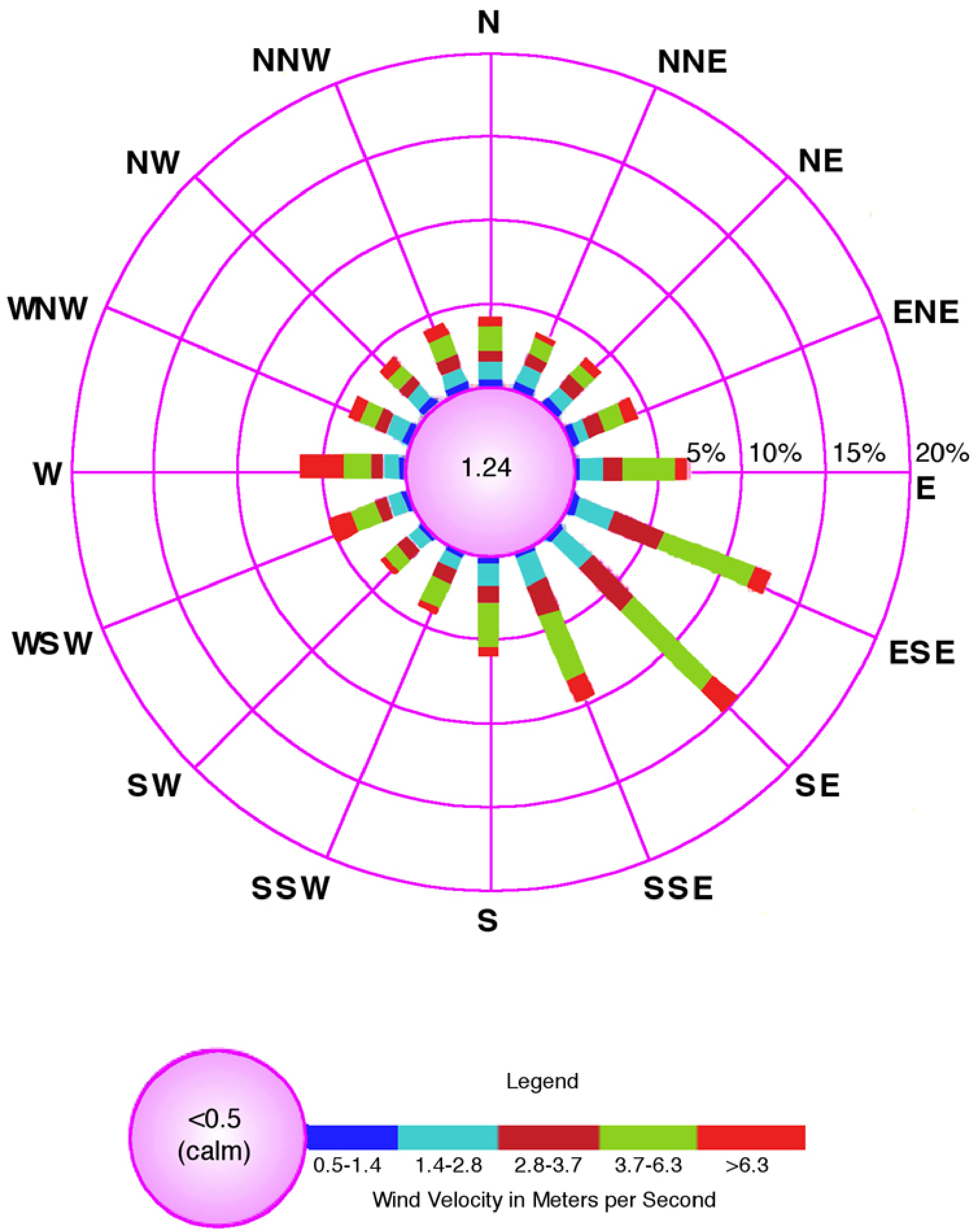


Figure 2-52. 1998 Annual Wind Rose at 10-m (33-ft.) Height at WIPP Site

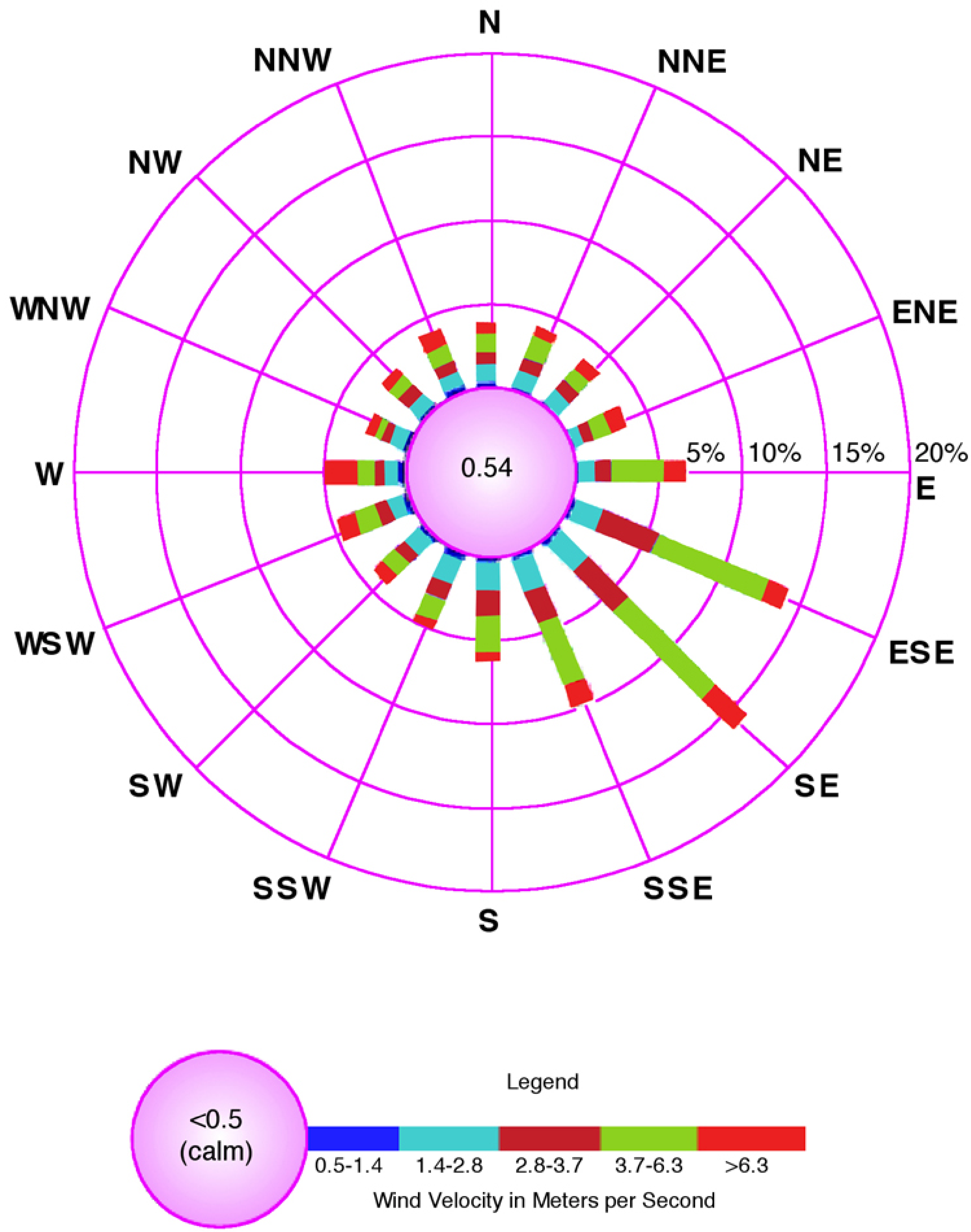


Figure 2-53. 1999 Annual Wind Rose at 10-m (33-ft.) Height at WIPP Site

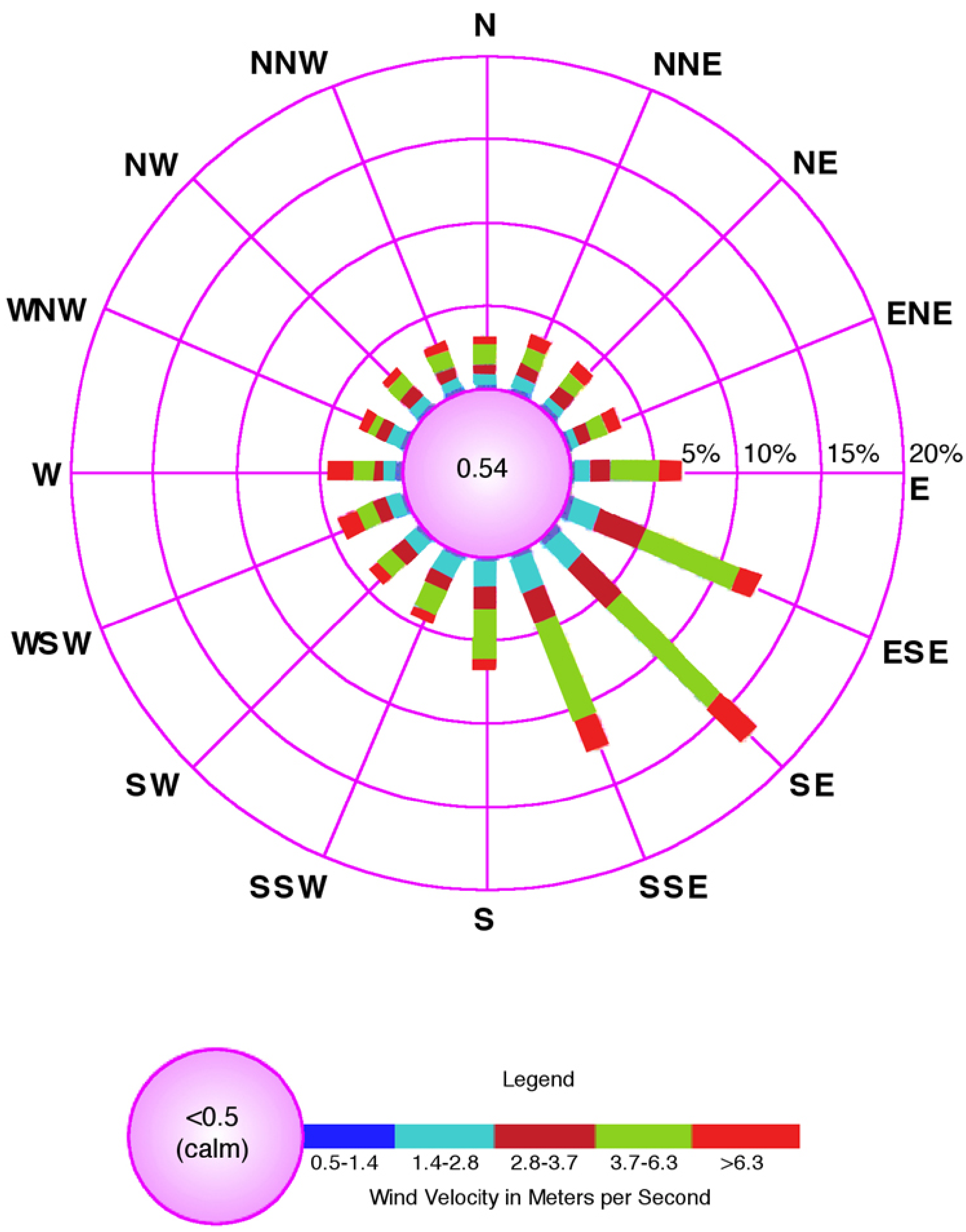


Figure 2-54. 2000 Annual Wind Rose at 10-m (33-ft.) Height at WIPP Site

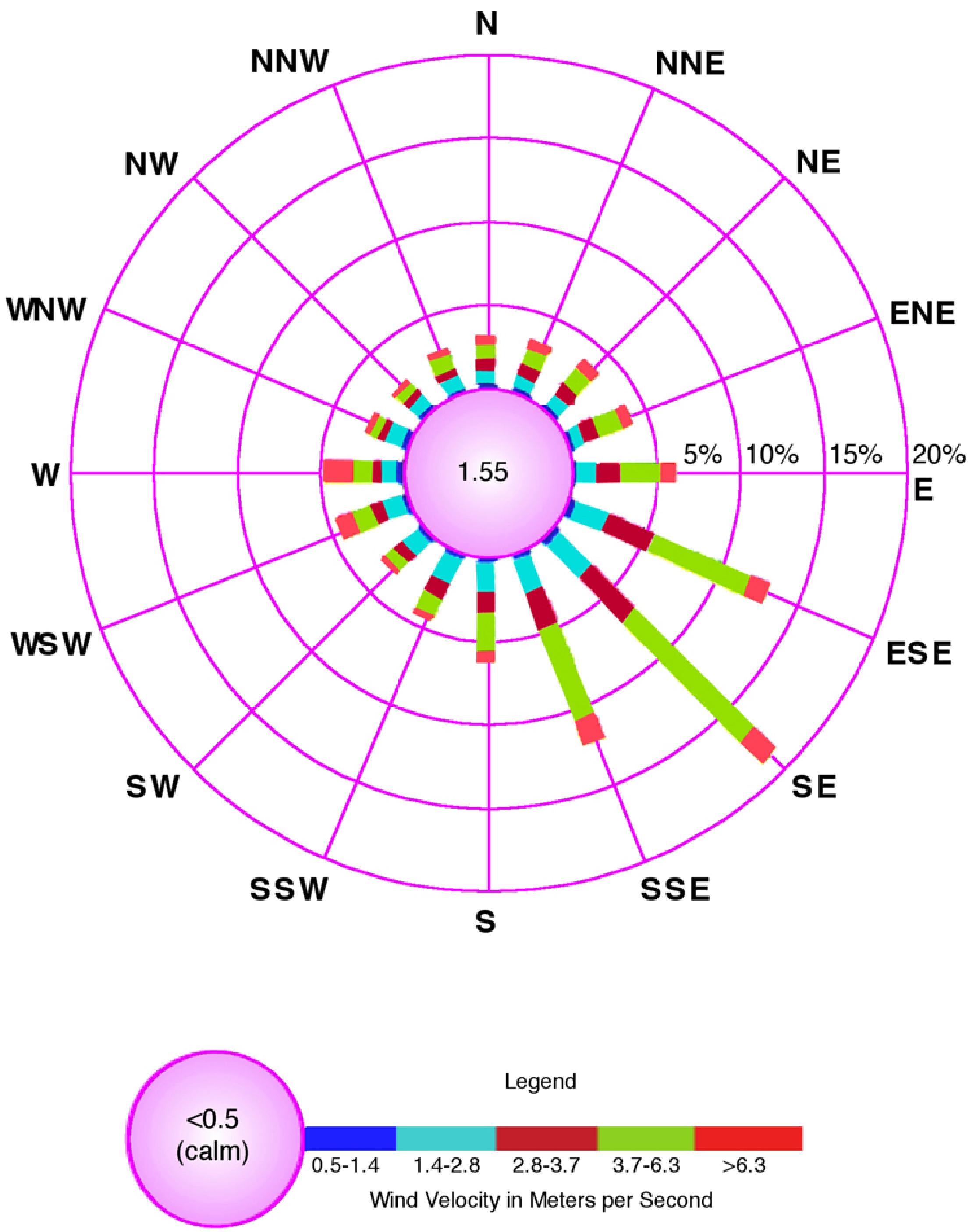


Figure 2-55. 2001 Annual Wind Rose at 10-m (33-ft.) Height at WIPP Site

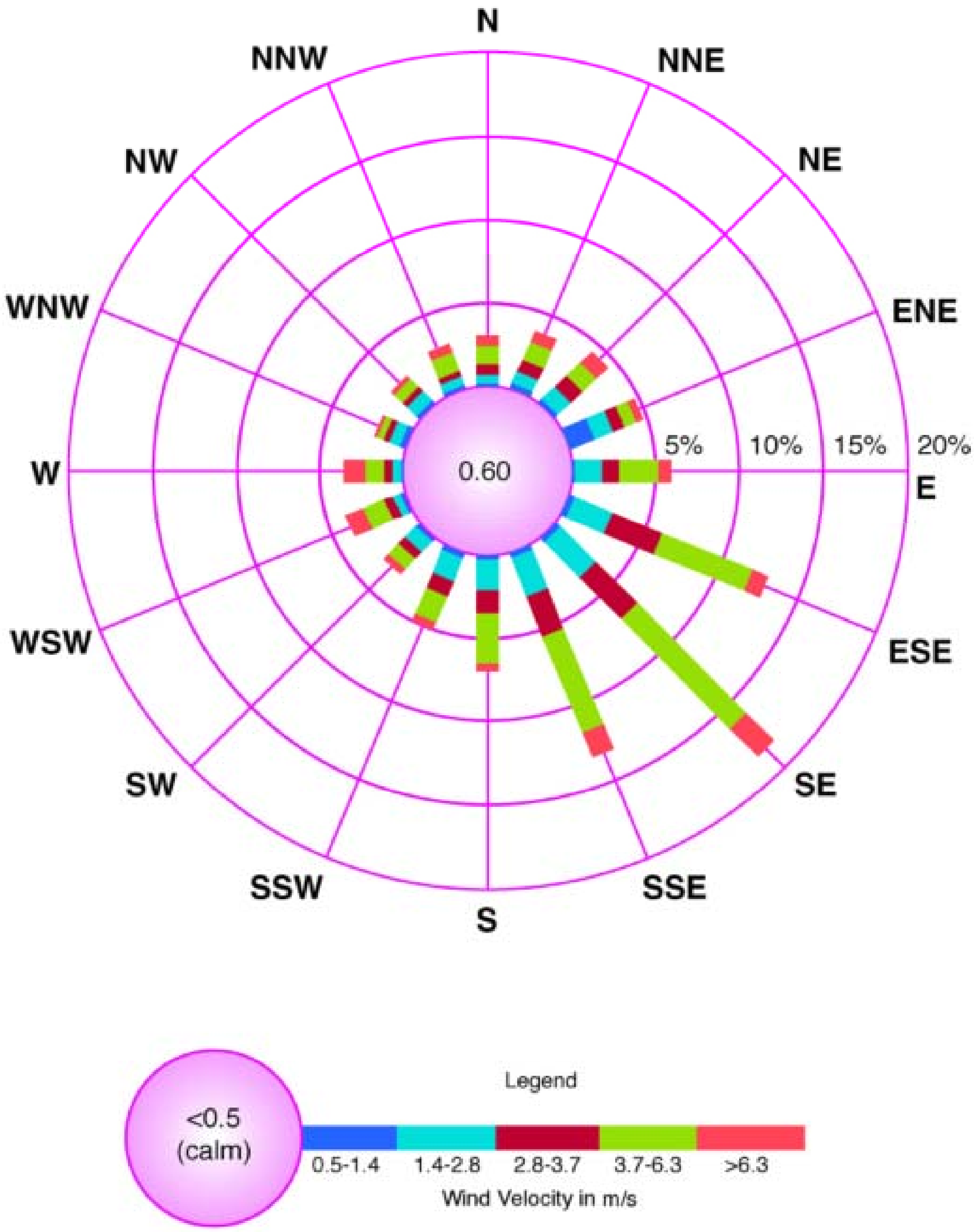
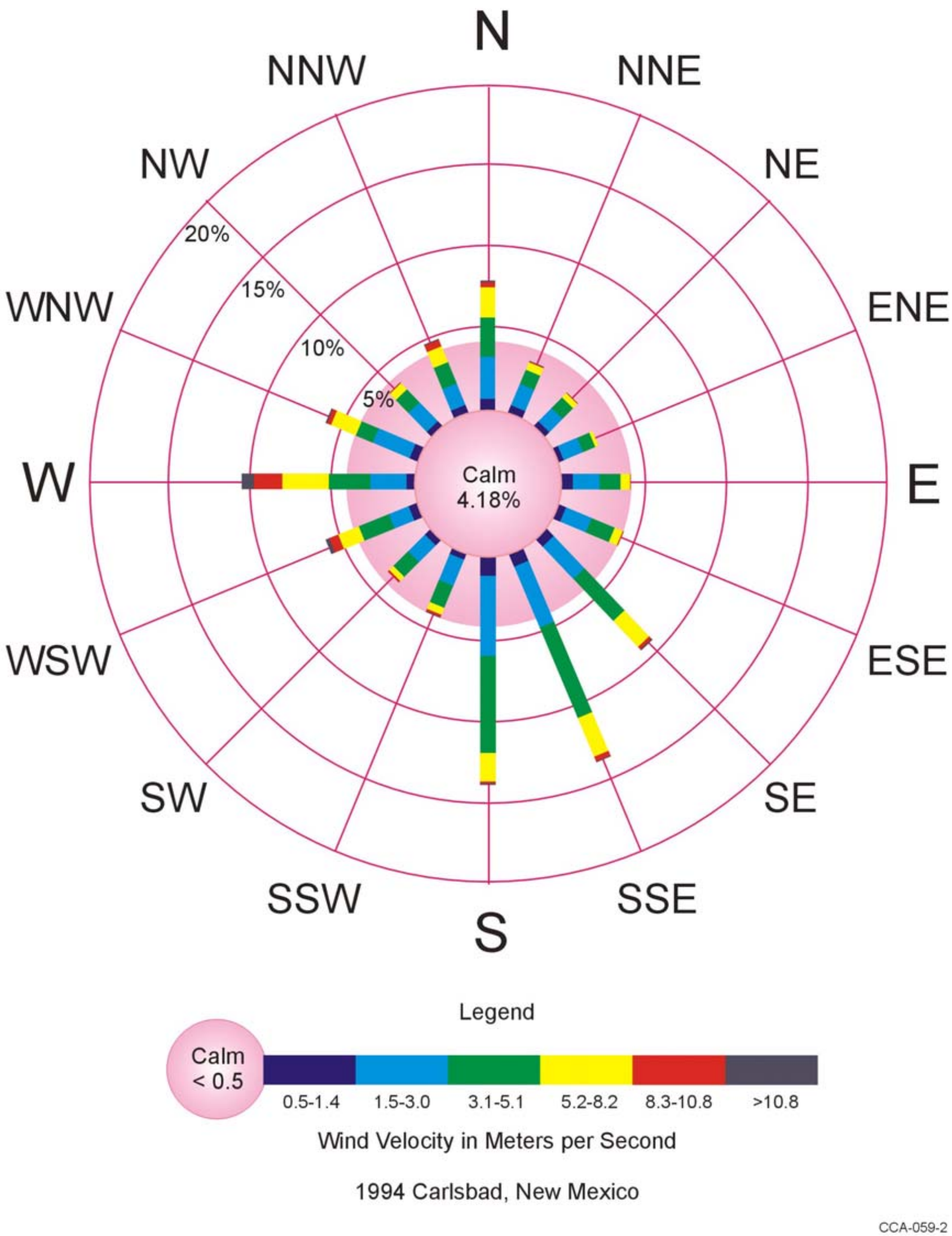


Figure 2-56. 2002 Annual Wind Rose at 10-m (33-ft.) Height at WIPP Site



~~**Figure 2-46. 1994 Annual Wind Rose Carlsbad, NM**~~

modified Mercalli intensity scale. Most of the magnitudes were determined by the New Mexico Institute of Mining and Technology or are described in ***CCA*** Appendix GCR and references therein.

2.6.1 Seismic History

Seismic data are presented in two time frames, before and after the time when seismographic data for the region became available. The earthquake record in southern New Mexico dates back only to 1923, and seismic instruments have been in place in the state since 1961. Various records have been examined to determine the seismic history of the area within 180 mi (288 km) of the site. With the exception of a weak shock in 1926 at Hope, New Mexico (approximately 64 km [40 mi] northwest of Carlsbad), and shocks in 1936 and 1949 felt at Carlsbad, all known shocks in the region before 1961 occurred to the west and southwest of the site more than 160 km (100 mi) away.

The strongest earthquake on record occurring within 288 km (180 mi) of the site was the Valentine, Texas earthquake of August 16, 1931. It has been estimated to have been of magnitude 6.4 on the Richter scale (Modified Mercalli Intensity of VIII). The Valentine earthquake was 208 km (130 mi) south-southwest of the site. Its Modified Mercalli Intensity at the site is estimated to have been V; this is believed to be the highest intensity felt at the site in this century.

In 1887, a major earthquake occurred in northeast Sonora, Mexico. Although about 536 km (335 mi) west-southwest of the site, it is indicative of the size of earthquakes possible in the eastern portion of the Basin and Range Province, west of the province containing the site. Its magnitude was estimated to have been 7.8 (VIII to IX in Modified Mercalli Intensity). It was felt over an area of 1.3 million km^2 (0.5 million mi^2) (as far as Santa Fe to the north and Mexico City to the south); fault displacements near the epicenter were as large as 18 m (26 ft).

Since 1961, instrumental coverage has become comprehensive enough to locate most of the moderately strong earthquakes (local magnitude >3.5) in the region. Instrumentally determined shocks that occurred within 288 km (180 mi) of the site between 1961 and 1994 are shown in Figure 2-~~47~~***57***. The distribution of these earthquakes may be biased by the fact that seismic stations were more numerous and were in operation for longer periods north and west of the site. Pre-1961 earthquakes can be found in ***CCA*** Appendix GCR, Figure 5.2-1.

Except for the activity southeast of the site, the distribution of epicenters since 1961 differs little from that of shocks before that time. There are two clusters, one associated with the Rio Grande Rift on the Texas-Chihuahua border and another associated with the Central Basin Platform in Texas near the southeastern corner of New Mexico. The latter activity was not reported before 1964. It is not clear from the record whether earthquakes were occurring in the Central Basin Platform before 1964, although local historical societies and newspapers tend to confirm their absence before that time.

The April 14, 1995, earthquake near Marathon, Texas, was located 240 km (150 mi) south of the WIPP site. The USGS estimated that moment magnitude for this event was 5.7. At a distance of

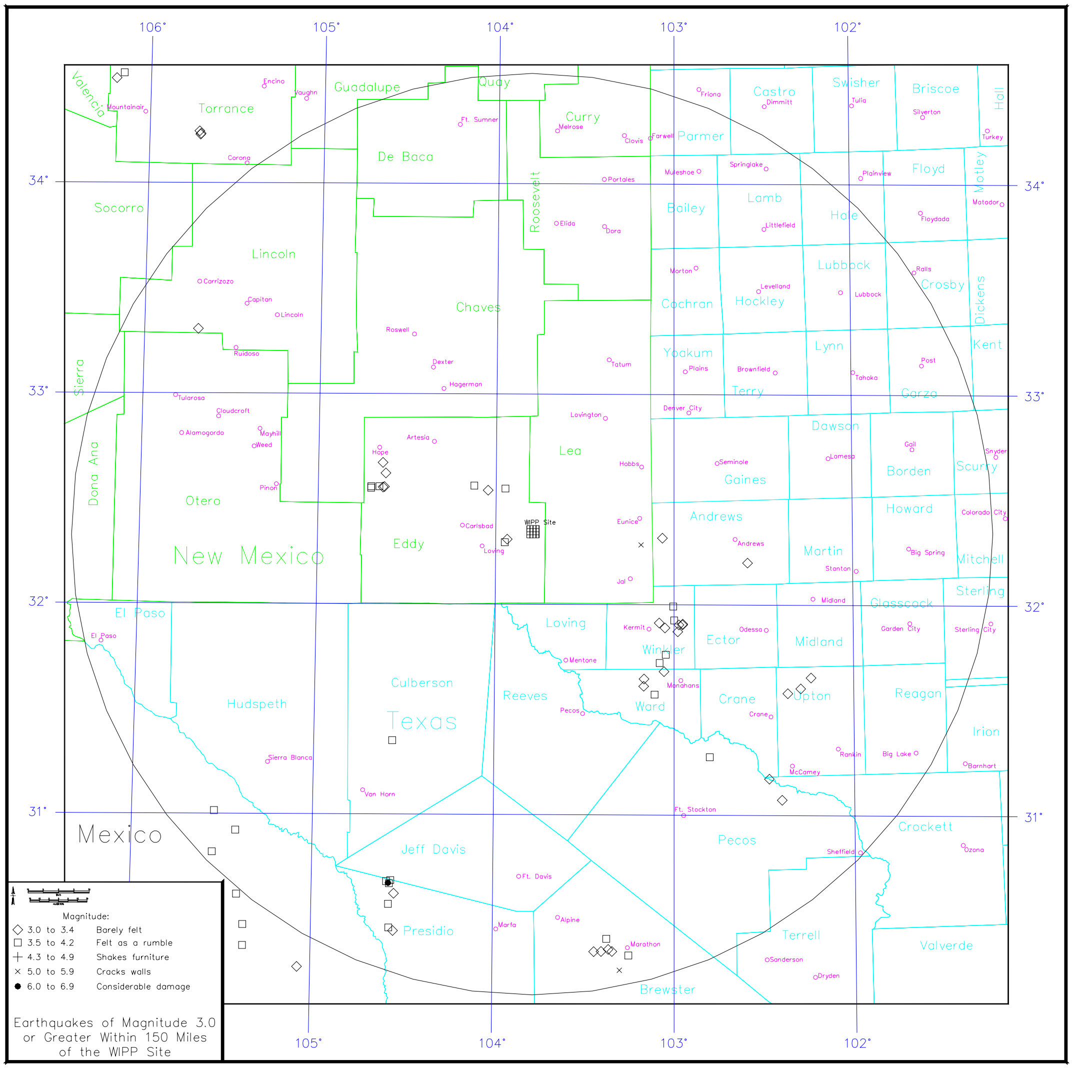


Figure 2-~~47~~*57*. Regional Earthquake Epicenters Occurring between 1961 and 2002

240 km (149 mi), an event of magnitude 5.7 would produce a maximum acceleration at the WIPP site of less than 0.01 g ***(acceleration due to gravity)***.

The Marathon earthquake should not be considered an unanticipated event. The shock occurred in the Basin and Range Province, a seismotectonic province with evidence for 24 Quarternary faults in West Texas and adjacent parts of Mexico. Two of these faults had recent surface-faulting events in the Holocene. Strong earthquakes have occurred within the West Texas part of the Basin and Range Province, most notably the M_W = 6.4 (Richter) Valentine, Texas earthquake on August 15, 1931.

The WIPP site is located within the Great Plains seismotectonic province, a region that has no evidence of Quarternary faulting, even above major buried structures such as the Central Basin Platform. Because the Great Plains seismotectonic province is geologically distinct from the Basin and Range Province and lacks evidence for recent faulting, the maximum possible or credible earthquake for this region would be substantially smaller than that for the Basin and Range Province of West Texas.

2.6.2 Seismic Risk

Procedures exist that allow for formal determination of earthquake probabilistic design parameters. In typical seismic risk analyses of this kind, the region of study is divided into seismic source areas within which future events are considered equally likely to occur at any location. For each seismic source area, the rate of occurrence of events above a chosen threshold level is estimated using the observed frequency of historical events. The sizes of successive events in each source are assumed to be independent and exponentially distributed; the slope of the log number versus frequency relationship is estimated from the relative frequency of different sizes of events observed in the historical data. This slope, often termed the b value, is determined either for each seismic source individually or for all sources in the region jointly. Finally, the maximum possible size of events for each source is determined using judgement and the historical record. Thus, all assumptions underlying a measure of earthquake risk derived from this type of analysis are explicit, and a wide range of assumptions may be employed in the analysis procedure.

In this section, the particular earthquake risk parameter calculated is peak acceleration expressed as a function of annual probability of being exceeded at the WIPP site. The particular analysis procedure applied to the calculation of this probabilistic peak acceleration is taken from a computer program written by McGuire ~~in~~ ***(***1976***)***. In that program, the seismic source zones are modeled geometrically as quadrilaterals of arbitrary shape. Contributions to site earthquake risk from individual source zones are integrated into the probability distribution of acceleration, and the average annual probability of exceedence then follows directly.

In the analysis, the principal input parameters are as follows: site region acceleration attenuation, source zone geometry, recurrence statistics, and maximum magnitudes. Based on these parameters, several curves showing probabilistic peak acceleration are developed, and the conclusions that may be drawn from these curves are considered. The data treated in this way are used to arrive at a general statement of risk from vibratory ground motion at the site during its active phase of development and use.

2.6.2.1 Acceleration Attenuation

The first input parameters considered have to do with acceleration attenuation in the site region as a function of earthquake magnitude and hypocentral distance. The risk analysis used in this study employs an attenuation law of the form

$$a = b_1 \exp(b_2 M_L) R\text{-}b_3 , \qquad \textbf{\textit{(2.3)}}$$

where a is acceleration in ***cm/s^2***, M_L is Richter local magnitude, and R is the distance in km. The particular formula used in this study is based on a central United States model developed by Nuttli (1973). The formula coefficients $b_1 = 17$, $b_2 = 0.92$, and $b_3 = 1.0$ were selected. A justification for this assumption can be found in ~~Section 5.3.2 of~~ ***CCA*** Appendix GCR, Section 5.3.2.