RAI Volume 3, Chapter 2.2.1.3.13, First Set, Number 2:

Provide a technical basis for sampling wind speed and direction as uncorrelated, randomized parameters for the altitude intervals used in the DOE Ashplume model. This information is needed to determine compliance with 10 CFR 63.114(a)(1, 2).

Basis: For each altitude interval above Yucca Mountain, the DOE Ashplume model for tephra dispersal randomly samples wind speed and direction from a data set of atmospheric measurements for that altitude (SAR Section 2.3.11.4.2.2.2). Wind speed and direction appear to be correlated parameters within a specified altitude interval. Data in SNL (2007, Appendix D) show that wind speeds generally increase with altitude, and that biases in wind direction also occur with increases in altitude. Thus, wind speed and direction do not appear to be uncorrelated processes for different altitude intervals. DOE should justify the use of wind speed and direction as randomized, uncorrelated parameters in the performance assessment.

1. RESPONSE

1.1 CORRELATION BETWEEN WIND SPEED AND DIRECTION

Figures 1 to 9 show wind rose diagrams of normalized wind speed, wind direction probability, and overall wind speed for various heights ranging from 0 to 1 km and 8 to 9 km. The data source shown is the Desert Rock wind station data documented in *Atmospheric Dispersal and Deposition of Tephra from a Potential Volcanic Eruption at Yucca Mountain, Nevada* (SNL 2007, Appendix D). Although the wind data exist for heights up to 12 to 13 km, only data up to 8 to 9 km were examined because the range of values for eruptive power in the total system performance assessment (TSPA) model results in a maximum column height of 8.2 km (SNL 2007, Section 6.5.2.7).

For the ASHPLUME model, wind speed and direction are represented by two cumulative distributions that are sampled independently. Within each height range, the distributions comprise histograms of all wind speeds and directions from the Desert Rock wind data. The wind speed histogram uses intervals of 1 m/s, and the wind direction histogram uses sectors with a 30-degree angular width. Additionally, wind speed data are partitioned into twelve groups corresponding to the sectors used for the wind speed distribution.

Wind speed data shown in Figures 1 to 9 are grouped into 30-degree direction intervals for each height. The compass directions shown in the figures represent the direction toward which the wind is blowing using the ASHPLUME convention for wind direction (i.e., wind blowing towards the east is considered to be 0 degrees, and wind blowing towards the north is considered to be +90 degrees.) For each 30-degree interval, the probability of the wind blowing in that direction and statistics for the normalized wind speed conditional on that direction interval are plotted on the radial axis of the figures. Statistics for the uncorrelated ASHPLUME wind speed within a specific height interval are also provided on each figure as a dashed line circle. The

wind speed values are normalized by the maximum wind speed for any sector to facilitate display on a common radial axis with a range of 0 to 1.

Figures 1 to 9 show that for winds directed south toward the reasonably maximally exposed individual (RMEI) location (i.e., in the 30-degree interval between −75 to −105 degrees), the wind speed is nearly identical to the wind speed for the entire data set of all directions for a specific height interval. The figures also show that for each height interval, the highest probability wind directions are within a relatively narrow range directed toward the east or northeast. The wind direction probability distribution is represented by the green line and symbols on the figures. The TSPA model samples wind direction from this distribution for a specific height interval. Within the range of wind directions that have the highest probability of occurrence, the figures show that the wind speed for a specific direction interval does not vary significantly from the overall wind speed for that height. The figures generally show that wind speed is not highly correlated with direction for winds with an easterly directed component but is more significantly correlated with direction for winds with a westerly directed component.

1.2 CONCLUSIONS

The TSPA model calculates dose due to direct deposition at the RMEI location and fluvial redistribution of contaminated ash from the Fortymile Wash drainage basin to the RMEI location. Significant direct ash deposition at the RMEI location can only occur when wind is blowing toward the south. Figures 1 to 9 show that within a specific height interval, the distributions for southerly directed wind speeds are similar to the ASHPLUME distribution for wind speed for that height interval. Similarly, significant deposition of contaminated ash in the Fortymile Wash drainage basin can only occur when wind is directed toward the east or northeast. Figures 1 to 9 generally show that within a specific height interval, the distributions for wind speed for easterly or northeasterly directed winds are similar to the ASHPLUME distribution for wind speed. Therefore, for these directions, randomly sampling wind speed from the entire data set is reasonable. The distributions for wind speed differ from the ASHPLUME distribution for winds with a westerly directed component. However, winds directed toward the west have a low probability of occurring, and if they occur, the resulting ash deposition in the Fortymile Wash drainage basin or directly at the RMEI location is small. These conclusions provide the technical basis for sampling wind speed and direction as uncorrelated, randomized parameters for the altitude intervals used in the TSPA model.

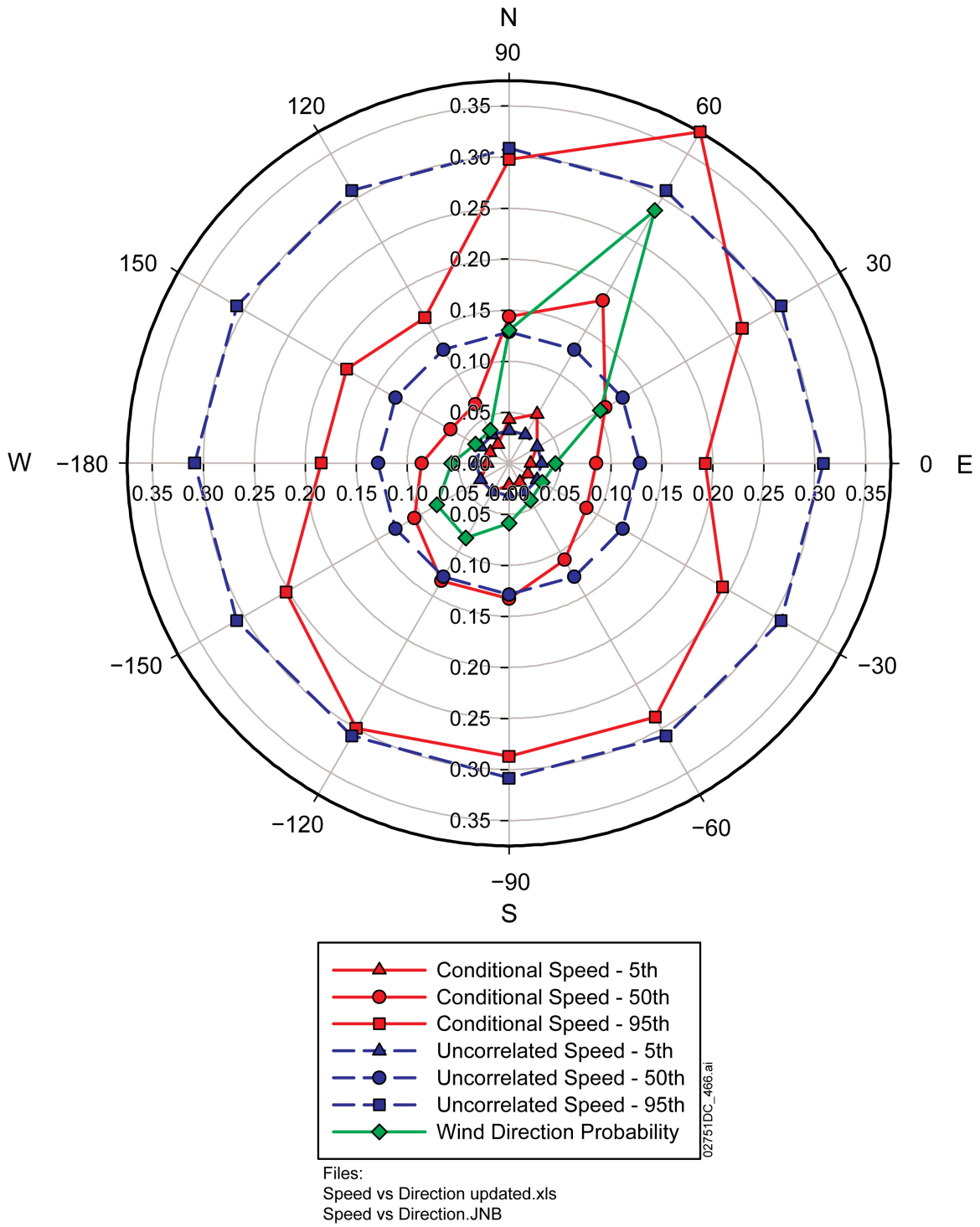

Figure 1. Normalized 5th, 50th, and 95th percentile Wind Speed and Wind Direction Probability for Heights of 0 to 1 km

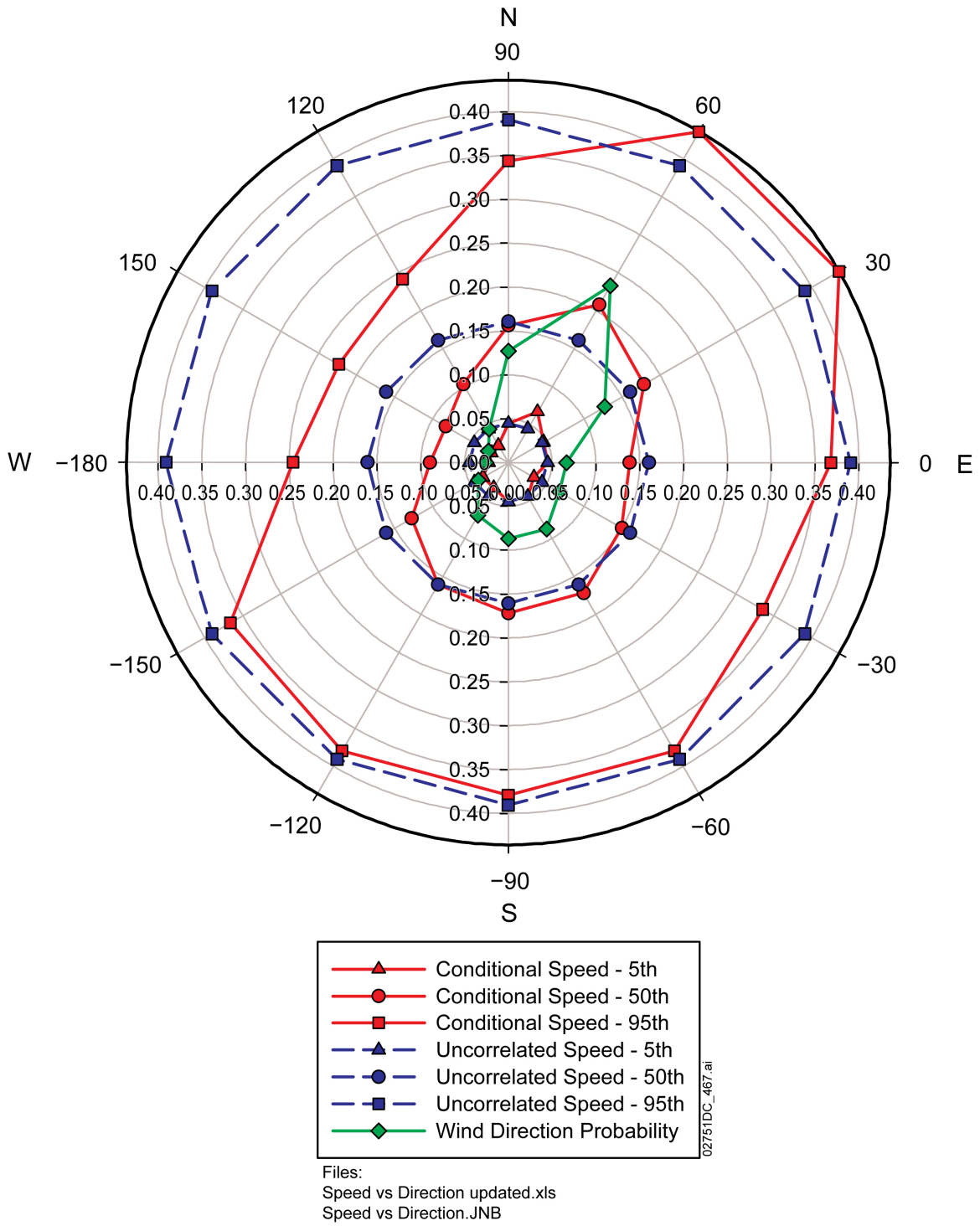

Figure 2. Normalized 5th, 50th, and 95th percentile Wind Speed and Wind Direction Probability for Heights of 1 to 2 km

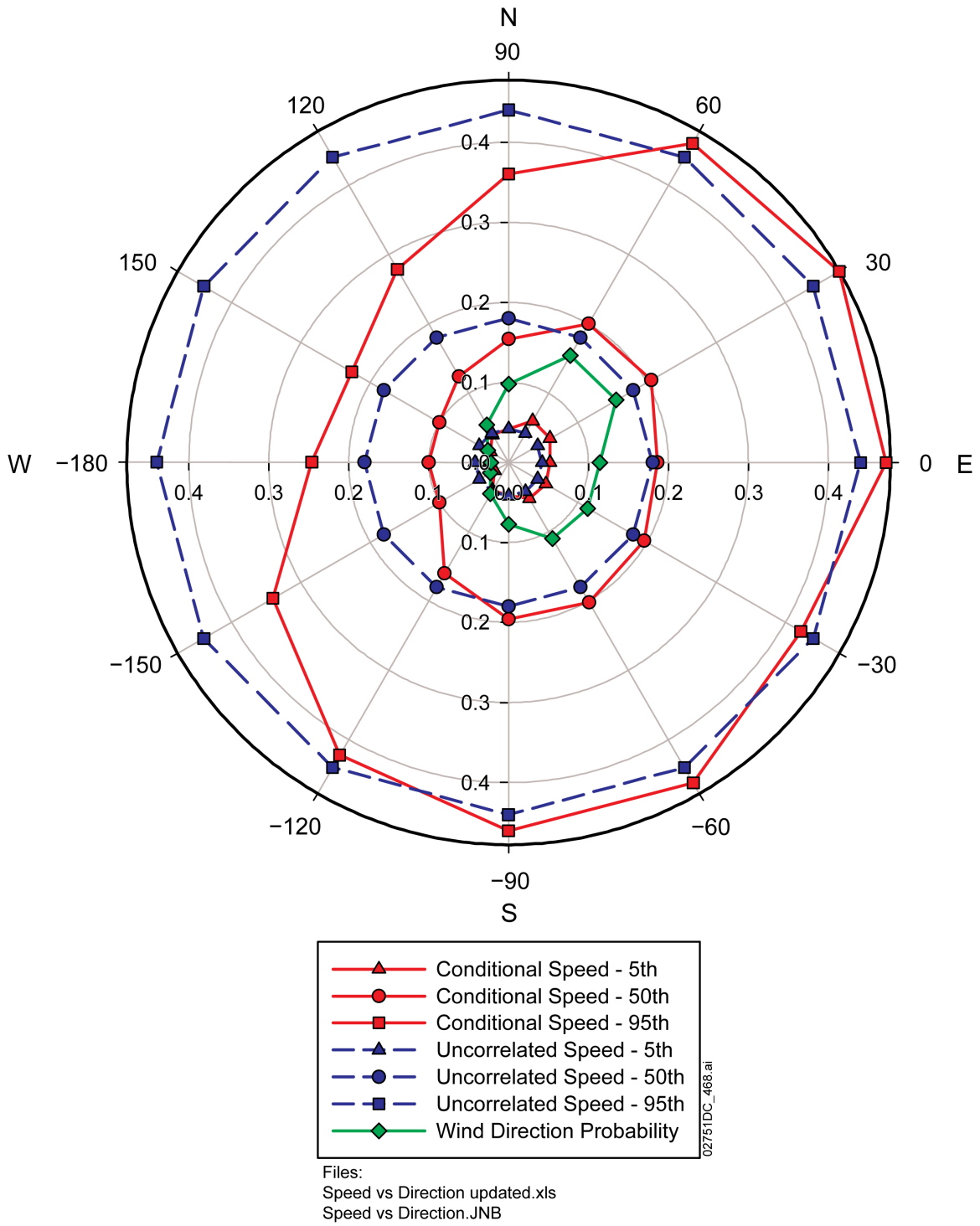

Figure 3. Normalized 5th, 50th, and 95th percentile Wind Speed and Wind Direction Probability for Heights of 2 to 3 km

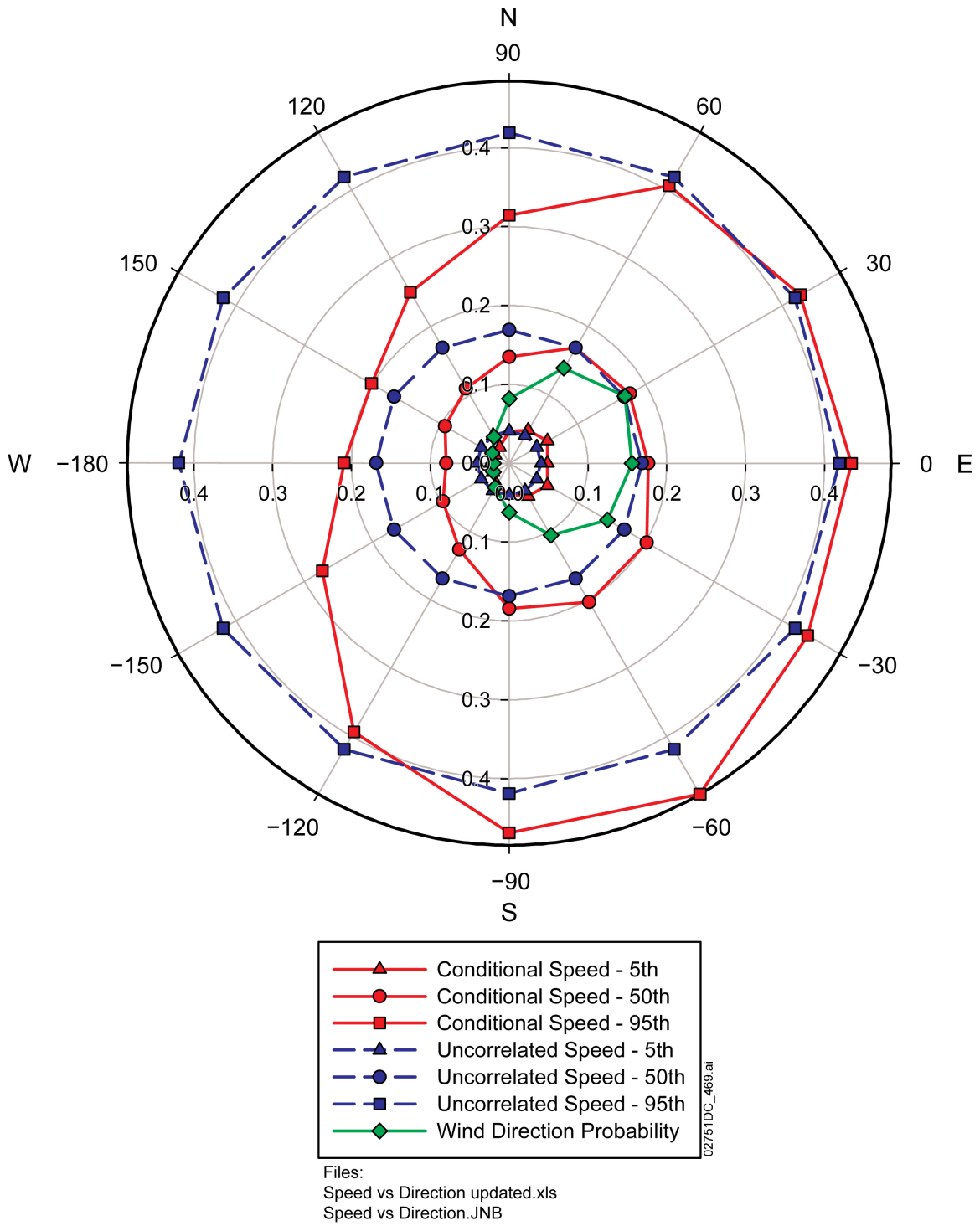

Figure 4. Normalized 5th, 50th, and 95th percentile Wind Speed and Wind Direction Probability for Heights of 3 to 4 km

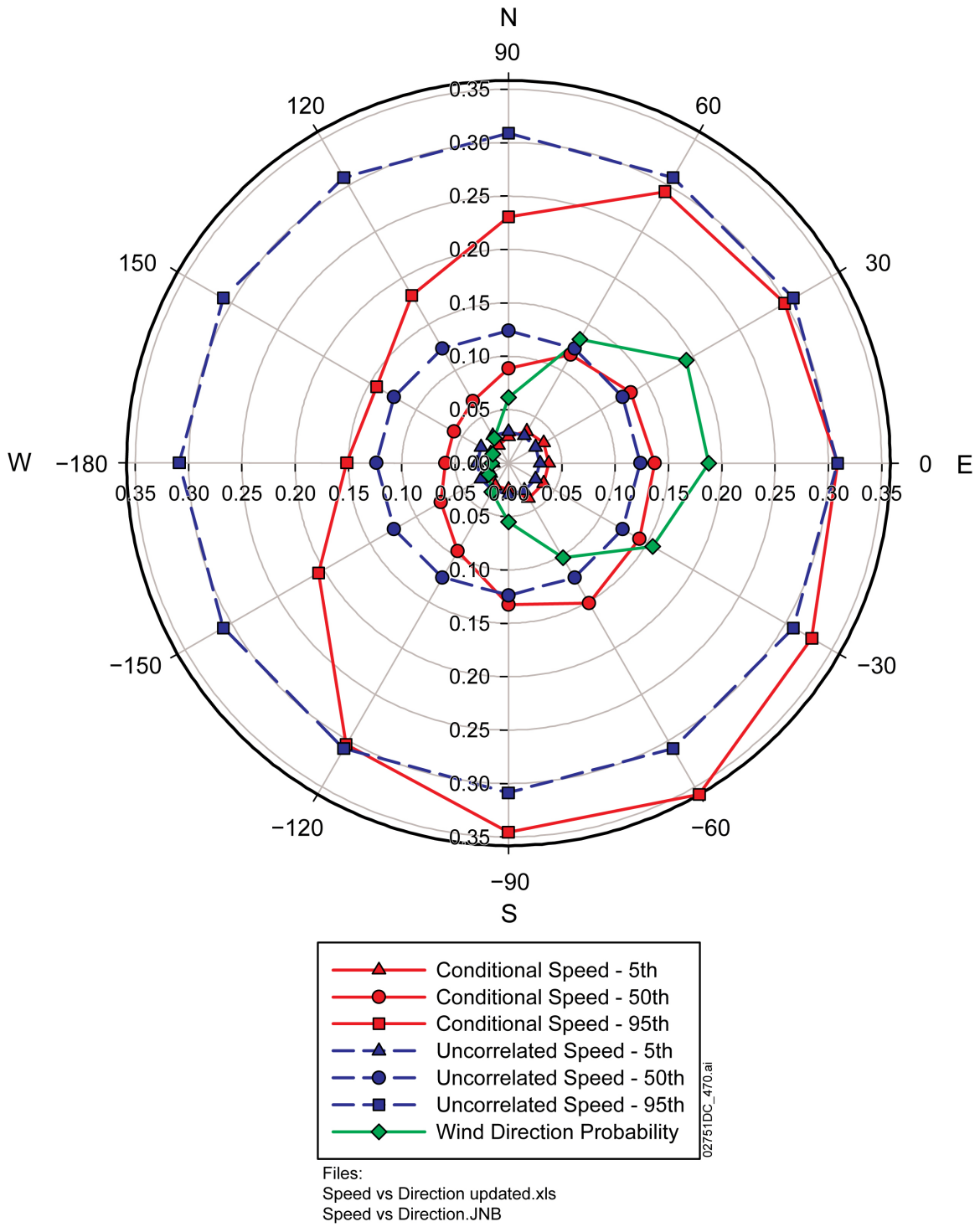

Figure 5. Normalized 5th, 50th, and 95th percentile Wind Speed and Wind Direction Probability for Heights of 4 to 5 km

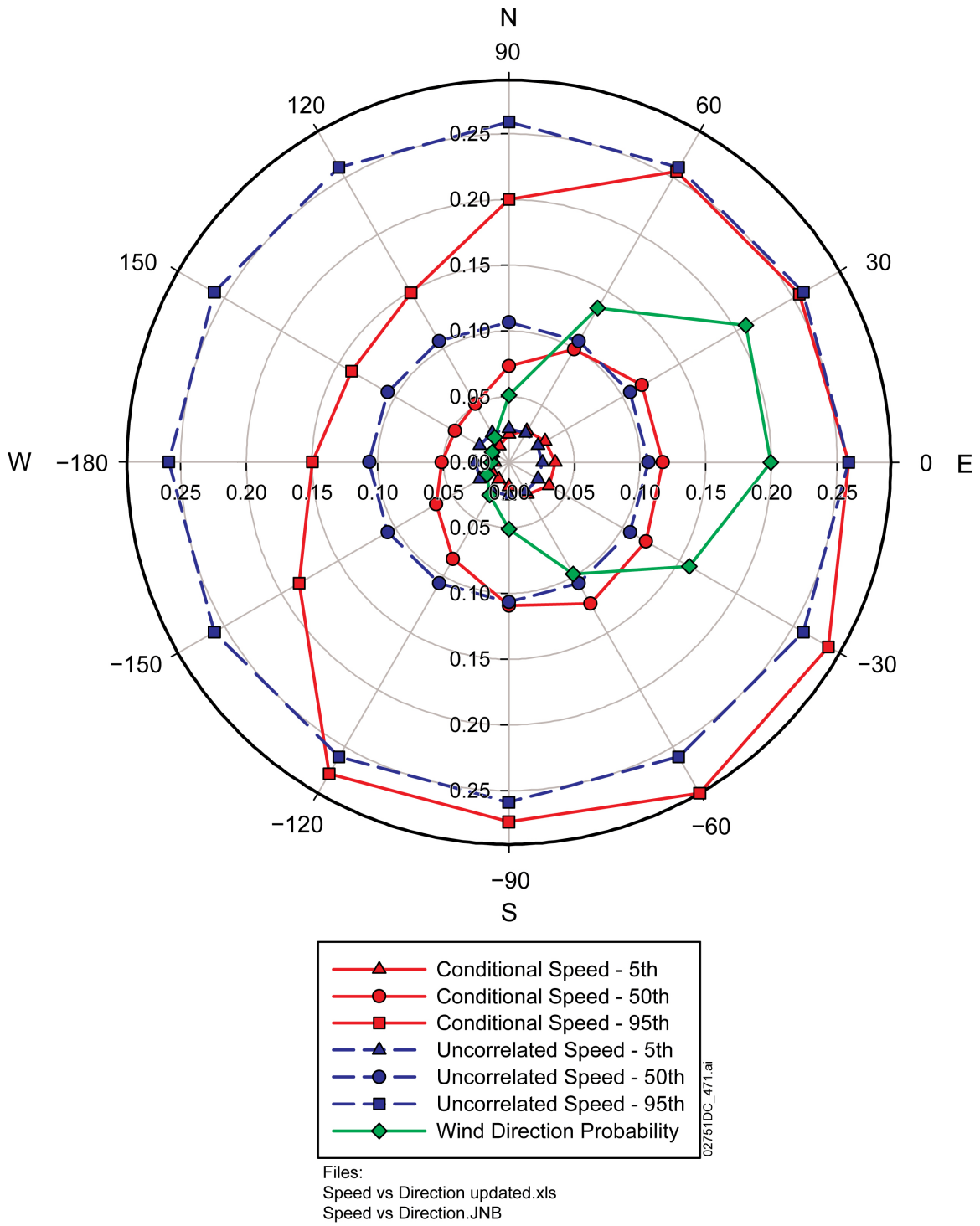

Figure 6. Normalized 5th, 50th, and 95th percentile Wind Speed and Wind Direction Probability for Heights of 5 to 6 km

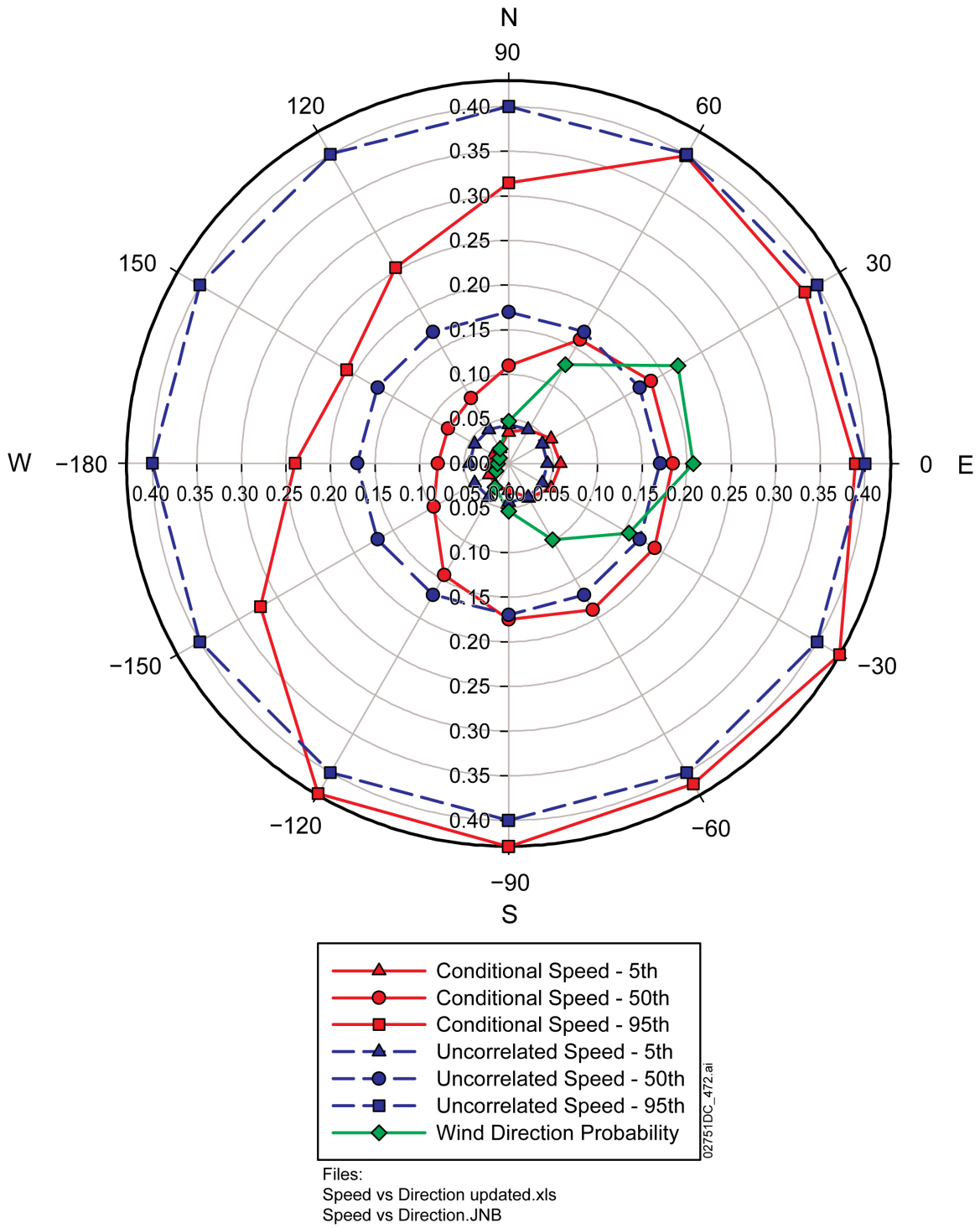

Figure 7. Normalized 5th, 50th, and 95th percentile Wind Speed and Wind Direction Probability for Heights of 6 to 7 km

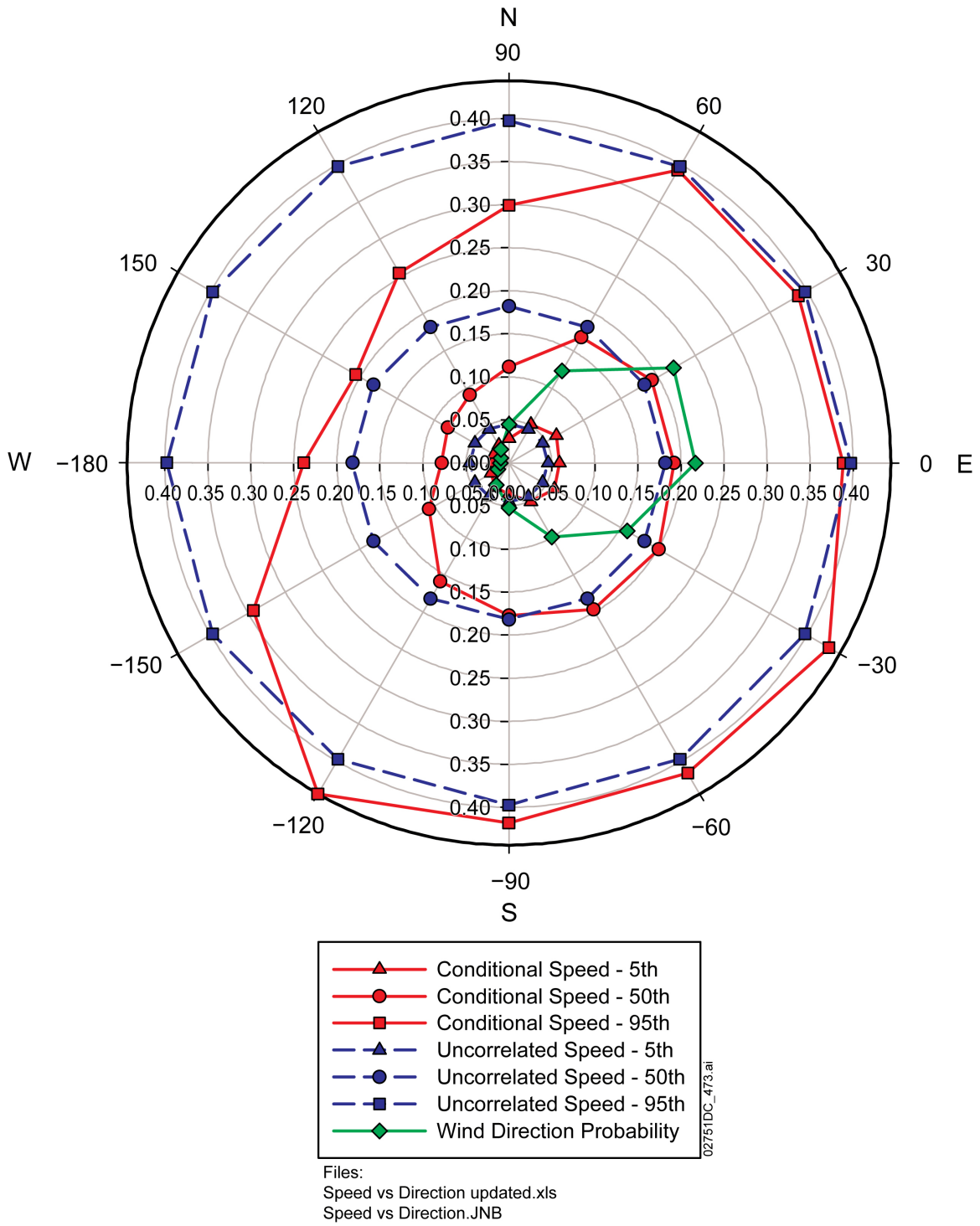

Figure 8. Normalized 5th, 50th, and 95th percentile Wind Speed and Wind Direction Probability for Heights of 7 to 8 km

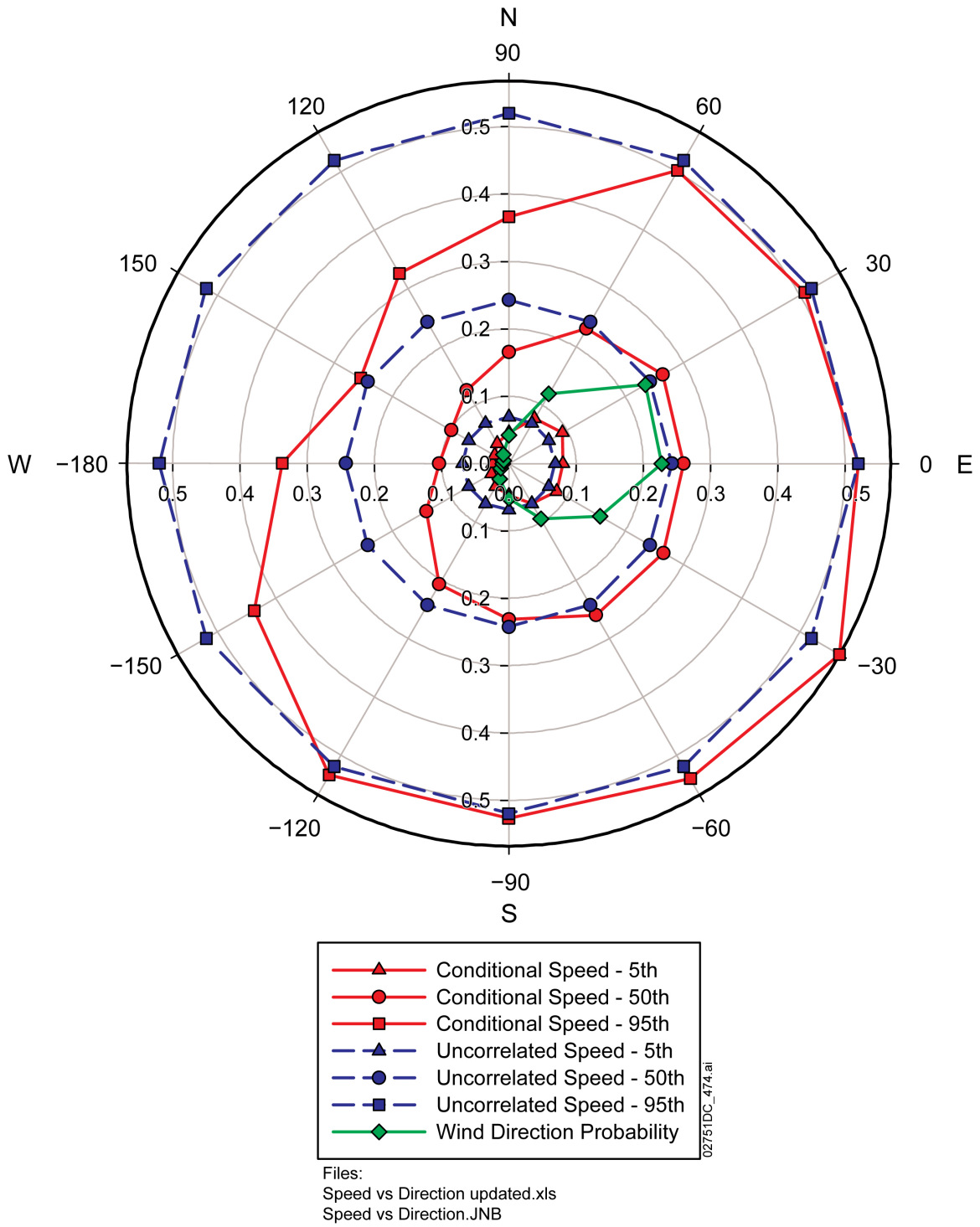

Figure 9. Normalized 5th, 50th, and 95th percentile Wind Speed and Wind Direction Probability for Heights of 8 to 9 km

2. COMMITMENTS TO NRC

None.

3. DESCRIPTION OF PROPOSED LA CHANGE

None.

4. REFERENCES

SNL (Sandia National Laboratories) 2007. *Atmospheric Dispersal and Deposition of Tephra from a Potential Volcanic Eruption at Yucca Mountain, Nevada.* MDL-MGR-GS-000002 REV 03. Las Vegas, Nevada: Sandia National Laboratories. ACC: DOC.20071010.0003; LLR.20080522.0090.

RAI Volume 3, Chapter 2.2.1.3.13, First Set, Number 3:

> Provide a demonstration of the variation in waste mass per unit mass of deposited tephra (such as the unitless ratio of waste mass to tephra mass deposited per unit area) with distance from the assumed volcanic vent for the igneous extrusive event scenario. This information is needed to determine compliance with 10 CFR 63.114(a)(1, 2).
>
> Basis: DOE performance assessment results for the volcanic ash exposure (igneous extrusive) scenario are sensitive to the amount of high-level waste contamination in tephra deposited directly at the reasonably maximally exposed individual location and in the catchment basin of Fortymile Wash (SAR Section 2.3.11.4.2.2.3). In SNL (2007, p. 6-10), the applicant states that "waste concentration in tephra varies with location (dependent on distance and direction from vent)" but does not present data that specifically demonstrates the variation. If waste mass per unit mass of tephra varies significantly for different ground surface location within individual realizations, a technical basis is needed for the variations.

1. RESPONSE

A demonstration of the variation in the ratio of waste mass to tephra mass with distance from the assumed volcanic vent for the igneous extrusion event is provided by extracting the ASHPLUME calculated tephra density and waste density in g/cm^2 as a function of location within the Fortymile Wash drainage basin and calculating the ratio of the two values as a function of location. Realization number 5 of the total system performance assessment (TSPA) volcanic eruption modeling case is a typical model realization with wind blowing into the Fortymile Wash catchment basin and is used to provide the demonstration. Table 1 provides the ASHPLUME model input parameter values for this realization.

Figure 1 shows cross sections of tephra density and the ratio of waste density to tephra density for three distances downwind from the volcanic vent. The ratio represents the unitless ratio of waste mass to tephra mass deposited per unit area. The figure shows that the ratio of waste mass to tephra mass varies with distance downwind from the vent and in the crosswind direction perpendicular to the downwind direction. The ratio becomes smaller with distance downwind and toward the edges of the deposit in the crosswind direction.

The technical basis for the variation in the ratio of waste mass to tephra mass lies in the mechanism employed by the ASHPLUME model to incorporate waste particles with tephra particles for transport. Conceptually, the ASHPLUME model uses an incorporation ratio to associate waste particles with tephra particles for transport downwind (SNL 2007a, Equation 6-9). The incorporation ratio is the logarithm of the ratio of ash particle diameter to waste particle diameter that may be combined for transport. An incorporation ratio with a constant value of zero (Table 1) was used in the TSPA model for all ASHPLUME realizations (SNL 2008, Table 6.5-4), which conceptually means that waste particles may be incorporated into ash particles of equal or larger diameter. Smaller tephra particles have less mass than larger

particles, so they are more buoyant and will generally be transported farther downwind than larger particles. Thus, the tephra deposit farther from the vent will generally be composed of smaller particles; using an incorporation ratio of zero, smaller tephra particles also carry less waste, and the smallest tephra particles may not carry any waste. Therefore, the ratio of total waste mass to total ash mass for all particles at a particular location will decrease with distance from the vent. The same is true in the crosswind direction as well because the smaller particles will experience a longer settling time and thus experience a longer time for dispersion to the outer edges of the plume.

Although data for a typical model realization presented in Figure 1 demonstrate that the ratio of waste mass to tephra mass varies with location depending on distance and direction from the vent, TSPA model dose results are not dependent on this ratio. For direct deposition at the reasonably maximally exposed individual (RMEI) location, the ASHPLUME model calculates tephra mass deposition and waste mass deposition separately at the RMEI location, and dose is calculated based on the waste mass deposited, not the ratio of waste mass to tephra mass. Similarly, for deposition in the Fortymile Wash drainage basin, the ASHPLUME model calculates tephra and waste mass deposition separately, and both ash and waste are mobilized independently and transported by fluvial processes to the RMEI location on the alluvial fan by the tephra redistribution model. The waste concentration at the RMEI location used for dose calculations is determined from the ratio of total mobilized waste to total mobilized tephra that reaches the RMEI location (SNL 2007b, Section 6.3.3, Step 5), and is not dependent on the variation of waste concentration in tephra with location in the drainage basin. Therefore, performance assessment results for the volcanic ash exposure scenario are not sensitive to the ratio of waste contamination in tephra deposited directly at the RMEI location or in the catchment basin of Fortymile Wash.

Table 1. ASHPLUME Parameter Values for Realization Number 5

ASHPLUME Parameter	Parameter Value Realization Number 5
Wind direction	60 degrees
Wind speed	1,233.4 cm/s
Mean ash particle diameter	0.001451 cm
Ash particle diameter standard deviation	0.57169 log(cm)
Minimum waste particle size	0.0001 cm
Mode waste particle size	0.0013 cm
Maximum waste particle size	0.2 cm
Beta	0.30393
Eruption power	6.73×10^{10} Watts
Eruption duration	1.48×10^{5} s
Eruption velocity	4,555 cm/s
Rhocut (waste incorporation ratio)	0

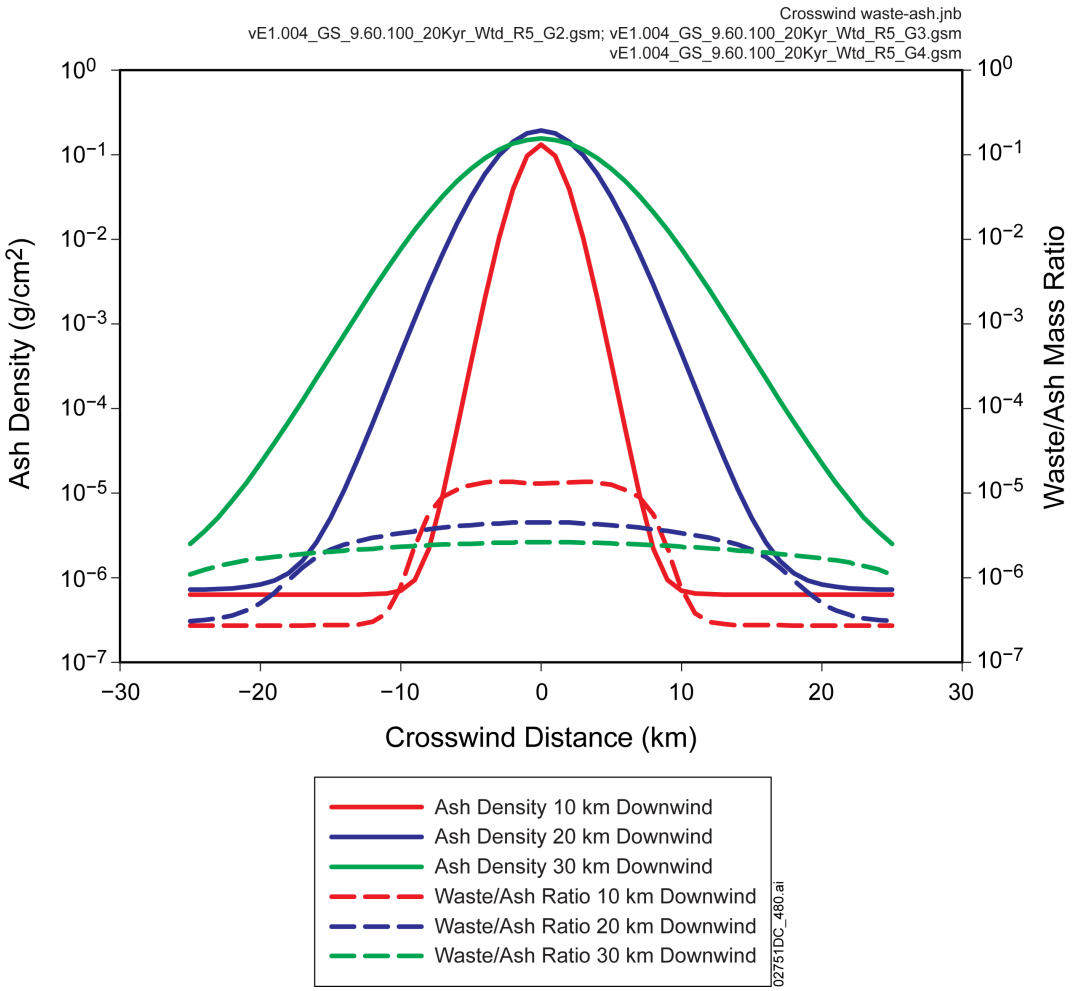

Figure 1. Ash Density and Waste/Ash Mass Ratio at Three Distances Downwind from the Volcanic Vent

2. COMMITMENTS TO NRC

None.

3. DESCRIPTION OF PROPOSED LA CHANGE

None.

4. REFERENCES

SNL (Sandia National Laboratories) 2007a. *Atmospheric Dispersal and Deposition of Tephra from a Potential Volcanic Eruption at Yucca Mountain, Nevada.* MDL-MGR-GS-000002 REV 03. Las Vegas, Nevada: Sandia National Laboratories. ACC: DOC.20071010.0003; LLR.20080522.0090.

SNL 2007b. *Redistribution of Tephra and Waste by Geomorphic Processes Following a Potential Volcanic Eruption at Yucca Mountain, Nevada.* MDL-MGR-GS-000006 REV 00. Las Vegas, Nevada: Sandia National Laboratories. ACC: DOC.20071220.0004; LLR.20080423.0011.

SNL 2008. *Total System Performance Assessment Model /Analysis for the License Application.* MDL-WIS-PA-000005 REV 00 AD 01. Las Vegas, Nevada: Sandia National Laboratories. ACC: DOC.20080312.0001; LLR.20080414.0037; LLR.20080507.0002; LLR.20080522.0113; DOC.20080724.0005; DOC.20090106.0001[a].

NOTE: [a]Provided as an enclosure to letter from Williams to Sulima dtd 02/17/2009. "Yucca Mountain – Request for Additional Information Re: License Application (Safety Analysis Report Section 2.1), Safety Evaluation Report Volume 3 – Postclosure Chapters 2.2.1.1 and 2.2.1.3.7 – Submittal of Department of Energy Reference Citations."