). The specific averaging time associated with sustained winds varies by data source and application. The nearest approximation to an hourly observation (that is the basis of the upper 1% extreme value cited above) in the Site 1 data is the hourly average, so these data were used to compare with the extreme 1% value previously mentioned.

Rationale (occurrences of one-minute averages)–The second portion of this assumption involves the occurrence of wind speeds that meet the velocity criterion (Reference 2.2.20) stated as a sustained wind speed of 40 mph. Sustained wind speeds are defined for averaging periods of one and two minutes or longer (Reference 2.2.4). The use of maximum one-minute average wind speed data is a common meteorological practice (Reference 2.2.4). The Site 1 maximum one-minute average wind speed data are the best on-site data for the purpose of investigating sustained wind speeds. The one-minute data were used to calculate the probability of occurrence of 40 mph, and to count the actual occurrences of winds exceeding this value in the ten years of data analyzed.

4. METHODOLOGY

4.1 QUALITY ASSURANCE

This analysis was prepared in accordance with EG-PRO-3DP-G04B-00037, *Calculations and Analyses* (Reference 2.1.1). The straight wind hazard curves will apply to each important to safety and conventional facilities design. Therefore, this analysis is categorized as Safety Category: important to safety or important to waste isolation, or both. The approved version, therefore, is designated as QA: QA. The quality assurance program is subject to the requirements of QA-DIR-10, *Quality Management Directive* (Reference 2.1.4).

Where appropriate, the data used and the calculation file were controlled in accordance with IT-PRO-0009, *Control of the Electronic Management of Information* (Reference 2.1.2).

4.2 USE OF SOFTWARE

The commercial off the shelf software products Microsoft Access 2000, Microsoft Excel 2000, and Microsoft Word 2000 were used in this calculation (Microsoft Office Professional, STN: 610236-2000-00). These programs are not required to comply with IT-PRO-0011, *Software Management* (Reference 2.1.3). These programs are documented in the Software Baseline Report as Level 2 or 3 software.

The numerical calculations and graph preparations in this analysis were performed using Microsoft Excel 2000 using a Dell OptiPlex GX260 X86 based personal desktop computer with management and operating contractor property identification number 152130, and a Dell OptiPlex GX620 based personal desktop computer with property identification number YMP004634.

The analysis process and equations documented in Section 6 of this document were checked by hand calculations.

4.3 ANALYSIS REQUIREMENT

This analysis provides a hazard curve for extreme winds for surface facilities in the North Portal Area, per NUREG-1804 (Reference 2.2.18, Section 2.1.1.1.2). Local summaries of meteorological data are used from onsite measurements in accordance with Regulatory Guide 1.23 (Reference 2.2.17) to ensure that surface facilities in the North Portal Area are designed to withstand specified natural phenomena of extreme wind associated with local meteorology. This analysis determines straight wind hazard curves for two maximum wind speeds: the three-second gust and the one-minute average. The monitoring program is described in TWP-MGR-MM-000001 (Reference 2.2.1).

This analysis also produces estimates of the occurrences of sustained wind speeds over 40 mph. This wind occurrence is relevant to HVAC system capability to provide adequate building conditions to contain certain releases of airborne material (Reference 2.2.20, Section 2.1.2, p. 8).

4.4 ANALYSIS BACKGROUND AND CODE APPLICABILITY

The overall approach to identifying structural wind loading is found in ASCE/SEI 7-05, covering design loads (Reference 2.2.16).

Climatic design information for HVAC design is from ASHRAE (Reference 2.2.21, Chapter 27). This information includes design wind speeds, including those based on the extreme 1% annual percentile value (Reference 2.2.21, p. 27.3).

4.5 ANALYSIS DISCUSSION

4.5.1 Extreme Wind Speeds

ASCE/SEI 7-05 (Reference 2.2.16) identifies the Yucca Mountain area as a special wind region. This means that local topography could influence extreme wind events and that calculations using representative data are needed to characterize extreme wind speeds. Such a calculation would use an approved extreme-value statistical-analysis procedure and suitable wind data. ASCE/SEI 7-05 (Reference 2.2.16, Section C6.5.4) recommends the Fisher-Tippet Type I extreme value distribution method to analyze gust data. Furthermore, this section states that a choice of regional climatic data must consider instrument exposure and data quality issues. The wind data used in this analysis are taken from the primary wind-measuring project site that is approximately one kilometer south of the North Portal area in a similar topographic exposure. Assumption 3.2.1 states that the wind data, collected at meteorological monitoring Site 1 near the proposed surface facility area, meet the exposure and data quality requirements.

In the extreme value statistical-analyses method by Simiu and Scanlan (Reference 2.2.3, Section 3.2.1, p. 96), the Fisher-Tippet Type I frequency distribution of the yearly maximum speeds is utilized to characterize the probabilistic behavior of the largest annual speeds. The Fisher-Tippet Type I method is also recommended in ASCE/SEI 7-05 (Reference 2.2.16, Section C6.5.4). Investigations of data from stations with relatively short term records have shown that the monthly maximum speeds can adequately represent the distribution needed to calculate extreme speeds (Reference 2.2.3, Sections 3.2.1 and 3.2.3, pp. 97, 100, and 101). The calculation method utilizes the sample mean and standard deviation of monthly highest speeds to calculate the mean estimate and sampling error of the extreme speed corresponding to a selected recurrence interval. A similar calculation of the estimated extreme speeds using the annual values was also performed for comparison with the values calculated from the monthly statistics. The estimates of mean and standard deviation are empirical equations and the results are normally distributed (Reference 2.2.3, Section 3.2.3, p. 100-101), so the calculation of upper and lower 5% confidence levels can be made using standard statistical values.

A wind speed versus frequency of exceedance curve is one main product in developing wind climatology of the site, which in turn supports structural design, according to *Probabilistic Structural Mechanics Handbook, Theory and Industrial Applications,* Extreme-Wind Risk Assessment (Reference 2.2.2, Chapter 20). The straight wind hazard curve produced in this analysis shows the probability values from 0.1 to 10^{-6} with the associated wind speed values, and the upper and lower 5% confidence levels as separate curves on the graph.

The highest three-second gust and one-minute average wind speeds at the 10 m agl height at meteorological monitoring Site 1, during daily and every ten-minute periods, are available for years 1997 through 2006. The source files are listed by data tracking numbers (DTNs) as References 2.2.5 through 2.2.14 and 2.2.22. Both the daily maximum three-second gust and one-minute average wind speeds were used to calculate separate wind hazard curves.

4.5.2 HVAC Wind Velocity Criterion

One wind velocity (speed) criterion for HVAC building leakage calculations (Reference 2.2.20) is a sustained wind speed of 40 mph. Depending on the source of data and its application, sustained winds have been defined as an average over one minute, two minutes, and longer periods. The point is that sustained winds are not the same as gusts that are the typical measure for structural loading considerations (Reference 2.2.16).

The HVAC wind velocity criterion is based on the extreme 1% wind speed of 25 mph for Mercury, Nevada, shown in ASHRAE wind data (Reference 2.2.21, pp. 27.3 and 27.14). The HVAC criterion (Reference 2.2.20, p. 8) includes a 50% factor of safety and is rounded up from 37.5 to 40 mph. The extreme 1% speed based on the on-site data (Assumption 3.2.1) was calculated for comparison with the ASHRAE data. Assumption 3.2.2 introduced the use of hourly average data to determine a 1% on-site value similar to the ASHRAE value. A sufficient amount of data (values over about 10 m/sec) were sorted and copied from Access database files to the Excel file in Attachment 1, wind-hazard.xls, and the 88th hourly value was identified as the annual 1% value. Then, the mean of the annual values from the ten-year period was calculated for comparison with the ASHRAE value.

Two approaches were used to estimate occurrences of one-minute wind speeds at least 40 mph. One estimate was made by calculating the probability of occurrence per year of this speed from the analytic expressions identified to develop wind hazard curves. The Excel file containing the calculation was used iteratively with the recurrence interval as the independent variable until the calculated wind speed of 17.9 m/sec (40 mph) was achieved. Another estimate of occurrences was made by counting the maximum one-minute values in the ten-minute data for total number of occurrences, and occurrences in the daily data for the number of days per year.

5. LIST OF ATTACHMENTS

Attachment 1: Microsoft Excel File Containing the Input Data, Calculations and Wind Hazard Curve Plots.

6. BODY OF CALCULATION

6.1 CREATION OF WIND SPEED TABLES USED IN CALCULATIONS

Daily maximum values of three-second gust and one-minute average wind speeds were extracted from the Technical Data Management System site and engineering properties Microsoft Access data tables, containing annual Site 1 data files for 1997 through 2006. The source files by DTN are listed as References 2.2.5 through 2.2.14. Since the calculation was originally performed, the 2005 data were superseded; the new reference 2.2.22 is listed. The wind data in the superseding 2005 database were not changed from the original data, so the calculation was not repeated.

The extracted three-second and one-minute wind speed data were copied into a Microsoft Excel workbook file (Attachment 1). The highest of the daily maximum values in 30-day periods for each year were identified using the Excel MAX command. These values provide the monthly maximum values that are the basis of the calculation of extreme wind speeds and related statistics shown in Sections 6.2 through 6.4. Annual maximum values were also identified using the Excel MAX command for use in the alternative method calculation described in Section 6.5. Monthly and annual maximum values are listed in Table 1 (Section 7).

The Microsoft Access data tables previously discussed also include the maximum one-minute average wind speeds recorded every ten minutes, and the daily maximum values. These data were used for the HVAC calculation described in Section 6.7.

6.2 CALCULATION OF EXTREME WIND SPEEDS

The extreme wind speed estimates were calculated from the monthly maximum values of the three-second gust and the one-minute average wind speeds shown in Table 1 (Section 7). The calculation utilizes the sample mean, X, sample standard deviation, s_m, and the mean recurrence interval, N (years), using Equation 1 as shown, and as found in Equation 3.2.3 by Simiu and Scanlan (Reference 2.2.3). The Excel ROUND function was used to limit the result to tenths of a meter per second.

$$V = X + 0.78 \bullet [\ln (12 \bullet N) - 0.577] \bullet s_m \quad \text{(Eq. 1)}$$

where

V = estimated extreme wind speed
X = sample mean
ln = natural logarithm function
N = mean recurrence interval in years
s_m = sample standard deviation

The input sample data are in units of meters per second. The sample means and standard deviations were transformed to units of miles per hour by dividing the meters per second results by 0.44704 in accordance with *CRC Handbook of Chemistry and Physics* (Reference 2.2.15, p. 1-26). The Excel ROUND function was used to limit the result to tenths mph.

Tables 2 and 3 (Section 7) contain the X and s_m results of the three-second and the one-minute averages, respectively, based on the monthly maximum values. The table also shows V occurring during N and associated probability of occurrences ($1/N$). The X and standard deviation results are shown in meters per second and in miles per hour, while the extreme speed estimates are in miles per hour.

Equation 1 was used to calculate the probabilities of occurrences of certain annual maximum one-minute wind speeds. This calculation was performed in the Excel file by varying the mean recurrence interval until the associated speed was the value of interest. These results are shown in Table 3. Specifically, the annual probability of a 90 mph one-minute average speed is 2.3×10^{-6}, and the probability of a 117.5 mph one-minute average speed is 1.3×10^{-9}.

6.3 CALCULATION OF STANDARD DEVIATION OF SAMPLING ERROR

The standard deviation of sampling error in the estimation of the extreme wind speed estimate is calculated from the s_m, the recurrence interval, and the sample size, using Equation 2 as shown, and as found in Equation 3.2.4 by Simiu and Scanlan (Reference 2.2.3). The Excel ROUND function was used to limit the result to tenths mph.

$$SD = 0.78 \bullet \{1.64 + 1.46 \bullet [ln\ (12 \bullet N) - 0.577] + 1.1 \bullet [ln\ (12 \bullet N) - 0.577]^2\}^{1/2} \bullet s_m / n_m^{1/2} \qquad \text{(Eq. 2)}$$

where

SD = standard deviation of sample error
ln = natural logarithm function
n_m = sample size (number of months)
N = mean recurrence interval in years
s_m = sample standard deviation

6.4 CALCULATION OF CONFIDENCE INTERVAL FOR WIND SPEED

The upper and lower five percent confidence levels related to the extreme wind speed estimate are shown in Equation 3 (Reference 2.2.19, Table I, value obtained by interpolation):

$$V\ (5\%) = V \pm 1.645 \bullet (SD) \qquad \text{(Eq. 3)}$$

where

SD = standard deviation of sample error
V = estimated extreme wind speed

Tables 2 and 3 (Section 7) include listings of *SD* and *V* (5%) values corresponding to *N*, the values are in miles per hour.

6.5 CALCULATIONS BASED ON ANNUAL MAXIMUM VALUES

The calculations described in Sections 6.2 through 6.4 were based on the monthly maximum values of the three-second and one-minute average wind speeds. The method of using monthly, rather than annual, data to estimate annual maximum values was developed because many weather stations have shorter periods of record than would typically suffice for statistical analyses. Further discussion of this approach can be found in Reference 2.2.3, Section 3.2.3. Since the ten-year period of record is relatively short, the primary calculation method for this analysis utilized the monthly data.

A corroborative calculation using annual maximum values, however, was made to identify potential differences between the results based on monthly or annual maximum values. The annual data used are shown in Table 1 (Section 7). The calculation is based on Reference 2.2.3, Section 3.2.2. Equation 4 was used to calculate *V* and Equation 5 was used to calculate *SD*. These equations use *X* and the standard deviation (*s*) of the annual data, and the sample size (*n*). The Excel ROUND function was used to limit results to tenths of meters per second or miles per hour.

$$V = X + 0.78 \cdot [ln\ (N) - 0.577] \cdot s \qquad \text{(Eq. 4)}$$

$$SD = 0.78 \cdot \{1.64 + 1.46 \cdot [ln\ (N) - 0.577] + 1.1 \cdot [ln\ (N) - 0.577]^2\}^{1/2} \cdot s / n^{1/2} \qquad \text{(Eq. 5)}$$

Extreme speed estimates based on monthly and annual maximum data show similar results. For example, Tables 2 and 3 (Section 7) show that the 50-year mean recurrence interval three-second estimates are 71.4 and 69.8 mph for the monthly and annual data sets, respectively. Similarly, the 10^6 year estimates are 117.5 and 112.8 mph, respectively.

Tables 4 and 5 (Section 7) contain *X* and *s* results of the three-second and one-minute averages, respectively, based on the annual maximum values. The table also shows the *V* occurring during *N* and associated probability of occurrences (*1/N*) shown. The sample mean and standard deviation results are shown in both meters per second and miles per hour, while the extreme speed estimates are in miles per hour. Tables 4 and 5 also show *SD* and *V* (5%) values corresponding to *N*.

6.6 WIND HAZARD CURVES

Extreme wind estimates, based on monthly maximum three-second and one-minute average wind speed data shown in Tables 2 through 4 (Section 7), are shown graphically as wind hazard curves in Figures 1 and 2 (Section 7). The primary line in each graph is the mean extreme wind estimates; the secondary lines are the upper and lower 5% confidence intervals. The form of the curves shown in Figures 1 through 3 (Section 7) have the speed on the horizontal axis (abscissa), and a logarithmic vertical axis (ordinate) of probability of annual occurrence. The choice of linear speed and logarithmic probability produces linear curves. The 0.02 probability (50-year recurrence interval) line was added to each figure to help show the relevant speed estimates for that occurrence which is typically of interest in design considerations.

Comparisons of the three-second and one-minute average estimates are shown in the two wind hazard curves shown in Figure 3 (Section 7). The slopes of the two curves are similar. The ratio of the three-second to one-minute values is approximately 1.26. Atmospheric and wind engineering studies have shown that maximum gust speeds increase for shorter averaging times of wind gusts for periods from one hour to one second (Reference 2.2.3, Section 2.3.6, pp. 69 and 70; Reference 2.2.15, Figure C-4, p. 308). The ratio of three-second to one-minute values in these tables and figures is 1.216, which is 96% of the value calculated from the Site 1 data. Thus, the Site 1 data have similar characteristics to those of other data sets.

6.7 SUSTAINED WINDS GREATER THAN 40 mph

The HVAC design for some buildings includes a requirement of operating with sustained winds of 40 mph. As previously discussed, this requirement was based on historical data published by ASHRAE (Reference 2.2.21). The results in this section are presented for purposes of comparing the ASHRAE value with one calculated from the on-site meteorological monitoring program.

6.7.1 Extreme One Percent Speed

The extreme 1% wind speed is simply the wind speed that is met or exceeded only 1% of the time. There are 8,760 hourly periods in a year (365 days). Thus, 1% of the time is included in 88 hours. The hourly average wind speed data were sorted in descending order by speed in the Excel file in Attachment 1, and the 88th value was identified as the extreme 1% value. As the data are stored in units of meters per second, the conversion to miles per hour was made.

The results show that the annual extreme 1% values ranged from 21.7 to 24.8 mph, with an average of 23.0 mph. This value is only slightly below the 25 mph value published for Mercury, which is the basis for the 40 mph sustained wind speed requirement. Thus, the result using data from the on-site program is very similar to the published value used to develop the requirement (Reference 2.2.20). Using the published value is a conservative approach compared to a value that would be based on the on-site data.

6.7.2 Occurrences of Sustained Wind Speeds At Least 40 mph

Occurrences of sustained winds at least 40 mph in the Site 1 data were examined by two methods.

In the first method, Equation 1 was used to calculate the annual probability of a daily maximum one-minute wind speed of 40 mph. The calculation was performed using the mean recurrence interval as an independent variable, adjusting it until the estimated wind speed was 40 mph. The result is shown in the first line of Table 2 (Section 7). The mean recurrence interval is 0.59 years, or a frequency of 1.7 days per year.

In the second method, Access database query results of maximum one-minute wind speeds at least 15 m/sec were copied to the Excel workbook file. Then, the Excel COUNTIF function was used separately to count the number of ten-minute and daily periods with maximum one-minute wind speeds at least 40 mph (17.9 m/sec). These speeds occurred between zero and two days per year, with an average of 1.3 days per year. The number of ten-minute periods per year with these speeds ranged from zero (during two years) to 23 (during 2004). The average for the period was 8.9 occurrences of ten-minute periods with a maximum one-minute wind speeds at least 40 mph.

7. SUMMARY

Ten years of representative wind speed data taken from 10 m agl at Site 1, which is about one kilometer south of the North Portal area in similar elevation and topographic exposure, were used to characterize extreme wind speeds in the area. The results can be used to perform hazard analyses related to surface structures in the primary area of the proposed repository. Extreme values of two types of wind speed data were examined: the three-second gust and the one-minute averages. The analyses were performed following methods in reputable sources of building standards and wind engineering texts.

Table 6 contains a summary of the results. The results show the mean (and upper and lower 5% confidence level estimates) of the annual maximum three-second gust and one-minute average wind speeds. The speed estimates are for mean recurrence intervals of 50, 10,000 and 1,000,000 years (annual probabilities of 0.02, 10^{-4} and 10^{-6}, respectively). This table shows the mean estimate of the maximum three-second gust for the 10^{-6} probability level is 117.5 mph and the corresponding probability for the one-minute average speed is 93.0 mph. For comparison, the maximum observed three-second gust at Site 1 in the 1997 through 2006 period was 27.6 m/sec (61.7 mph); the maximum observed one-minute average during this period was 21.7 m/sec (48.6 mph).

Regarding the HVAC sustained wind speed criterion of 40 mph (Reference 2.2.20), the average of the annual extreme 1% speeds is 23.0 mph. This value is only slightly less than the 25 mph value published for Mercury used to establish the HVAC requirement. The sustained winds at least 40 mph occurred during an average of 8.9 ten-minute periods per year, on an average of 1.3 days per year. Therefore, the 40 mph wind speed HVAC criterion seems reasonable and acceptable, based upon actual on-site data.

Table 1. Monthly and Annual Maximum Values of Three-Second and One-Minute Average Wind Speeds from the 10 m Level at Site 1

Maximum three-second gust wind speed (m/sec) in 30 day periods per year, with annual maxima									
1997	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
19.1	19.4	17.0	18.9	17.5	17.9	19.1	18.7	20.4	21.9
21.5	18.7	22.4	17.7	18.9	18.9	24.8	18.1	16.9	18.5
16.3	19.8	19.5	21.4	18.6	21.9	20.6	18.6	16.0	20.4
18.8	17.3	20.3	18.9	20.2	27.1	22.7	18.5	22.9	21.4
20.6	20.9	18.6	20.5	17.9	19.9	22.0	27.6	24.8	22.8
18.2	24.6	20.5	21.7	21.9	20.3	17.9	21.5	20.3	22.4
22.1	15.7	18.2	19.4	18.9	17.2	17.7	17.7	19.9	19.1
16.7	19.4	17.8	17.7	17.0	22.7	22.1	18.2	17.1	17.6
18.5	24.1	20.0	20.6	16.2	20.4	21.5	24.6	19.0	18.9
22.5	17.0	20.7	17.6	19.7	16.8	14.7	21.1	19.9	22.8
20.6	16.1	14.1	17.0	14.2	22.0	15.9	19.2	16.3	16.0
20.3	18.2	22.4	20.4	21.8	19.2	27.1	20.8	22.2	27.6
Annual maxima of three-second gust speeds									
22.5	24.6	22.4	21.7	21.9	27.1	27.1	27.6	24.8	27.6
Maximum one-minute wind speed (m/sec) in 30 day periods per year, with annual maxima									
1997	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
16.0	15.7	13.5	15.3	13.7	14.0	15.4	14.6	16.1	17.5
17.2	13.6	17.1	14.4	14.7	14.2	20.8	14.5	14.1	14.9
13.6	15.6	15.6	17.1	14.8	17.2	16.2	14.7	13.4	15.7
14.6	13.6	15.9	16.4	16.8	21.0	17.4	15.9	17.3	17.6
14.3	16.6	14.7	17.1	14.3	15.9	16.7	21.7	19.7	17.1
13.3	20.5	17.7	17.2	18.1	15.5	14.3	17.2	15.9	17.6
16.8	12.4	14.3	15.5	15.1	14.2	13.6	13.8	14.3	15.2
14.2	16.4	13.2	13.0	12.6	17.3	16.6	13.7	13.7	14.3
13.8	20.2	15.7	14.3	13.1	15.7	16.6	19.3	14.9	14.2
16.9	14.5	16.8	14.0	16.2	12.6	12.1	17.2	15.4	17.1
14.6	12.6	11.2	13.5	11.7	17.5	13.0	14.6	13.3	13.5
15.3	15.2	19.2	15.8	17.1	14.7	20.1	17.2	16.8	21.6
Annual maxima of one-minute speeds									
17.2	20.5	19.2	17.2	18.1	21.0	20.8	21.7	19.7	21.6

Table 2. Results of the Three-Second Gust Extreme Wind Speed Calculation Using Monthly Maximum Values

Sample mean (*X*)	**19.8 m/sec**	**44.3 mph**	**Three-second gust data from 10 m level at Site 1 from 1997 through 2006 Speeds are in mph unless noted**		
Sample standard deviation (s_m)	**2.67 m/sec**	**5.97 mph**			
Sample size (n_m)	**120 periods**				
Recurrence interval (years)	**Probability (per year)**	**Mean estimate**	**Sampling error (*SD*)**	**Lower 5% CI**	**Upper 5% CI**
1	1	53.2	1.23	51.2	55.2
10	0.1	63.9	2.22	60.2	67.6
50	0.02	71.4	2.93	66.6	76.2
100	1.0E-02	74.6	3.23	69.3	79.9
1.0E+03	1.0E-03	85.4	4.25	78.4	92.4
2.7E+03	3.7E-04	90.0	4.69	82.3	97.7
1.0E+04	1.0E-04	96.1	5.27	87.4	104.8
1.0E+05	1.0E-05	106.8	6.30	96.4	117.2
1.0E+06	1.0E-06	117.5	7.32	105.5	129.5

CI = confidence intervals; *SD* = standard deviation of sample error.

Table 3. Results of the One-Minute Average Extreme Wind Speed Calculation Using Monthly Maximum Values

Sample mean (*X*)	**15.6 m/sec**	**34.9 mph**	**One-minute average data from 10 m level at Site 1 from 1997 through 2006 Speeds are in mph unless noted**		
Sample standard deviation (s_m)	**2.12 m/sec**	**4.74 mph**			
Sample size (n_m)	**120 periods**				
Recurrence interval (years)	**Probability (per year)**	**Mean estimate**	**Sampling error (*SD*)**	**Lower 5% CI**	**Upper 5% CI**
0.59	1.695	40.0	0.81	38.7	41.3
1	1	42.0	0.98	40.4	43.6
10	0.1	50.5	1.76	47.6	53.4
50	0.02	56.4	2.32	52.6	60.2
100	1.0E-02	59.0	2.57	54.8	63.2
1.0E+03	1.0E-03	67.5	3.38	61.9	73.1
1.0E+04	1.0E-04	76.0	4.19	69.1	82.9
1.0E+05	1.0E-05	84.5	5.00	76.3	92.7
4.4E+05	2.3E-06	90.0	5.52	80.9	99.1
1.0E+06	1.0E-06	93.0	5.81	83.4	102.6
7.5E+08	1.3E-09	117.5	8.15	104.1	130.9

CI = confidence intervals; *SD* = standard deviation of sample error.

Table 4. Results of the Three-Second Gust Extreme Wind Speed Calculation Using Annual Maximum Values

Sample mean (*X*)	**24.7 m/sec**	**55.3 mph**	**Three-second gust data from 10 m level at Site 1 from 1997 through 2006 Speeds are in mph unless noted**		
Sample standard deviation (*s*)	**2.49 m/sec**	**5.57 mph**			
Sample size (*n*)	**10 years**				
Recurrence interval (years)	**Probability (per year)**	**Mean estimate (mph)**	**Sampling error (*SD*) (mph)**	**Lower 5% CI (mph)**	**Upper 5% CI (mph)**
1	1	52.8	1.48	50.4	55.2
10	0.1	62.8	3.75	56.6	69.0
50	0.02	69.8	5.95	60.0	79.6
100	1.0E-02	72.8	6.92	61.4	84.2
1.0E+03	1.0E-03	82.8	10.19	66.0	99.6
2.7E+03	3.7E-04	87.1	11.6	68.0	106.2
1.0E+04	1.0E-04	92.8	13.48	70.6	115.0
1.0E+05	1.0E-05	102.8	16.78	75.2	130.4
1.0E+06	1.0E-06	112.8	20.09	79.8	145.8

CI = confidence intervals; *SD* = standard deviation of sample error.

Table 5. Results of the One-Minute Average Extreme Wind Speed Calculation Using Annual Maximum Values

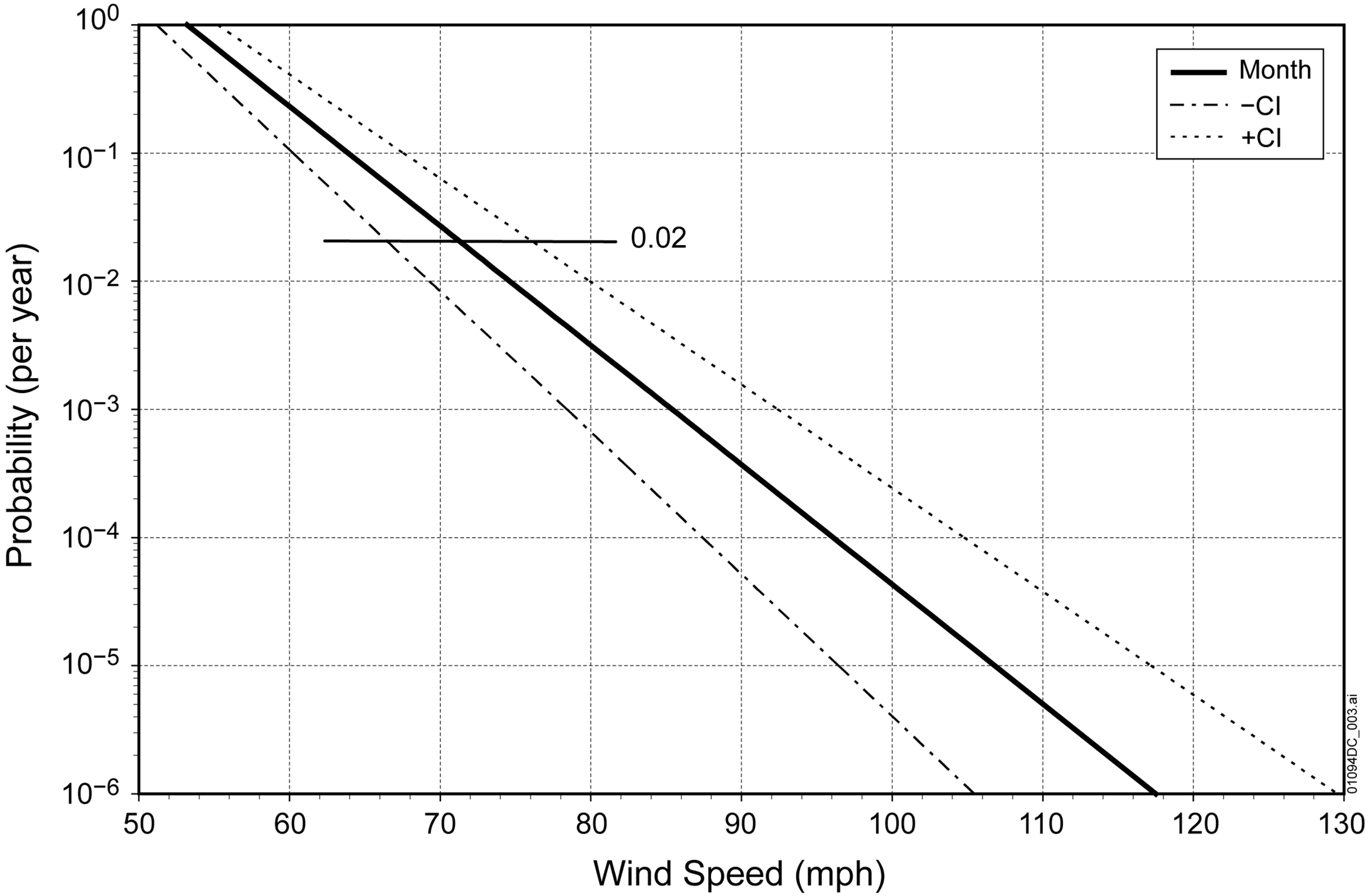
Sample mean (*X*)	**19.7 m/sec**	**44.1 mph**	**One-minute average data from 10 m level at Site 1 from 1997 through 2006 Speeds are in mph unless noted**		
Sample standard deviation (*s*)	**1.72 m/sec**	**3.85 mph**			
Sample size (*n*)	**10 years**				
Recurrence interval (years)	**Probability (per year)**	**Mean estimate (mph)**	**Sampling error (*SD*) (mph)**	**Lower 5% CI (mph)**	**Upper 5% CI (mph)**
1	1	42.4	1.02	40.7	44.1
10	0.1	49.3	2.59	45.0	53.6
50	0.02	54.1	4.11	47.3	60.9
100	1.0E-02	56.2	4.78	48.3	64.1
1.0E+03	1.0E-03	63.1	7.04	51.5	74.7
1.0E+04	1.0E-04	70.0	9.32	54.7	85.3
1.0E+05	1.0E-05	76.9	11.60	57.8	96.0
4.4E+05	2.3E-06	81.4	13.07	59.9	102.9
1.0E+06	1.0E-06	83.9	13.88	61.1	106.7
7.5E+08	1.3E-09	103.7	20.47	70.0	137.4

CI = confidence intervals; *SD* = standard deviation of sample error.

Table 6. Summary of Extreme Wind Speed Calculations Using Monthly Maximum Values

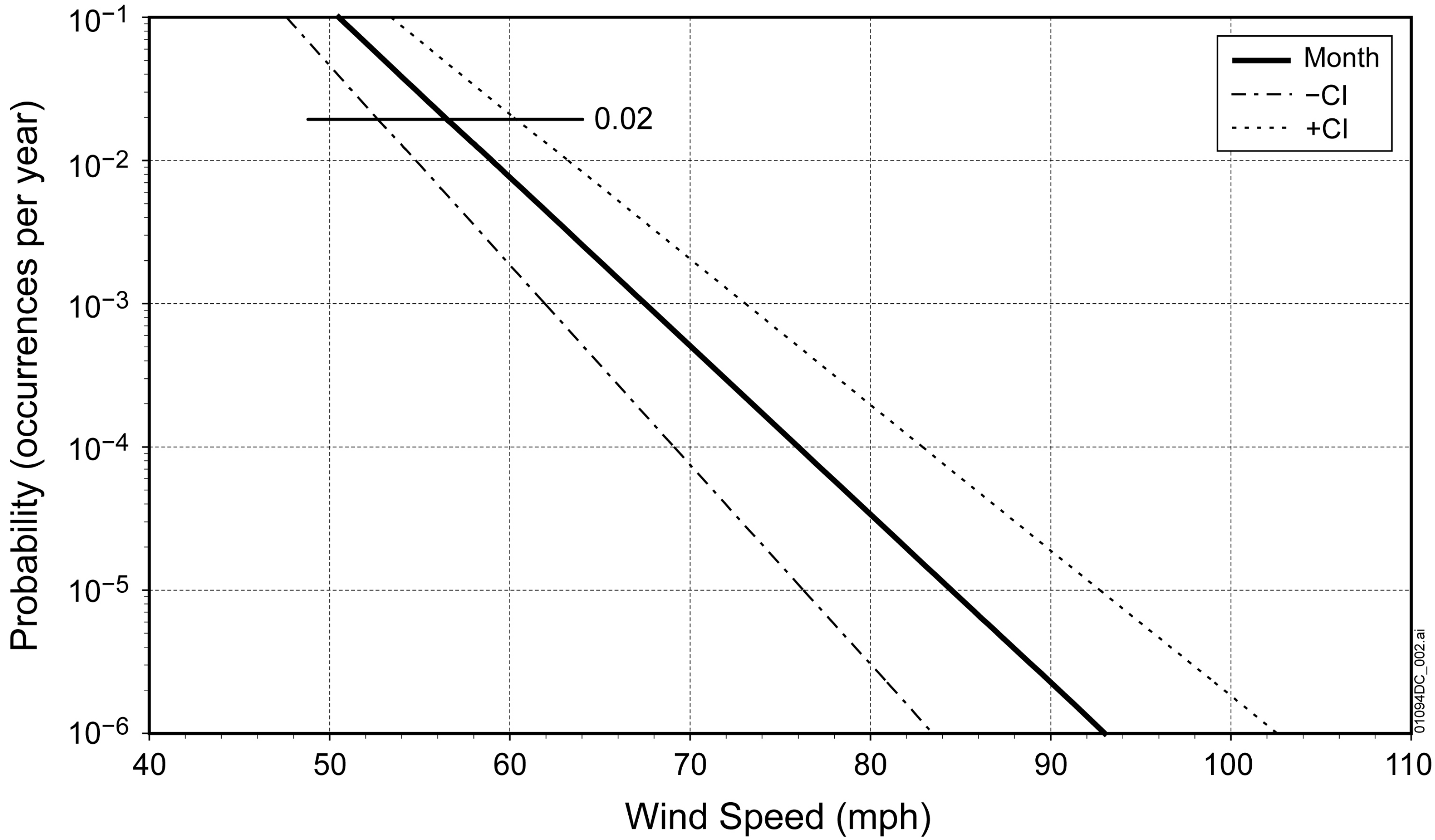
Speed averaging time	**Mean recurrence interval (years)**	**Mean estimate (mph)**	**Lower 5% CI (mph)**	**Upper 5% CI (mph)**
Three-second gust	50	71.4	66.6	76.2
	10,000	96.1	87.4	104.8
	1,000,000	117.5	105.5	129.5
One-minute average	50	56.4	52.6	60.2
	10,000	76.0	69.1	82.9
	1,000,000	93.0	83.4	102.6

CI = confidence intervals.



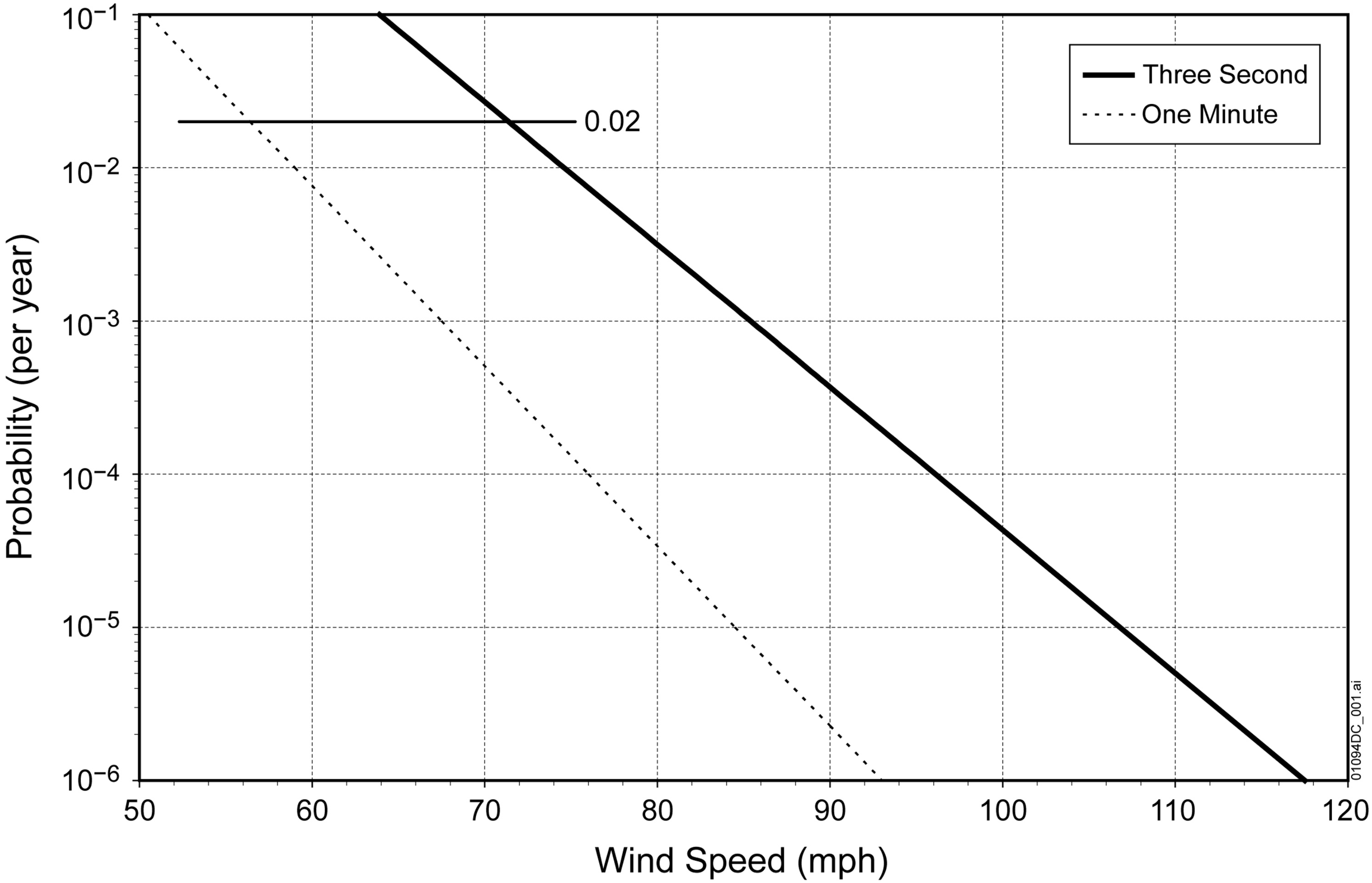
NOTE: Maximum three-second gust speed wind hazard curve with 5% confidence intervals (CI) based on monthly maximum values from the 10 m level at Site 1 for 1997 through 2006.

Figure 1. Straight Wind Hazard Curve: Three-Second Gust Speed



NOTE: Maximum one-minute average speed wind hazard curve with 5% confidence intervals (CI) based on monthly maximum values from the 10 m level at Site 1 for 1997 through 2006.

Figure 2. Straight Wind Hazard Curve: One-Minute Average Speed



NOTE: Maximum three-second gust and one-minute average speeds wind hazard curves based on monthly maximum values from the 10 m level at Site 1 for 1997 through 2006.

Figure 3. Straight Wind Hazard Curve: Three-Second Gust and One-Minute Average Speeds

ATTACHMENT 1
MICROSOFT EXCEL FILE CONTAINING INPUT DATA, CALCULATIONS, AND WIND HAZARD CURVE PLOTS

1.1 DESCRIPTION OF EXCEL FILE ON COMPACT DISC

The Microsoft Excel workbook containing the input data, calculations, wind hazard curve plots, and supportive notes, named *wind-hazard.xls*, is being submitted to the Records Processing Center on a compact disc with the final copy of this analysis. The content of this file is described in this attachment, organized by the worksheet names shown in quotation marks in the *wind-hazard.xls* file.

"notes" shows the following information:

- DTNs of the acquired source data used in the analysis
- Equations from Simiu and Scanlan (Reference 2.2.3) used in the calculations
- An abbreviated description of the contents of the worksheets in the file
- Additional information on the basis of the statistical analysis.

"Site 1-3s" contains:

- Daily maximum three-second gust data (m/sec) for the years 1997 through 2006, copied from Microsoft Access data tables, and the corresponding DTN (References 2.2.5 through 2.2.14); blanks indicate missing data.

- The annual maximum values are shown below the daily listings, with a calculation of the mean and standard deviation of the annual values (m/sec and mph); these were used as checks on the annual maxima shown with the tabular listing of maxima from the 30-day intervals described in this Attachment.

- The top 20 daily maximum values for each year are listed under the values described in the previous bullet.

- The maximum three-second gust values in 30-day (approximately monthly) periods, with the additional five or six days in the final interval, are shown for each year starting with the top of column N. The annual maximum values are shown below the last 30-day period values.

- The sample average and standard deviation (m/sec and mph) for the monthly (30-day) and annual intervals, and the sample size (count) data are shown under the table of 30-day maxima. The highest observed gust value is also shown below the sample size information.

- The data in the cells starting with cell M31 are the calculations of mean estimate maximum annual gust value (vm) using Equation 1 (Section 6.1) and the monthly mean and standard deviation values. The speeds in this block of cells are all in mph.

- The same cell block also shows the standard deviation (SDm) calculated using Equation 2 (Section 6.3), and the plus or minus 5% confidence interval values (x-CIm and x+CIm) using Equation 3 (Section 6.4).

- The same mean estimate annual gust values are shown starting with cell T31 that were calculated from the annual maximum values using Equations 4 and 5 (Section 6.5), and Equation 3 (Section 6.4).

"3sec" contains the wind hazard curve plot shown in Figure 1.

"Site 1-1m" contains the same information as "Site 1-3s", except this worksheet contains the one-minute maximum values.

"1min" contains the wind hazard curve plot shown in Figure 2.

"both" contains a wind hazard curve plot of the mean estimates of three-second and one-minute values.

"1min-queries" contains ten-minute and daily maximum one-minute wind speed data copied from Microsoft Access data tables corresponding to the DTN cited; blanks are missing data. This worksheet also contains hourly averages shown in the columns labeled "WS_10", starting with column N for 1997. The data copied were above threshold speeds shown, and then were sorted in descending order:

- Starting with columns H (maximum one-minute speed in the ten-minute data) and K (maximum one-minute speed in the daily data), row 3 contains the number of occurrences in the ten-minute and daily data of wind speeds greater than 17.9 m/sec (40 mph)

- Starting with column N (hourly averages), the cells in row 3 refer to row 94, which contain the extreme 1% value (88th value in the descending order sorted list) of hourly average speeds. Thus, there are 87 hourly values each year (approximately 1% of the 8,760 hours) that exceed the extreme 1% value.

- The individual annual counts of occurrences in the ten-minute and daily data of one-minute average speeds of at least 40 mph (17.9 m/sec) are shown in columns B and C, rows 6 through 15. The annual extreme 1% values are shown in column D. The maximum, minimum, and average of the annual values are shown in rows below the individual annual values. The speeds from the database are in meters per second, so the summary statistics of the 1% extreme values are also shown in miles per hour in rows 21 through 23 of column D.

1.2 COMPACT DISC FOR ELECTRONIC WORKBOOK FILES FOR CALCULATIONS PRESENTED IN THE ANALYSIS

The directory path, size, and date of *wind-hazard.xls* on compact disc are as follows:

Microsoft Windows XP [Version 5.1.2600]
(C) Copyright 1985-2001 Microsoft Corp.
H:\>D:
D:\>dir
Volume in drive D is wind-hazard.xls
Volume Serial Number is 46A4-804E

Directory of D:\

07/23/2007 10:05 AM 1,165,312 wind-hazard.xls

1 File(s) 1,165,312 bytes
0 Dir(s) 653,975,552 bytes free

D:\>D: