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Risk-Based Wind Loss and Mitigation for Residential Wood Framed Construction

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RISK-BASED WIND LOSS AND MITIGATION FOR RESIDENTIAL WOOD FRAMED CONSTRUCTION

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To my beloved husband, Reza, and our son, Ryan
To my Family

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ABSTRACT

As a result of increasing windstorm losses in the United States over the past 50 years, a variety of residential wind hazard mitigation methods have been suggested. Mitigation undoubtedly reduces windstorm losses; however, the expected economic risk reduction of mitigation practices over the life of the building depends on the building characteristics (i.e., capacity) and the intensity and occurrence of wind speeds (i.e., demand). Effective decision making requires estimation of potential future losses based on many variables. Many models, primarily mechanics-based simulation models, have been developed to predict building damage from wind events; however; fewer models of economic loss have been developed, although economic losses are more easily quantified over a spatial domain and have the potential for more effective widespread use. Additionally, many existing models consider damage and loss as a function of basic wind speed in open terrain and few address the variation in loss due to changes in surface roughness, although surface roughness is a critical component in surface wind speed. In spite of advancements in damage and loss modeling, the limitations of existing publications (e.g., geographically limited in scope, limited to specific building types, limited to specific events, limited to open terrain) prevent generalization and application of the results on a nationwide basis to support development of a mitigation decision-making framework.

To address these limitations, this research presents a methodology to calculate tabular expected annual loss (EAL) results for 160 variations of one-story, single-family homes at each ASCE 7-10 wind contour through Monte Carlo simulation of local annual maximum wind speeds convolved with Hazus-MH economic loss functions for open terrain and non-open terrain. The results are integrated into a decision-making framework designed to provide customized consumer-level guidance to assist the mitigation decision-making process based on location,

terrain, years of interest, and building configuration. The results provide practical results in an easy-to-use format to facilitate consumer-level mitigation decision making.

CHAPTER 1: INTRODUCTION

Hurricanes are one of the most deadly and economically devastating natural hazards in the United States (Wang & Rosowsky, 2012). As a result of increasing windstorm losses over the last 50 years (NSB, 2007), many studies have presented hurricane risk assessment for buildings through damage and loss models (e.g. Barbato et al., 2013; Heneka & Ruck, 2008; Huang et al., 2001b; Khanduri & Morrow, 2003; Li & Ellingwood, 2006; Li & van de Lindt, 2012; Pinelli et al., 2004; Pita et al., 2013b; Rosowsky & Ellingwood, 2002; Vickery et al., 2006b). Most of these models are mechanics-based structural models (e.g. Ellingwood et al., 2004; Li & Ellingwood, 2006; Pinelli et al., 2004; Vickery et al., 2006b); however, economic losses are more easily quantified and reported than measures of building damage, so loss models have the potential for more effective widespread calibration (Powell et al., 2005). The results of loss models also provide economic justification to support building code reform at community, state and national levels (Kopp et al., 2010; Pita et al., 2013a) and estimated loss can serve as a decision-making criterion for building performance objectives (Dao & van de Lindt, 2011; Rosowsky & Ellingwood, 2002; Taggart & van de Lindt, 2009; van de Lindt & Dao, 2009). Economic losses serve as a proxy for building damage (Liang et al., 2010; Pinelli et al., 2004; Unanwa & McDonald, 2000), which provides insights into community resilience and sustainability (Berke, 1995; Burby et al., 2000; Friedland & Gall, 2012). Thus, probabilistic estimation of wind-induced economic building loss holds significant potential for risk assessment and integrated decision making.

While this capability exists, current implementation of loss models do not effectively support building-level mitigation decision making. Existing research has limitations which prevent integration of results on a nationwide basis, specifically limitations in the evaluation of geographical areas (e.g. Pinelli et al., 2008; Torkian et al., 2013; Vickery et al., 2006b), a specific building type (e.g Amoroso & Fennell, 2008a), terrain and its effect on loss functions (e.g. Heneka

& Ruck, 2008; Huang et al., 2001b; Li & Ellingwood, 2006), and specific events (e.g. Huang et al., 2001a), rather than evaluation across geographical areas, for several building configurations, for any terrain, and with results that can be customized for the life of the building. Because of these shortcomings, baseline expectations of building performance do not exist to assess or track reductions in economic losses realized by mitigation (Legg et al., 2012; Peacock, 2003), which are required to quantify the benefit of mitigation. Most importantly for residential decision makers, a comprehensive consumer benefit-cost decision-making framework to evaluate the cost effectiveness of mitigation strategies that can be customized based on location, decision-making time horizon, and building configuration does not exist.

1.1 Problem Statement

Existing wind loss models do not provide results that can be easily, flexibly, and effectively integrated into consumer-level decision making to reduce life cycle losses from wind events. While many of the required methods have been developed, they have not been incorporated in a manner that facilitates application across a wide geographic domain with variable surface roughness for multiple building types over variable years of interest.

1.2 Goal of the Study

The overarching goal of this dissertation research is to quantitatively model wind hazard direct economic losses and avoided losses achieved through wind hazard mitigation for wood framed, one-story, single family residential construction in the continental U.S. to support consumer-level mitigation decision making. In order to address the overarching goal, three specific objectives are identified:

- Calculate windstorm expected annual losses (EAL) for wood framed, one-story, single family homes in the continental United States in open terrain.

- Consider the effect of terrain on EAL for wood framed, one-story, single family homes and create a methodology to calculate EAL for any terrain.
- Create a computational decision-making framework to evaluate the cost effectiveness of mitigation strategies to enhance consumer decision making that is customized based on location, terrain, years of interest, and building configuration.

1.3 Scope of the Study

This dissertation evaluates economic losses for wind storms in the continental United States as a function of expected annual loss for any terrain. Using expected annual loss for multiple building configurations, the benefit of each construction technique (i.e., avoided loss) is calculated, and mitigation effectiveness is evaluated based on the ratio of benefit to cost to facilitate consumer-level mitigation decision making.

1.4 Limitations of the Study

This study is limited to direct economic loss functions for wood framed, one-story, single family homes extracted from FEMA's Hazus-MH Hurricane Model (FEMA, 2012) and therefore reflects the inherent limitations of building configurations, mitigation options, and loss functions. Variability within the building types is not considered. Further, this research investigated expected annual loss only in terms of the mean loss. Variability of the mean and other statistical measures such as probable maximum loss and quantile losses are not considered. The Extreme Value Type I (Gumbel) distribution is used to predict wind extremes and in evaluation of the effects of surface roughness on local wind speed, a fully transitioned boundary layer is considered. The majority of cost data used in the research were collected from RSMeans Residential Cost Data and the variability in the cost data and uncertainty in economic aspects are not considered. However, the methodologies are developed generally with the goal of future adaptation for other input, loss functions, and cost data.

1.5 Organization of the Dissertation

This dissertation is organized by objective topic. Chapter 2 presents expected annual windstorm losses for wood framed, one-story, single family homes in open terrain. Chapter 3 presents expected annual windstorm losses for wood framed, one-story, single family homes in all other terrains. Chapter 4 presents a computational benefit/cost framework to facilitate consumer mitigation decision making using results of Chapters 2 and 3. Chapter 5 presents conclusions and areas of future work for these topics.

CHAPTER 2: EXPECTED ANNUAL WINDSTORM LOSSES FOR WOOD FRAMED, ONE-STORY, SINGLE FAMILY HOMES

2.1 Introduction

This chapter expands previous methodologies to present a probabilistic wind loss estimation framework to quantitatively model total direct expected annual loss (EAL) as a parameter for evaluating long-term wind hazard risk. This chapter considers wood framed, one-story, single family homes within the continental United States, evaluated at each ASCE 7-10 peak gust wind speed contour (i.e., 700 year mean recurrence intervals; 110-180 mph). Extreme value annual wind maxima are calculated at each of the ASCE 7 wind speed contours and fit using the Gumbel distribution. Using Monte Carlo simulation, a representation of average annual loss (EAL) is determined for each building type at each wind contour in open terrain.

2.2 Selection of Loss Functions

To develop this loss estimation framework, economic loss functions as a function of wind speed are required. These functions must be publicly available, applicable to multiple U.S. building configurations, consider the effects of terrain, and preferably used by others for economic loss research. Given these criteria, only one model, Hazus-MH (Vickery et al., 2006a; Vickery et al., 2006b), is determined to be suitable. While other models have been developed, they are subject to limitations (e.g., proprietary loss functions) that preclude their use in this research. Hazus-MH is a nationally applicable risk assessment methodology that has been used widely for loss studies (e.g. Amoroso & Fennell, 2008b; Bjarnadottir et al., 2011; Davidson et al., 2003; Jain & Davidson, 2007; Jain et al., 2005; Legg et al., 2010; Pan, 2011; Rose et al., 2007). The Hazus software is open source with 160 building configurations for wood framed, one story, single family homes considered over five terrain classes. Separate loss functions for building, contents, and loss of use are provided within the model.

The Hazus-MH Model itself provides the capability to conduct probabilistic or historic event loss estimation over an aggregated study area in a geographic information systems (GIS) platform. The ability to consider individual buildings only exists through the user-defined building functions or by integrating a user inventory into a separate program, the Comprehensive Data Management Software (CDMS). Thus, the default implementation of Hazus does not support loss estimation of a particular building type in a specific location over a time period of interest, as proposed in this research. To accomplish the objective of this chapter, only the three loss functions (i.e., building, contents, and loss of use) are extracted from the Hazus model, along with building attributes for the 160 model types.

While the loss functions within Hazus have many benefits, there are also shortcomings. The primary shortcoming is that the Hazus loss functions only address the mean economic loss by wind speed for each building type; therefore, inherent variability in loss is neglected by the Hazus functions and therefore in the final results. To overcome these shortcomings, the methodology presented in this and subsequent chapters are developed generally to be flexible with regard to input loss functions, rather than relying heavily on the format and content of Hazus-specific data. Therefore, as improved loss functions are developed within the wind engineering community, the developed methodology will accommodate their use and provide improved estimates of loss.

2.3 Methodology

In this chapter, a systematic methodology is developed to quantify probabilistic wind hazard risk, expressed as expected annual loss (EAL). To calculate EAL, extreme value distributions of wind speeds are convolved with economic loss functions from FEMA’s Hazus-MH model representing building, contents, and loss of use economic losses. Since there is considerable inherent uncertainty in wind loss estimation due to the uncertainty in both the intensity and occurrence of the winds, it is more realistic to simulate the large sample of wind

maxima and corresponding wind-induced loss as a stochastic quantity by Monte Carlo simulation and average the results over the number of iterations to derive the mean, or expected annual wind loss (EAL). The methodological framework is shown in Figure 2.1 and described in more detail in the following sections.

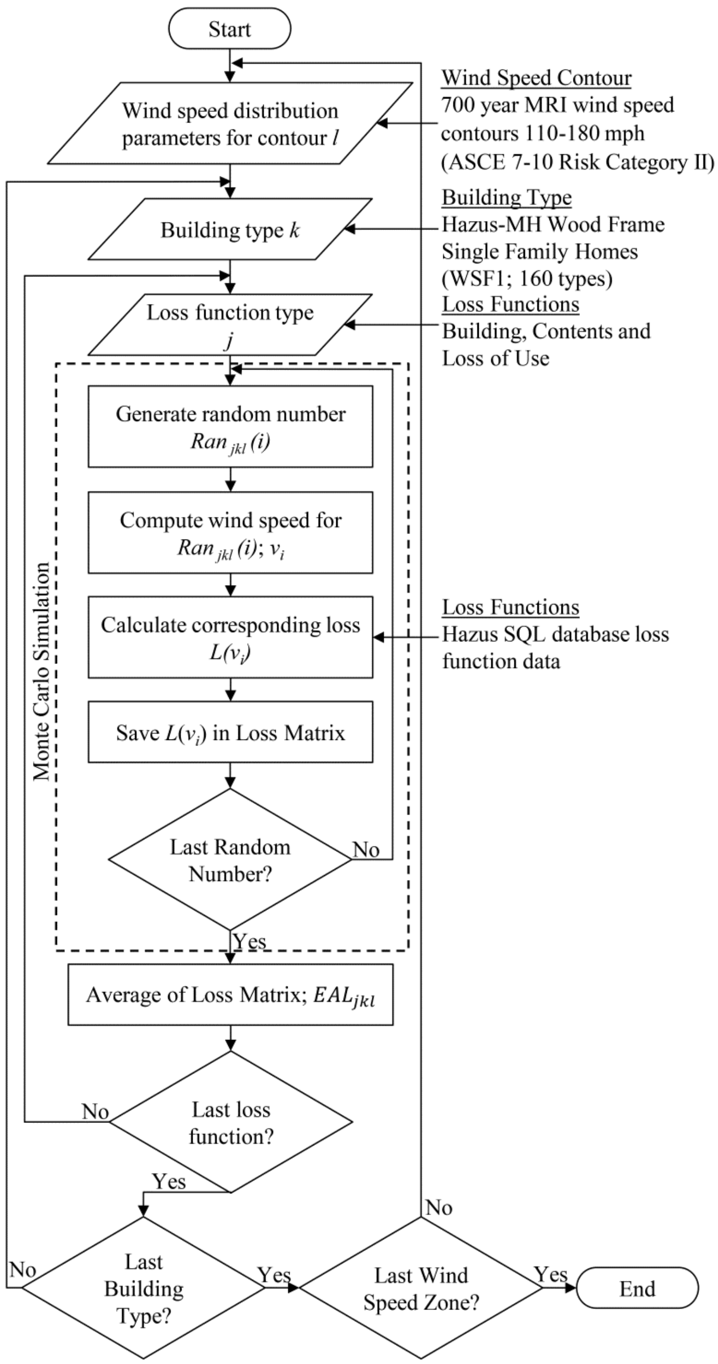


Figure 2.1 Flowchart of Methodology Concept

2.3.1 Annual Extreme Wind Speeds

The Extreme Value Type I (Gumbel) distribution is used here to predict wind extremes. The Weibull distribution is also appropriate for annual maxima (Barthelmie & Pryor, 2003; Pavia & O'Brien, 1986) and is one of the parent distributions of the Gumbel distribution (Palutikof et al., 1999); however, the Gumbel distribution is used because of traditional acceptance for predicting wind extremes (Abild et al., 1992; Gusclla, 1991; Hundecha et al., 2008; Ross, 1987), and for its simplicity of use. Therefore, the probability of wind speed $F_V(v)$ is calculated by the cumulative distribution function (CDF) of the Gumbel Extreme Value Distribution (Equation 2.1).

$$F_V\ (v)\ =\ exp\{-exp[-(v-\ \mu)/\ \sigma]\} \tag{2.1}$$

Where μ is the mode of distribution, and σ is the scale factor. By transforming Equation 2.1, wind speed v is calculated (Equation 2.2) and may be expressed in terms of mean recurrence interval R (Equation 2.3). For large R, the simplified approach by Holmes (2001) is used and wind speed is estimated using Equation 2.4 as a function of return period and Gumbel parameters. Plotting wind speed v versus year R on a logarithmic axis results in a line with slope σ and y-intercept μ. Using Equation 2.4, Gumbel parameters are estimated for known values of wind speed and return period.

$$v = \mu + \sigma\{-log_e[-log_e(F_V(v))]\} \tag{2.2}$$

$$v = \mu + \sigma\left\{-log_e\left[-log_e\left(1-\frac{1}{R}\right)\right]\right\} \tag{2.3}$$

$$v = \mu + \sigma\{log_e R\} \tag{2.4}$$

Using the derived Gumbel parameters, the CDF of annual maximum wind speed for a given location is represented by Equation 2.1 and used in the Monte Carlo simulation described in Section 2.3.3.

2.3.2 Building Inventory and Economic Loss Functions

Wood-framed, single family, one-story buildings (WSF1) are investigated in this chapter, and are typical low-rise, marginally engineered or non-engineered single family homes with

attached garages and asphalt shingle roofs (FEMA, 2012a). Within Hazus, WSF1 are categorized into 160 different types (Table 2.1), with options for roof type, roof-deck attachment, roof-wall connection, garage door, shutters, and secondary water resistance (SWR) (FEMA, 2012a). In Hazus, all WSF1 buildings with reinforced garage door in compliance with the 1994 South Florida Building Code (SFBC 1994) are coupled with shutter mitigation; therefore, reinforced garage doors are not considered separately as an individual mitigation. Table 2.1 provides the Hazus building ID (WBID) corresponding to each of the 160 model types by building characteristics.

Table 2.1 Hazus-MH WSF1 Building ID (WBID) and Corresponding Building Characteristics

Roof Deck Attachment	Garage Door	Shutter	Strap Roof-Wall Connection				Toe-Nail Roof-Wall Connection			
			No SWR		SWR		No SWR		SWR	
			G	H	G	H	G	H	G	H
6d @ 6 in/12 in	None	No	1	81	41	121	6	86	46	126
		Yes	2	82	42	122	7	87	47	127
	Standard	No	3	83	43	123	8	88	48	128
	SFBC 1994	Yes	4	84	44	124	9	89	49	129
	Weak	No	5	85	45	125	10	90	50	130
6d/8d Mix @ 6 in/6 in	None	No	11	91	51	131	16	96	56	136
		Yes	12	92	52	132	17	97	57	137
	Standard	No	13	93	53	133	18	98	58	138
	SFBC 1994	Yes	14	94	54	134	19	99	59	139
	Weak	No	15	95	55	135	20	100	60	140
8d @ 6 in/12 in	None	No	21	101	61	141	26	106	66	146
		Yes	22	102	62	142	27	107	67	147
	Standard	No	23	103	63	143	28	108	68	148
	SFBC 1994	Yes	24	104	64	144	29	109	69	149
	Weak	No	25	105	65	145	30	110	70	150
8d @ 6 in/6 in	None	No	31	111	71	151	36	116	76	156
		Yes	32	112	72	152	37	117	77	157
	Standard	No	33	113	73	153	38	118	78	158
	SFBC 1994	Yes	34	114	74	154	39	119	79	159
	Weak	No	35	115	75	155	40	120	80	160

Number indicates Hazus-assigned WBID

Roof Type: G = Gable, H = Hip; SWR = Secondary Water Resistance

As shown in Table 2.1, the mitigation options available within Hazus for wind hazard mitigation are: 1) roof decks may be mitigated by increasing nail size (i.e. 6d to 8d), decreasing nail spacing from 6 in./12 in. (edge/field nailing spacing) to 6 in./6 in., or a combination of nail size and spacing; 2) roof-wall connections may be mitigated by using straps instead of toe-nail connections; 3) water intrusion resulting from loss of roof cover may be mitigated through the application of secondary water resistance (SWR), which covers the spaces between roof sheathing panels to prevent water penetration through the roof; 4) windows may be mitigated with the use of shutters; and 5) garage doors may be mitigated through the use of a reinforced door in compliance with the South Florida Building Code (SFBC) 1994). From Table 2.1, the most vulnerable building configuration is WBID6 – a building with a gable roof, toe-nail roof-wall connection, no SWR, no shutters, no garage door, and 6d @ 6 in./12 in. roof nails. The most robust building configuration is WBID154 – a building with a hip roof, strap roof-wall connection, SWR, shutters, SFBC 1994 reinforced garage door, and 8d @ 6 in./6 in. roof nails.

Within the Hazus loss functions, economic loss functions representing building, contents, and loss of use for each of the building configurations within Hazus are separately represented as a function of peak gust wind speed. Building loss is expressed as a ratio of the estimated repair or replacement cost to total building value and thus ranges between zero and one. Contents loss also ranges between zero and one and represents the damage to the interior of the building, expressed as a ratio of the content value, which is assumed to be 50% of the building value. Building loss of use functions represent an estimate of the median time (in days) for cleanup, recovery and repair time, and temporary lodging required in terms of days. Lost days are converted to relative building value using a rent-price ratio, defined as the monthly rent divided by the building purchase price. Generally, rent-price ratios range from 0.8% to 1.5%, depending on a number of factors. For this chapter, the assumption made by Amoroso and Fennell (2008) was adopted that one year of rent

is equivalent to one-seventh of the building value, an equivalent rent-price ratio of approximately 1.2%. All loss functions represent direct economic losses and do not consider indirect economic losses.

Economic loss functions are provided within Hazus-MH for five terrain classifications, corresponding to surface roughness (z_0) of 0.03, 0.15, 0.35, 0.70, 1.00 m. For the 160 WSF1 building configurations, there are 3 loss functions for each of the 5 terrain classifications, yielding 2,400 economic loss functions. For this chapter, the open terrain loss functions (z_0 = 0.03 m) were used in simulation. Thus, 480 loss functions were used that describe economic loss associated with building, contents and loss of use for the 160 building configurations shown in Table 2.1.

2.3.3 Expected Annual Total Loss (EAL_T)

Expected annual loss is a parameter to evaluate long-term risk from a probabilistic standpoint (Huang et al., 2001a, 2001b; Torkian et al., 2013; Unanwa et al., 2000) and is calculated by convolving the continuous loss curve and continuous probability density function for annual wind maxima (Amoroso & Fennell, 2008b; Bjarnadottir et al., 2011; Li, 2012; Li & Ellingwood, 2006), where $E[L]$ is the expected loss, $f_V\ (v)$ is the probability density function (PDF) of wind maxima, and $L(v)$ is the loss curve as a function of wind speed, v (Equation 2.5).

$$E[L] = \int_0^\infty f_V\ (v)L(v)dv \qquad (2.5)$$

Monte Carlo simulation is used to implement the loss estimation framework to account for wind speed uncertainty and ensure stability of results. When implemented over multiple iterations, the mean and median of the datasets converge toward the true average. The number of Monte Carlo iterations required is based on convergence of the simulation by monitoring averages and variances. For each iteration, a random number between zero and one is generated and used as input in the inverse of the wind speed CDF to calculate the annual extreme wind speed for each year. The annual wind speed maxima are then used as input for the building vulnerability functions

to calculate the loss for each iteration year. Economic loss functions are reported at 5 mph intervals; therefore, linear interpolation is used to calculate loss for intermediate wind speed values. Using Monte Carlo simulation over *N* iterations, the expected annual loss for each direct economic loss function (building, contents, and loss of use), EAL_j is expressed as a ratio of building value, content value, or loss of use in days, and is the summation of total losses divided by the number of iterations, *N*, where *i* is the iteration counter from 1 to *N*, $F_V(v)^{-1}[Ran(i)]$ is the inverse of the CDF of the wind speed for each iteration, *Ran(i)* is a random number between 0 and 1 with continuous uniform distribution, and $L_j(v_i)$ is the economic loss corresponding to annual extreme wind speed v_i for function type *j* (Equation 2.6).

$$EAL_j = \frac{1}{N}\sum_{\mathrm{i}=1}^{N} F_V\ (v)^{-1}[Ran(i)] \times L_j(v_i) \tag{2.6}$$

To calculate the total expected annual direct loss in monetary terms ($EAL_{T,D}$), the fractional EAL ratios for building (EAL_B), contents (EAL_C), and loss of use (EAL_U) are multiplied by building value (V_B), contents value (V_C), and loss of use in days (L_U), respectively, and summed (Equation 2.7). Considering the assumptions that content value is equal to 50% of building value, and the value of one year of rent is equivalent to one-seventh of the building value (Equation 2.8), the terms are expressed in terms of building value and EAL_T, as a ratio of building value, is determined (Equation 9). For a specific real estate market or because of post-event rent inflation, the rent-price ratio should be determined based on the relevant market and building value. For other rent-price ratios, EAL_T can be calculated using Equation 2.9 and the fractional EAL ratios for building, contents, and loss of use found Tables 2.4 to 2.6.

$$EAL_{T,D} = EAL_B * V_B + EAL_C * V_c + EAL_U * L_U \tag{2.7}$$

$$EAL_{T,D} = \ (EAL_B + \frac{1}{2}EAL_C + \frac{1}{365*7}EAL_U)V_B \tag{2.8}$$

$$EAL_T = \ EAL_B + \frac{1}{2}EAL_C + \frac{1}{365*7}EAL_U \tag{2.9}$$

2.4 Results

2.4.1 Wind Speed Parameters

To represent the wind speed distribution for the continental United States, peak gust wind speeds were obtained from the ATC "Windspeed by Location" website (www.windspeed.atcouncil.org) corresponding with ASCE/SEI 7 (ASCE 2010) open terrain Occupancy Category II 3-second peak gust wind speed contours with an approximate mean recurrence interval (MRI) of 700 years. The highest wind speed contours (i.e., 160 – 180 mph) are present only in portions of Florida, Louisiana, Mississippi, and Alabama, while 700-year wind speeds of 120 – 150 mph are found along the Gulf and Atlantic Coasts. Interior locations of the continental U.S. have a 700-year wind speed of 115 mph, and west coast states of Washington, Oregon, and California have a 700-year wind speed of 110 mph.

Wind speeds were queried for seven return periods (10, 25, 50, 100, 300, 700, 1700 year MRI) from the website at locations corresponding to the ASCE 7 700-year wind speed contours. Along the contours, slight variations in wind speed with return period were found, although differences did not exceed 1-2 mph in most cases and the maximum difference observed for any return period was 6 mph. Table 2.2 provides generalized wind speed data corresponding to 10, 20, 25, 50, 100, 300 (ASCE 7-10 Risk Category I), 700 (ASCE 7-10 Risk Category II), and 1700 (ASCE 7-10 Risk Category III-IV) year mean recurrence intervals. Note that the 700-year wind speeds represent the Risk Category II contours found in ASCE 7-10. From these wind speeds and return intervals, the Gumbel parameters were calculated for each 700-year open terrain 3-second peak gust wind speed contour using Equation 2.4 (Table 2.3).

Table 2.2 Peak Gust Wind Speed (mph) by Mean Recurrence Interval

Mean Recurrence Interval (MRI)	3-second peak gust wind speed (mph)								
10 years	72	76	76	76	77	81	84	89	88
25 years	79	84	85	90	92	99	104	113	113
50 years	85	90	94	100	103	112	117	127	128
100 years	91	96	101	109	113	123	130	140	146
RC I (300 years)	100	105	112	120	130	140	148	158	165
RC II (700 years)	110	115	120	130	140	150	160	170	180
RC III (1700 years)	115	120	129	138	150	160	175	181	193

Risk Categories (RC) correspond to approximate MRI: I – 300 years, II – 700 years, III – 1700 years

Table 2.3 Calculated Gumbel Parameters

Gumbel Distribution Parameters	700-year open terrain 3-second gust wind speed, mph								
	110	115	120	130	140	150	160	170	180
μ	51.53	55.796	52.635	51.454	46.044	49.703	47.328	55.025	46.97
σ	8.6348	8.7581	10.333	11.942	14.31	15.329	17.393	17.575	20.284

2.4.2 Expected Annual Total Loss (EAL_T)

The primary result of this analysis is the expected annual total loss (EALT), which is an estimate of the combined direct economic losses for building, contents, and loss of use, expressed as ratio of the building value. EAL_T's were calculated for all 160 Hazus WSF1 building types for the 700-year MRI peak gust wind speed contours provided within ASCE 7-10 for the continental U.S. To determine the number of Monte Carlo iterations required, a test of convergence was performed for 100 simulations, with the results provided in Figure 2.2. Figure 2.2 (a) shows an example of the average value of expected loss for three of the 100 simulations to show variation detail. Around 50,000 iterations, the average values become more stable and the individual simulation averages become closer. Figure 2.2 (b) shows the variance of the average expected loss value in the 100 simulations for an example using the 180 mph wind speed contour. The variance of the average also stabilizes and approaches zero around 50,000 iterations. Based on this evaluation, 50,000 iterations were performed for all Monte Carlo simulation.

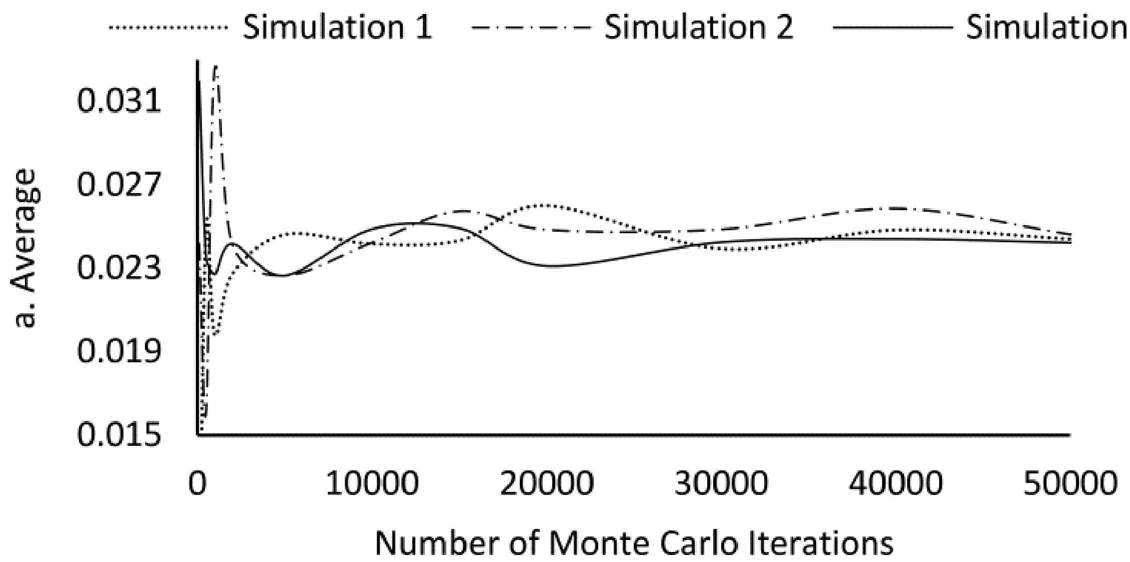


Figure 2.2 Computational Monte Carlo Convergence (a) Average Value of Expected Loss in Three Simulations and (b) Variance of the Average Expected Loss Value in 100 Simulations

EAL_T results are provided in Table 2.4 by WBID and Appendix A contains corresponding values for EAL_B, EAL_C, EAL_U, representing fractional building, contents, and loss of use economic losses for each WBID. Appendix B contains standard deviation values for EAL_B, EAL_C, EAL_U, and EAL_T. The results provided in Table 2.4 were calculated from the Appendix tables (without truncation) using Equation 2.9.

Table 2.4 Total Expected Annual Loss, EAL_T, as a Ratio of Building Value (10^{-2})

ID	700-year open terrain 3-second gust wind speed, mph								
	110	115	120	130	140	150	160	170	180
1	0.239	0.394	0.478	0.763	0.991	1.696	2.385	3.718	3.883
2	0.229	0.362	0.422	0.615	0.789	1.274	1.727	2.653	2.880
3	0.180	0.297	0.401	0.645	0.895	1.534	2.185	3.436	3.628
4	0.165	0.254	0.318	0.492	0.612	1.022	1.409	2.245	2.347
5	0.233	0.394	0.496	0.783	1.067	1.707	2.506	3.778	4.166
6	0.270	0.454	0.570	0.895	1.216	2.005	2.815	4.275	4.453
7	0.221	0.368	0.431	0.609	0.809	1.306	1.761	2.871	3.013
8	0.218	0.350	0.475	0.800	1.168	2.002	2.758	4.349	4.659
9	0.158	0.253	0.318	0.510	0.690	1.124	1.518	2.439	2.609
10	0.387	0.615	0.873	1.463	1.968	3.243	4.225	6.810	6.725
11	0.101	0.160	0.249	0.406	0.599	1.089	1.543	2.440	2.719
12	0.073	0.124	0.150	0.210	0.300	0.493	0.702	1.126	1.213
13	0.078	0.135	0.219	0.382	0.595	1.032	1.598	2.449	2.837
14	0.056	0.094	0.121	0.175	0.260	0.443	0.614	0.993	1.082
15	0.080	0.146	0.219	0.369	0.577	1.065	1.602	2.433	2.769
16	0.122	0.218	0.314	0.565	0.912	1.495	2.168	3.395	3.708
17	0.078	0.129	0.161	0.265	0.384	0.660	0.924	1.596	1.710
18	0.127	0.197	0.349	0.632	0.953	1.678	2.285	3.733	4.078
19	0.057	0.103	0.138	0.221	0.349	0.600	0.874	1.460	1.668
20	0.123	0.218	0.353	0.579	0.941	1.573	2.449	3.741	4.099
21	0.227	0.351	0.425	0.646	0.940	1.445	2.039	3.314	3.412
22	0.199	0.325	0.370	0.532	0.656	1.060	1.403	2.145	2.280
23	0.175	0.285	0.372	0.593	0.849	1.354	1.924	3.106	3.323
24	0.152	0.245	0.294	0.415	0.536	0.893	1.188	1.919	2.073
25	0.220	0.349	0.442	0.672	0.929	1.544	2.132	3.355	3.613
26	0.252	0.423	0.547	0.829	1.157	1.879	2.629	4.158	4.362
27	0.214	0.332	0.388	0.545	0.706	1.172	1.603	2.474	2.651
28	0.213	0.356	0.469	0.791	1.098	1.897	2.678	4.190	4.513
29	0.148	0.257	0.306	0.474	0.615	1.014	1.449	2.233	2.410
30	0.373	0.650	0.940	1.492	1.987	3.247	4.235	6.775	6.803
31	0.093	0.153	0.224	0.387	0.616	1.032	1.487	2.394	2.670
32	0.074	0.122	0.149	0.224	0.304	0.501	0.711	1.104	1.268
33	0.083	0.144	0.201	0.367	0.620	1.080	1.571	2.510	2.795
34	0.054	0.093	0.118	0.178	0.252	0.446	0.599	0.992	1.182
35	0.088	0.147	0.216	0.390	0.634	1.020	1.516	2.492	2.734
36	0.128	0.226	0.337	0.581	0.858	1.440	2.158	3.364	3.653
37	0.078	0.128	0.167	0.268	0.369	0.623	0.969	1.549	1.740
38	0.115	0.211	0.335	0.600	0.984	1.588	2.367	3.827	4.177
39	0.062	0.103	0.142	0.231	0.344	0.567	0.894	1.457	1.575
40	0.126	0.221	0.336	0.622	0.905	1.559	2.322	3.785	4.054
41	0.218	0.353	0.439	0.654	0.872	1.473	2.026	3.275	3.521
42	0.198	0.311	0.354	0.493	0.635	0.980	1.328	2.175	2.228

Table 2.4 Total Expected Annual Loss, EAL_T, as a Ratio of Building Value (10^{-2}) (Continued)

ID	700-year open terrain 3-second gust wind speed, mph								
	110	115	120	130	140	150	160	170	180
43	0.165	0.271	0.345	0.554	0.766	1.330	1.897	3.084	3.354
44	0.139	0.215	0.251	0.363	0.443	0.775	1.085	1.700	1.807
45	0.222	0.339	0.458	0.699	0.919	1.572	2.253	3.631	3.838
46	0.259	0.403	0.518	0.794	1.118	1.849	2.508	3.903	4.142
47	0.198	0.319	0.369	0.496	0.658	1.104	1.462	2.363	2.446
48	0.196	0.320	0.462	0.743	1.076	1.755	2.458	4.026	4.317
49	0.141	0.221	0.258	0.390	0.508	0.845	1.245	1.952	2.065
50	0.368	0.629	0.858	1.409	1.988	3.222	4.172	6.545	6.617
51	0.097	0.146	0.221	0.377	0.583	1.034	1.432	2.305	2.567
52	0.069	0.113	0.128	0.177	0.226	0.362	0.480	0.762	0.859
53	0.078	0.131	0.203	0.363	0.574	0.977	1.555	2.397	2.710
54	0.053	0.085	0.103	0.151	0.197	0.318	0.450	0.737	0.820
55	0.086	0.142	0.195	0.344	0.590	1.000	1.547	2.374	2.789
56	0.124	0.222	0.316	0.546	0.862	1.424	2.115	3.340	3.574
57	0.072	0.120	0.149	0.239	0.327	0.530	0.760	1.288	1.496
58	0.116	0.202	0.338	0.583	0.972	1.635	2.322	3.626	3.998
59	0.056	0.096	0.121	0.198	0.302	0.491	0.767	1.274	1.498
60	0.116	0.215	0.335	0.584	1.014	1.627	2.344	3.733	3.968
61	0.192	0.311	0.355	0.538	0.697	1.204	1.689	2.634	2.874
62	0.169	0.263	0.271	0.336	0.380	0.557	0.707	1.098	1.130
63	0.151	0.246	0.308	0.491	0.704	1.207	1.597	2.549	2.915
64	0.126	0.196	0.200	0.259	0.310	0.488	0.642	1.000	1.043
65	0.189	0.310	0.390	0.578	0.816	1.310	1.848	2.916	3.150
66	0.229	0.362	0.454	0.734	0.998	1.659	2.266	3.638	3.871
67	0.177	0.279	0.284	0.375	0.447	0.740	1.002	1.509	1.747
68	0.190	0.314	0.409	0.668	0.999	1.791	2.402	3.789	4.106
69	0.127	0.201	0.219	0.318	0.398	0.695	0.963	1.537	1.663
70	0.361	0.618	0.871	1.385	1.890	3.142	4.147	6.505	6.531
71	0.094	0.157	0.223	0.360	0.574	0.950	1.459	2.319	2.570
72	0.069	0.110	0.133	0.178	0.221	0.341	0.488	0.761	0.825
73	0.085	0.136	0.198	0.362	0.570	1.017	1.516	2.390	2.668
74	0.053	0.083	0.101	0.144	0.182	0.320	0.430	0.696	0.773
75	0.083	0.135	0.211	0.364	0.557	1.011	1.494	2.440	2.690
76	0.134	0.213	0.333	0.581	0.867	1.398	2.147	3.197	3.587
77	0.074	0.118	0.152	0.224	0.307	0.525	0.768	1.265	1.439
78	0.108	0.203	0.336	0.581	0.871	1.647	2.371	3.607	4.035
79	0.058	0.090	0.121	0.199	0.292	0.527	0.756	1.223	1.446
80	0.137	0.212	0.325	0.595	0.907	1.569	2.332	3.717	3.907
81	0.207	0.322	0.408	0.614	0.843	1.401	1.961	3.043	3.308
82	0.181	0.297	0.350	0.495	0.632	1.033	1.356	2.191	2.364
83	0.153	0.253	0.325	0.549	0.754	1.235	1.884	3.002	3.133
84	0.134	0.228	0.278	0.410	0.529	0.904	1.192	1.880	1.987

Table 2.4 Total Expected Annual Loss, EAL_T, as a Ratio of Building Value (10^{-2}) (Continued)

ID	700-year open terrain 3-second gust wind speed, mph								
	110	115	120	130	140	150	160	170	180
85	0.193	0.321	0.407	0.638	0.900	1.526	2.074	3.349	3.491
86	0.212	0.357	0.447	0.695	0.933	1.557	2.248	3.473	3.697
87	0.182	0.301	0.347	0.527	0.670	1.074	1.447	2.288	2.325
88	0.166	0.268	0.371	0.607	0.898	1.545	2.185	3.433	3.711
89	0.138	0.228	0.268	0.414	0.578	0.932	1.288	2.070	2.230
90	0.212	0.378	0.514	0.819	1.178	2.035	2.777	4.410	4.714
91	0.073	0.126	0.179	0.314	0.525	0.915	1.305	2.110	2.377
92	0.056	0.096	0.127	0.197	0.276	0.459	0.637	0.979	1.124
93	0.069	0.106	0.193	0.329	0.510	0.924	1.320	2.171	2.515
94	0.046	0.075	0.099	0.172	0.248	0.430	0.564	0.943	1.074
95	0.065	0.108	0.168	0.342	0.515	0.907	1.319	2.182	2.450
96	0.093	0.152	0.235	0.458	0.681	1.163	1.669	2.813	3.084
97	0.059	0.097	0.131	0.213	0.300	0.507	0.707	1.190	1.321
98	0.084	0.141	0.219	0.460	0.698	1.247	1.807	2.940	3.264
99	0.048	0.075	0.111	0.181	0.276	0.486	0.712	1.172	1.312
100	0.075	0.140	0.228	0.420	0.685	1.268	1.839	2.934	3.230
101	0.193	0.315	0.377	0.591	0.824	1.333	1.900	2.856	3.112
102	0.180	0.286	0.342	0.484	0.623	0.977	1.282	2.026	2.114
103	0.147	0.251	0.316	0.525	0.740	1.219	1.730	2.760	3.081
104	0.136	0.216	0.269	0.417	0.525	0.848	1.161	1.849	1.959
105	0.181	0.302	0.419	0.616	0.839	1.375	1.869	3.011	3.215
106	0.201	0.347	0.434	0.685	0.946	1.516	2.165	3.411	3.625
107	0.186	0.291	0.354	0.502	0.650	1.024	1.380	2.194	2.275
108	0.159	0.263	0.368	0.620	0.918	1.543	2.134	3.417	3.640
109	0.137	0.220	0.278	0.402	0.547	0.918	1.292	2.026	2.174
110	0.230	0.365	0.492	0.808	1.201	2.035	2.835	4.402	4.725
111	0.076	0.128	0.195	0.355	0.517	0.909	1.323	2.144	2.405
112	0.057	0.097	0.126	0.201	0.272	0.456	0.651	1.017	1.131
113	0.064	0.111	0.170	0.333	0.487	0.913	1.302	2.169	2.443
114	0.044	0.076	0.109	0.177	0.247	0.418	0.614	0.908	1.082
115	0.063	0.112	0.172	0.327	0.481	0.879	1.328	2.147	2.400
116	0.088	0.152	0.223	0.433	0.680	1.163	1.694	2.786	3.065
117	0.059	0.101	0.137	0.215	0.311	0.519	0.764	1.176	1.366
118	0.074	0.140	0.230	0.416	0.733	1.173	1.877	2.888	3.182
119	0.044	0.080	0.111	0.171	0.280	0.500	0.719	1.175	1.330
120	0.081	0.132	0.225	0.425	0.720	1.221	1.791	2.970	3.259
121	0.185	0.295	0.355	0.533	0.724	1.168	1.707	2.694	2.858
122	0.161	0.257	0.284	0.386	0.445	0.725	0.955	1.522	1.647
123	0.137	0.224	0.298	0.464	0.637	1.139	1.665	2.556	2.776
124	0.118	0.190	0.213	0.291	0.370	0.606	0.811	1.296	1.406
125	0.177	0.283	0.371	0.573	0.805	1.346	1.820	2.968	3.225
126	0.189	0.311	0.382	0.598	0.812	1.347	1.906	3.044	3.321

Table 2.4 Total Expected Annual Loss, EAL_T, as a Ratio of Building Value (10^{-2}) (Continued)

ID	700-year open terrain 3-second gust wind speed, mph								
	110	115	120	130	140	150	160	170	180
127	0.165	0.263	0.295	0.396	0.476	0.781	1.014	1.585	1.690
128	0.155	0.242	0.346	0.539	0.803	1.406	1.947	3.212	3.462
129	0.117	0.191	0.212	0.308	0.384	0.638	0.922	1.456	1.558
130	0.211	0.337	0.495	0.805	1.140	1.980	2.604	4.303	4.386
131	0.071	0.123	0.165	0.323	0.476	0.843	1.270	1.981	2.281
132	0.056	0.089	0.111	0.164	0.216	0.339	0.475	0.737	0.775
133	0.069	0.117	0.178	0.281	0.506	0.861	1.304	2.078	2.304
134	0.042	0.068	0.089	0.135	0.193	0.309	0.425	0.697	0.770
135	0.060	0.110	0.164	0.322	0.485	0.888	1.322	2.067	2.296
136	0.083	0.142	0.229	0.389	0.650	1.086	1.655	2.595	2.949
137	0.053	0.094	0.123	0.191	0.247	0.430	0.598	0.952	1.094
138	0.074	0.142	0.233	0.409	0.698	1.199	1.825	2.837	3.202
139	0.043	0.072	0.100	0.159	0.234	0.393	0.599	0.970	1.139
140	0.083	0.131	0.209	0.434	0.677	1.237	1.741	2.900	3.182
141	0.181	0.283	0.331	0.493	0.652	1.068	1.501	2.366	2.554
142	0.156	0.254	0.268	0.337	0.371	0.597	0.722	1.133	1.127
143	0.139	0.228	0.274	0.446	0.617	1.025	1.429	2.408	2.539
144	0.112	0.183	0.198	0.265	0.306	0.488	0.617	0.968	0.994
145	0.164	0.273	0.344	0.548	0.725	1.195	1.623	2.555	2.847
146	0.185	0.310	0.389	0.590	0.829	1.345	1.890	2.954	3.243
147	0.157	0.255	0.274	0.359	0.424	0.671	0.859	1.355	1.349
148	0.148	0.238	0.326	0.525	0.825	1.343	1.885	3.155	3.371
149	0.117	0.187	0.212	0.302	0.355	0.598	0.794	1.251	1.421
150	0.218	0.340	0.466	0.761	1.069	1.900	2.760	4.261	4.432
151	0.077	0.121	0.189	0.330	0.491	0.909	1.281	2.073	2.379
152	0.053	0.091	0.115	0.170	0.210	0.350	0.470	0.745	0.800
153	0.058	0.108	0.168	0.297	0.513	0.904	1.283	2.080	2.339
154	0.040	0.073	0.088	0.141	0.191	0.318	0.444	0.721	0.773
155	0.062	0.109	0.171	0.310	0.514	0.891	1.293	2.061	2.377
156	0.082	0.146	0.235	0.414	0.631	1.137	1.621	2.670	3.019
157	0.053	0.094	0.125	0.188	0.251	0.413	0.586	0.959	1.076
158	0.091	0.130	0.208	0.409	0.685	1.171	1.736	2.922	3.210
159	0.043	0.073	0.099	0.158	0.228	0.410	0.592	0.942	1.132
160	0.079	0.131	0.213	0.444	0.693	1.195	1.855	2.920	3.188

The loss calculation process is not linear and depends significantly on the inflection points in the individual loss functions. Therefore, calculation of EAL_T for intermediate wind speeds is not as straightforward as linear interpolation. The ratio of $EAL_{calculated}$ to $EAL_{interpolated}$ was investigated for all 160 WBID for the 10 mph contours, and was found to range between 0.80 to

1.28, without stabilization or trending with wind speed. As an example, the calculated EAL for WBID1 with a 145 mph 700-year 3-second gust is 0.0145 while linear interpolation of the 140 and 150 mph contour EAL_T yields 0.01343. Expected annual loss for WBID1 with a 125 mph 700-year 3-second gust is 0.00614, while linear interpolation of the 120 and 130 mph contour EAL_T yields 0.00620. Therefore, to apply the EAL_T result values to intermediate 700-year wind speeds, it is recommended that 1) the EAL_T associated with the upper contour be used (conservative approach); 2) linear interpolation be used with an acceptance of unknown interpolation error; or 3) threshold values can be calculated considering that $EAL_{calculated}$ / $EAL_{interpolated}$ was found to range between 0.80 to 1.28 for the entire set of results.

2.5 Example Applications

The applicability of the results are presented within the context of mitigation decision making, demonstrating the benefit of wind hazard mitigation, defined as the avoided loss that occurs through implementation of the mitigation activity. Table 2.8 provides annual losses for select WBID from Table 2.7 corresponding to single family homes with a gable roof with and without mitigation. WBID6 reflects the most vulnerability, consisting of a gable roof, toe-nail roof-wall connection, no SWR, no shutters, no garage door, and 6d @ 6 in./12 in. roof nails. Using this as a baseline, individual mitigation measures are considered separately - WBID7 window protection (shutters), WB36 larger nails at closer spacing, WBID1 straps instead of toe-nail roof-wall connections, WBID46 SWR at the roof sheathing joints, WBID9 reinforced garage door and window protection, and WBID74 all mitigation options.

Using WBID6 as the baseline building, absolute and relative decrease in loss for each wind speed contour are calculated to describe the benefit of each mitigation technique (Table 2.9). Relative decrease in loss is calculated as the absolute decrease in loss divided by the unmitigated state loss and expressed as a percentage.

Table 2.5 EAL_T Comparison for Different Mitigation Options by Wind Speed Contour (10^{-2})

Description	WBID	700-year open terrain 3-second gust wind speed, mph								
		110	115	120	130	140	150	160	170	180
Unmitigated Building	6	0.270	0.454	0.570	0.895	1.216	2.005	2.815	4.275	4.453
Install Shutters	7	0.221	0.368	0.431	0.609	0.809	1.306	1.761	2.871	3.013
Upgrade Roof Nailing	36	0.128	0.226	0.337	0.581	0.858	1.440	2.158	3.364	3.653
Upgrade Roof-Wall Connection	1	0.239	0.394	0.478	0.763	0.991	1.696	2.385	3.718	3.883
Apply Secondary Water Resistance	46	0.259	0.403	0.518	0.794	1.118	1.849	2.508	3.903	4.142
Install Reinforced Garage Door and Shutters	9	0.158	0.253	0.318	0.510	0.690	1.124	1.518	2.439	2.609
All Mitigation Options Above	74	0.053	0.083	0.101	0.144	0.182	0.320	0.430	0.696	0.773

Table 2.6 Decrease in Loss (10^{-2}), and Relative Decrease in Loss, %, Resulting from Mitigation Options by Wind Speed Contour

WBID	700-year open terrain 3-second gust wind speed, mph																	
	110	115	120	130	140	150	160	170	180	110	115	120	130	140	150	160	170	180
	Decrease in loss (10^{-2})									Relative Decrease in loss, %								
7	0.05	0.09	0.14	0.29	0.41	0.70	1.05	1.40	1.44	18.1	18.9	24.4	32.0	33.5	34.9	37.4	32.8	32.3
36	0.14	0.23	0.23	0.31	0.36	0.57	0.66	0.91	0.80	52.6	50.2	40.9	35.1	29.4	28.2	23.3	21.3	18
1	0.03	0.06	0.09	0.13	0.23	0.31	0.43	0.56	0.57	11.5	13.2	16.1	14.7	18.5	15.4	15.3	13.0	12.8
46	0.01	0.05	0.05	0.10	0.10	0.16	0.31	0.37	0.31	4.1	11.2	9.1	11.3	8.1	7.8	10.9	8.7	7.0
9	0.11	0.20	0.25	0.39	0.53	0.88	1.30	1.84	1.84	41.5	44.3	44.2	43.0	43.3	43.9	46.1	42.9	41.4
74	0.22	0.37	0.47	0.75	1.03	1.69	2.39	3.58	3.68	80.4	81.7	82.3	83.9	85.0	84.0	84.7	83.7	82.6

Based on this analysis, the following key findings for each mitigation measure are obtained:

- Installing shutters (WBID7) has a positive trend in relative loss reduction with increasing wind speed. Shutters provide 18% relative decrease in loss for the 110 mph contour and increase in effectiveness to nearly 37.5% at 160 mph contour. Although the initial investment of the mitigation is higher than other mitigation options, the effectiveness of the mitigation is more than others in high wind speed contours 160-180 mph, so installing shutters for openings is highly recommended in high wind hazard prone areas.
- Improving the roof sheathing nailing pattern (WBID36) has a negative trend in relative loss reduction with increasing wind speed. Increasing nail size from 6d to 8d and changing the roof sheathing nailing pattern from 6 in./12 in. to 6 in./6 in. provides a significant relative decrease in loss of almost 53% at 110 mph, 41% at 120 mph, and 30% at 140 mph. This mitigation is economically advantageous to owners, especially for new construction, as significant benefits can be obtained for a small additional initial investment just by adding hundreds more nails over the building.
- Upgrading the roof-wall connection (WBID1) has a generally positive trend in relative loss reduction with wind speed from 110 mph to 140 mph, followed by a negative trend to 180 mph. Installing hurricane straps instead of toe-nails results in an 11.5% relative decrease in loss for the 110 mph contour, reaching its maximum of 18.5% at 140 mph, then decreasing to 12.8% at 180 mph.
- Applying secondary water resistance (WBID46) has an overall slightly positive trend in relative loss reduction with wind speed, although there is not a consistent relationship. Protecting the roof sheathing joints provides a 4.1% relative decrease in loss for the 110 mph contour, with maximum relative loss reduction of 11.3% for 130 mph. While the relative loss

reduction for this mitigation is low, its very low cost (less than $500 additional investment) may make it a worthwhile investment for owners and decision makers when installing a new or replacement roof.

- Installing both shutters and a reinforced garage door (WBID9) has a nearly constant trend in relative loss reduction with wind speed, with relative loss reductions ranging between 41.4% (180 mph) and 46.1% (160 mph), with an average of 43.5%.
- Applying all five mitigation options (WBID74) has a positive trend in relative loss reduction with wind speed from 110 mph to 140 mph, followed by a constant maximum relative loss reduction for 140-160 mph (approximately 84%) and a negative trend to 180 mph (82.6%). All mitigation options are highly effective at reducing relative losses, with an average of 83.2% relative loss reduction; however, the high cost of all mitigation should be compared against the potential benefit to assess the overall economic benefit. For new construction, where mitigation may be economized by optimizing initial construction costs, and for buildings with a long useful life, the reduction in EAL over the building life may provide a positive economic return on the mitigation investment.
- Considering only the relative decrease in loss for the individual mitigation options, the effectiveness of mitigation by wind speed contours are:
    - For wind speed contours 110-120 mph, upgrading the nailing pattern results in the largest relative loss reduction (average 50.6%), followed by installing a reinforced garage door and shutters (average 43.3%). Installing shutters is the third most effective mitigation option, but it is noted that relative loss reduction drops sharply by not upgrading the garage door, to an average of 20.5%.
    - For wind speed contours 130-180 mph, the largest relative loss reduction is achieved by installing a reinforced garage door and shutters (average 43.4%), followed by

installing shutters only (average 33.8%), except for 130 mph, where upgrading the nailing pattern ranks second. The effectiveness of upgrading the roof nailing pattern ranks third, with average relative decrease in loss of 24.6%.

Note that the effectiveness of these options reflects only relative loss reduction, and does not consider mitigation cost and investment payback considerations, which are vital for determination of the most economically viable solution. For low wind speed contours, although a large relative reduction may be achieved with mitigation measures, the use of mitigation may not be entirely justified because the magnitude of losses is low. Similarly, for high wind speed contours, small relative reductions in losses may translate to large economic savings because the magnitude of losses is high. Additional information regarding cost of mitigation and calculation of benefit-cost ratios are required to fully assist the decision maker.

2.6 Summary and Conclusions

This chapter presented a probabilistic methodology to quantitatively model the total expected annual loss (EAL) as a risk-based assessment parameter. The model is applied to the 160 generalized single-story, wood framed, single family dwellings within FEMA's Hazus-MH Hurricane Model in open terrain. Extreme value annual wind maxima are calculated for each wind contour within ASCE 7-10 using the Gumbel distribution and convolved with Hazus-MH economic loss functions. Monte Carlo simulation is used to obtain the mean, or expected annual loss for building, contents, loss of use, and total loss, expressed as a ratio of the building value. A significant feature of the proposed methodology is the ability to calculate the generalized benefit of wind mitigation for each type of building across geographic areas. Important contributions of the study are:

- Calculation of wind hazard EAL for generalized building types across geographic areas is addressed, allowing evaluation of annual loss based on building characteristics and location.

- The economic benefit (i.e., avoided loss) of wind mitigation can be directly evaluated, facilitating mitigation decision making.
- Utilization of tabular results allows efficient communication of risk-based economic loss information to decision makers, insurance companies, and governmental agencies regarding the effectiveness of mitigation techniques

CHAPTER 3: INFLUENCE OF TERRAIN ON EXPECTED ANNUAL WINDSTORM LOSSES FOR ONE-STORY, WOOD-FRAMED, SINGLE FAMILY HOMES

3.1 Introduction

Wind hazards are responsible for the majority of natural hazard losses (Emanuel et al., 2006; Emanuel et al., 2008; Knutson et al., 2010; Lin et al., 2012; Lin et al., 2010), and are among the most deadly hazards in the United States (Wang & Rosowsky, 2012). As a result of increasing windstorm frequency and intensity (NSB, 2007; Rosenzweig & Solecki, 2014) and the inherent uncertainty of future events (Pita et al., 2014; Rosenzweig & Solecki, 2014), many damage and loss models have been developed to assess wind hazard risk (e.g. Heneka & Ruck, 2008; Huang et al., 2001b; Khanduri & Morrow, 2003; Li & Ellingwood, 2006; Li & van de Lindt, 2012; Pinelli et al., 2004; Pita et al., 2013b; Powell et al., 2005; Rosowsky & Ellingwood, 2002; Vickery et al., 2006b). Many of these models consider damage and loss as a function of basic wind speed in open terrain (e.g. Heneka & Ruck, 2008; Huang et al., 2001b; Li & Ellingwood, 2006); however surface roughness is a critical component in surface wind speed (Panofsky & Townsend, 1964; Wieringa, 1986) and winds loads and associated damage and loss are very strongly dependent on the actual terrain (Powell et al., 2005; Vickery et al., 2006a; Vickery et al., 2006b). Therefore, one of the most important factors in estimation of wind-induced loss and risk assessment is surface roughness.

Existing literature typically does not address the variation in loss due to changes in terrain, and presents theoretical loss estimation methodologies illustrated with an example in a specific place. As examples, Li and van de Lindt (2012) developed a loss-based formulation to calculate the risk to residential building in Charleston, South Carolina; Pan (2011) proposed an approach to estimating economic losses and focused on Houston-Galveston, Texas; Bjarnadottir et al. (2011) presented a probabilistic risk assessment framework for residential buildings through various scenarios of maximum wind speed for a case study in Miami-Dade, Florida; Huang et al. (2001a)

expanded event-based hurricane simulation techniques theoretically to evaluate hazard risk, and demonstrated the application of methodology by considering residential construction in South Carolina.

In fact, few loss models address terrain in a flexible manner, which is needed to extend the methodology developed in Chapter 2 to any surface roughness. In addition to a terrain-constrained approach, other limitations of existing models include evaluation of limited geographical areas (e.g. Pinelli et al., 2008; Torkian et al., 2013; Vickery et al., 2006b), specific building classes (e.g. Amoroso & Fennell, 2008b), and event-based results (e.g. Huang et al., 2001a). To address these latter issues, Chapter 2 proposed a probabilistic wind loss framework to quantify total direct expected annual loss (EAL_T) for wood framed, one-story, single family homes (WSF1) contained within FEMA's Hazus-MH Hurricane Model (FEMA, 2012b) for the continental United States, evaluated at each ASCE 7-10 (American Society Civil Engineers ASCE, 2010) peak gust wind speed contour in open terrain.

This chapter expands the methodology presented in Chapter 2 by addressing non-open terrain loss functions within Hazus-MH and presents a methodology to calculate EAL_T for any WSF1 in any location in the continental U.S. with any surface roughness. A reference non-open terrain is considered, and maximum open terrain wind speeds are converted to reference non-open terrain (local) wind speeds using a hurricane boundary model. Monte Carlo simulation is used to obtain the expected annual loss for reference non-open terrain (EAL_{TR}). The relationship between surface roughness and EAL_{TR} is then examined to define terrain influence factors (TIF) to calculate EAL_T for any interested surface roughness. The methodology and results of this chapter support the integration of risk assessment that can be easily applied to consumer-level decision making and allows rapid estimation of the expected annual loss at any location with any surface roughness.

3.2 Effect of Terrain on Local Wind Speed

While the gradient wind speed is considered a constant above the gradient wind height, the surface boundary layer is significantly affected by frictional forces near the earth's surface. Ground surface roughness is expressed in terms of roughness length parameter z_0, which is approximately one-tenth the height of upwind terrain roughness elements. The local wind speed experienced near the ground is a function of the measurement height and surface roughness, with smoother terrain (e.g., open terrain) resulting in faster local wind speed and rougher terrain (e.g., heavily treed and urban terrain) resulting in slower local wind speed (Figure 3.1). Because individual buildings experience the local wind speed, the application of loss functions, which are often given as a function of open terrain wind speed, must be adjusted to account for the local surface roughness characteristics.

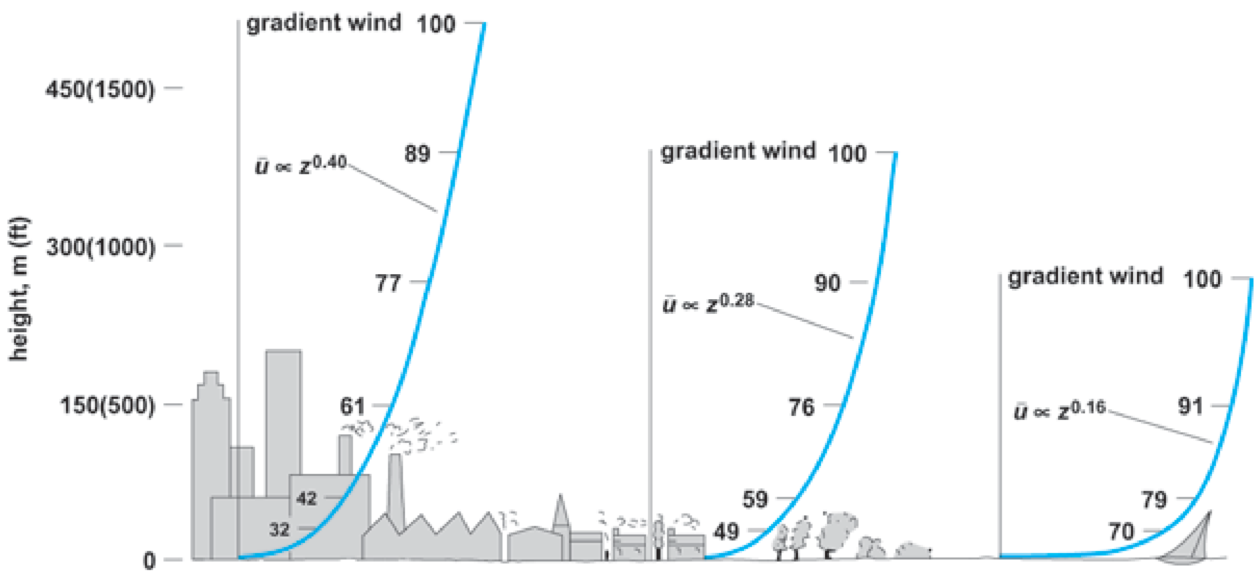


Figure 3.1 Graphical Depiction of the Effects of Surface Roughness on Wind Speed by Height (http://septiankmasdi.files.wordpress.com/2012/05/profil-kecepatan.gif)

To convert open terrain wind speed to local wind speed, two approaches are considered – the power law and the log law. The power law wind shear model (Equation 3.1) is an empirically developed model that has been found to be quite accurate and is often used (DeMarrais, 1959; Hsu

et al., 1994), where z and z_g are the target and reference heights, respectively; u_z and u_{z_g} are the target and reference height wind speeds, respectively, and α is an empirical exponent.

$$\frac{u_z}{u_{z_g}} = (\frac{z}{z_g})^{\alpha} \tag{3.1}$$

The gradient height varies based on surface roughness (Vickery et al., 2000); however, gradient wind speed is constant, independent of surface roughness (Munro & Oke, 1975). Calculating wind speed based on the power law considering a constant wind at the gradient height yields Equation 3.2, where u_{z_1} and u_{z_i} represent wind speed in open terrain and terrain i; z_1 and z_i represent the surface roughness of open terrain and terrain i; z_{g_1} and z_{g_i} represent the gradient height for open terrain and terrain i; and α_1 and α_i are empirical exponents for open terrain and terrain i.

$$u_{z_i} = (\frac{z_{g_1}}{z_1})^{\alpha_1} \times u_{z_1} / (\frac{z_{g_i}}{z_i})^{\alpha_i} \tag{3.2}$$

To achieve a reasonable approximation of Equation 3.2, the empirical exponent α and gradient height z_g as defined in in ASCE 7-10 are calculated (Equations 3.3 and 3.4), where c_1 and c_2 are 5.65 (6.62) and 450 (1273), respectively if the units are in meters (feet). Within the Hazus-MH Model, five terrain classifications are defined: open terrain, z_0 = 0.03 m; light suburban terrain, z_0 = 0.15 m; suburban terrain, z_0 = 0.35 m; light tree terrain, z_0 = 0.7 m; and treed terrain, z_0 = 1.0 m. For these terrain classifications, the values of reference height and α are provided in Table 3.1.

$$\alpha = c_1 {z_0}^{-0.1333} \tag{3.3}$$

$$z_g = c_2 {z_0}^{0.125} \tag{3.4}$$

Table 3.1 Calculated Empirical Exponent α and Gradient Height z_g for the Given Hazus-MH Surface Roughness Values

Terrain ID	Description	z_0 (m)	z_g (m)	α	1/α
T1	Open	0.03	290.304	9.007231	0.111
T2	Light Suburban	0.15	354.996	7.271572	0.138
T3	Suburban	0.35	394.658	6.496619	0.154
T4	Light Trees	0.7	430.378	5.924482	0.169
T5	Trees	1	450.000	5.65	0.177

The log law wind profile is a semi-empirical model (Equation 3.5), where k is the dimensionless von-Karman constant (0.4), u_* is the shear velocity (m/s), z is the observational height (m), and z_0 is the surface roughness (m). Shear velocity is related to the surface shear stress (Equation 3.6), where C_d is the surface drag coefficient and U_{10} is the wind speed at a height of 10 m. From Equation 3.6, u_* is calculated in terms of 10-meter wind speed (Equation 3.7), and drag coefficients for the five Hazus terrain categories were determined through least squares fitting of wind speed ratios (local wind speed/open terrain wind speed) as a function of surface roughness data from Hazus (FEMA, 2012b). Using Equation 3.5, Table 3.2 presents the terrain-adjusted 10-meter peak gust local wind speeds for terrains T2-T5 corresponding with open terrain wind speed in 5-mph increments. From Table 3.2, the ratio of local wind speed to open terrain wind speed ranges from 0.88 (T2) to 0.71 (T5), demonstrating a significant reduction in wind speed with increasing surface roughness. Based on data presented in (FEMA, 2012b), the log law was chosen due to better fit with Hazus-MH wind speed data.

$$U_z = \frac{u_*}{K} \ln \frac{Z}{Z_0} \quad (3.5)$$

$$\tau = \rho u_*^2 = \rho C_d U_{10}^2 \quad (3.6)$$

$$u_* = U_{10}\sqrt{C_d} \quad (3.7)$$

Table 3.2 Terrain-Adjusted (Local) 10-Meter Peak Gust Wind Speed (mph) for Terrains T_2-T_5 and Corresponding Open Terrain (T_1) Calculated Using Power and Log Laws

T 1	Power law				Log law			
	T 2	T 3	T 4	T 5	T 2	T 3	T 4	T 5
50	44.4	41.3	38.5	37.0	44.4	40.8	37.3	35.6
55	48.8	45.4	42.3	40.7	48.9	44.9	41.1	39.2
60	53.3	49.5	46.2	44.5	53.3	49.0	44.8	42.7
65	57.7	53.6	50.0	48.2	57.8	53.0	48.5	46.3
70	62.2	57.8	53.9	51.9	62.2	57.1	52.3	49.9
75	66.6	61.9	57.7	55.6	66.7	61.2	56.0	53.4
80	71.0	66.0	61.6	59.3	71.1	65.3	59.7	57.0
85	75.5	70.1	65.4	63.0	75.5	69.4	63.5	60.6
90	79.9	74.3	69.3	66.7	80.0	73.4	67.2	64.1
95	84.4	78.4	73.1	70.4	84.4	77.5	70.9	67.7
100	88.8	82.5	77.0	74.1	88.9	81.6	74.7	71.2
105	93.2	86.6	80.8	77.8	93.3	85.7	78.4	74.8
110	97.7	90.8	84.7	81.5	97.8	89.8	82.1	78.4
115	102.1	94.9	88.5	85.2	102.2	93.9	85.9	81.9
120	106.6	99.0	92.4	88.9	106.7	97.9	89.6	85.5
125	111.0	103.1	96.2	92.6	111.1	102.0	93.3	89.1
130	115.4	107.3	100.0	96.3	115.5	106.1	97.1	92.6
135	119.9	111.4	103.9	100.0	120.0	110.2	100.8	96.2
140	124.3	115.5	107.7	103.7	124.4	114.3	104.5	99.7
145	128.8	119.7	111.6	107.4	128.9	118.3	108.3	103.3
150	133.2	123.8	115.4	111.1	133.3	122.4	112.0	106.9
155	137.7	127.9	119.3	114.8	137.8	126.5	115.7	110.4
160	142.1	132.0	123.1	118.5	142.2	130.6	119.5	114.0
165	146.5	136.2	127.0	122.2	146.7	134.7	123.2	117.5
170	151.0	140.3	130.8	126.0	151.1	138.7	126.9	121.1
175	155.4	144.4	134.7	129.7	155.5	142.8	130.7	124.7
180	159.9	148.5	138.5	133.4	160.0	146.9	134.4	128.2
185	164.3	152.7	142.4	137.1	164.4	151.0	138.1	131.8
190	168.7	156.8	146.2	140.8	168.9	155.1	141.9	135.4
195	173.2	160.9	150.1	144.5	173.3	159.1	145.6	138.9
200	177.6	165.0	153.9	148.2	177.8	163.2	149.3	142.5
205	182.1	169.2	157.8	151.9	182.2	167.3	153.1	146.0
210	186.5	173.3	161.6	155.6	186.6	171.4	156.8	149.6
215	190.9	177.4	165.5	159.3	191.1	175.5	160.5	153.2
220	195.4	181.5	169.3	163.0	195.5	179.5	164.3	156.7
225	199.8	185.7	173.2	166.7	200.0	183.6	168.0	160.3
230	204.3	189.8	177.0	170.4	204.4	187.7	171.7	163.9
235	208.7	193.9	180.9	174.1	208.9	191.8	175.5	167.4
240	213.1	198.0	184.7	177.8	213.3	195.9	179.2	171.0
245	217.6	202.2	188.5	181.5	217.8	199.9	182.9	174.5
250	222.0	206.3	192.4	185.2	222.2	204.0	186.7	178.1

3.3 Economic Loss as a Function of Local Wind Speed

This chapter uses the pre-calculated economic loss functions contained within the Hazus-MH Model. For each building type, building, contents, and loss of use economic losses are provided as a function of open terrain peak gust wind speed measured at a height of 10 m in 5 mph increments for the five terrain categories shown in Table 3.1. Figure 3.2 shows an example loss curve for the five basic terrain categories with roughness length (z_0) varying between 0.03 m (open terrain) and 1.0 m (treed terrain). Figure 3.2 clearly demonstrates the strong dependence between building loss functions and terrain.

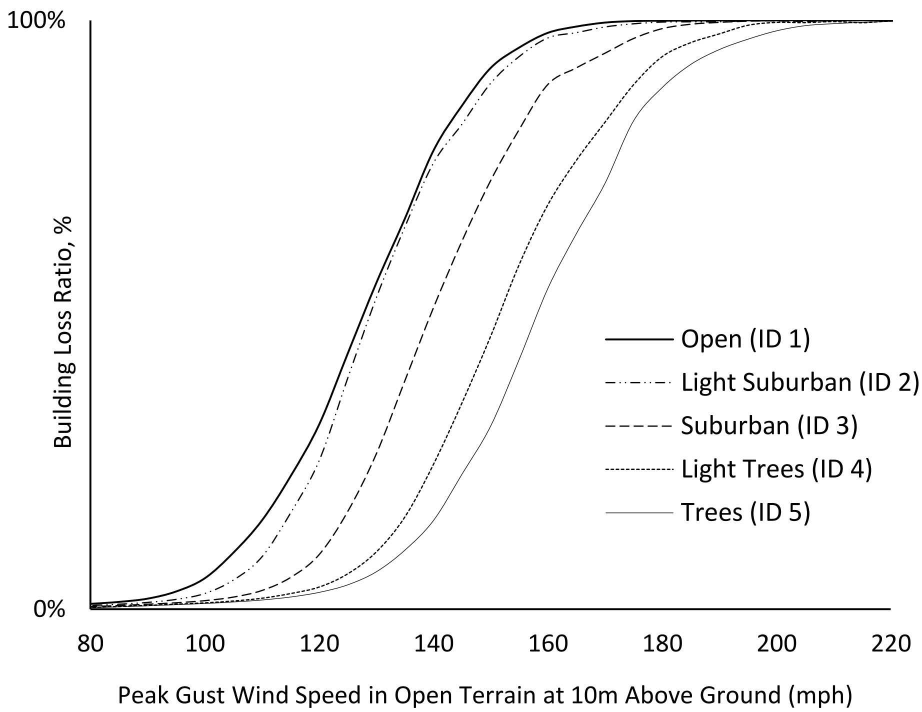


Figure 3.2 Example Building Loss Versus Open Terrain Peak Gust Wind Speed for Varying Terrain

Using the log law local wind speed results in Table 3.2, loss functions were replotted for the 160 building types (Figure 3.3) and evaluated using a one-way analysis of variance (ANOVA) with $\alpha = 0.05$ to test the null hypothesis $H_o: \mu_{T1}=\mu_{T2}=\mu_{T3}=\mu_{T4}=\mu_{T5}$ for 15 points along the loss

curves in 5 mph increments between 90 to 160 mph. Where the means of the loss functions were significantly different, a pairwise comparison was conducted to examine which pairs of the compared means were significantly different. For all 15 points, the p-value was less than 0.05; therefore, the null hypothesis was rejected (i.e., there is an evidence that a significant difference exists between the compared means at the alpha level of 0.05). The pairwise testing demonstrated that the Terrain 1 loss function is significantly different from the other terrains. The rationale for the difference between open terrain loss functions and non-open terrain loss functions is that open terrain environments are not as conducive to the production of windborne missiles as non-open terrain environments, resulting in lower damage in open terrain at equivalent local wind speeds (FEMA, 2012b). Therefore, it was concluded that each building type has two classes of loss functions: open terrain loss functions discussed in Chapter 2, and non-open terrain loss functions.

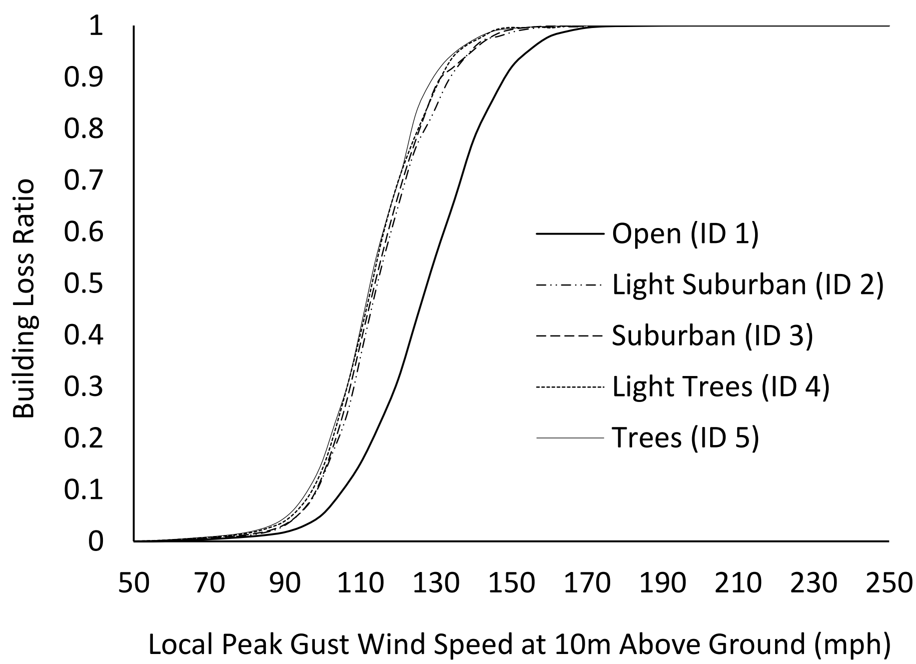


Figure 3.3 Example Building Loss Functions Versus Local Wind Speed Calculated by Log Law

3.4 Expected Annual Loss for Reference Non-Open Terrain

To address non-open terrain loss functions, reference non-open terrain is selected as Terrain 2; defined by z_0 = 0.15 m. Similar to the conversion of non-open terrain loss functions to open terrain in other studies, the reference non-open terrain is used as the basic terrain to which all other non-open terrain loss functions are converted.

The methodology described in Chapter 2 is used to calculate expected annual loss. Extreme value annual wind maxima are calculated for each wind contour within ASCE 7-10 using the Gumbel distribution and convolved with the reference non-open terrain economic loss functions (Equation 3.8), where $E[L]$ is the expected loss, $f_V\ (v)$ is the probability density function (PDF) of wind maxima, and $L(v)$ is the loss curve as a function of wind speed, v.

$$E[L] = \int_0^{\infty} f_V\ (v)L(v)dv \tag{3.8}$$

Total expected annual loss for each direct economic loss function (building, contents, and loss of use), EAL_j, is expressed as a ratio of building value, content value, or loss of use in days, and is the summation of total losses divided by the number of Monte Carlo iterations, N (50,000 for the present analysis), i is the iteration counter from 1 to N, $F_V(v)^{-1}[Ran(i)]$ is the inverse of the wind speed cumulative density function (CDF) for each iteration, *Ran(i)* is a random number between 0 and 1 with continuous uniform distribution, and $L_j(v_i)$ is the economic loss corresponding to annual extreme wind speed v_i for function type j (Equation 3.9).

$$EAL_j = \frac{1}{N}\sum_{\mathrm{i}=1}^{N} L_j(F^{-1}{}_V\ (v)[Ran(i)]) \tag{3.9}$$

To calculate reference non-open terrain expected annual loss for each function j (EAL_{jR}), the annual maximum wind speed, u_{z_1}, is converted to local wind speed for reference non-open terrain, $u_{z_{iR}}$, where u_{*1} and u_{*R} are the shear velocity (m/s) for open terrain and reference non-open terrain, z is the observational height (m), and z_{0_1} and z_{0_R} are the surface roughness (m) for open

terrain and reference non-open terrain (Equation 3.10). By combining Equations 9 and 10, where u_{zi} equals to $F^{-1}{}_{V}(v)[Ran(i)]$, Equation 3.11 is derived to calculate reference non-open terrain expected annual loss for function *j*, (EAL_{jR}).

$$u_{z_R} = \frac{u_{*R}}{u_{*1}} \times u_{z_1} \times \frac{\ln\frac{z}{z_{0_R}}}{\ln\frac{z}{z_{0_1}}} \tag{3.10}$$

$$EAL_{jR} = \frac{1}{N}\sum_{\mathrm{i}=1}^{N} L_{jR}(F^{-1}{}_{V}\ (v)[Ran(i)] \times \frac{u_{*R}}{u_{*1}} \times \frac{\ln\frac{z}{z_{0_R}}}{\ln\frac{z}{z_{0_1}}}) \tag{3.11}$$

To calculate the total expected annual direct loss in monetary terms for reference non-open terrain ($EAL_{TR,D}$), The reference non-open terrain expected annual loss for building (EAL_{BR}), contents (EAL_{CR}), and loss of use (EAL_{UR}) functions are provided in Appendix C, are multiplied by building value (V_B), contents value (V_C), and loss of use in days (L_U), respectively, and summed (Equation 3.12). Standard deviation values corresponding with Appendix C EAL values are provided in Appendix D. Considering the assumptions that content value is equal to 50% of building value, and the value of one year of rent is equivalent to one-seventh of the building value (Equation 3.13), the terms are expressed in terms of building value and total fractional expected annual direct loss (EAL_{TR}), as a ratio of building value, is determined (Equation 3.14). The result of the total expected annual loss for reference non-open terrain (EAL_{TR}) for all 160 Hazus WSF1 building types for the 700-year MRI peak gust wind speed contours provided within ASCE 7-10 for the continental U.S. is calculated and presented in Table 3.3, with values of standard deviation presented in Appendix D. The results provided in Table 3.3 were calculated from the Appendix tables (without truncation) using Equation 3.9.

$$EAL_{TR,D} = EAL_{BR} * V_B + EAL_{CR} * V_c + EAL_{UR} * L_U \tag{3.12}$$

$$EAL_{TR,D} = \ (EAL_{BR} + \frac{1}{2}EAL_{CR} + \frac{1}{365*7}EAL_{UR})V_B \tag{3.13}$$

$$EAL_{TR} = \ EAL_{BR} + \frac{1}{2}EAL_{CR} + \frac{1}{365*7}EAL_{UR} \tag{3.14}$$

Table 3.3 Total Expected Annual Loss, EAL_{TR}, for Reference Non-open Terrain, z_0=0.15 m, as a Ratio of Building Value (10^{-2})

ID	700-year open terrain 3-second gust wind speed, mph								
	110	115	120	130	140	150	160	170	180
1	0.132	0.220	0.272	0.435	0.629	1.082	1.501	2.453	2.750
2	0.120	0.190	0.221	0.332	0.459	0.766	1.058	1.621	1.881
3	0.097	0.156	0.217	0.352	0.543	0.936	1.318	2.161	2.354
4	0.084	0.137	0.164	0.248	0.352	0.635	0.889	1.468	1.587
5	0.113	0.189	0.247	0.403	0.598	1.038	1.503	2.316	2.531
6	0.167	0.278	0.385	0.668	0.925	1.633	2.296	3.675	3.850
7	0.113	0.198	0.229	0.361	0.468	0.805	1.181	1.885	2.084
8	0.118	0.203	0.274	0.485	0.797	1.291	1.880	2.987	3.486
9	0.087	0.135	0.170	0.284	0.408	0.747	1.063	1.687	1.910
10	0.156	0.249	0.380	0.666	1.022	1.740	2.456	3.918	4.138
11	0.049	0.085	0.133	0.226	0.367	0.663	1.003	1.582	1.883
12	0.034	0.057	0.070	0.111	0.169	0.250	0.441	0.694	0.820
13	0.043	0.065	0.124	0.204	0.360	0.624	0.957	1.615	1.816
14	0.025	0.042	0.056	0.092	0.133	0.247	0.411	0.646	0.808
15	0.039	0.075	0.119	0.212	0.337	0.613	0.930	1.591	1.851
16	0.080	0.151	0.239	0.497	0.793	1.331	2.036	3.067	3.429
17	0.040	0.061	0.088	0.151	0.254	0.461	0.717	1.164	1.397
18	0.065	0.100	0.193	0.369	0.637	1.123	1.659	2.531	3.015
19	0.029	0.052	0.072	0.144	0.226	0.430	0.701	1.081	1.324
20	0.059	0.118	0.185	0.385	0.643	1.068	1.635	2.650	2.968
21	0.125	0.194	0.250	0.386	0.536	0.900	1.372	2.054	2.236
22	0.109	0.175	0.199	0.290	0.378	0.626	0.862	1.370	1.461
23	0.094	0.158	0.203	0.345	0.486	0.818	1.254	1.952	2.181
24	0.081	0.130	0.160	0.229	0.307	0.520	0.751	1.214	1.355
25	0.106	0.176	0.226	0.378	0.520	0.875	1.328	2.063	2.320
26	0.158	0.265	0.365	0.652	0.907	1.563	2.232	3.534	3.763
27	0.116	0.182	0.217	0.317	0.447	0.730	1.093	1.691	1.921
28	0.126	0.207	0.282	0.477	0.746	1.322	1.848	2.974	3.244
29	0.083	0.144	0.169	0.263	0.389	0.666	0.969	1.561	1.742
30	0.153	0.255	0.401	0.686	1.012	1.714	2.419	3.942	4.200
31	0.046	0.079	0.121	0.236	0.364	0.640	1.034	1.636	1.822
32	0.034	0.054	0.067	0.109	0.161	0.282	0.451	0.696	0.851
33	0.043	0.075	0.110	0.201	0.354	0.596	0.988	1.566	1.816
34	0.027	0.042	0.055	0.088	0.134	0.248	0.389	0.642	0.825
35	0.038	0.075	0.114	0.195	0.340	0.648	1.009	1.610	1.850
36	0.083	0.152	0.262	0.461	0.766	1.330	1.982	3.124	3.463
37	0.037	0.061	0.087	0.153	0.242	0.453	0.670	1.101	1.377
38	0.061	0.117	0.201	0.390	0.646	1.118	1.709	2.762	3.004
39	0.029	0.051	0.076	0.126	0.234	0.417	0.651	1.071	1.338
40	0.061	0.120	0.201	0.375	0.634	1.159	1.629	2.728	3.014
41	0.121	0.200	0.260	0.384	0.588	0.971	1.380	2.215	2.474

Table 3.3 Total Expected Annual Loss, EAL_{TR}, for Reference Non-open Terrain, z_0=0.15 m, as a Ratio of Building Value (10^{-2}) (Continued)

ID	700-year open terrain 3-second gust wind speed, mph								
	110	115	120	130	140	150	160	170	180
42	0.107	0.170	0.191	0.282	0.371	0.612	0.893	1.363	1.531
43	0.091	0.157	0.191	0.322	0.484	0.838	1.179	1.876	2.199
44	0.076	0.119	0.137	0.191	0.274	0.472	0.632	1.080	1.259
45	0.105	0.167	0.225	0.377	0.535	0.933	1.294	2.120	2.369
46	0.155	0.264	0.375	0.619	0.903	1.508	2.242	3.424	3.817
47	0.112	0.178	0.206	0.311	0.384	0.679	1.005	1.581	1.756
48	0.109	0.184	0.275	0.442	0.709	1.249	1.795	2.921	3.180
49	0.077	0.123	0.145	0.234	0.336	0.588	0.858	1.439	1.566
50	0.147	0.255	0.383	0.652	0.953	1.689	2.506	3.715	4.157
51	0.046	0.077	0.126	0.218	0.359	0.621	0.995	1.544	1.896
52	0.033	0.053	0.064	0.098	0.127	0.222	0.331	0.523	0.658
53	0.038	0.066	0.105	0.197	0.341	0.620	0.929	1.516	1.778
54	0.024	0.039	0.048	0.080	0.111	0.214	0.330	0.550	0.610
55	0.038	0.071	0.108	0.191	0.340	0.593	0.973	1.499	1.765
56	0.081	0.153	0.249	0.449	0.769	1.270	1.957	3.030	3.447
57	0.034	0.060	0.082	0.140	0.234	0.431	0.644	1.013	1.217
58	0.063	0.106	0.191	0.361	0.582	1.063	1.699	2.638	3.065
59	0.030	0.048	0.068	0.131	0.205	0.379	0.633	0.969	1.246
60	0.060	0.113	0.191	0.386	0.626	1.065	1.773	2.604	2.935
61	0.112	0.185	0.215	0.307	0.475	0.780	1.084	1.775	1.887
62	0.097	0.151	0.156	0.197	0.231	0.358	0.512	0.774	0.867
63	0.083	0.142	0.183	0.288	0.418	0.738	1.078	1.674	1.948
64	0.071	0.112	0.115	0.154	0.183	0.313	0.471	0.701	0.821
65	0.098	0.159	0.207	0.308	0.463	0.780	1.145	1.823	2.043
66	0.146	0.243	0.342	0.565	0.869	1.467	2.139	3.323	3.665
67	0.101	0.164	0.173	0.244	0.334	0.539	0.768	1.235	1.434
68	0.108	0.190	0.257	0.431	0.679	1.161	1.737	2.812	3.132
69	0.075	0.120	0.133	0.191	0.297	0.509	0.712	1.107	1.364
70	0.145	0.246	0.366	0.635	0.987	1.617	2.393	3.739	4.100
71	0.050	0.081	0.128	0.218	0.373	0.610	0.968	1.515	1.757
72	0.032	0.052	0.066	0.093	0.128	0.222	0.337	0.529	0.642
73	0.042	0.066	0.105	0.185	0.332	0.604	0.926	1.489	1.843
74	0.023	0.039	0.047	0.075	0.108	0.190	0.304	0.500	0.641
75	0.039	0.069	0.119	0.195	0.347	0.590	0.916	1.483	1.789
76	0.090	0.140	0.261	0.473	0.754	1.352	1.911	2.994	3.415
77	0.038	0.056	0.086	0.136	0.231	0.401	0.628	0.976	1.206
78	0.067	0.114	0.198	0.383	0.640	1.104	1.598	2.728	3.047
79	0.028	0.044	0.067	0.129	0.203	0.364	0.611	0.976	1.227
80	0.060	0.116	0.195	0.371	0.622	1.106	1.671	2.729	2.960
81	0.207	0.322	0.408	0.614	0.843	1.401	1.961	3.043	3.308
82	0.181	0.297	0.350	0.495	0.632	1.033	1.356	2.191	2.364

Table 3.3 Total Expected Annual Loss, EAL_{TR}, for Reference Non-open Terrain, z_0=0.15 m, as a Ratio of Building Value (10^{-2}) (Continued)

ID	700-year open terrain 3-second gust wind speed, mph								
	110	115	120	130	140	150	160	170	180
83	0.153	0.253	0.325	0.549	0.754	1.235	1.884	3.002	3.133
84	0.134	0.228	0.278	0.410	0.529	0.904	1.192	1.880	1.987
85	0.193	0.321	0.407	0.638	0.900	1.526	2.074	3.349	3.491
86	0.212	0.357	0.447	0.695	0.933	1.557	2.248	3.473	3.697
87	0.182	0.301	0.347	0.527	0.670	1.074	1.447	2.288	2.325
88	0.166	0.268	0.371	0.607	0.898	1.545	2.185	3.433	3.711
89	0.138	0.228	0.268	0.414	0.578	0.932	1.288	2.070	2.230
90	0.212	0.378	0.514	0.819	1.178	2.035	2.777	4.410	4.714
91	0.073	0.126	0.179	0.314	0.525	0.915	1.305	2.110	2.377
92	0.056	0.096	0.127	0.197	0.276	0.459	0.637	0.979	1.124
93	0.069	0.106	0.193	0.329	0.510	0.924	1.320	2.171	2.515
94	0.046	0.075	0.099	0.172	0.248	0.430	0.564	0.943	1.074
95	0.065	0.108	0.168	0.342	0.515	0.907	1.319	2.182	2.450
96	0.093	0.152	0.235	0.458	0.681	1.163	1.669	2.813	3.084
97	0.059	0.097	0.131	0.213	0.300	0.507	0.707	1.190	1.321
98	0.084	0.141	0.219	0.460	0.698	1.247	1.807	2.940	3.264
99	0.048	0.075	0.111	0.181	0.276	0.486	0.712	1.172	1.312
100	0.075	0.140	0.228	0.420	0.685	1.268	1.839	2.934	3.230
101	0.193	0.315	0.377	0.591	0.824	1.333	1.900	2.856	3.112
102	0.180	0.286	0.342	0.484	0.623	0.977	1.282	2.026	2.114
103	0.147	0.251	0.316	0.525	0.740	1.219	1.730	2.760	3.081
104	0.136	0.216	0.269	0.417	0.525	0.848	1.161	1.849	1.959
105	0.181	0.302	0.419	0.616	0.839	1.375	1.869	3.011	3.215
106	0.201	0.347	0.434	0.685	0.946	1.516	2.165	3.411	3.625
107	0.186	0.291	0.354	0.502	0.650	1.024	1.380	2.194	2.275
108	0.159	0.263	0.368	0.620	0.918	1.543	2.134	3.417	3.640
109	0.137	0.220	0.278	0.402	0.547	0.918	1.292	2.026	2.174
110	0.230	0.365	0.492	0.808	1.201	2.035	2.835	4.402	4.725
111	0.076	0.128	0.195	0.355	0.517	0.909	1.323	2.144	2.405
112	0.057	0.097	0.126	0.201	0.272	0.456	0.651	1.017	1.131
113	0.064	0.111	0.170	0.333	0.487	0.913	1.302	2.169	2.443
114	0.044	0.076	0.109	0.177	0.247	0.418	0.614	0.908	1.082
115	0.063	0.112	0.172	0.327	0.481	0.879	1.328	2.147	2.400
116	0.088	0.152	0.223	0.433	0.680	1.163	1.694	2.786	3.065
117	0.059	0.101	0.137	0.215	0.311	0.519	0.764	1.176	1.366
118	0.074	0.140	0.230	0.416	0.733	1.173	1.877	2.888	3.182
119	0.044	0.080	0.111	0.171	0.280	0.500	0.719	1.175	1.330
120	0.081	0.132	0.225	0.425	0.720	1.221	1.791	2.970	3.259
121	0.185	0.295	0.355	0.533	0.724	1.168	1.707	2.694	2.858
122	0.161	0.257	0.284	0.386	0.445	0.725	0.955	1.522	1.647
123	0.137	0.224	0.298	0.464	0.637	1.139	1.665	2.556	2.776

Table 3.3 Total Expected Annual Loss, EAL_{TR}, for Reference Non-open Terrain, z_0=0.15 m, as a Ratio of Building Value (10^{-2}) (Continued)

ID	700-year open terrain 3-second gust wind speed, mph								
	110	115	120	130	140	150	160	170	180
124	0.118	0.190	0.213	0.291	0.370	0.606	0.811	1.296	1.406
125	0.177	0.283	0.371	0.573	0.805	1.346	1.820	2.968	3.225
126	0.189	0.311	0.382	0.598	0.812	1.347	1.906	3.044	3.321
127	0.165	0.263	0.295	0.396	0.476	0.781	1.014	1.585	1.690
128	0.155	0.242	0.346	0.539	0.803	1.406	1.947	3.212	3.462
129	0.117	0.191	0.212	0.308	0.384	0.638	0.922	1.456	1.558
130	0.211	0.337	0.495	0.805	1.140	1.980	2.604	4.303	4.386
131	0.071	0.123	0.165	0.323	0.476	0.843	1.270	1.981	2.281
132	0.056	0.089	0.111	0.164	0.216	0.339	0.475	0.737	0.775
133	0.069	0.117	0.178	0.281	0.506	0.861	1.304	2.078	2.304
134	0.042	0.068	0.089	0.135	0.193	0.309	0.425	0.697	0.770
135	0.060	0.110	0.164	0.322	0.485	0.888	1.322	2.067	2.296
136	0.083	0.142	0.229	0.389	0.650	1.086	1.655	2.595	2.949
137	0.053	0.094	0.123	0.191	0.247	0.430	0.598	0.952	1.094
138	0.074	0.142	0.233	0.409	0.698	1.199	1.825	2.837	3.202
139	0.043	0.072	0.100	0.159	0.234	0.393	0.599	0.970	1.139
140	0.083	0.131	0.209	0.434	0.677	1.237	1.741	2.900	3.182
141	0.181	0.283	0.331	0.493	0.652	1.068	1.501	2.366	2.554
142	0.156	0.254	0.268	0.337	0.371	0.597	0.722	1.133	1.127
143	0.139	0.228	0.274	0.446	0.617	1.025	1.429	2.408	2.539
144	0.112	0.183	0.198	0.265	0.306	0.488	0.617	0.968	0.994
145	0.164	0.273	0.344	0.548	0.725	1.195	1.623	2.555	2.847
146	0.185	0.310	0.389	0.590	0.829	1.345	1.890	2.954	3.243
147	0.157	0.255	0.274	0.359	0.424	0.671	0.859	1.355	1.349
148	0.148	0.238	0.326	0.525	0.825	1.343	1.885	3.155	3.371
149	0.117	0.187	0.212	0.302	0.355	0.598	0.794	1.251	1.421
150	0.218	0.340	0.466	0.761	1.069	1.900	2.760	4.261	4.432
151	0.077	0.121	0.189	0.330	0.491	0.909	1.281	2.073	2.379
152	0.053	0.091	0.115	0.170	0.210	0.350	0.470	0.745	0.800
153	0.058	0.108	0.168	0.297	0.513	0.904	1.283	2.080	2.339
154	0.040	0.073	0.088	0.141	0.191	0.318	0.444	0.721	0.773
155	0.062	0.109	0.171	0.310	0.514	0.891	1.293	2.061	2.377
156	0.082	0.146	0.235	0.414	0.631	1.137	1.621	2.670	3.019
157	0.053	0.094	0.125	0.188	0.251	0.413	0.586	0.959	1.076
158	0.091	0.130	0.208	0.409	0.685	1.171	1.736	2.922	3.210
159	0.043	0.073	0.099	0.158	0.228	0.410	0.592	0.942	1.132
160	0.079	0.131	0.213	0.444	0.693	1.195	1.855	2.920	3.188

3.5 Terrain Influence Factor

To allow application of the reference non-open terrain expected annual loss (EAL_{TR}) values (Table 3.3) for any surface roughness, a terrain influence factor (TIF) is introduced. Using the methodology presented in the previous section, total expected annual losses for each terrain ($[EAL_T]_k$) for k = Terrain 3, 4, and 5 were calculated for the 160 building types and presented in Appendix E. The standard deviation of total expected annual losses for terrains 3,4, and 5 are presented in Appendix F. The total expected loss ratio (*TELR*) is calculated as $[EAL_T]_i$ divided by the reference non-open terrain total expected annual loss, EAL_{TR} (Equation 3.15).

$$TELR = [EAL_T]_{terrain\ i} / EAL_{TR},\ k=3,\ 4,\ and\ 5 \tag{3.15}$$

Figure 3.4 provides the relationship of average TELR by surface roughness for all nine wind speed contours. TELR varies most significantly based on building characteristics and second on wind speed contours. Therefore, at achieve a more accurate result, the 160 building types were divided into three groups (Table 3.4) based on analysis of the histogram of TELR values.

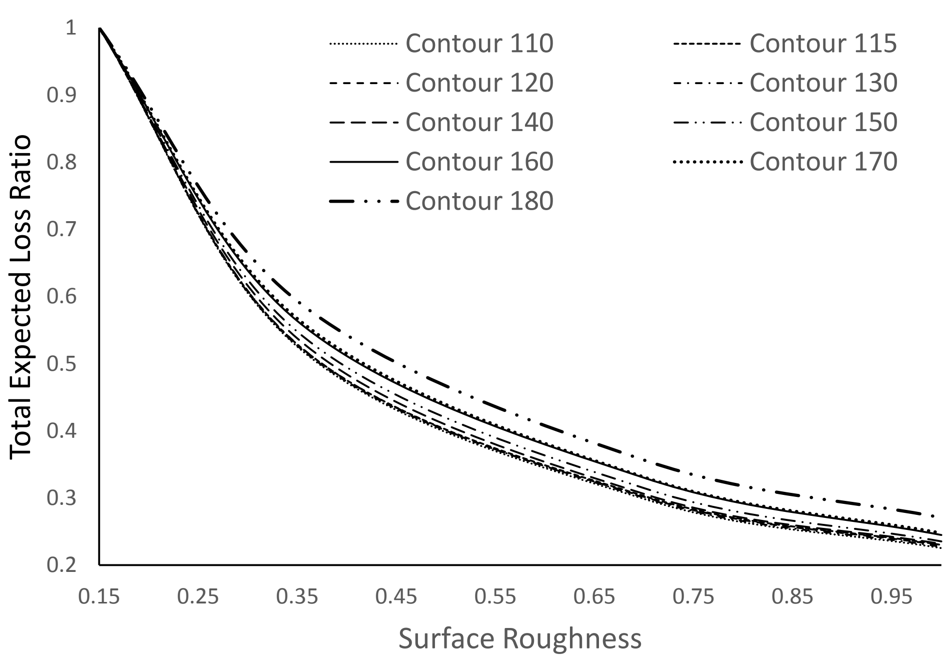


Figure 3.4 Total Expected Loss Ratio (TELR) Versus Surface Roughness for All Nine Wind Speed Contours

Table 3.4 Hazus-MH WSF1 Building ID (WBID) and Corresponding Building Characteristics

Roof Deck Attachment	Garage Door	Shutter	Strap Roof-Wall Connection				Toe-Nail Roof-Wall Connection			
			No SWR		SWR		No SWR		SWR	
			G	H	G	H	G	H	G	H
6d @ 6 in/12 in	None	No								
		Yes	*	*	*	*	*	*	*	*
	Standard	No								
	SFBC 1994	Yes	*	*	*	*	*	*	*	*
	Weak	No							o	
6d/8d Mix @ 6 in/6 in	None	No	o	o	o	o	o	o	o	o
		Yes	*							
	Standard	No	o	o	o	o	o	o	o	o
	SFBC 1994	Yes								
	Weak	No	o	o	o	o	o	o	o	o
8d @ 6 in/12 in	None	No								
		Yes	*	*	*	*	*	*	*	*
	Standard	No								
	SFBC 1994	Yes	*	*	*	*	*	*	*	
	Weak	No							o	o
8d @ 6 in/6 in	None	No		o	o	o	o	o	o	o
		Yes	*							
	Standard	No	o	o	o	o	o	o	o	o
	SFBC 1994	Yes								
	Weak	No	o	o	o	o	o	o	o	o

Number indicates Hazus-assigned WBID

Roof Type: G = Gable, H = Hip; SWR = Secondary Water Resistance

o = Group 1, blank = Group 2, * = Group 3

To calculate the terrain influence factor (TIF), TELRs corresponding to Terrain 3, 4, and 5 were plotted and power regression (Equation 3.16) was used to obtain best curve fits on the data. Table 3.5 provides the power regression parameters and goodness of fit for the three groups of building type.

$$\text{TIF} = a{z_0}^{b} + \text{c} \tag{3.16}$$

Table 3.5 Regression Parameters and Goodness of Fit

Building Group	Fitted Curve Parameters $TIF = az_0^b+c$			Coefficients with 95% confidence bounds						Goodness of Fit		
				Lower Band			Upper Band			SSE	R-Square	RMSE
	a	b	c	a	b	c	a	b	c			
Group 1	0.267	-0.749	-0.105	0.251	-0.773	-0.124	0.283	-0.725	-0.087	2.67	0.986	0.038
Group 2	0.327	-0.633	-0.084	0.311	-0.650	-0.101	0.342	-0.616	-0.068	2.714	0.989	0.031
Group 3	0.469	-0.466	-0.136	0.429	-0.492	-0.178	0.509	-0.44	-0.094	0.987	0.988	0.029

Equation 3.16 is used to calculate TIF for any building type (*bt*) for any surface roughness (z_i), with the parameters listed in Table 3.11 related to the building group shown in Table 3.10, $TIF_{(bt,z_i)}$. The total expected annual loss for building type (*bt*) and surface roughness (z_i), $EAL_{T(bt,z_i)}$, is calculated by multiplying $TIF_{(bt,z_i)}$ by EAL_{TR} for building type (*b*), $EAL_{TR(bt)}$ (Equation 3.17).

$$EAL_{T(bt,z_i)} = EAL_{TR(bt)} \times TIF_{(bt,z_i)} \tag{3.17}$$

3.6 Example Implementation

This section illustrates the application of the methodology to calculate expected annual loss for any single family residential building throughout the U.S. with any surface roughness. Three case studies related to three building groups, all located in wind speed contour 140 mph are selected, and total expected annual losses for surface roughness z_0=0.35, 0.7, and 1 meter are calculated.

- In the first case study related to Building Group 1, WBID 11 is selected: one story wood frame residential, gable roof, 6d and 8d nail mix @ 6 in./6 in. (edge/field nailing spacing) sheathing nail pattern, strap roof-wall connection, and without secondary water resistance, garage door, or shutters.
- In the second case study related to Building Group 2, WBID 1 is selected: one story wood frame residential, gable roof, 6d nail 6 in./12 in. sheathing nails, strap roof-wall connection, and without secondary water resistance, garage door, or shutters.
- In the third case study related to Building Group 3, WBID 2 is selected: one story wood frame residential, gable roof, 6d nail 6 in. / 12 in. sheathing nails, strap roof-wall connection, with shutter, and without secondary water resistance, garage door.

Using Equation 3.16 and the parameters provided in Table 3.5, the TIF corresponding to the three case studies are calculated for three surface roughness; $TIF_{11,0.35}$, $TIF_{11,0.7}$, $TIF_{11,1}$,

$TIF_{1,0.35}$, $TIF_{1,0.7}$, $TIF_{1,1}$, $TIF_{2,0.35}$, $TIF_{2,0.7}$, $TIF_{2,1}$. Reference non-open terrain expected annual loss (EAL_{TR}) values corresponding to WBID 11, 1, and 2 in wind contour 140 are extracted from Table 3.6, and using Equation 3.14, $EAL_{T(b, zi)}$ values are calculated. To validate the estimated result using the proposed methodology, the expected annual losses for each of these cases were also calculated computationally, and the results are provided in Table 3.6, and shown graphically in Figure 3.5.

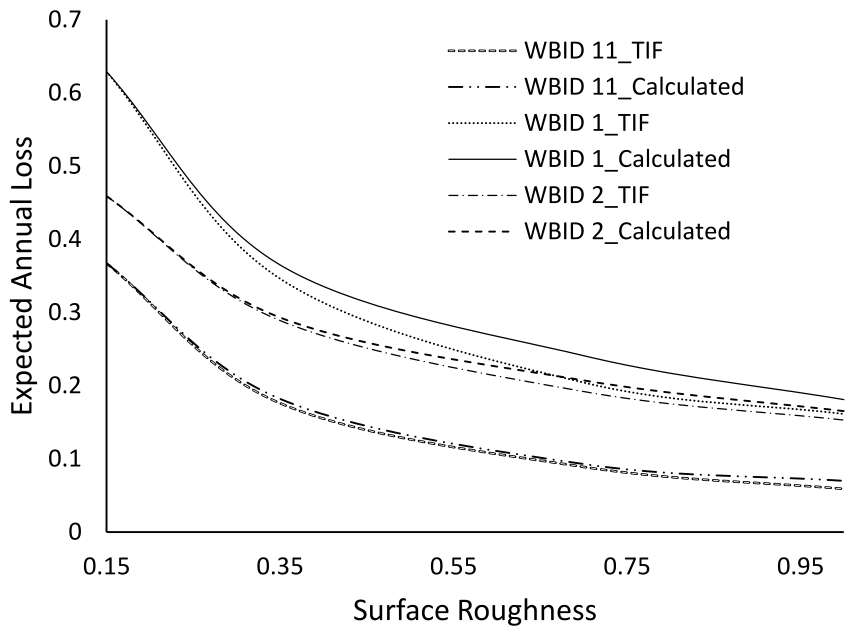


Figure 3.5 Total Expected Loss (EAL_T), 10^{-2} Versus Surface Roughness

Figure 3.5 illustrates the expected annual loss for the case study building types versus surface roughness using the terrain influence factor (TIF) and computational calculated. Generally, there is a good agreement between the TIF and computational results, although WBID 1 shows larger error in EAL_T using the two methods than WBID 2 or 11, with a maximum error of 15% with 0.70 m surface roughness. For these latter cases, the difference between the methods is small.

By comparing the results based on proposed methodology and computational calculated, the maximum error is almost 15%; however the absolute difference in EAL_T is 0.037%, which, for a $200,000 home would result in an error of $74.

Table 3.6 Case Study Results

WB ID (bt)	Wind Contour	Group	EAL_{TR}, 10^{-2}	Result								
				Surface Roughness 0.35 m			Surface Roughness 0.7 m			Surface Roughness 1 m		
				TIF		Calculated	TIF		Calculated	TIF		Calculated
				$TIF_{n,0.35}$	EAL_T, 10^{-2}	EAL_T, 10^{-2}	$TIF_{n,0.7}$	EAL_T, 10^{-2}	EAL_T, 10^{-2}	$TIF_{n,1}$	EAL_T, 10^{-2}	EAL_T, 10^{-2}
11	140	1	0.367	0.4808	0.176	0.182	0.2435	0.089	0.093	0.1617	0.059	0.070
1	140	2	0.629	0.5502	0.346	0.365	0.3249	0.204	0.241	0.2422	0.161	0.181
2	140	3	0.459	0.6296	0.289	0.293	0.4184	0.192	0.207	0.3335	0.153	0.165

3.7 Summary and Conclusions

Surface roughness is a critical component in the modeling of wind induced damage and loss to buildings. This chapter developed a methodology to calculate expected annual loss for wood framed, one-story, single family homes located in non-open terrain of any surface roughness up to 1.0 m throughout the U.S. Total expected annual loss for reference non-open terrain (EAL_{TR}), was calculated by convolving local wind speed with reference loss functions identified from Hazus-MH. Through investigation of the behavior of the ratio of EAL for given terrain to EAL for the reference non-open terrain (i.e., the total expected loss ratio, *TELR*), a terrain influence factor (TIF) was introduced as a factor to allow calculation of expected annual loss (EAL_{TR}) values for any surface roughness up to 1.0 m. The methodology was illustrated by calculating expected annual loss for three case studies located with surface roughness z_0=0.35, 0.7, and 1.0 m., and the results were validated using computationally calculated results.

Important contributions of the study are:

- A theoretical methodology was developed to calculate EAL_T for any surface roughness and wind speed contour based on Hazus-MH building, contents, and loss of use economic loss functions.
- A terrain influence factor (TIF) was defined based on the total expected annual loss (EAL_T) ratio for Terrains 3, 4, and 5 to the reference non-open terrain. The TIF was optimized for three Building Groups based on convergence of this ratio.
- The tabular format of EAL_T results and determination of TIF complements the results for open terrain and facilitates rapid evaluation of annual loss for buildings in any terrain and wind speed contour.

CHAPTER 4: CONSUMER WIND HAZARD MITIGATION DECISION FRAMEWORK

4.1 Introduction

The majority of natural hazard economic losses in the United States are caused by wind hazards (Emanuel et al., 2006; Knutson et al., 2010; Lin et al., 2012; Lin et al., 2010; Wang & Rosowsky, 2012). Because of the increasing trend in wind frequency, intensity (NSB, 2007; Rosenzweig & Solecki, 2014), and losses over the past 50 years in the U.S. (Torkian et al., 2013), studies have focused on wind risk reduction and suggested a variety of mitigation methods against wind hazards (e.g., Heneka & Ruck, 2008; Huang et al., 2001a; Khanduri & Morrow, 2003; Li & Ellingwood, 2006; Peacock, 2003; Pinelli et al., 2008; Pita et al., 2013b; Rosowsky & Ellingwood, 2002; Torkian et al., 2013; Vickery et al., 2006b); however, there is a persistent lack of sufficient information to assess or track reductions in economic losses caused by mitigation (Legg et al., 2012; Peacock, 2003), and there is not any practical method to calculate the economic benefit of mitigations (Powell et al., 2005; Torkian et al., 2013). Systematic implementation of all available wind mitigation measures is not necessarily advisable, as this may result in overly robust high-cost building stock which exceeds expected reliability with benefit-cost ratios that do not indicate a positive return (Rose et al., 2007; Simmons et al., 2002); therefore, the demand of economically evaluation of hazard risk reduction by implementing mitigations has been increased between decision makers (Hawley et al., 2012).

Cost-benefit analysis (CBA) is a method used for economic evaluation of risk reduction investment that determines the potential positive effects (i.e., the loss avoided by implementing the mitigation) of mitigation actions and compares them to the cost of the action (FEMA, 2009). CBA is used for the economic evaluation of risk reduction investment, rather than responding to the impacts of a future disaster event (Shreve & Kelman, 2014; Venton, 2010). Basically, CBA is concerned with efficiency (Godschalk et al., 2009), and applied widely in existing literature to

measure the economic benefits of various natural hazard mitigation methods (e.g. FEMA, 2007, 2009; Li, 2012; Pinelli et al., 2009; Smyth, Andrew W et al., 2004; Smyth, Andrew W. et al., 2004; Torkian et al., 2013). In spite of the usefulness of CBA in assessing the cost effectiveness of mitigation(s), the existing limitations of loss models described in Chapters 2 and 3 prohibit the use of CBA because of the lack of underlying loss information to calculate the benefit (i.e., avoided loss) derived from mitigation. These shortcomings also reduce the ability of stakeholders, especially consumers, in their individual mitigation decision making process.

The purpose of this chapter is to create a computational decision making framework to evaluate the cost effectiveness of mitigation strategies to enhance decision making for stakeholders that can be customized based on location, years of interest, and building configuration. This chapter includes three main parts: 1) calculation of the mitigation benefit, defined as the loss avoided through the implementation of mitigation, 2) calculation of the cost of mitigation, and 3) presentation of the CBA mitigation decision making framework for consumers. In benefit and cost calculations, economic aspects of uncertainty including inflation and discount rate are considered to evaluate the actual present value of future expenses over the years of interest. The results of this research are used to extract conclusions about the effectiveness and benefit of mitigation methods that can be customized based on location, years of interest, and building configuration. These conclusions can be used by home builders and owners to enhance decision making for stakeholders and simplify the mitigation decision making process, ultimately enhancing reliability and reducing risk.

4.2 Methodology

The goal of risk assessment is to measure potential losses to assist in selection of appropriate mitigation techniques (Bründl et al., 2009). To evaluate the effectiveness of wind mitigation techniques, the concept of cost benefit analysis (CBA) as an economic tool for

comparing the benefit and cost is applied (FEMA, 2007, 2009; Kull et al., 2013; Shreve & Kelman, 2014). Through CBA, the benefits and costs of wind mitigation are quantified and compared, where ratios in excess of one are considered to have a net benefit. However, benefits and losses incurred over time require a common time period for evaluation. Therefore, two main factors identified in economic theory – inflation and discount rate, are considered to evaluate the real present value of future expense (e.g. Chang & Shinozuka, 1996; Gluch & Baumann, 2004; Islam et al., 2014; Moon & Lee, 2000; Woodward, 1997). The three primary components of the methodology are: (1) calculate the benefit of wind mitigation for a year of building life, and expand it for the number of years of interest (i.e., decision-making time horizon), (2) calculate the cost of wind mitigation for a year of building life, and expand it for the number of years of interest, and (3) analyze the benefit and cost of mitigation in a framework that supports consumer decision making.

4.2.1 Benefit

The benefit of wind mitigation is the avoided loss that occurs through implementation of the mitigation activity. A key factor in calculating the benefit of hazard mitigation is the uncertainty of future events. Using the concept of risk analysis which integrates probabilistic estimates of hazard, vulnerability, and consequence to capture the hazard's uncertain frequency of occurrence and magnitude allows evaluation of future uncertainties.

Cumulative monetary benefit over the decision-making time horizon is the evaluation of mitigation options and can be estimated based on expected annual loss (Li, 2012; Torkian et al., 2013). To calculate the expected annual benefit of mitigation, EABT, total expected annual loss (EALT, expressed as a ratio of building value) is calculated for both the mitigated and unmitigated states using the methodology presented in Chapters 2 and 3 and differenced (Equation 4.1).

$$EAB_T = [EAL_T]_{unmitigated} - [EAL_T]_{mitigated} \quad (4.1)$$

To calculate total expected annual loss *(EAL_T)* for the mitigated and unmitigated states, the methodologies developed for open and non-open terrain presented in Chapters 2 and 3, respectively, are used (Equation 4.2). For buildings located in open terrain (i.e. z_0=0.03 m), EAL_T is taken directly from Table 2.7 based on building type and wind speed contour. For buildings located in non-open terrain, reference non-open terrain total expected annual loss (EAL_{TR}) is taken from Table 3.6, also dependent on building type and wind speed contour, and adjusted to the appropriate surface roughness (z_i) using the terrain influence factor ($TIF_{(bt,z_i)}$) for building type (*bt*). The terrain influence factor is calculated using the parameters in Table 3.11 based on building group presented in Table 3.10 (Equation 4.3).

$$EAL_T = \begin{cases} EAL_{T(bt,z_0)}, bt = 1, 2 \dots 160 & for\ z_0 = 0.03\ m \\ EAL_{T(bt,z_i)} = EAL_{TR(bt)} \times TIF_{(bt,z_i)},\ bt = 1, 2 \dots 160 & for\ z_i > 0.03\ m \end{cases} \quad (4.2)$$

$$TIF_{(b,z_i)} = a{z_i}^b + c\ \ where \begin{cases} a, b, and\ c\ taken\ from\ Table\ 3.5\ based\ on\ building \\ group\ as\ assigned\ by\ building\ type\ (bt)\ in\ Table\ 3.4 \end{cases} \quad (4.3)$$

The expected annual benefit can be used to calculate the cumulative monetary benefit over the decision-making time horizon; however, the expected annual loss for each year of the building life-cycle must be discounted to present value to establishing equivalence between future monetary losses. The concept of discounted present value (DPV) is used to calculate the equivalent present value of future cost (Equation 4.4), where *DPV* is discounted present value, C_f is a future expense in year *k* (considering the present is year 0), and *R* is the discount rate.

$$DPV = \frac{C_{f_k}}{(1+R)^k} \quad (4.4)$$

A future expense in year *k* is calculated as a function of present cost, C_p, and inflation rate, *F* (Equation 4.5). To calculate the expected cumulative loss, *ECL*, of the building (Equation 4.6), Equations 4.4 and 4.5 are combined, present cost shown in Equation 4.3 is replaced with the expected annual loss, and the discounted present value of future expenses are summed over the decision-making time horizon of *K* years. To calculate expected cumulative benefit, *ECB*, the

expected cumulative loss for the unmitigated and mitigated states are differenced (Equation 4.7) and represented as a function of expected annual loss, EAL_T, and discount and inflation rates (Equation 4.8).

$$C_{f_k} = C_p \times (1 + F)^k \tag{4.5}$$

$$ECL = \sum_{k=1}^{K} \left(EAL_T \times \frac{(1+F)^k}{(1+R)^k} \right) \tag{4.6}$$

$$ECB = [ECL]_{unmitigated} - [ECL]_{mitigated} \tag{4.7}$$

$$ECB = \sum_{k=1}^{n} \left[\left([EAL_T]_{unmitigated} - [EAL_T]_{mitigated} \right) \times \frac{(1+F)^k}{(1+R)^k} \right] \tag{4.8}$$

4.2.2 Cost

In this research, the cost of mitigation considers monetary costs in terms of the initial investment *C(ii)* and ongoing and future costs. The total present value cost of mitigation *i*, C_i, is the summation of all costs expressed in present value (Equation 4.9). To estimate ongoing and future costs, operation *C(op)*, maintenance *C(m)*, replacement *C(rep)*, energy *C(e)*, and residual *C(res)* costs are expressed in terms of their current value, inflated using the inflation rate (*F*) to represent costs incurred in year *k*, and discounted using the discount rate (*R*) to yield present value. These costs are summed over *K* years of the decision-making time horizon and added to the initial investment *C(ii)* to yield the present value cost of mitigation *i* over the period of interest (C_i; Equation 4.10).

$$C_i = C(ii) + C(\quad)_{PV} \tag{4.9}$$

$$C_i = C(ii) + \sum_{k=1}^{K} \left([C(op) + C(m) + C(rep) + C(e) + C(res)] \times \frac{(1+F)^k}{(1+R)^k} \right) \tag{4.10}$$

4.2.3 Decision Making Framework

Figure 4.1 shows the proposed decision making framework to facilitate the mitigation decision making process. The process consists of eight steps, divided into four subprocesses: 1)

data acquisition, 2) data evaluation, 3) cost benefit calculation, and 4) results comparison and decision making.

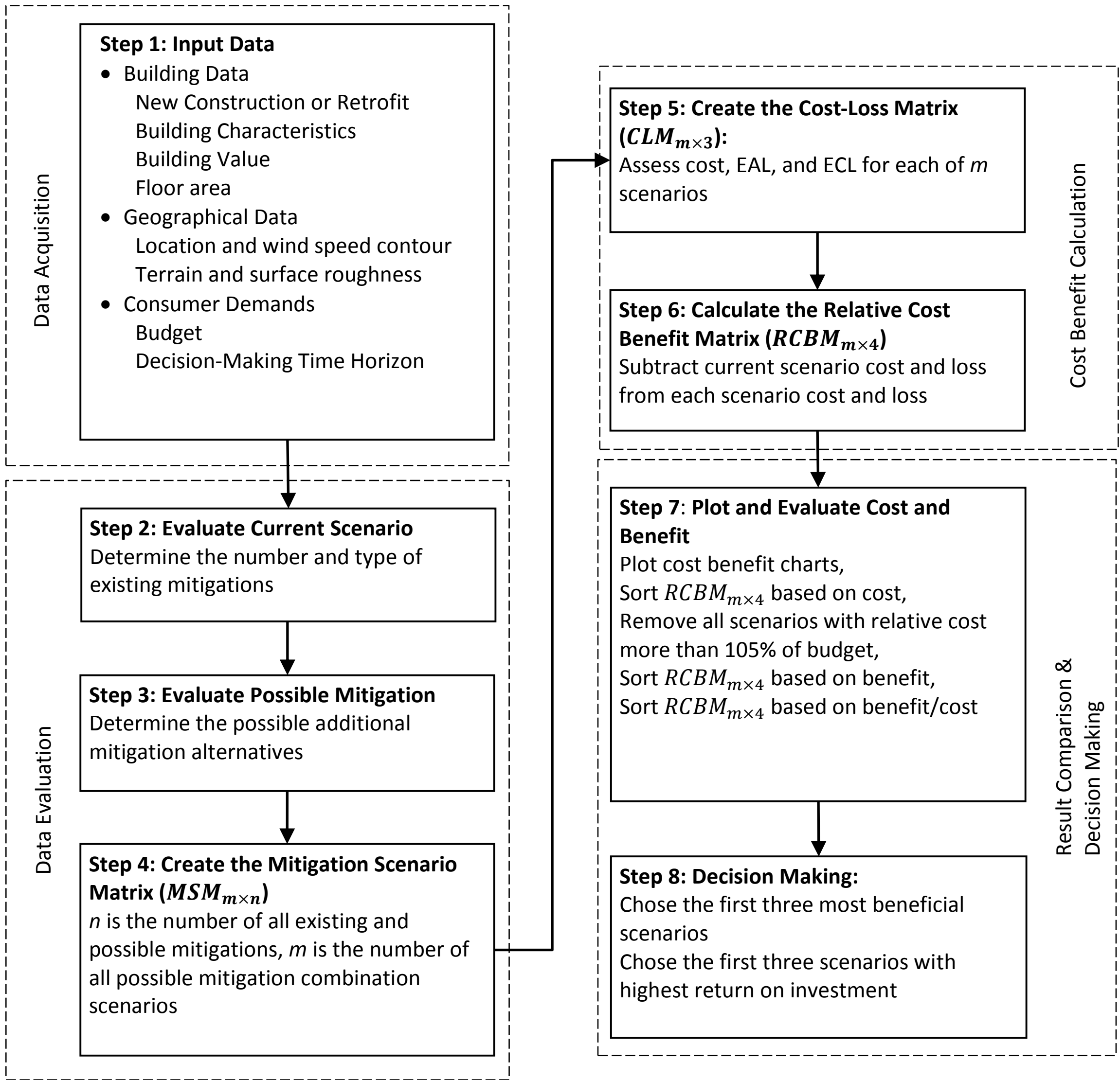


Figure 4.1 Decision Making Framework Flowchart

In the first subprocess, Data Acquisition, information about building characteristics, building location and environment, and consumer requirements are collected. For this step, the consumer provides information relevant to the building, including value, age, size and characteristics to allow evaluation of the current scenario in Step 2. The consumer will then provide location information which will be geolocated to determine the wind speed contour and

the surface roughness length z_0. Existing datasets, such as those integrated into the ATC Wind Speed website (wind speed contour) and Hazus-MH Hurricane model (surface roughness) are used as default values. Consumer requirements are also required to define the available budget for mitigating the building and the decision-making time horizon (i.e., years of interest for mitigation decision).

In the second subprocess, Data Evaluation, the current scenario is evaluated to determine the building WBID, determine possible mitigation actions, and create the Mitigation Scenario Matrix, which defines existing and possible mitigation and identifies all possible mitigation combinations. The five mitigation categories considered by Hazus are: roof shape, secondary water resistance, roof-deck attachment, roof-wall connection, and shutter and garage door configuration. Based on the building characteristics input in Step 1, some mitigation options may already be in place; therefore, the number and type of existing mitigation alternatives are evaluated in Step 2 based on the remaining mitigation categories and alternatives. Removing existing mitigation or choosing to weaken the building are not considered as options; therefore, the remaining possible additional mitigation alternatives and categories are selected in Step 3.

In Step 4, all possible combinations of existing and additional mitigation alternatives are evaluated. Assuming ***n*** is the number of mitigation categories (for Hazus, $n=5$), and ***m*** is the number of combination scenarios of existing and possible mitigation alternatives. Each scenario is populated in the Mitigation Scenario Matrix ($MSM_{m\times n}$) and represented by an *n*-digit code which designates each building WBID. Table 4.1 provides the five mitigation categories used within Hazus and the mitigation alternative coding for each category. As an example of the coding method, the code for building WBID 86 with hip roof, without secondary water resistance, 6d 6in./12in. roof deck attachment, toe-nail roof-wall connection, and without shutters and without garage door is 1,0,0,1,0, where each digit is selected from the mitigation categories in Table 4.1.

Table 4.1 Hazus-MH WSF1 Mitigation Categories and Mitigation Alternative Coding

(1) Roof shape	(2) SWR	(3) Roof deck attachment	(4) Roof-wall connection	(5) Shutter and garage door configuration
Gable → 0 Hip → 1	No SWR → 0 With SWR → 1	6d @ 6 in./12 in. → 0 6d/8d Mix @ 6 in./6 in. → 1 8d @ 6 in./12 in. → 2 8d @ 6 in./6 in. → 3	Strap → 0 Toe-nail → 1	without shutter, without garage door → 0 with shutter, without garage door → 1 without shutter, standard garage door → 2 with shutter, reinforced garage door → 3 without shutter, weak garage door → 4

When considering new construction, the number of mitigation scenarios, *m*, is 160. For retrofit construction, the framework does not consider changing roof shape; therefore, for an existing building, the number of mitigation scenarios is 80. As more mitigation alternatives exist in the current scenario, the number of possible scenarios decreases as selecting a weaker mitigation alternative is not considered. It is also noted that using the building code within$MSM_{m \times n}$, the Hazus-MH WBID can be calculated for any scenario using Equation 4.11.

$$WBID_m = MSM_{m,1} * 80 + MSM_{m,2} * 40 * MSM_{m,3} * 10 + MSM_{m,4} * 5 + MSM_{m,5} + 1 \quad (4.11)$$

In the third subprocess, Cost Benefit Calculation, the cost and benefit of each scenario are assessed through the construction of the Cost-Loss and Relative Cost Benefit Matrices. The Cost-Loss Matrix ($CLM_{m \times 3}$; Equation 4.12) contains the cost and expected loss of each scenario for all m scenarios defined in Step 4. The first column of each row of the $CLM_{m \times 3}$ matrix represents the present cost for implementing the scenario. To calculate total cost of each scenario *m* (CS_m), the present value cost of each selected scenario mitigation *i* is summed for n mitigation categories (Equation 4.13), where the cost of mitigation *i* is determined using Equation 4.10. The second column of the $CLM_{m \times 3}$ matrix represents the annual expected loss calculated through Equations 4.2 and 4.3 and the third column represents the expected cumulative loss of the building calculated from Equation 4.6.

$$CLM = \begin{bmatrix} CS_1 & EAL_1 & ECL_1 \\ CS_2 & EAL_2 & ECL_2 \\ . & . & . \\ . & . & . \\ . & . & . \\ CS_m & EAL_m & ECL_m \end{bmatrix} \quad (4.12)$$

$$CS_m = \sum_{i=1}^{n} C_i \quad (4.13)$$

The Relative Cost Benefit Matrix ($RCBM_{m\times4}$) compares the cost and reduction in loss (i.e., benefit) resulting from alternative mitigation scenarios, and also defines the benefit-cost ratio of each scenario. The first column ($RCBM_{m,1}$) defines the cost of each mitigation scenario above the cost of the current scenario by subtracting the cost of the current scenario from the cost of each scenario. The second and third columns ($RCBM_{m,2}$ and $RCBM_{m,3}$) define the annual and cumulative benefit of each mitigation scenario above the current scenario by subtracting the current EAL and ECL of each scenario from the EAL and ECL of the current scenario. The last column ($RCBM_{m,4}$) represents the benefit/cost ratio for each scenario by dividing of the cumulative benefit of scenario *m* ($RCBM_{m,3}$) by the cost of the scenario ($RCBM_{m,1}$), where $CS_{current}$, $EAL_{current}$, and $ECL_{current}$ represent cost, expected annual loss, and expected cumulative loss for the current scenario (Equation 4.14). The ($RCBM_{m\times4}$) is expressed in terms of expected annual benefit (*EAB*; Equation 4.1), expected cumulative benefit (*ECB*; Equation 4.7) and benefit/cost ratio for each scenario (*BCR*) for each scenario *m* in Equation 4.15.

$$RCBM = \begin{bmatrix} CS_1 - CS_{Current} & EAL_{Current} - EAL_1 & ECL_{Current} - ECL_1 & RCBM_{1,3}/RCBM_{1,1} \\ CS_2 - CS_{Current} & EAL_{Current} - EAL_2 & ECL_{Current} - ECL_2 & RCBM_{2,3}/RCBM_{3,1} \\ . & . & . & . \\ . & . & . & . \\ . & . & . & . \\ CS_m - CS_{Current} & EAL_{Current} - EAL_m & ECL_{Current} - ECL_m & RCBM_{m,3}/RCBM_{m,1} \end{bmatrix} \quad (4.14)$$

$$RCBM = \begin{bmatrix} CS_1 - CS_{Current} & EAB_1 & ECB_1 & BCR_1 \\ CS_2 - CS_{Current} & EAB_2 & ECB_2 & BCR_2 \\ . & . & . & . \\ . & . & . & . \\ . & . & . & . \\ CS_m - CS_{Current} & EAB_m & ECB_m & BCR_m \end{bmatrix} \quad (4.15)$$

In the final subprocess, Result Comparison and Decision Making, two charts are plotted and evaluated to determine the most beneficial scenario(s), and the scenario(s) with the highest return on investment are returned as output. For the first chart, the benefit of each mitigation

scenario is plotted on the vertical axis versus cost on the horizontal axis to demonstrate the effectiveness and expensiveness of each scenario. For the second chart, the benefit-cost ratio of each scenario is plotted versus cost to illustrate the return on investment of each scenario. A threshold benefit=cost line is drawn on the outputs to identify scenarios where cost exceeds benefit and are rejected from further consideration. Additionally, a cost line representing the budget input in Step 1 is drawn to identify mitigation scenarios where the cost exceeds the budget.

In the example shown in Figure 4.2, each point illustrates the benefit vs. cost (Figure 4.2[a]), and the benefit cost ratio vs. cost (Figure 4.2[b]) for each scenario of a hypothetical evaluation. Scenarios A, B, C and D are specifically mentioned for demonstration. In Figure 4.2, scenarios A, B, and C are not acceptable choices as their benefit is less than their cost. Additionally, scenarios A and C have cost which exceeds the specified budget. Of the four scenarios identified, D would be appropriate, as the benefit exceeds the cost and the cost is under budget.

Selecting the “best” scenario is not necessarily straightforward, as the needs/wants of the consumer may not necessarily align with the selection of the scenario with the highest benefit or the highest benefit cost ratio. Therefore, the best three choices from each plot are identified as optimal choices to allow the consumer to evaluate the output based on his or her needs. Additionally, some scenarios with cost that is slightly higher than the budget input by the consumer may deliver a substantial benefit. Therefore, results within 5% of the maximum budget input in Step 1 are also considered acceptable outputs.

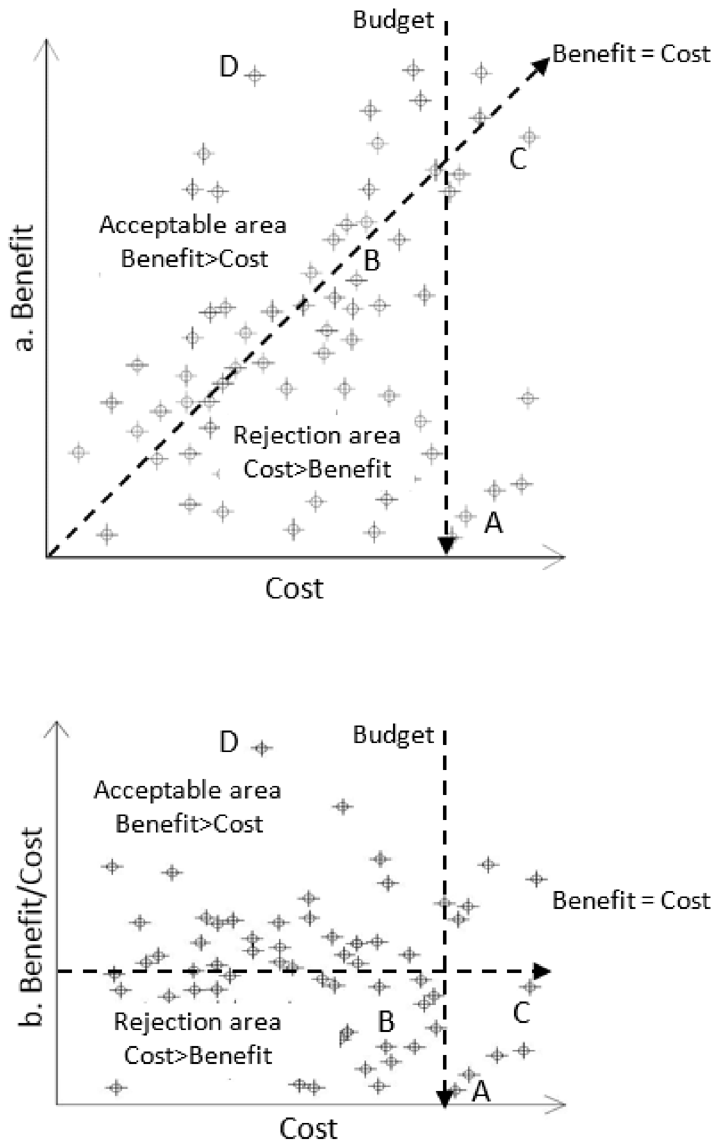


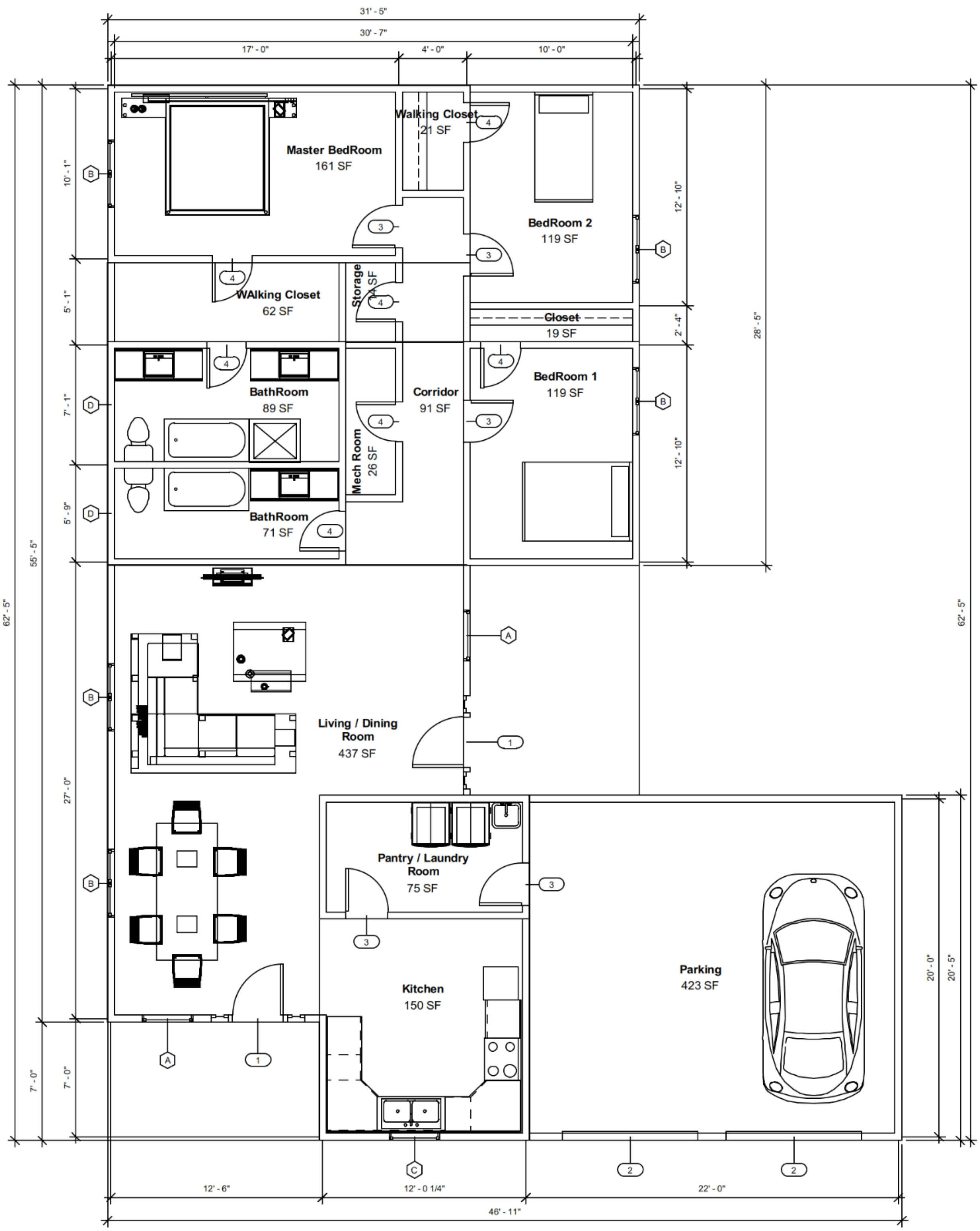
Figure 4.2 Example Benefit Cost Charts

4.3 Example Application

As an illustrative example, mitigation decision making for a five-year-old single family home located in Miami, Florida, is considered to find the three best mitigation scenarios.

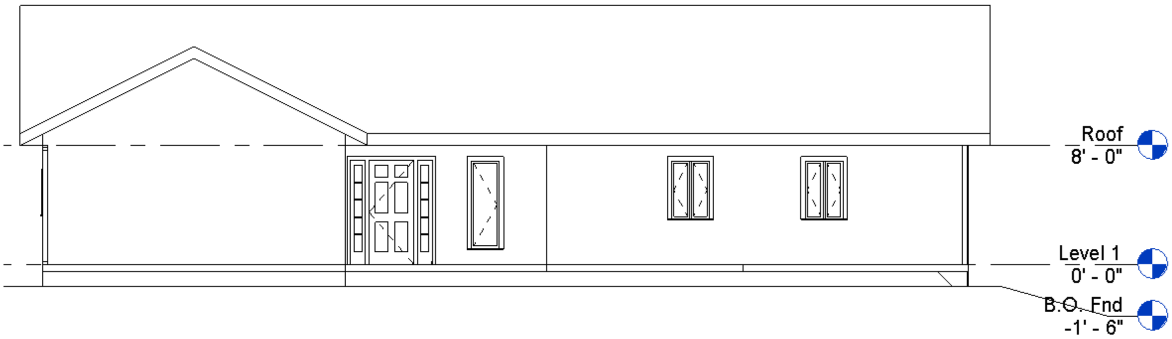
4.3.1 Step 1: Input Data

Figure 4.3 shows the schematic of the building`s floor plan, elevation, and 3D view. Input data collected in Step 1 of the framework are provided in Table 4.2.

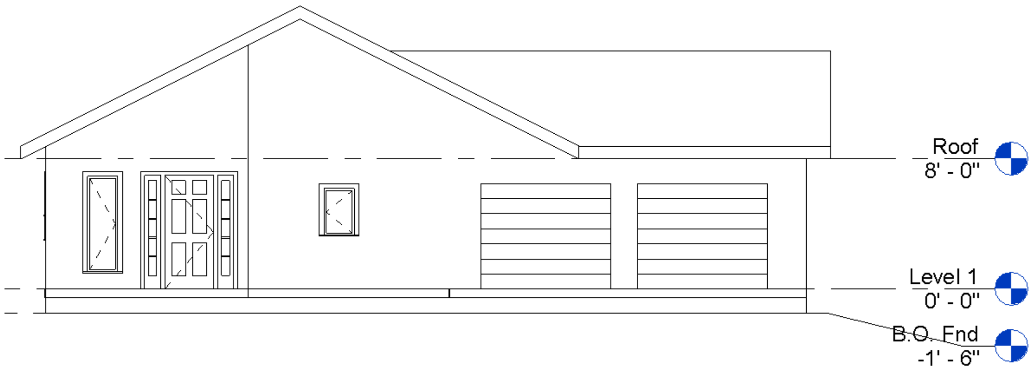


a) Floor Plan

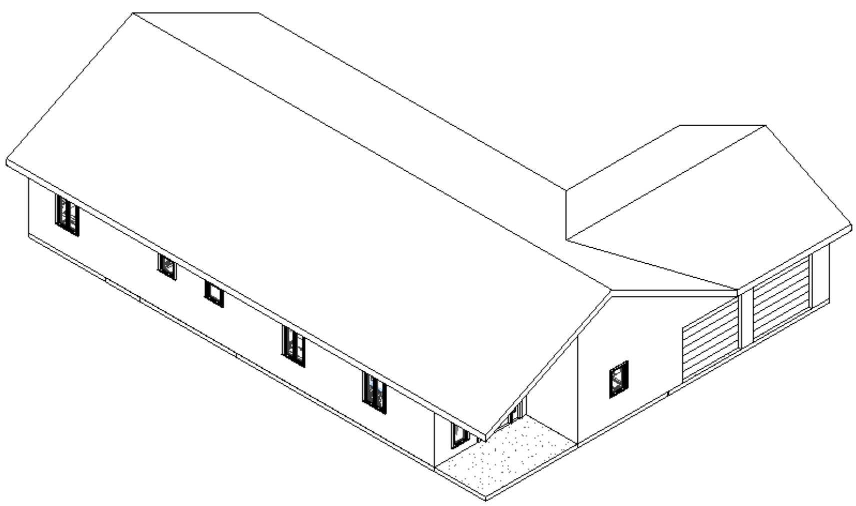
Figure 4.3 A Schematic of the Building`s Floor Plan, Elevations, and 3D View



b) East Elevation



c) South Elevation



d) 3D View

Figure 4.3 A Schematic of the Building`s Floor Plan, Elevations, and 3D View (Continued)

Table 4.2 Input Data Collected in Step 1 for Case Study Example

New Construction or Retrofit	Retrofit
Stories	1
Structure	Wood Framing
Exterior	Siding
Primary Roof Shape	Gable
Roof Slope	6/12
SWR	No
Roof Deck Attachment	6d 6”/12”
Roof-Wall Conection	Toe-Nail
Garage Door	Standard
Shutter	No
Building Value	$258,487
Floor Area	2,213 SF
Location	Latitude 25.75 Longitude -80.20
Wind Speed Contour	170 mph
Terrain	Suburban
Surface Roughness, z_0	0.35 m
Owner Budget	$15,000
Decision-Making Time Horizon	30 years

4.3.2 Step 2: Evaluate Current Scenario

The current scenario is defined in Table 4.3 using the coding system provided in Table 4.1.

Table 4.3 Current Scenario Description with Digit Code

Scenario	Mitigation					WBID
	1	2	3	4	5	
current	0	0	0	1	2	8

Mitigation 1= roof shape, Mitigation 2= apply secondary water resistant, Mitigation 3= upgrade roof deck attachment, Mitigation 4= upgrade roof wall connection Mitigation 5= shutter and garage door

4.3.3 Step 3: Evaluate Possible Mitigation Alternatives

The current scenario for the case study building has only one mitigation alternative selected: standard garage door. Removing the garage door or replacing it with a weak garage door are not considered as options. Additionally, because the case study building considers a retrofit,

the only available mitigation alternative for roof deck attachment is to change from 6d @ 6 in./12 in. to 6d/8d Mix @ 6 in./6 in. by adding additional 8d nails at 12 inches on center to the field nailing. The remaining possible mitigation alternatives, including the current scenario, are shown in Table 4.4.

Table 4.4 Possible Mitigation Alternatives

(1) Roof shape	(2) SWR	(3) Roof deck attachment	(4) Roof-wall connection	(5) Shutter and garage door configuration
Gable → 0	No SWR → 0	6d @ 6 in./12 in. → 0	Strap → 0	without shutter, standard garage door → 2
	With SWR → 1	6d/8d Mix @ 6 in./6 in.→ 1	Toe-nail → 1	with shutter, reinforced garage door → 3

4.3.4 Step 4: Create the Mitigation Scenario Matrix ($MSM_{m\times n}$)

By evaluating the current mitigation scenario and the possible additional mitigation alternatives, the $MSM_{m\times n}$ is constructed, where m = 16 (i.e., the unique number of mitigation alternative scenarios) and n = 5 (Table 4.5).

Table 4.5 Possible Mitigation Scenario Coding with Calculated WBID

Scenario	Mitigation					WBID
	1	2	3	4	5	
1	0	0	0	0	2	3
2	0	0	0	0	3	4
3 (current)	0	0	0	1	2	8
4	0	0	0	1	3	9
5	0	0	1	0	2	13
6	0	0	1	0	3	14
7	0	0	1	1	2	18
8	0	0	1	1	3	19
9	0	1	0	0	2	43
10	0	1	0	0	3	44
11	0	1	0	1	2	48
12	0	1	0	1	3	49
13	0	1	1	0	2	53
14	0	1	1	0	3	54
15	0	1	1	1	2	58
16	0	1	1	1	3	59

Mitigation 1= roof shape, Mitigation 2= apply secondary water resistant, Mitigation 3= upgrade roof deck attachment, Mitigation 4= upgrade roof wall connection Mitigation 5= shutter and garage door

4.3.5 Step 5: Create the Cost-Loss Matrix ($CLM_{m\times 3}$)

For this case study, only the initial investment of the mitigation is considered and future operation, maintenance, replacement, energy, and residual costs are neglected. Cost data represent material, labor, equipment, and overhead costs, obtained from a local builder's supply, big box stores, and published component-level housing cost data included in R.S. Means (2013). Cost data and assumptions are provided in Tables 4.6 and 4.7.

Table 4.6 Cost and Assumptions for Each Mitigation Alternative

Mitigation Alternative	Total Cost	Cost Assumptions
Add secondary water resistance (SWR)	$11,120	$1,200 for taping ($450 material and $750 installation) and $9,920 for removing roof shingles and installing new roof shingles (3.2 per square foot)
Upgrade roof-deck attachment	$10,770	$850 for adding nails (1,044 more nails needed and the labor installation rate of 0.25 per square feet) and $9,920 for removing and installing new roof shingles
Add SWR and upgrade roof-deck attachment	$11,970	$1,200 for taping, $850 for adding nails, and $9,920 for removing and installing new roof shingles
adding hurricane straps	$1,700	$250 material cost for 180 straps, and $1450 installation, considering that the top 4 inches of sheetrock needs to be removed and reinstalled
reinforce the 2 standard garage doors	$1,200	$600 per door based on FEMA (2011)
Install shutters	$3,128	See window schedule for the case study building and the price of shutters are provided in Table 4.7

Table 4.7 Window Schedule and Shutter Price for Solid Raised Polystyrene Panels

Size	Count	Cost/Unit	Total Cost
30" × 72"	2	$224	$896
32" × 48"	5	$150	$1,500
24" × 48"	1	$150	$300
24" × 24"	2	$108	$432
		Total Cost	$3,128

Using the cost data provided in Tables 4.6 and 4.7 and EAL and ECL data for each of the mitigation scenarios, the cost-loss matrix $CLM_{16\times3}$ is created (Equation 4.16). The inflation rate (F) and discounted rate (R) are assumed to be constant for 30 years with rates of 4.3% and 8%, respectively.

$$CLM = \begin{bmatrix} \$4,780 & \$3,288 & \$62,247 \\ \$9,108 & \$2,319 & \$43,896 \\ \$3,080 & \$4,454 & \$84,317 \\ \$7,408 & \$2,675 & \$50,649 \\ \$15,550 & \$2,187 & \$41,400 \\ \$19,878 & \$938 & \$17,764 \\ \$13,850 & \$3,831 & \$72,523 \\ \$18,178 & \$1,569 & \$29,704 \\ \$15,900 & \$2,781 & \$52,655 \\ \$20,228 & \$1,799 & \$34,060 \\ \$14,200 & \$4,175 & \$79,032 \\ \$18,528 & \$2,192 & \$41,498 \\ \$16,750 & \$2,029 & \$38,415 \\ \$21,078 & \$688 & \$13,017 \\ \$15,050 & \$3,738 & \$70,762 \\ \$19,378 & \$1,522 & \$28,823 \end{bmatrix} \tag{4.16}$$

4.3.6 Step 6: Create the Relative Cost Benefit Matrix ($RCBM_{m\times4}$)

The first three columns of relative cost benefit matrix ($RCBM_{m,1}$, $RCBM_{m,2}$, and $RCBM_{m,3}$) represent the cost, expected annual benefit (EAL), and expected cumulative benefit (ECB) over the current scenario (Equation 4.14). The fourth column of the matrix ($RCBM_{m,4}$) represents the benefit/cost ratio (BCR) of each scenario, defined as the ECB/cost of each scenario above the current scenario. The relative cost benefit matrix ($RCBM_{m,4}$) for the case study is presented in Equation 4.17.

$$RCBM = \begin{bmatrix} \$1,700 & \$1,166 & \$22,070 & 13.0 \\ \$6,028 & \$2,135 & \$40,421 & 6.7 \\ \$0 & \$0 & \$0 & NA \\ \$4,328 & \$1,778 & \$33,668 & 7.8 \\ \$12,470 & \$2,267 & \$42,917 & 3.4 \\ \$16,898 & \$3,515 & \$66,553 & 4.0 \\ \$10,770 & \$623 & \$11,794 & 1.1 \\ \$15,098 & \$2,885 & \$54,613 & 3.6 \\ \$12,820 & \$1,672 & \$31,662 & 2.5 \\ \$17,148 & \$2,655 & \$50,257 & 2.9 \\ \$11,120 & \$279 & \$5,285 & 0.5 \\ \$15,448 & \$2,262 & \$42,819 & 2.8 \\ \$13,670 & \$2,425 & \$45,902 & 3.4 \\ \$17,998 & \$3,766 & \$71,300 & 4.0 \\ \$11,970 & \$716 & \$13,555 & 1.1 \\ \$16,298 & \$2,931 & \$55,493 & 3.4 \end{bmatrix} \quad (4.17)$$

4.3.7 Step 7: Plot and Evaluate Cost and Benefit

Using the Relative Cost Benefit Matrix, the scenario benefit (Figure 4.4 [a]) and benefit cost ratio (Figure 4.4 [b]) are plotted versus cost. In both figures, threshold benefit=cost and user input budget lines are shown.

The relative cost benefit matrix ($RCBM_{m\times 4}$) is sorted based on cost (Equation 4.18) to evaluate and remove the mitigation scenario(s) with cost more than budget, considering a margin of 5% of the budget input in Step 1 is considered as the maximum budget ($16,500 for this case study).

Based on the chart, the cost of scenarios 16, 6, 10, and 14 corresponding to WBID 59, 14, 44, and 54, respectively, are more than 105% of budget ($15,750); therefore, they are removed from consideration. The remaining scenarios are sorted based on benefit (Equation 4.19) and benefit-cost ratio (Equation 4.20) to find the most beneficial scenario(s) and the scenario(s) with the highest return on investment.

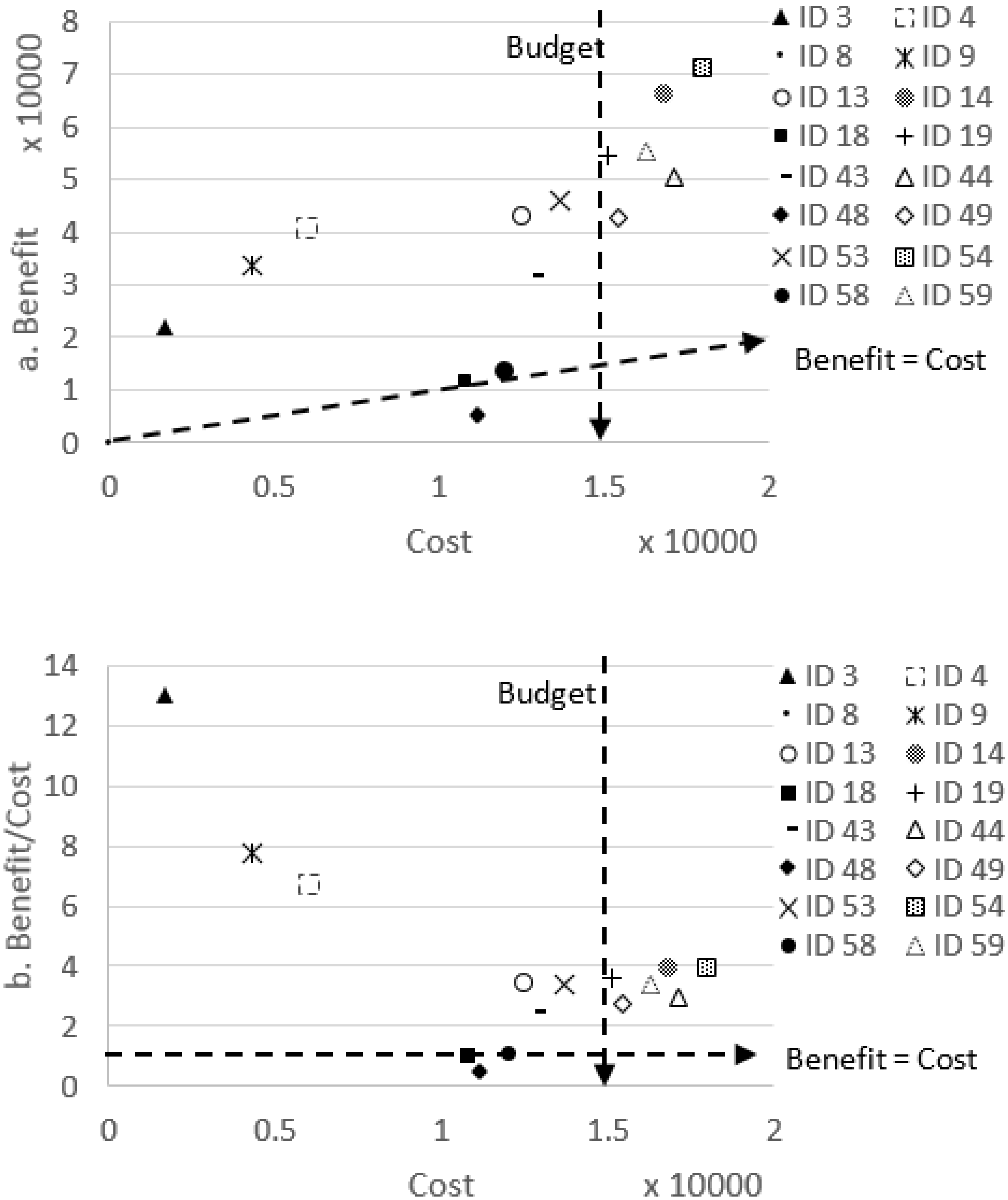


Figure 4.4 (a) Benefit of Each Scenario Versus Cost, (b) Benefit/Cost of Each Scenario Versus Cost

$$
\begin{matrix}Sorted\ RCBM\\ based\ on\ Cost\end{matrix}
\begin{bmatrix}
S3: WBID\ 8\\
S1: WBID\ 3\\
S4: WBID\ 9\\
S2: WBID\ 4\\
S7: WBID\ 18\\
S11: WBID\ 48\\
S15: WBID\ 58\\
S5: WBID\ 13\\
S9: WBID\ 43\\
S13: WBID\ 53\\
S8: WBID\ 19\\
S12: WBID\ 49\\
\cancel{S16: WBID\ 59}\\
\cancel{S6: WBID\ 14}\\
\cancel{S10: WBID\ 44}\\
\cancel{S14: WBID 54}
\end{bmatrix}
\begin{bmatrix}
\$0 & \$0 & \$0 & NA\\
\$1{,}700 & \$1166 & \$22{,}070 & 13.0\\
\$4{,}328 & \$1{,}778 & \$33{,}668 & 7.8\\
\$6{,}028 & \$2{,}135 & \$40{,}421 & 6.7\\
\$10{,}770 & \$623 & \$11{,}794 & 1.1\\
\$11{,}120 & \$279 & \$5{,}285 & 0.5\\
\$11{,}970 & \$716 & \$13{,}555 & 1.1\\
\$12{,}470 & \$2{,}267 & \$42{,}917 & 3.4\\
\$12{,}820 & \$1{,}672 & \$31{,}662 & 2.5\\
\$13{,}670 & \$2{,}425 & \$45{,}902 & 3.4\\
\$15{,}098 & \$2{,}885 & \$54{,}613 & 3.6\\
\$15{,}448 & \$2{,}262 & \$42{,}819 & 2.8\\
\cancel{\$16{,}298} & \cancel{\$2{,}931} & \cancel{\$55{,}494} & \cancel{3.4}\\
\cancel{\$16{,}798} & \cancel{\$3{,}515} & \cancel{\$66{,}553} & \cancel{4.0}\\
\cancel{\$17{,}148} & \cancel{\$2{,}655} & \cancel{\$50{,}257} & \cancel{2.9}\\
\cancel{\$17{,}998} & \cancel{\$3{,}766} & \cancel{\$71{,}300} & \cancel{4.0}
\end{bmatrix}
\quad (4.18)
$$

$$
\begin{matrix}Sorted\ remaining\\ scenarios\\ based\ on\ benefit\end{matrix}
\begin{bmatrix}
S3: WBID\ 8\\
S11: WBID\ 48\\
S7: WBID\ 18\\
S15: WBID\ 58\\
S1: WBID\ 3\\
S9: WBID\ 43\\
S4: WBID\ 9\\
S2: WBID\ 4\\
S12: WBID\ 49\\
S5: WBID\ 13\\
S13: WBID\ 53\\
S8: WBID\ 19
\end{bmatrix}
\begin{bmatrix}
\$0 & \$0 & \$0 & NA\\
\$11{,}120 & \$279 & \$5{,}285 & 0.5\\
\$10{,}770 & \$623 & \$11{,}794 & 1.1\\
\$11{,}970 & \$716 & \$13{,}555 & 1.1\\
\$1{,}700 & \$1{,}166 & \$22{,}070 & 13.0\\
\$12{,}820 & \$1{,}672 & \$31{,}662 & 2.5\\
\$4{,}328 & \$1{,}778 & \$33{,}668 & 7.8\\
\$6{,}028 & \$2{,}135 & \$40{,}421 & 6.7\\
\$15{,}448 & \$2{,}262 & \$42{,}819 & 2.8\\
\$12{,}470 & \$2{,}267 & \$42{,}917 & 3.4\\
\$13{,}670 & \$2{,}425 & \$45{,}902 & 3.4\\
\$15{,}098 & \$2{,}885 & \$54{,}613 & 3.6
\end{bmatrix}
\quad (4.19)
$$

$$
\begin{matrix}Sorted\ remaining\\ scenarios\\ based\ on\ benefit/cost\end{matrix}
\begin{bmatrix}
S11: WBID\ 48\\
S3: WBID\ 8\\
S7: WBID\ 18\\
S15: WBID\ 58\\
S9: WBID\ 43\\
S12: WBID\ 49\\
S13: WBID\ 53\\
S5: WBID\ 13\\
S8: WBID\ 19\\
S2: WBID\ 4\\
S4: WBID\ 9\\
S1: WBID\ 3
\end{bmatrix}
\begin{bmatrix}
\$11{,}120 & \$279 & \$5{,}285 & 0.5\\
\$0 & \$0 & \$0 & NA\\
\$10{,}770 & \$623 & \$11{,}794 & 1.1\\
\$11{,}970 & \$716 & \$13{,}555 & 1.1\\
\$12{,}820 & \$1{,}672 & \$31{,}662 & 2.5\\
\$15{,}448 & \$2{,}262 & \$42{,}819 & 2.8\\
\$13{,}670 & \$2{,}425 & \$45{,}902 & 3.4\\
\$12{,}470 & \$2{,}267 & \$42{,}917 & 3.4\\
\$15{,}098 & \$2{,}885 & \$54{,}613 & 3.6\\
\$6{,}028 & \$2{,}135 & \$40{,}421 & 6.7\\
\$4{,}328 & \$1{,}778 & \$33{,}668 & 7.8\\
\$1{,}700 & \$1{,}166 & \$22{,}070 & 13.0
\end{bmatrix}
\quad (4.20)
$$

4.3.8 Step 8: Decision Making

The three scenarios with the highest benefit are selected based on the sorted scenario by benefit. However, there are some scenarios that deliver considerable benefit but at a lower cost; therefore, the three scenarios with highest benefit-cost ratio are also consider as possible solutions. These 6 scenarios are provided to the consumer as the best mitigation scenarios, and the consumer can choose the best solution based on his or her needs (Table 4.8). Additionally, the consumer can be provided the full output from the Relative Cost Benefit Matrix ($RCBM_{m \times 4}$) and sorted scenarios based on cost, benefit, and benefit-cost ratio to choose the optimal mitigation scenario.

Scenarios 8, 13 and 5, corresponding to WBID 19, 53, and 13, have the highest benefits, respectively, within 105% of the proposed budget. Scenarios 1, 4, and 2 corresponding to WBID 3, 9, and 4 have the highest return on investment (benefit/cost ratio). These 6 scenarios are considered as optimal solutions for the consumer.

Table 4.8 Optimal Mitigation Scenarios Output to Consumer for Case Study Building

Mitigation Actions	Cost	Expected Annual Benefit	Expected Cumulative Benefit	Benefit/Cost Ratio
• Add 8d nails at 12" on center to existing field nailing (requires replacement of roof cover and may be more economical if done in conjunction with needed roof replacement) • Install rated shutters over windows and reinforce garage doors	$15,098	$2,885	$54,613	3.6
• Add 8d nails at 12" on center to existing field nailing <u>and secondary water resistance</u> (requires replacement of roof cover and may be more economical if done in conjunction with needed roof replacement) • Replace toe-nail roof-wall connections with rated strap connections (requires the top 4 inches of sheetrock to be removed and reinstalled)	$13,670	$2,425	$45,902	3.4

Table 4.8 Optimal Mitigation Scenarios Output to Consumer for Case Study Building (Continued)

Mitigation Actions	Cost	Expected Annual Benefit	Expected Cumulative Benefit	Benefit/Cost Ratio
• Add 8d nails at 12" on center to existing field nailing (requires replacement of roof cover and may be more economical if done in conjunction with needed roof replacement) • Replace toe-nail roof-wall connections with rated strap connections (requires the top 4 inches of sheetrock to be removed and reinstalled)	$12,470	$2,267	$42,917	3.4
• Replace toe-nail roof-wall connections with rated strap connections (requires the top 4 inches of sheetrock to be removed and reinstalled) • Install rated shutters over windows and reinforce garage doors	$6,028	$2,135	$40,421	6.7
• Install rated shutters over windows and reinforce garage doors	$4,328	$1,778	$33,668	7.8
• Replace toe-nail roof-wall connections with rated strap connections (requires the top 4 inches of sheetrock to be removed and reinstalled)	$1,700	$1,166	$22,070	13.0

4.4 Summary and Conclusions

This chapter presents a computational benefit-cost decision-making framework to evaluate the cost effectiveness of mitigation strategies to support multiple levels of mitigation decision making that can be customized based on location, decision-making time horizon, and building configuration. The avoided economic loss achieved through mitigation is considered the benefit and the cost of mitigation considers both the initial investment and lifecycle cost of mitigation. The economic concepts of inflation and discount rates are applied to calculate benefit and cost of mitigation over the decision-making time horizon. The proposed computational decision-making framework consists of four subprocess: data acquisition, data evaluation, cost benefit calculation, and result comparison and decision making. By considering the existing mitigation scenario, the

decision-making framework determines all combinations of possible mitigation scenarios, evaluates the cost and benefit of each mitigation scenario over the decision-making time horizon, and suggests the six best scenarios based on consumer budget, benefit, and benefit cost ratio.

Important contributions of the study are:

- A computational decision-making framework was developed that: 1) designates the existing mitigation and other available mitigation alternatives by data acquisition, 2) determines all possible mitigation scenarios and assigns a unique code for each scenario, 3) calculates the benefit and cost of each mitigation scenario over the decision-making time horizon, and 4) generates customized mitigation solutions considering the cost, benefit, and benefit-cost ratio of each mitigation scenario.
- The results of this framework provide consumer-level guidance to assist the mitigation decision-making process customized based on location, decision-making time horizon, building configuration, and budget.

CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

The overarching goal of this dissertation research was to quantitatively model wind hazard direct economic losses and avoided losses achieved through wind hazard mitigation for wood framed, one-story, single family residential construction in the continental U.S. to support consumer-level mitigation decision making. In order to address the overarching goal, three specific objectives were addressed:

- Calculate windstorm expected annual losses (EAL) for wood framed, one-story, single family homes in the continental United States in open terrain.
- Consider the effect of terrain on EAL for wood framed, one-story, single family homes and create a methodology to calculate EAL for any terrain.
- Create a computational decision-making framework to evaluate the cost effectiveness of mitigation strategies to enhance consumer decision making that is customized based on location, terrain, years of interest, and building configuration.

Chapter 2 through Chapter 4 described the work accomplished to achieve these objectives and summaries of the work and findings for each of the objectives were presented at the end of each chapter. This chapter discusses the conclusion of the three objectives and explains how each of these objectives is applied within multi-criteria risk assessment for residential, wood framed construction, and outlines future work for this topic.

5.2 Expected Annual Windstorm Losses for One-Story, Wood-Framed, Single Family Homes in Open Terrain

Existing damage and loss model used for wind risk assessment for buildings were found to be geographically limited in scope, limited to specific building types, and limited to specific events, making generalization and direct application of these model on a nationwide basis not feasible. Therefore, the first objective of this dissertation was to calculate expected annual

windstorm losses for the entire class of wood framed, one-story, single family homes contained within FEMA's Hazus-MH hurricane model for the continental United States in open terrain.

Chapter 2 presented a methodology to calculate expected annual loss (EAL) for the U.S. based on ASCE 7-10 wind contour through Monte Carlo simulation of annual maximum wind speeds convolved with Hazus-MH economic loss functions. Chapter 2 demonstrated the methodology and provided expected annual loss results in tabular format for 160 generalized variations of one-story, single-family homes in open terrain for nine wind speed contours. A significant feature of the proposed methodology is the ability to calculate the generalized benefit of wind mitigation for each type of building across geographic areas.

An example was presented to illustrate the applicability of the results within the context of mitigation decision making. In the case study, a single family homes with a gable roof without any mitigation was considered. By adding different mitigation alternatives, the economic benefit (i.e., avoided loss) of wind mitigation was directly evaluated. Considering only relative decrease in loss for the individual mitigation options, the effectiveness of each mitigation by wind speed contour was evaluated. The results showed that for low wind speed contours, upgrading the nailing pattern results in the largest relative loss reduction, followed by installing a reinforced garage door and shutters, and installing shutters only as the third most effective mitigation option. For high wind speed contours, the largest relative loss reductions are achieved by installing a reinforced garage door and shutters followed by installing shutters only.

The results of Chapter 2 provide practical estimation of annual expected loss that can be easily applied to support building-level decision-making, regional loss modeling, and economic justification for building code reform for wind hazards.

5.3 Influence of Terrain on Expected Annual Windstorm Losses for One-Story, Wood-Framed, Single Family Homes

After calculation of expected annual loss for all general wood-frame, single family homes in open terrain in the U.S., Chapter 3 focused on the influence of surface roughness on expected annual loss. Because much existing literature considers loss as a function of basic wind speed in open terrain, the effect of surface roughness as a critical component in surface wind speed is often neglected; however, winds loads and associated loss are very strongly dependent on the actual terrain. Therefore, Chapter 3 addressed the variation in loss due to changes in surface roughness as an important factor in estimation of wind-induced loss.

To investigate the effect of surface roughness, the Hazus-MH loss functions were adjusted to account for local surface roughness characteristics by converting open terrain wind speed to local wind speed through the log law and power law. The results of this evaluation showed that there are two unique loss function types within Hazus for each building type: open terrain and non-open terrain. To address non-open terrain loss functions, reference non-open terrain was selected with a surface roughness z_0=0.15 meter, and expected annual loss for reference non-open terrain was calculated by convolving the local wind speed with non-open terrain loss functions. By extending the methodology developed in Chapter 2 for light suburban terrain, suburban terrain, light tree terrain, and tree terrain, total expected annual loss was calculated. Using the four terrain classifications, the non-linear relationship between surface roughness and total expected annual loss was explored, and defined using a terrain influence factor (TIF), which was optimized for three Building Groups and allows calculation of expected annual loss for any surface roughness.

The application of methodology was illustrated by calculating expected annual loss (EAL) for three case studies located along the 140 mph wind speed contour with surface roughness z_0=0.35, 0.7, and 1.0 m., and the results were validated using computationally calculated results.

The maximum error between the TIF-estimated and computational validated EAL was approximately 15%; however, the absolute difference in EAL was less than 0.04%.

A significant outcome of the methodology developed in Chapter 3 is the ability to calculate expected annual loss for each type of building across geographic areas with any surface roughness. The results of this chapter will allow rapid application of the EAL methodology to any location with any surface roughness to achieve rapid estimates of economic building loss.

5.4 Consumer Wind Hazard Mitigation Decision Framework

Mitigation undoubtedly reduces windstorm losses; however, a comprehensive framework to calculate the economic benefit of mitigation over time for unique building configurations has not been developed. Therefore, the purpose of Chapter 4 was to create a computational decision-making framework to evaluate the cost effectiveness of mitigation strategies that can be customized based on location, years of interest, and building configuration. Based on the methodology developed in previous chapters to calculate wind-induced expected annual loss throughout the U.S. in any terrain, the economic loss avoided through mitigation is considered the potential positive effect (benefit). The cost of mitigation is the monetary value of the initial investment and the lifecycle costs associated with mitigation. In benefit and cost calculations, inflation and discount rates are considered to evaluate the present value of future benefits and costs over the consumer decision-making time horizon.

The computational decision-making framework consists of eight steps, divided into four subprocesses: 1) data acquisition, 2) data evaluation, 3) cost benefit calculation, and 4) results comparison and decision making. The computational framework determines the current mitigation scenario, identifies all possible mitigation scenarios, and assigns a unique numerical code to each mitigation scenarios. The benefit and cost of each mitigation scenario are calculated for the input decision-making time horizon, and by considering the cost, benefit, and benefit-cost ratio of each

mitigation plan, the top six results are returned to the user for determination of the best scenario based on his or her needs. The mitigation scenarios are customized based on location, decision-making time horizon, building configuration, and budget.

To provide demonstration of the framework, a case study a wood-framed single family home in suburban Miami, Florida, was presented. Considering retrofit mitigation with a $15,000 budget and a decision-making time horizon of 30 years, 16 mitigation scenarios are identified, and results for the top six scenarios based on budget, benefit, and cost are output to the consumer.

The results of the framework developed in chapter 4, provide consumer-level guidance to assist the mitigation decision-making process customized based on location, decision-making time horizon, building configuration, and budget.

5.5 Final Remarks and Recommendations

The overarching goal of this dissertation was quantitatively model wind hazard direct economic losses and avoided losses achieved through wind mitigation for wood framed, one-story, single family residential construction in the continental U.S. that can be easily applied at all levels of decision making. This was accomplished primarily through the developed a framework to allow application of existing loss functions to calculate expected annual loss at any location, which was integrated into a consumer decision making framework. The preceding sections detail the progress made by this dissertation research, including all foundational work carried out.

While the research provided in this dissertation does in part accomplish the goal by presenting the framework to calculate expected annual loss at any location and decision making framework that can be used for risk-based wind loss and mitigation decision making, the proposed model and framework undoubtedly have limitations.

In this research, direct economic loss was considered; however, in future models, indirect economic aspects such as longer-term effects on regional economy, changes in sales and income,

and also social losses in terms of casualties, displaced households, and short-term shelter should be considered for better evaluation of risk. The loss function used in this research were extracted from the Hazus-MH hurricane model; however, variability within the building types was not considered. In developing the methodology in general, it is anticipated that it will be extended to libraries of loss functions that consider uncertainty in the future. Stochastic simulation of these loss functions within the proposed framework will lead to more reliable results. Furthermore, this research investigated expected annual loss in terms of the mean loss; however, future work will investigate the variability of the mean and other key statistical measures such as probable maximum loss and quantile losses. Since comprehensive comparable data do not exist at this time, the expected annual loss calculated by the proposed methodology will be validated in the future once comparable data are available.

The Gumbel distribution is well accepted in the wind engineering community; however, the applicability of other extreme value distributions (i.e., Weibull distribution) will be further investigated in future versions of the model. Additionally, in calculation of the local wind speed, a fully transitioned boundary layer was considered and it was assumed that wind speed is influenced only by the immediate local terrain, and not the previous terrain. In reality, the wind transitions gradually from one surface roughness to another surface roughness; therefore, in future work, the boundary transition should be considered.

The cost data used in the research relied heavily on RSMeans Residential Cost Data, and the variability in the cost data and uncertainty in economic aspects are not considered. As improved cost data are developed for wind hazard mitigation, these data will be implemented into the model.

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APPENDIX A: EXPECTED ANNUAL LOSS FOR BUILDING, CONTENT, AND LOSS OF USE IN OPEN TERRAIN

Table A.1 Fractional Expected Annual Building Loss (EAL_B), as a Ratio of Building Value, (10^{-3}), Open Terrain, z_0=0.03 m

ID	700-year open terrain 3-second gust wind speed, mph									ID	700-year open terrain 3-second gust wind speed, mph								
	110	115	120	130	140	150	160	170	180		110	115	120	130	140	150	160	170	180
1	1.96	3.16	3.57	5.45	6.78	11.22	15.20	23.96	24.36	**81**	1.68	2.58	3.14	4.48	5.80	9.53	12.94	19.71	20.83
2	1.90	3.01	3.30	4.67	5.61	9.00	12.08	18.18	19.42	**82**	1.53	2.49	2.81	3.84	4.69	7.52	9.65	15.51	16.75
3	1.44	2.32	2.93	4.58	5.94	9.98	13.50	21.79	22.16	**83**	1.22	2.00	2.37	3.80	5.13	8.12	12.24	19.38	19.50
4	1.38	2.12	2.52	3.77	4.45	7.21	9.64	15.27	15.66	**84**	1.13	1.91	2.24	3.16	3.87	6.57	8.32	13.00	13.36
5	1.82	3.03	3.52	5.46	7.07	10.91	15.80	23.38	25.64	**85**	1.53	2.53	2.94	4.50	5.93	9.82	13.09	21.23	21.71
6	2.12	3.51	4.09	6.09	7.78	12.85	17.66	26.44	27.22	**86**	1.68	2.89	3.38	4.93	6.05	10.15	14.17	22.23	22.93
7	1.86	3.08	3.27	4.55	5.69	9.14	11.77	19.41	20.02	**87**	1.52	2.55	2.81	4.04	5.00	7.77	10.07	15.81	15.52
8	1.63	2.63	3.30	5.18	7.22	12.26	16.48	26.17	28.21	**88**	1.29	2.09	2.62	4.13	5.76	9.78	13.25	20.98	22.18
9	1.31	2.05	2.45	3.83	4.91	7.77	10.06	16.23	16.80	**89**	1.15	1.91	2.12	3.14	4.20	6.62	8.99	14.27	14.90
10	2.55	4.07	5.50	8.86	12.01	19.46	24.98	39.64	38.43	**90**	1.59	2.82	3.46	5.33	7.35	12.22	16.79	26.43	28.37
11	0.78	1.25	1.77	2.72	3.72	6.72	9.40	14.64	15.81	**91**	0.56	0.99	1.27	2.11	3.46	5.85	7.73	12.87	14.22
12	0.63	1.06	1.22	1.63	2.25	3.59	4.87	7.92	8.25	**92**	0.49	0.82	1.04	1.54	2.08	3.36	4.60	6.81	7.80
13	0.58	0.98	1.53	2.48	3.65	6.14	9.51	14.11	16.81	**93**	0.51	0.79	1.33	2.12	3.13	5.76	7.96	13.08	15.13
14	0.48	0.81	0.98	1.38	1.90	3.19	4.27	6.81	7.11	**94**	0.39	0.63	0.80	1.32	1.84	3.11	3.98	6.55	7.28
15	0.61	1.12	1.54	2.33	3.46	6.36	9.74	14.05	15.88	**95**	0.48	0.80	1.17	2.31	3.20	5.54	7.86	13.18	14.52
16	0.87	1.58	2.03	3.61	5.73	8.95	13.07	19.93	21.34	**96**	0.71	1.07	1.66	3.15	4.36	6.92	9.82	17.24	18.49
17	0.66	1.05	1.27	1.95	2.67	4.37	6.08	10.64	10.72	**97**	0.48	0.81	1.03	1.63	2.15	3.66	4.74	8.08	8.59
18	0.88	1.28	2.18	3.75	5.66	9.97	13.20	21.40	23.20	**98**	0.59	0.95	1.33	2.88	4.14	7.41	10.73	16.95	18.59
19	0.47	0.86	1.04	1.62	2.39	4.03	5.44	9.38	10.56	**99**	0.40	0.62	0.87	1.37	1.96	3.38	4.67	7.80	8.39
20	0.86	1.55	2.13	3.41	5.39	9.08	14.28	21.55	23.77	**100**	0.53	0.97	1.45	2.59	4.01	7.58	10.86	17.13	18.19
21	1.89	2.84	3.30	4.63	6.51	9.57	13.00	21.15	21.15	**101**	1.57	2.57	2.96	4.23	5.53	9.26	12.29	18.26	19.70
22	1.69	2.73	2.99	4.14	4.95	7.85	9.96	15.07	15.75	**102**	1.53	2.42	2.78	3.77	4.71	7.20	9.08	14.48	14.84
23	1.40	2.30	2.76	4.01	5.65	8.63	12.02	18.91	20.13	**103**	1.17	2.00	2.36	3.71	4.92	7.96	10.99	17.56	19.13
24	1.28	2.03	2.39	3.14	3.86	6.47	8.40	13.47	14.26	**104**	1.16	1.82	2.15	3.27	3.84	6.06	8.22	12.93	13.37
25	1.74	2.74	3.22	4.57	6.19	9.89	13.10	20.86	22.32	**105**	1.42	2.33	3.15	4.28	5.46	9.03	11.71	18.63	19.94
26	2.00	3.25	3.91	5.65	7.54	12.05	16.65	25.52	26.49	**106**	1.62	2.81	3.22	4.82	6.31	9.86	13.90	21.29	21.76
27	1.78	2.78	3.09	4.11	5.12	8.26	11.08	16.93	17.38	**107**	1.59	2.45	2.86	3.85	4.82	7.36	9.70	15.38	15.32
28	1.61	2.67	3.24	5.21	6.72	11.74	16.08	25.19	26.82	**108**	1.24	2.03	2.76	4.32	5.91	9.52	13.06	20.82	21.69
29	1.24	2.16	2.40	3.52	4.31	6.97	9.58	14.96	15.49	**109**	1.14	1.85	2.22	3.03	3.97	6.64	9.00	13.95	14.58
30	2.43	4.25	5.86	8.96	11.70	19.14	24.67	38.89	39.43	**110**	1.70	2.63	3.34	5.30	7.51	12.50	16.90	25.98	27.63
31	0.72	1.19	1.60	2.63	4.03	6.61	8.99	14.30	15.27	**111**	0.59	0.98	1.41	2.36	3.26	5.79	8.00	13.21	14.27
32	0.64	1.04	1.24	1.75	2.24	3.68	4.95	7.74	8.75	**112**	0.49	0.82	1.00	1.60	2.02	3.29	4.70	7.24	7.88
33	0.62	1.07	1.37	2.35	3.99	6.55	9.49	14.86	16.55	**113**	0.48	0.84	1.19	2.12	2.94	5.58	7.84	13.26	14.19
34	0.45	0.79	0.97	1.43	1.84	3.16	4.19	6.90	8.18	**114**	0.37	0.64	0.86	1.40	1.78	3.03	4.43	6.25	7.29
35	0.65	1.10	1.51	2.59	3.91	6.05	9.05	14.87	15.97	**115**	0.44	0.84	1.12	2.09	2.92	5.22	7.84	12.63	14.33
36	0.93	1.64	2.33	3.68	5.25	8.38	12.83	19.91	20.98	**116**	0.64	1.11	1.53	2.84	4.30	7.14	10.34	16.72	17.86
37	0.66	1.07	1.31	2.04	2.60	4.16	6.51	10.27	11.18	**117**	0.50	0.86	1.13	1.65	2.25	3.73	5.20	7.95	8.95
38	0.78	1.41	2.09	3.59	5.81	9.24	13.71	22.31	24.10	**118**	0.51	1.00	1.52	2.49	4.46	6.71	11.45	16.76	18.28
39	0.52	0.86	1.11	1.65	2.25	3.73	5.83	9.43	9.47	**119**	0.36	0.67	0.88	1.26	1.98	3.50	4.77	7.70	8.63
40	0.84	1.54	2.07	3.97	5.29	9.07	13.21	21.80	23.40	**120**	0.56	0.88	1.44	2.71	4.35	7.03	10.57	16.99	18.59
41	1.81	2.86	3.40	4.73	5.76	9.83	13.17	20.78	21.91	**121**	1.56	2.46	2.79	4.07	4.92	7.67	11.22	17.09	17.92
42	1.69	2.65	2.87	3.83	4.77	7.01	9.09	14.85	14.81	**122**	1.41	2.25	2.40	3.13	3.46	5.43	6.86	10.97	11.59
43	1.31	2.21	2.52	3.88	4.97	8.40	11.60	19.02	20.62	**123**	1.13	1.82	2.25	3.27	4.27	7.60	10.38	16.12	16.88
44	1.19	1.84	2.03	2.80	3.23	5.60	7.66	11.86	12.02	**124**	1.02	1.64	1.80	2.32	2.84	4.47	5.87	9.27	9.54
45	1.73	2.64	3.31	4.68	5.99	10.12	14.14	22.52	23.68	**125**	1.42	2.19	2.76	3.91	5.47	8.63	11.09	18.58	19.85
46	2.05	3.15	3.80	5.37	7.41	11.54	15.44	23.97	24.97	**126**	1.51	2.52	2.90	4.32	5.31	8.60	11.99	18.67	20.36
47	1.69	2.69	2.96	3.80	4.82	7.96	9.88	15.96	16.01	**127**	1.44	2.27	2.45	3.18	3.63	5.85	7.19	11.10	11.35
48	1.53	2.42	3.17	4.86	6.64	10.36	14.71	24.08	25.43	**128**	1.23	1.90	2.54	3.59	5.07	8.70	11.82	19.51	20.80
49	1.19	1.87	2.05	2.96	3.60	5.89	8.33	12.95	13.21	**129**	1.02	1.66	1.75	2.43	2.80	4.64	6.45	10.12	10.15
50	2.48	4.19	5.37	8.69	12.07	18.89	24.33	37.70	38.77	**130**	1.53	2.50	3.42	5.05	7.05	11.98	15.40	25.61	25.60
51	0.77	1.14	1.65	2.43	3.79	6.26	8.42	13.59	14.91	**131**	0.57	0.95	1.18	2.17	3.06	5.42	7.76	11.97	13.27
52	0.61	0.99	1.09	1.45	1.75	2.78	3.49	5.49	6.01	**132**	0.48	0.77	0.92	1.33	1.68	2.55	3.40	5.29	5.29
53	0.57	0.99	1.36	2.40	3.54	5.80	9.43	13.70	15.57	**133**	0.51	0.90	1.25	1.73	3.34	5.08	7.80	12.50	13.45
54	0.47	0.74	0.86	1.26	1.48	2.39	3.26	5.23	5.57	**134**	0.36	0.58	0.74	1.10	1.46	2.28	3.05	4.90	5.18

ID	700-year open terrain 3-second gust wind speed, mph									ID	700-year open terrain 3-second gust wind speed, mph								
	110	115	120	130	140	150	160	170	180		110	115	120	130	140	150	160	170	180
55	0.68	1.05	1.38	2.16	3.80	6.15	9.25	14.09	16.44	**135**	0.43	0.80	1.12	2.17	3.00	5.33	7.80	11.88	12.82
56	0.91	1.57	2.10	3.23	5.21	8.32	12.29	19.68	20.53	**136**	0.63	1.07	1.55	2.50	4.09	6.59	9.80	15.46	17.26
57	0.61	1.03	1.20	1.85	2.32	3.67	4.89	8.39	9.55	**137**	0.46	0.80	1.02	1.48	1.80	3.13	4.02	6.41	7.31
58	0.76	1.33	2.16	3.45	5.97	9.37	13.33	20.75	23.19	**138**	0.50	0.97	1.48	2.53	4.27	7.01	10.72	16.35	18.51
59	0.47	0.80	0.94	1.46	2.07	3.22	4.90	8.13	9.27	**139**	0.36	0.61	0.81	1.20	1.67	2.66	3.99	6.36	7.24
60	0.81	1.45	2.15	3.38	6.52	9.81	13.78	21.77	22.30	**140**	0.61	0.90	1.30	2.64	3.99	7.21	10.02	17.06	18.05
61	1.63	2.61	2.80	3.96	4.76	8.17	10.58	16.58	17.66	**141**	1.51	2.37	2.62	3.61	4.48	7.42	9.62	14.98	15.53
62	1.51	2.33	2.35	2.79	3.05	4.36	5.26	8.16	7.94	**142**	1.37	2.24	2.30	2.83	3.00	4.66	5.44	8.45	8.09
63	1.24	2.01	2.31	3.46	4.59	7.69	9.92	15.26	17.07	**143**	1.14	1.86	2.13	3.14	4.13	6.45	8.90	15.22	15.37
64	1.10	1.73	1.71	2.15	2.47	3.72	4.63	7.30	7.30	**144**	0.99	1.60	1.69	2.19	2.42	3.73	4.56	7.05	6.93
65	1.48	2.41	2.91	3.98	5.27	8.23	11.14	17.77	18.65	**145**	1.31	2.12	2.52	3.87	4.82	7.76	10.11	15.71	17.25
66	1.86	2.88	3.27	4.89	6.32	10.38	13.94	21.83	22.72	**146**	1.54	2.52	3.03	4.18	5.61	8.71	12.01	18.27	20.10
67	1.55	2.45	2.40	3.00	3.38	5.42	6.83	10.10	11.20	**147**	1.37	2.24	2.31	2.92	3.35	5.02	6.13	9.66	9.19
68	1.46	2.40	2.83	4.34	6.20	11.06	14.16	22.09	23.73	**148**	1.17	1.91	2.32	3.52	5.13	8.47	11.46	19.23	20.47
69	1.11	1.75	1.81	2.54	2.84	4.93	6.54	10.20	10.39	**149**	1.01	1.61	1.79	2.41	2.58	4.33	5.50	8.49	9.53
70	2.45	4.13	5.48	8.31	11.19	18.18	24.32	37.36	37.38	**150**	1.65	2.52	3.13	4.83	6.45	11.49	16.41	25.06	26.47
71	0.75	1.21	1.63	2.39	3.62	5.97	9.05	14.00	14.87	**151**	0.60	0.92	1.39	2.24	3.14	5.70	7.77	12.50	14.24
72	0.60	0.96	1.14	1.47	1.74	2.59	3.57	5.47	5.78	**152**	0.46	0.79	0.96	1.38	1.61	2.62	3.38	5.44	5.53
73	0.65	1.02	1.36	2.38	3.54	5.88	8.87	14.05	15.36	**153**	0.43	0.78	1.17	1.91	3.24	5.61	7.65	12.46	13.79
74	0.46	0.72	0.86	1.15	1.40	2.40	3.07	4.91	5.32	**154**	0.35	0.63	0.73	1.13	1.47	2.39	3.21	5.16	5.25
75	0.63	1.03	1.49	2.34	3.48	5.98	8.82	14.52	15.56	**155**	0.47	0.79	1.20	2.04	3.09	5.44	7.68	12.19	13.86
76	0.94	1.50	2.23	3.68	5.16	8.24	12.63	18.34	20.99	**156**	0.64	1.09	1.62	2.67	3.81	7.07	9.87	15.82	17.53
77	0.63	0.99	1.23	1.69	2.23	3.66	5.01	8.30	9.09	**157**	0.45	0.78	1.02	1.49	1.85	2.94	4.04	6.46	6.96
78	0.71	1.38	2.13	3.56	5.08	9.68	13.95	20.38	23.00	**158**	0.64	0.91	1.38	2.47	4.23	6.94	10.20	17.26	18.48
79	0.49	0.75	0.95	1.46	2.02	3.44	4.73	7.79	9.03	**159**	0.36	0.62	0.82	1.23	1.62	2.87	4.00	6.22	7.15
80	0.97	1.50	2.08	3.73	5.38	9.34	13.75	21.40	22.35	**160**	0.56	0.89	1.44	2.77	4.17	7.01	10.97	17.10	18.09

Table A.2 Fractional Expected Annual Content Loss (EAL_C), as a Ratio of Content Value, (10^{-4}), Open Terrain, z_0=0.03 m

ID	700-year open terrain 3-second gust wind speed, mph									ID	700-year open terrain 3-second gust wind speed, mph								
	110	115	120	130	140	150	160	170	180		110	115	120	130	140	150	160	170	180
1	0.870	1.457	2.115	3.527	4.599	8.450	11.509	17.671	18.090	**81**	0.781	1.256	1.699	2.723	3.799	6.716	9.505	14.349	16.164
2	0.838	1.343	1.913	2.832	4.184	6.579	8.914	14.111	14.879	**82**	0.658	1.108	1.521	2.355	3.141	5.429	7.043	11.368	12.037
3	0.694	1.164	1.761	2.717	4.207	6.960	10.564	15.747	16.344	**83**	0.578	0.917	1.497	2.692	3.486	5.864	8.481	13.938	14.718
4	0.593	0.896	1.408	2.187	2.985	5.258	7.409	11.754	12.377	**84**	0.489	0.838	1.161	1.922	2.816	4.749	6.504	10.276	10.709
5	0.879	1.449	2.207	3.459	4.790	7.885	11.611	18.439	18.992	**85**	0.705	1.222	1.798	2.806	4.502	7.225	9.687	15.526	16.343
6	0.999	1.750	2.478	3.906	5.785	9.088	12.836	19.603	20.346	**86**	0.803	1.315	1.790	3.176	4.462	7.310	10.125	15.492	17.170
7	0.740	1.282	2.138	2.876	4.186	6.757	9.025	14.547	15.027	**87**	0.702	1.063	1.421	2.529	3.103	5.561	7.651	11.976	12.283
8	0.823	1.330	1.954	3.657	5.593	9.336	11.937	19.221	20.223	**88**	0.659	0.965	1.427	2.780	4.050	6.938	10.179	15.270	16.671
9	0.565	1.012	1.434	2.247	3.412	5.721	7.699	12.179	13.367	**89**	0.515	0.827	1.134	1.963	2.930	4.915	6.593	10.384	11.138
10	1.605	2.614	3.728	6.398	8.121	14.111	18.342	29.349	29.644	**90**	0.817	1.360	2.077	3.704	5.148	9.059	12.060	20.087	20.715
11	0.360	0.568	1.060	1.783	2.570	4.556	6.517	10.967	12.270	**91**	0.298	0.480	0.844	1.473	2.304	4.330	6.386	9.669	11.110
12	0.247	0.415	0.608	1.023	1.462	2.454	3.830	5.749	6.420	**92**	0.190	0.348	0.520	0.916	1.461	2.386	3.310	5.562	6.064
13	0.327	0.558	0.889	1.622	2.846	4.490	7.189	11.466	12.414	**93**	0.287	0.435	0.839	1.624	2.461	4.335	5.927	9.860	11.098
14	0.183	0.304	0.503	0.763	1.251	2.232	3.181	5.398	5.889	**94**	0.178	0.280	0.425	0.780	1.209	2.247	2.957	5.036	5.630
15	0.301	0.530	0.874	1.580	2.770	4.828	6.766	11.057	12.274	**95**	0.260	0.458	0.781	1.356	2.463	4.229	6.248	9.739	10.612
16	0.501	0.849	1.408	2.461	3.833	6.624	9.397	15.030	16.237	**96**	0.317	0.756	1.015	1.849	2.987	5.607	7.551	12.545	13.517
17	0.277	0.487	0.665	1.201	1.846	3.203	4.369	7.357	8.383	**97**	0.226	0.390	0.630	0.963	1.557	2.568	3.741	5.996	6.964
18	0.522	0.839	1.509	2.856	4.380	7.385	10.446	16.850	17.888	**98**	0.311	0.653	0.989	2.193	3.410	5.523	7.967	13.332	14.181
19	0.201	0.353	0.583	0.994	1.636	2.884	4.373	6.575	7.599	**99**	0.167	0.300	0.493	0.832	1.340	2.428	3.663	5.962	6.641
20	0.468	0.792	1.550	2.878	4.292	7.443	10.512	16.707	17.286	**100**	0.281	0.620	1.013	2.038	3.012	5.600	8.224	12.711	14.913
21	0.793	1.286	1.582	2.919	4.222	6.537	9.662	15.021	15.480	**101**	0.681	1.159	1.526	2.777	3.818	6.090	8.919	13.939	14.304
22	0.677	1.169	1.534	2.427	3.270	5.299	7.468	11.760	12.153	**102**	0.642	1.029	1.409	2.260	3.155	5.224	6.973	11.072	11.377
23	0.653	0.998	1.565	2.662	3.904	6.582	8.389	15.000	15.545	**103**	0.564	0.945	1.327	2.452	3.283	5.791	8.030	12.956	14.460
24	0.530	0.898	1.201	2.044	2.847	4.511	6.245	10.259	11.242	**104**	0.472	0.752	1.183	1.858	2.711	4.691	6.316	9.967	10.914
25	0.812	1.248	1.865	3.142	4.148	7.218	10.256	15.415	16.051	**105**	0.700	1.151	1.677	2.875	4.022	6.394	8.915	14.801	15.060
26	0.915	1.640	2.314	3.648	5.227	8.507	11.497	19.006	19.515	**106**	0.705	1.196	1.938	2.970	4.145	7.155	9.774	16.082	16.885
27	0.742	1.202	1.614	2.676	3.497	5.592	7.730	12.316	13.693	**107**	0.645	1.073	1.480	2.408	3.155	5.355	7.024	11.216	12.061
28	0.805	1.398	2.008	3.342	4.921	8.245	11.766	18.511	19.312	**108**	0.640	1.057	1.426	2.548	3.919	7.121	10.068	15.750	16.691
29	0.518	0.885	1.284	2.148	3.102	5.050	7.082	11.228	12.304	**109**	0.518	0.797	1.166	1.989	2.613	4.577	6.664	10.253	11.150
30	1.527	2.570	3.980	6.307	9.322	13.958	18.155	30.053	29.048	**110**	0.882	1.460	2.222	3.476	5.471	8.784	12.522	19.572	20.766
31	0.313	0.540	0.925	1.760	2.661	4.604	6.721	10.951	12.699	**111**	0.263	0.526	0.787	1.637	2.456	4.236	6.409	10.035	11.094
32	0.248	0.427	0.593	1.029	1.541	2.625	3.825	5.811	6.331	**112**	0.208	0.362	0.610	0.909	1.469	2.509	3.501	5.571	5.834
33	0.313	0.563	0.887	1.657	2.566	4.600	6.737	11.102	12.513	**113**	0.262	0.432	0.754	1.442	2.402	4.203	5.936	9.678	11.169
34	0.203	0.322	0.469	0.724	1.238	2.276	3.083	5.084	5.781	**114**	0.162	0.278	0.470	0.794	1.290	2.118	3.022	5.220	5.737
35	0.284	0.567	0.890	1.682	2.800	4.963	6.779	11.361	12.096	**115**	0.276	0.489	0.875	1.509	2.260	4.123	6.079	9.781	10.604
36	0.528	0.873	1.430	2.704	3.893	6.792	9.737	15.032	16.995	**116**	0.356	0.588	1.000	1.885	3.018	5.385	7.326	12.960	13.849
37	0.257	0.446	0.664	1.159	1.711	3.235	4.600	7.396	7.941	**117**	0.213	0.372	0.535	0.999	1.536	2.618	3.984	6.071	6.983
38	0.455	0.939	1.513	2.581	4.529	7.239	10.262	16.528	17.963	**118**	0.335	0.639	0.971	2.168	3.072	5.578	8.159	12.722	14.287
39	0.205	0.380	0.592	1.095	1.624	2.923	4.187	6.918	7.797	**119**	0.165	0.287	0.485	0.853	1.367	2.517	3.550	5.766	6.506
40	0.466	0.824	1.553	2.479	4.114	7.402	10.800	16.685	17.622	**120**	0.378	0.649	1.018	1.725	3.286	5.881	7.966	13.213	14.570
41	0.694	1.236	1.680	2.846	4.226	6.790	9.515	15.863	15.925	**121**	0.586	0.925	1.363	2.170	3.367	5.521	7.738	12.485	13.285
42	0.671	1.059	1.426	2.186	2.906	4.968	6.961	11.276	11.573	**122**	0.490	0.806	1.045	1.582	2.065	3.539	4.902	7.980	8.012
43	0.568	0.886	1.451	2.415	3.490	6.131	9.140	13.676	14.774	**123**	0.465	0.755	1.161	2.041	2.887	5.022	7.618	11.419	12.143
44	0.447	0.742	1.011	1.601	2.251	3.862	5.347	8.483	9.304	**124**	0.371	0.600	0.781	1.274	1.767	3.030	4.183	6.421	7.554
45	0.813	1.212	1.827	3.257	4.308	7.329	10.276	16.410	17.084	**125**	0.575	1.005	1.475	2.599	3.558	6.284	8.384	13.435	14.468
46	0.838	1.433	2.122	3.438	4.925	8.463	11.517	17.429	17.972	**126**	0.703	1.095	1.509	2.517	3.828	6.258	8.603	13.887	14.624
47	0.668	1.101	1.463	2.157	3.044	5.069	7.114	11.956	12.143	**127**	0.507	0.860	1.149	1.651	2.224	3.713	5.057	7.938	8.607
48	0.696	1.179	1.886	3.036	4.841	7.927	10.806	17.420	19.600	**128**	0.598	0.890	1.361	2.341	3.651	6.120	8.570	14.073	15.157
49	0.450	0.708	1.089	1.746	2.411	3.956	5.827	9.971	10.017	**129**	0.362	0.605	0.830	1.303	1.918	3.100	4.289	6.911	7.638
50	1.422	2.493	3.789	6.034	8.065	13.974	17.445	28.444	27.610	**130**	0.832	1.229	2.042	3.328	5.085	8.336	11.893	18.420	19.289
51	0.306	0.516	0.847	1.562	2.460	4.544	6.479	10.420	11.137	**131**	0.247	0.466	0.774	1.440	2.186	3.747	5.676	9.278	11.214
52	0.207	0.333	0.439	0.689	1.005	1.657	2.302	3.698	4.164	**132**	0.188	0.290	0.426	0.736	0.986	1.699	2.502	3.835	4.249
53	0.260	0.507	0.869	1.710	2.719	4.602	6.638	11.150	12.260	**133**	0.295	0.386	0.781	1.382	2.134	4.224	5.964	9.174	10.515
54	0.151	0.261	0.390	0.554	0.871	1.356	2.149	3.308	3.859	**134**	0.146	0.240	0.351	0.552	0.931	1.586	2.182	3.524	3.853
55	0.262	0.498	0.767	1.555	2.638	4.456	6.381	10.763	11.997	**135**	0.228	0.469	0.706	1.387	2.246	4.198	5.826	9.395	10.454
56	0.433	0.895	1.325	2.681	3.707	6.617	9.831	14.486	15.260	**136**	0.309	0.552	0.985	1.875	2.926	4.903	7.706	11.783	13.114
57	0.214	0.389	0.555	0.977	1.360	2.406	3.571	5.888	6.685	**137**	0.172	0.341	0.483	0.841	1.190	2.099	3.135	4.799	5.464
58	0.492	0.877	1.432	2.617	4.049	7.484	10.231	15.821	17.317	**138**	0.340	0.615	0.966	1.827	3.076	5.251	8.017	12.689	13.841

ID	700-year open terrain 3-second gust wind speed, mph									ID	700-year open terrain 3-second gust wind speed, mph								
	110	115	120	130	140	150	160	170	180		110	115	120	130	140	150	160	170	180
59	0.188	0.317	0.476	0.784	1.526	2.367	3.616	5.928	6.651	**139**	0.158	0.276	0.394	0.689	1.113	1.865	2.813	4.638	5.356
60	0.428	0.825	1.377	2.729	3.879	7.139	10.393	16.232	17.259	**140**	0.292	0.560	1.008	2.024	3.326	5.496	7.638	12.828	14.402
61	0.571	0.954	1.182	2.197	2.972	4.735	7.625	12.083	12.427	**141**	0.621	0.950	1.299	2.080	2.832	4.482	6.668	11.169	12.432
62	0.470	0.760	0.877	1.344	1.646	2.601	3.464	5.385	5.769	**142**	0.486	0.753	0.951	1.316	1.640	2.781	3.627	5.796	5.954
63	0.452	0.735	1.191	1.996	2.938	5.301	7.066	12.139	12.903	**143**	0.428	0.763	0.987	2.001	2.746	4.862	6.574	10.269	11.505
64	0.380	0.576	0.677	1.004	1.382	2.262	3.253	4.878	5.177	**144**	0.316	0.556	0.705	1.069	1.365	2.326	3.118	4.887	5.312
65	0.664	1.057	1.447	2.392	3.533	5.990	8.411	12.934	14.362	**145**	0.557	0.989	1.415	2.294	3.490	5.439	7.408	11.820	12.799
66	0.795	1.199	1.812	3.131	4.354	7.413	10.245	16.573	17.244	**146**	0.636	1.038	1.509	2.530	3.527	5.976	8.382	13.408	13.765
67	0.493	0.814	0.967	1.493	1.985	3.300	4.804	7.157	8.158	**147**	0.484	0.784	0.993	1.493	1.807	3.171	4.230	6.952	6.916
68	0.627	1.131	1.609	2.767	4.197	7.624	10.569	16.941	17.915	**148**	0.487	0.835	1.443	2.301	3.775	5.708	8.451	13.846	14.123
69	0.376	0.606	0.765	1.180	1.803	3.027	4.451	7.177	8.208	**149**	0.351	0.598	0.732	1.248	1.650	2.822	3.883	6.347	6.962
70	1.399	2.444	3.661	6.114	8.040	13.776	17.317	27.295	27.083	**150**	0.754	1.264	2.028	3.371	4.805	8.193	11.681	18.268	18.781
71	0.331	0.586	0.882	1.520	2.511	4.388	6.167	10.211	11.742	**151**	0.269	0.499	0.765	1.473	2.274	4.079	6.023	9.332	10.661
72	0.197	0.365	0.448	0.711	0.943	1.579	2.278	3.634	4.033	**152**	0.180	0.301	0.455	0.735	0.989	1.783	2.461	3.922	4.205
73	0.315	0.529	0.814	1.460	2.638	4.918	6.606	10.382	11.712	**153**	0.211	0.456	0.784	1.363	2.189	3.839	5.946	9.280	10.360
74	0.152	0.260	0.336	0.582	0.809	1.449	2.102	3.469	3.716	**154**	0.142	0.243	0.359	0.610	0.897	1.551	2.149	3.490	3.989
75	0.287	0.487	0.844	1.726	2.444	4.464	6.573	10.736	11.930	**155**	0.281	0.425	0.749	1.344	2.358	3.878	5.649	9.315	10.616
76	0.510	0.860	1.405	2.705	3.823	6.575	9.146	14.756	16.140	**156**	0.308	0.613	0.998	1.794	2.912	5.053	7.530	11.859	14.091
77	0.224	0.423	0.530	0.923	1.335	2.351	3.740	5.830	6.439	**157**	0.191	0.324	0.499	0.746	1.267	2.092	2.876	4.914	5.506
78	0.513	0.810	1.390	2.676	4.026	7.171	10.003	15.933	17.116	**158**	0.395	0.516	0.877	1.976	3.032	5.436	7.866	12.791	13.877
79	0.189	0.304	0.505	0.892	1.311	2.378	3.368	5.529	6.332	**159**	0.168	0.252	0.383	0.667	1.106	1.743	2.836	4.534	5.260
80	0.487	0.765	1.412	2.799	4.006	6.928	9.918	15.883	17.148	**160**	0.356	0.575	0.876	1.937	2.927	5.484	8.318	12.946	13.896

Table A.3 Fractional Expected Annual Loss of Use (EAL_U), Expressed in Days, Open Terrain, z_0=0.03 m

ID	700-year open terrain 3-second gust wind speed, mph									ID	700-year open terrain 3-second gust wind speed, mph								
	110	115	120	130	140	150	160	170	180		110	115	120	130	140	150	160	170	180
1	1.81	4.10	7.48	16.00	26.59	48.74	83.05	126.11	147.86	**81**	1.54	2.94	5.53	11.93	22.81	37.00	58.99	101.98	118.51
2	1.16	1.65	3.51	7.35	12.76	23.37	34.06	56.64	71.08	**82**	0.57	0.89	1.85	3.85	8.04	13.71	23.12	38.87	43.53
3	1.82	3.84	7.77	16.07	27.39	52.75	84.30	128.20	154.43	**83**	1.67	3.43	5.87	12.75	20.90	38.60	65.58	103.56	121.31
4	0.67	1.32	2.24	5.94	9.92	19.04	31.00	51.66	59.37	**84**	0.46	0.79	1.84	3.82	6.22	12.28	21.12	35.55	46.54
5	3.36	6.87	11.50	20.39	34.54	61.35	94.23	143.62	171.75	**85**	2.53	4.20	8.51	15.67	26.20	52.36	77.18	123.58	135.96
6	3.91	6.93	12.76	26.61	42.34	72.84	109.18	172.82	186.89	**86**	2.48	3.31	7.81	15.55	30.69	51.25	86.88	128.63	146.25
7	1.17	1.95	4.17	8.11	15.31	25.58	46.09	72.20	84.49	**87**	0.47	0.96	2.00	4.67	9.72	15.78	28.01	47.64	58.43
8	4.56	6.92	13.62	27.83	45.36	82.21	128.63	195.91	209.32	**88**	2.21	4.24	10.47	16.96	32.67	59.20	92.38	147.32	168.18
9	1.11	1.57	3.30	7.71	13.05	24.57	42.18	67.93	81.14	**89**	0.54	0.94	2.36	4.67	8.74	15.54	26.17	47.25	60.77
10	14.00	21.11	35.28	65.35	89.82	149.05	201.75	339.46	344.42	**90**	4.08	8.63	17.35	28.18	48.26	91.67	125.21	196.09	213.28
11	1.77	2.56	5.96	12.85	25.21	47.62	69.40	109.30	131.52	**91**	0.96	1.69	3.76	9.15	17.72	32.25	56.41	88.92	104.02
12	0.11	0.23	0.75	1.49	3.67	7.51	13.04	21.88	27.22	**92**	0.09	0.14	0.54	1.29	2.14	6.00	9.47	15.87	21.35
13	1.33	3.15	6.18	14.05	23.73	48.51	73.24	117.93	134.19	**93**	1.29	2.11	5.39	10.56	20.13	35.71	58.40	95.50	113.46
14	0.15	0.20	0.75	1.43	4.28	7.24	12.42	20.28	28.07	**94**	0.08	0.16	0.57	2.07	3.52	6.22	10.08	18.19	25.14
15	1.48	2.77	6.19	14.92	24.60	48.01	72.60	119.15	140.08	**95**	1.37	2.06	4.20	11.66	19.60	37.49	57.65	96.63	116.43
16	3.10	5.54	11.31	21.56	37.88	68.16	98.66	162.76	187.71	**96**	1.90	3.11	5.90	13.99	25.65	50.37	78.33	119.60	141.12
17	0.38	0.93	1.68	4.58	8.83	19.41	29.08	48.89	62.07	**97**	0.33	0.22	0.70	2.49	4.94	8.12	17.28	29.52	38.01
18	3.76	7.26	14.34	29.08	43.14	78.35	111.28	186.66	211.47	**98**	2.52	4.09	9.37	17.13	30.26	58.05	84.41	144.65	169.90
19	0.41	0.68	2.17	3.86	9.31	16.80	31.91	52.95	62.77	**99**	0.35	0.34	0.89	2.44	5.47	10.55	20.32	31.78	42.60
20	3.70	6.33	15.87	25.15	46.90	74.66	122.05	186.53	209.03	**100**	2.16	3.87	8.72	16.22	33.27	58.15	86.25	144.74	165.46
21	1.45	3.38	6.45	13.81	24.73	46.46	72.21	122.27	138.25	**101**	1.83	2.42	4.30	11.97	24.37	33.61	64.43	96.84	116.44
22	0.80	1.29	2.19	4.43	6.66	13.54	23.06	35.53	45.94	**102**	0.37	0.74	1.85	3.67	5.79	10.66	20.21	28.94	36.92
23	1.97	3.12	7.01	17.51	26.11	46.64	78.90	125.62	140.16	**103**	1.52	2.72	5.67	11.61	23.81	39.33	63.25	99.52	120.29
24	0.63	1.24	1.68	4.19	7.61	13.80	20.74	33.95	41.43	**104**	0.37	0.77	1.55	3.43	7.02	11.55	18.42	33.07	38.80
25	2.98	5.34	9.31	18.54	29.56	54.52	83.97	133.29	150.46	**105**	2.42	4.78	7.77	15.18	27.11	44.41	69.81	113.66	126.35
26	3.22	6.75	13.21	24.35	39.65	68.33	102.85	172.45	190.01	**106**	2.39	3.75	7.25	17.29	30.48	50.01	78.39	130.50	157.64
27	1.22	1.40	3.16	5.91	11.29	25.45	38.56	59.94	75.51	**107**	0.49	0.95	2.14	4.50	8.98	15.84	27.08	43.40	54.10
28	4.18	6.86	13.18	27.92	46.57	80.08	121.91	189.21	215.04	**108**	2.05	3.84	7.17	17.59	34.78	62.39	86.76	143.76	163.55
29	0.74	1.43	3.21	7.45	12.68	23.91	42.71	59.50	76.01	**109**	0.65	0.77	2.04	4.30	9.46	14.91	26.33	45.92	56.03
30	14.11	24.69	39.49	69.80	90.53	157.32	211.59	341.87	344.69	**110**	5.00	9.00	14.09	28.41	47.18	88.27	130.95	207.73	229.87
31	1.65	2.53	5.53	11.19	21.80	38.16	64.87	107.13	129.18	**111**	1.15	1.79	4.76	11.08	19.03	32.93	54.44	85.97	108.79
32	0.19	0.26	0.45	1.69	3.84	6.08	13.25	20.64	28.89	**112**	0.09	0.23	0.47	1.15	2.39	5.77	8.81	14.97	22.87
33	1.75	2.94	5.94	13.42	24.10	48.92	71.76	117.70	129.95	**113**	1.15	2.06	4.33	13.00	19.77	37.99	57.19	92.71	117.50
34	0.24	0.33	0.56	1.32	3.86	8.00	11.75	20.51	27.70	**114**	0.10	0.15	0.77	1.15	3.57	6.38	10.73	15.62	25.65
35	2.29	3.00	5.94	12.98	26.75	44.06	69.07	112.17	132.66	**115**	1.64	1.79	5.05	11.70	20.16	39.24	61.31	100.25	110.41
36	2.97	5.49	9.56	21.39	36.22	67.27	98.63	156.86	177.85	**116**	2.14	3.63	6.11	14.92	26.31	47.70	74.69	121.40	147.46
37	0.43	0.76	2.10	3.86	8.36	15.91	27.56	46.47	62.28	**117**	0.18	0.22	0.72	2.15	5.24	8.54	17.56	28.68	39.39
38	3.82	6.52	13.27	28.00	45.06	76.15	118.94	189.75	212.84	**118**	2.02	3.07	8.01	16.37	33.19	56.73	82.73	142.93	158.85
39	0.50	0.55	1.62	4.54	11.02	16.05	29.46	48.71	64.52	**119**	0.29	0.37	0.85	2.18	5.64	10.17	20.44	35.88	42.55
40	4.75	6.83	13.64	25.57	43.06	72.49	115.61	190.39	204.83	**120**	2.11	3.72	8.13	17.22	31.24	57.50	84.48	150.63	165.95
41	1.89	3.69	6.74	13.98	26.22	45.00	67.40	115.19	141.33	**121**	1.37	2.38	4.46	8.21	19.92	36.86	56.47	99.30	109.29
42	0.51	0.94	2.20	4.70	8.89	16.86	29.45	49.74	58.75	**122**	0.12	0.26	0.75	2.15	3.59	8.71	15.38	22.54	34.98
43	2.42	3.09	7.21	14.44	26.36	50.11	75.79	129.40	142.78	**123**	1.27	2.44	5.58	11.52	19.46	36.45	65.74	99.30	122.58
44	0.54	0.51	1.57	3.94	6.48	12.78	22.06	36.43	48.28	**124**	0.26	0.42	0.53	1.74	3.26	8.17	12.04	23.40	31.19
45	3.61	5.44	11.05	20.57	30.26	54.54	87.35	147.32	160.29	**125**	2.64	4.74	7.43	16.13	23.65	47.34	76.39	116.72	134.85
46	4.40	6.26	11.14	24.42	36.80	72.67	102.73	164.78	188.39	**126**	2.06	3.20	6.59	13.61	26.30	48.31	73.93	126.69	142.43
47	0.56	1.37	3.11	6.27	11.38	21.96	39.21	59.70	73.86	**127**	0.16	0.46	0.91	2.51	5.18	10.16	19.41	32.85	43.79
48	3.19	6.55	14.21	27.48	44.48	81.71	112.85	187.32	201.38	**128**	1.64	3.49	7.75	17.80	30.65	59.17	85.94	142.06	157.90
49	0.90	1.06	2.04	5.26	10.70	20.26	36.77	53.30	70.31	**129**	0.16	0.28	0.86	2.79	5.75	10.52	21.79	34.53	48.93
50	12.93	22.47	34.50	60.77	93.21	157.26	211.10	332.34	331.87	**130**	5.08	7.76	14.56	33.77	47.17	91.16	119.68	204.23	214.30
51	1.51	2.34	4.65	14.53	21.67	46.06	67.41	107.52	128.20	**131**	0.86	2.02	3.49	9.86	16.88	30.78	54.31	84.14	102.91
52	0.04	0.24	0.24	0.89	2.30	3.78	8.33	13.56	18.98	**132**	0.04	0.09	0.32	0.57	1.96	3.49	7.45	11.53	15.96
53	2.04	2.53	6.58	11.36	22.81	43.42	70.43	118.07	134.60	**133**	1.25	2.43	4.45	10.91	17.73	37.62	58.05	93.76	109.45
54	0.05	0.16	0.31	0.55	2.91	5.33	8.07	16.78	22.36	**134**	0.03	0.07	0.21	0.68	1.95	3.86	7.06	13.90	20.39
55	1.67	3.48	5.43	13.29	21.38	42.21	74.49	108.68	135.14	**135**	1.62	2.28	4.90	10.22	19.33	38.03	62.82	102.29	120.95
56	3.32	5.94	10.75	23.54	39.36	66.73	100.35	160.97	184.82	**136**	1.52	2.59	7.10	13.15	25.34	47.17	74.71	117.71	142.03
57	0.38	0.31	1.41	3.26	8.17	13.76	26.13	43.66	55.88	**137**	0.07	0.20	0.41	2.13	4.20	6.91	14.62	24.78	29.85
58	4.27	6.95	13.07	27.25	43.34	81.03	117.76	186.33	200.20	**138**	2.12	4.10	9.40	16.99	30.24	58.66	87.78	140.94	161.76

ID	700-year open terrain 3-second gust wind speed, mph									ID	700-year open terrain 3-second gust wind speed, mph								
	110	115	120	130	140	150	160	170	180		110	115	120	130	140	150	160	170	180
59	0.19	0.57	1.65	4.29	6.91	15.21	27.21	45.68	62.20	**139**	0.11	0.15	0.64	2.40	4.69	10.84	17.91	30.33	41.03
60	3.72	7.42	13.25	27.88	42.20	73.26	111.76	184.10	212.50	**140**	2.18	3.76	8.01	18.22	29.60	60.18	87.93	138.34	162.73
61	1.34	2.37	5.84	11.22	20.89	40.33	66.37	100.54	124.41	**141**	1.14	1.89	3.68	10.12	18.68	30.03	55.61	86.19	102.85
62	0.10	0.15	0.30	1.04	2.15	3.94	9.16	14.27	22.03	**142**	0.06	0.09	0.20	0.57	1.50	4.31	7.22	12.14	16.92
63	1.87	3.28	6.09	13.40	25.87	46.03	65.68	109.53	140.50	**143**	1.67	2.55	4.44	10.81	19.28	37.90	56.28	96.83	110.37
64	0.11	0.13	0.35	0.85	1.90	5.56	10.33	15.82	22.15	**144**	0.06	0.10	0.32	0.80	2.05	4.66	7.78	14.39	18.54
65	2.90	5.57	8.51	17.24	30.21	50.61	80.91	126.53	144.57	**145**	2.21	4.45	7.36	14.28	21.29	41.23	64.28	104.23	124.25
66	2.42	5.55	11.35	24.48	39.29	66.09	94.23	161.12	184.86	**146**	1.36	3.43	5.39	14.58	26.01	47.93	72.22	120.46	138.81
67	0.44	0.50	1.17	3.37	6.24	13.71	26.12	43.66	61.53	**147**	0.18	0.22	0.78	1.79	3.70	8.91	16.15	23.48	31.78
68	3.80	6.03	12.50	25.21	42.91	77.35	114.44	183.30	206.31	**148**	2.38	3.01	7.45	16.54	32.96	54.68	81.70	137.92	154.26
69	0.24	0.52	1.60	3.65	8.56	16.65	27.02	47.15	60.63	**149**	0.42	0.53	0.81	2.44	6.39	10.77	18.30	30.69	38.96
70	12.37	21.85	36.00	62.95	91.26	156.97	207.40	340.13	346.55	**150**	4.68	7.67	14.57	29.23	47.36	86.06	132.27	207.93	210.14
71	1.32	2.63	5.19	12.38	22.63	36.29	62.40	103.82	124.69	**151**	1.30	2.07	3.97	9.72	17.74	35.79	53.48	91.41	107.47
72	0.07	0.06	0.20	0.67	2.11	3.90	8.46	14.23	17.76	**152**	0.04	0.08	0.20	0.57	1.95	3.71	7.05	9.56	16.42
73	1.62	2.59	5.97	13.38	22.54	47.24	73.99	115.73	134.74	**153**	1.24	2.35	4.08	10.45	20.67	38.60	57.19	94.10	110.91
74	0.05	0.11	0.45	1.21	2.09	4.73	8.09	13.96	19.14	**154**	0.04	0.11	0.14	0.76	1.80	3.61	7.77	13.83	18.40
75	1.81	2.49	5.78	12.58	22.52	47.60	70.81	113.68	133.35	**155**	0.89	2.71	4.21	10.57	22.52	39.05	60.75	95.53	115.19
76	4.11	5.96	10.87	21.46	40.38	63.37	105.34	157.15	171.35	**156**	1.18	2.62	6.68	15.36	27.10	46.42	67.85	124.76	143.02
77	0.42	0.64	1.60	3.76	6.39	13.54	24.04	41.35	55.63	**157**	0.15	0.56	0.65	1.93	3.18	7.41	13.83	24.24	32.89
78	3.36	6.70	13.75	24.02	41.09	79.67	116.92	189.09	212.89	**158**	2.35	3.85	7.21	16.95	28.57	52.88	81.46	139.03	163.84
79	0.26	0.55	1.31	3.66	7.78	17.94	30.23	45.68	59.17	**159**	0.22	0.14	0.44	1.75	4.49	11.09	16.14	28.42	42.19
80	4.33	6.35	12.48	22.57	42.38	72.62	113.81	191.13	200.09	**160**	1.90	4.00	6.95	18.18	32.30	55.82	86.61	140.70	167.01

APPENDIX B: STANDARD DEVIATION OF EXPECTED ANNUAL LOSS FOR BUILDING, CONTENT, LOSS OF USE, AND TOTAL EXPECTED ANNUAL LOSS IN OPEN TERRAIN

Table B.1 Standard Deviation of Expected Annual Building Loss (EAL_B), as a Ratio of Building Value, Open Terrain, z_0=0.03 m

ID	700-year open terrain 3-second gust wind speed, mph									ID	700-year open terrain 3-second gust wind speed, mph								
	110	115	120	130	140	150	160	170	180		110	115	120	130	140	150	160	170	180
1	0.011	0.015	0.022	0.032	0.047	0.064	0.079	0.098	0.112	**81**	0.011	0.012	0.019	0.028	0.043	0.054	0.074	0.089	0.097
2	0.008	0.010	0.016	0.025	0.034	0.048	0.058	0.074	0.081	**82**	0.007	0.009	0.014	0.021	0.029	0.037	0.050	0.064	0.071
3	0.009	0.015	0.024	0.030	0.046	0.061	0.076	0.100	0.108	**83**	0.008	0.012	0.019	0.028	0.040	0.054	0.069	0.086	0.097
4	0.008	0.009	0.015	0.020	0.031	0.041	0.054	0.065	0.075	**84**	0.005	0.008	0.010	0.018	0.026	0.038	0.048	0.061	0.065
5	0.011	0.015	0.023	0.034	0.049	0.065	0.079	0.100	0.111	**85**	0.010	0.011	0.019	0.029	0.041	0.057	0.074	0.093	0.099
6	0.014	0.018	0.023	0.038	0.051	0.069	0.086	0.110	0.117	**86**	0.010	0.015	0.022	0.033	0.046	0.061	0.078	0.097	0.103
7	0.008	0.010	0.017	0.026	0.032	0.045	0.060	0.075	0.084	**87**	0.006	0.010	0.011	0.019	0.031	0.039	0.054	0.063	0.074
8	0.014	0.017	0.027	0.041	0.055	0.071	0.090	0.114	0.123	**88**	0.009	0.016	0.022	0.033	0.049	0.062	0.081	0.098	0.109
9	0.007	0.012	0.013	0.023	0.032	0.042	0.055	0.074	0.084	**89**	0.006	0.009	0.014	0.020	0.029	0.039	0.050	0.064	0.073
10	0.022	0.028	0.040	0.058	0.072	0.094	0.113	0.139	0.148	**90**	0.012	0.018	0.027	0.038	0.054	0.069	0.092	0.112	0.124
11	0.007	0.009	0.017	0.025	0.036	0.047	0.065	0.080	0.090	**91**	0.005	0.007	0.012	0.021	0.032	0.042	0.056	0.072	0.082
12	0.003	0.004	0.007	0.010	0.017	0.023	0.031	0.040	0.049	**92**	0.003	0.004	0.005	0.009	0.014	0.018	0.026	0.037	0.043
13	0.005	0.007	0.014	0.024	0.036	0.048	0.066	0.082	0.092	**93**	0.007	0.008	0.014	0.021	0.033	0.045	0.057	0.071	0.078
14	0.003	0.003	0.006	0.010	0.015	0.021	0.031	0.037	0.049	**94**	0.003	0.003	0.006	0.009	0.015	0.020	0.030	0.037	0.043
15	0.007	0.011	0.014	0.023	0.035	0.046	0.063	0.081	0.091	**95**	0.006	0.009	0.016	0.021	0.031	0.043	0.055	0.072	0.083
16	0.008	0.012	0.020	0.031	0.044	0.060	0.075	0.097	0.106	**96**	0.009	0.011	0.016	0.027	0.037	0.053	0.067	0.091	0.095
17	0.004	0.005	0.010	0.015	0.023	0.032	0.044	0.057	0.066	**97**	0.003	0.005	0.005	0.012	0.019	0.026	0.036	0.045	0.052
18	0.013	0.015	0.021	0.035	0.050	0.066	0.086	0.106	0.115	**98**	0.009	0.010	0.018	0.031	0.040	0.058	0.073	0.095	0.102
19	0.003	0.006	0.009	0.016	0.021	0.032	0.043	0.055	0.067	**99**	0.004	0.004	0.006	0.014	0.019	0.026	0.035	0.048	0.058
20	0.012	0.016	0.024	0.035	0.047	0.063	0.083	0.105	0.117	**100**	0.007	0.012	0.018	0.030	0.040	0.059	0.076	0.092	0.100
21	0.010	0.013	0.020	0.027	0.042	0.056	0.071	0.088	0.101	**101**	0.007	0.011	0.016	0.029	0.036	0.051	0.065	0.081	0.091
22	0.005	0.009	0.013	0.020	0.027	0.039	0.049	0.061	0.070	**102**	0.006	0.009	0.011	0.017	0.025	0.034	0.046	0.057	0.065
23	0.009	0.013	0.020	0.029	0.042	0.056	0.070	0.090	0.099	**103**	0.008	0.011	0.016	0.026	0.037	0.048	0.065	0.081	0.091
24	0.006	0.007	0.011	0.019	0.025	0.033	0.045	0.059	0.070	**104**	0.006	0.008	0.010	0.016	0.024	0.034	0.044	0.055	0.066
25	0.011	0.013	0.019	0.029	0.043	0.057	0.073	0.088	0.098	**105**	0.009	0.013	0.017	0.026	0.038	0.051	0.064	0.082	0.094
26	0.012	0.017	0.024	0.034	0.049	0.067	0.082	0.106	0.115	**106**	0.009	0.014	0.020	0.032	0.042	0.059	0.075	0.094	0.103
27	0.008	0.009	0.014	0.023	0.032	0.044	0.056	0.071	0.081	**107**	0.008	0.008	0.014	0.019	0.028	0.040	0.050	0.061	0.071
28	0.014	0.017	0.026	0.039	0.052	0.071	0.087	0.115	0.119	**108**	0.009	0.013	0.022	0.029	0.048	0.063	0.076	0.100	0.113
29	0.006	0.008	0.014	0.021	0.029	0.042	0.053	0.068	0.079	**109**	0.006	0.008	0.011	0.020	0.029	0.038	0.047	0.062	0.068
30	0.019	0.026	0.038	0.057	0.071	0.094	0.112	0.140	0.147	**110**	0.015	0.018	0.028	0.041	0.055	0.075	0.092	0.113	0.122
31	0.006	0.012	0.015	0.024	0.033	0.049	0.063	0.078	0.090	**111**	0.007	0.007	0.013	0.021	0.029	0.044	0.054	0.074	0.084
32	0.003	0.006	0.007	0.011	0.017	0.022	0.032	0.041	0.048	**112**	0.004	0.004	0.007	0.010	0.015	0.019	0.030	0.037	0.048
33	0.007	0.010	0.015	0.025	0.035	0.048	0.062	0.081	0.092	**113**	0.007	0.008	0.014	0.020	0.032	0.042	0.055	0.071	0.080
34	0.002	0.004	0.006	0.011	0.018	0.023	0.031	0.039	0.049	**114**	0.003	0.004	0.004	0.010	0.014	0.021	0.029	0.036	0.045
35	0.007	0.011	0.016	0.027	0.034	0.047	0.066	0.081	0.092	**115**	0.004	0.009	0.015	0.023	0.032	0.044	0.057	0.072	0.080
36	0.009	0.012	0.020	0.031	0.045	0.063	0.076	0.097	0.108	**116**	0.008	0.012	0.018	0.029	0.039	0.053	0.066	0.085	0.093
37	0.004	0.006	0.009	0.016	0.021	0.032	0.045	0.054	0.064	**117**	0.003	0.004	0.007	0.012	0.016	0.025	0.032	0.044	0.050
38	0.011	0.017	0.022	0.038	0.049	0.065	0.086	0.111	0.116	**118**	0.007	0.012	0.018	0.028	0.042	0.056	0.073	0.094	0.104
39	0.005	0.005	0.008	0.015	0.022	0.032	0.044	0.057	0.063	**119**	0.002	0.004	0.006	0.013	0.018	0.023	0.037	0.047	0.059
40	0.011	0.014	0.026	0.039	0.049	0.068	0.085	0.106	0.117	**120**	0.008	0.010	0.018	0.028	0.044	0.054	0.073	0.095	0.106
41	0.009	0.013	0.021	0.031	0.041	0.058	0.074	0.097	0.105	**121**	0.009	0.011	0.017	0.025	0.036	0.047	0.065	0.079	0.092
42	0.007	0.009	0.014	0.018	0.028	0.039	0.047	0.063	0.071	**122**	0.004	0.006	0.008	0.013	0.020	0.025	0.037	0.045	0.056
43	0.009	0.011	0.018	0.031	0.042	0.055	0.072	0.089	0.099	**123**	0.008	0.009	0.015	0.024	0.035	0.046	0.064	0.078	0.089
44	0.006	0.007	0.011	0.017	0.023	0.033	0.043	0.056	0.062	**124**	0.004	0.005	0.007	0.013	0.018	0.025	0.032	0.043	0.051
45	0.012	0.014	0.024	0.033	0.047	0.059	0.075	0.096	0.104	**125**	0.009	0.010	0.017	0.027	0.036	0.052	0.070	0.085	0.098
46	0.014	0.015	0.022	0.038	0.047	0.063	0.082	0.102	0.115	**126**	0.007	0.012	0.017	0.029	0.043	0.051	0.069	0.089	0.099
47	0.006	0.010	0.013	0.019	0.029	0.042	0.051	0.068	0.076	**127**	0.006	0.007	0.008	0.013	0.019	0.029	0.038	0.048	0.056
48	0.013	0.016	0.027	0.036	0.051	0.071	0.087	0.109	0.118	**128**	0.008	0.012	0.021	0.027	0.045	0.059	0.074	0.094	0.103
49	0.006	0.006	0.013	0.020	0.026	0.037	0.050	0.060	0.071	**129**	0.005	0.006	0.008	0.013	0.021	0.028	0.037	0.047	0.056
50	0.020	0.027	0.040	0.055	0.068	0.092	0.111	0.138	0.146	**130**	0.012	0.018	0.026	0.038	0.054	0.068	0.088	0.109	0.117
51	0.008	0.007	0.014	0.024	0.032	0.047	0.057	0.075	0.087	**131**	0.006	0.007	0.011	0.019	0.029	0.043	0.057	0.070	0.080
52	0.002	0.004	0.004	0.006	0.011	0.015	0.020	0.027	0.037	**132**	0.003	0.003	0.004	0.007	0.010	0.012	0.018	0.023	0.030
53	0.006	0.007	0.016	0.026	0.031	0.047	0.063	0.079	0.086	**133**	0.006	0.008	0.012	0.020	0.032	0.041	0.055	0.066	0.077

ID	700-year open terrain 3-second gust wind speed, mph									ID	700-year open terrain 3-second gust wind speed, mph								
	110	115	120	130	140	150	160	170	180		110	115	120	130	140	150	160	170	180
54	0.002	0.002	0.004	0.006	0.010	0.015	0.022	0.029	0.037	**134**	0.002	0.003	0.005	0.006	0.010	0.013	0.019	0.024	0.033
55	0.009	0.008	0.013	0.024	0.033	0.046	0.061	0.077	0.090	**135**	0.004	0.010	0.012	0.022	0.028	0.042	0.055	0.069	0.077
56	0.009	0.012	0.019	0.030	0.041	0.057	0.076	0.096	0.105	**136**	0.007	0.009	0.017	0.023	0.035	0.050	0.067	0.083	0.094
57	0.003	0.004	0.009	0.014	0.017	0.026	0.038	0.049	0.058	**137**	0.003	0.004	0.006	0.007	0.013	0.020	0.025	0.037	0.043
58	0.010	0.013	0.019	0.036	0.049	0.067	0.082	0.105	0.115	**138**	0.008	0.011	0.018	0.028	0.042	0.056	0.069	0.095	0.101
59	0.002	0.004	0.007	0.010	0.020	0.027	0.043	0.051	0.060	**139**	0.002	0.004	0.006	0.010	0.016	0.021	0.031	0.042	0.047
60	0.010	0.013	0.023	0.035	0.046	0.070	0.083	0.105	0.114	**140**	0.009	0.012	0.017	0.029	0.040	0.056	0.070	0.091	0.101
61	0.007	0.009	0.015	0.024	0.033	0.046	0.063	0.078	0.090	**141**	0.008	0.010	0.012	0.022	0.032	0.042	0.056	0.071	0.082
62	0.004	0.005	0.006	0.009	0.012	0.018	0.025	0.029	0.038	**142**	0.004	0.005	0.007	0.009	0.012	0.015	0.021	0.026	0.032
63	0.007	0.009	0.017	0.026	0.033	0.051	0.063	0.076	0.091	**143**	0.007	0.010	0.013	0.023	0.029	0.046	0.056	0.070	0.081
64	0.003	0.004	0.005	0.009	0.013	0.017	0.022	0.032	0.038	**144**	0.003	0.004	0.005	0.008	0.010	0.015	0.023	0.028	0.033
65	0.006	0.010	0.016	0.025	0.039	0.048	0.062	0.082	0.090	**145**	0.006	0.010	0.013	0.022	0.031	0.044	0.057	0.071	0.080
66	0.010	0.011	0.020	0.027	0.045	0.061	0.075	0.094	0.104	**146**	0.007	0.013	0.015	0.025	0.039	0.054	0.066	0.087	0.098
67	0.004	0.006	0.010	0.014	0.019	0.027	0.037	0.050	0.057	**147**	0.004	0.006	0.007	0.012	0.014	0.024	0.030	0.038	0.045
68	0.013	0.015	0.025	0.036	0.048	0.067	0.083	0.106	0.112	**148**	0.008	0.011	0.019	0.030	0.040	0.057	0.074	0.093	0.101
69	0.003	0.004	0.007	0.014	0.021	0.028	0.038	0.052	0.061	**149**	0.005	0.005	0.007	0.012	0.017	0.024	0.032	0.044	0.051
70	0.020	0.027	0.036	0.052	0.067	0.088	0.109	0.135	0.144	**150**	0.014	0.015	0.026	0.038	0.050	0.069	0.086	0.108	0.119
71	0.007	0.008	0.016	0.023	0.034	0.047	0.058	0.078	0.085	**151**	0.007	0.008	0.011	0.022	0.030	0.042	0.057	0.070	0.080
72	0.002	0.003	0.004	0.007	0.009	0.015	0.021	0.029	0.032	**152**	0.003	0.003	0.004	0.007	0.009	0.014	0.017	0.024	0.028
73	0.009	0.009	0.013	0.023	0.035	0.044	0.062	0.079	0.088	**153**	0.005	0.009	0.013	0.019	0.027	0.040	0.054	0.069	0.078
74	0.002	0.003	0.004	0.005	0.010	0.012	0.020	0.026	0.034	**154**	0.002	0.003	0.004	0.006	0.010	0.015	0.018	0.027	0.032
75	0.006	0.010	0.013	0.024	0.032	0.049	0.060	0.077	0.087	**155**	0.005	0.008	0.014	0.017	0.032	0.040	0.052	0.068	0.081
76	0.011	0.012	0.022	0.032	0.043	0.057	0.074	0.095	0.107	**156**	0.009	0.009	0.017	0.023	0.035	0.051	0.068	0.085	0.091
77	0.005	0.005	0.010	0.012	0.019	0.029	0.036	0.051	0.057	**157**	0.003	0.004	0.005	0.009	0.014	0.021	0.025	0.035	0.046
78	0.008	0.016	0.024	0.032	0.049	0.062	0.080	0.105	0.117	**158**	0.010	0.011	0.019	0.029	0.044	0.055	0.072	0.091	0.100
79	0.005	0.004	0.009	0.010	0.021	0.031	0.038	0.049	0.061	**159**	0.002	0.003	0.005	0.011	0.017	0.023	0.030	0.041	0.048
80	0.015	0.014	0.026	0.036	0.050	0.065	0.082	0.106	0.117	**160**	0.009	0.011	0.021	0.028	0.043	0.058	0.073	0.091	0.103

Table B.2 Standard Deviation of Expected Annual Content Loss (EAL_C), as a Ratio of Content Value, Open Terrain, z_0=0.03 m

ID	700-year open terrain 3-second gust wind speed, mph									ID	700-year open terrain 3-second gust wind speed, mph								
	110	115	120	130	140	150	160	170	180		110	115	120	130	140	150	160	170	180
1	0.007	0.010	0.014	0.023	0.038	0.049	0.063	0.084	0.092	**81**	0.005	0.005	0.010	0.020	0.029	0.040	0.059	0.074	0.084
2	0.002	0.005	0.006	0.012	0.017	0.022	0.035	0.046	0.053	**82**	0.001	0.002	0.004	0.008	0.012	0.019	0.028	0.036	0.042
3	0.005	0.008	0.014	0.025	0.034	0.052	0.065	0.085	0.093	**83**	0.006	0.007	0.011	0.020	0.028	0.043	0.055	0.074	0.081
4	0.002	0.003	0.007	0.010	0.015	0.019	0.030	0.041	0.048	**84**	0.001	0.002	0.005	0.008	0.013	0.017	0.026	0.033	0.041
5	0.007	0.010	0.018	0.026	0.039	0.054	0.069	0.086	0.092	**85**	0.006	0.008	0.015	0.021	0.032	0.046	0.060	0.075	0.082
6	0.008	0.011	0.021	0.030	0.043	0.061	0.076	0.096	0.108	**86**	0.009	0.010	0.018	0.024	0.036	0.050	0.067	0.082	0.094
7	0.002	0.005	0.009	0.012	0.023	0.031	0.042	0.060	0.063	**87**	0.004	0.004	0.007	0.009	0.015	0.024	0.030	0.037	0.049
8	0.013	0.015	0.023	0.033	0.047	0.066	0.082	0.104	0.117	**88**	0.007	0.010	0.016	0.026	0.039	0.056	0.074	0.088	0.101
9	0.004	0.003	0.006	0.014	0.022	0.028	0.041	0.056	0.066	**89**	0.001	0.002	0.006	0.007	0.016	0.023	0.035	0.041	0.052
10	0.019	0.024	0.034	0.049	0.066	0.087	0.105	0.133	0.140	**90**	0.011	0.014	0.026	0.034	0.052	0.069	0.085	0.104	0.115
11	0.006	0.009	0.013	0.024	0.032	0.046	0.062	0.079	0.084	**91**	0.006	0.006	0.012	0.016	0.028	0.042	0.053	0.068	0.078
12	0.001	0.001	0.002	0.005	0.010	0.014	0.022	0.028	0.034	**92**	0.000	0.001	0.001	0.004	0.007	0.010	0.018	0.024	0.031
13	0.006	0.007	0.012	0.023	0.037	0.049	0.062	0.078	0.087	**93**	0.003	0.007	0.010	0.020	0.028	0.042	0.054	0.068	0.077
14	0.000	0.001	0.001	0.007	0.009	0.013	0.024	0.029	0.035	**94**	0.000	0.001	0.001	0.003	0.009	0.015	0.020	0.023	0.032
15	0.006	0.008	0.015	0.024	0.036	0.046	0.061	0.077	0.089	**95**	0.003	0.006	0.010	0.017	0.027	0.039	0.050	0.068	0.075
16	0.009	0.012	0.017	0.026	0.042	0.056	0.073	0.091	0.105	**96**	0.005	0.008	0.013	0.024	0.035	0.050	0.061	0.081	0.093
17	0.002	0.002	0.004	0.010	0.022	0.027	0.037	0.047	0.056	**97**	0.001	0.001	0.003	0.005	0.009	0.019	0.027	0.036	0.043
18	0.012	0.012	0.018	0.034	0.047	0.065	0.083	0.105	0.110	**98**	0.006	0.011	0.016	0.024	0.039	0.057	0.073	0.091	0.099
19	0.004	0.004	0.008	0.010	0.019	0.028	0.041	0.051	0.061	**99**	0.002	0.002	0.002	0.009	0.018	0.021	0.030	0.041	0.045
20	0.009	0.014	0.024	0.033	0.045	0.065	0.086	0.105	0.113	**100**	0.008	0.009	0.017	0.026	0.038	0.055	0.070	0.089	0.098
21	0.008	0.008	0.012	0.021	0.036	0.049	0.062	0.072	0.092	**101**	0.006	0.005	0.009	0.017	0.030	0.037	0.052	0.066	0.080
22	0.002	0.003	0.005	0.007	0.010	0.016	0.023	0.029	0.038	**102**	0.001	0.003	0.003	0.006	0.011	0.015	0.022	0.024	0.036
23	0.005	0.010	0.016	0.024	0.034	0.047	0.063	0.080	0.092	**103**	0.004	0.005	0.011	0.019	0.026	0.040	0.053	0.068	0.079
24	0.002	0.002	0.004	0.008	0.012	0.018	0.022	0.030	0.040	**104**	0.001	0.002	0.003	0.006	0.008	0.015	0.023	0.029	0.035
25	0.009	0.009	0.014	0.025	0.034	0.049	0.061	0.080	0.094	**105**	0.006	0.008	0.011	0.023	0.030	0.044	0.054	0.069	0.081
26	0.011	0.013	0.019	0.029	0.043	0.057	0.076	0.095	0.106	**106**	0.006	0.011	0.018	0.024	0.033	0.050	0.065	0.086	0.094
27	0.003	0.003	0.007	0.013	0.020	0.028	0.041	0.051	0.058	**107**	0.001	0.002	0.004	0.008	0.015	0.023	0.028	0.038	0.047
28	0.014	0.015	0.024	0.034	0.047	0.067	0.081	0.107	0.114	**108**	0.006	0.009	0.016	0.029	0.041	0.056	0.069	0.089	0.102
29	0.004	0.004	0.010	0.014	0.020	0.029	0.043	0.054	0.065	**109**	0.003	0.003	0.005	0.011	0.016	0.023	0.033	0.043	0.052
30	0.019	0.025	0.035	0.053	0.069	0.089	0.110	0.137	0.142	**110**	0.008	0.016	0.022	0.033	0.051	0.066	0.082	0.106	0.113
31	0.004	0.006	0.012	0.021	0.030	0.044	0.060	0.074	0.088	**111**	0.007	0.008	0.012	0.019	0.028	0.040	0.056	0.066	0.075
32	0.000	0.001	0.001	0.003	0.007	0.013	0.017	0.025	0.034	**112**	0.001	0.001	0.003	0.002	0.012	0.013	0.017	0.026	0.029
33	0.008	0.009	0.016	0.021	0.036	0.047	0.058	0.075	0.089	**113**	0.005	0.009	0.013	0.019	0.028	0.039	0.052	0.066	0.075
34	0.001	0.001	0.002	0.005	0.008	0.013	0.019	0.026	0.036	**114**	0.001	0.001	0.002	0.006	0.006	0.012	0.021	0.027	0.033
35	0.005	0.010	0.015	0.023	0.035	0.046	0.060	0.077	0.086	**115**	0.005	0.006	0.012	0.017	0.029	0.040	0.054	0.071	0.078
36	0.006	0.013	0.020	0.030	0.042	0.057	0.072	0.091	0.102	**116**	0.007	0.012	0.014	0.022	0.035	0.047	0.060	0.080	0.092
37	0.002	0.002	0.005	0.011	0.018	0.025	0.040	0.048	0.055	**117**	0.000	0.001	0.002	0.008	0.010	0.016	0.027	0.033	0.041
38	0.011	0.017	0.021	0.033	0.049	0.064	0.083	0.104	0.113	**118**	0.008	0.012	0.017	0.027	0.040	0.054	0.072	0.089	0.103
39	0.002	0.003	0.008	0.013	0.020	0.025	0.039	0.053	0.056	**119**	0.001	0.003	0.006	0.010	0.015	0.023	0.029	0.040	0.045
40	0.010	0.014	0.023	0.032	0.052	0.064	0.080	0.106	0.112	**120**	0.009	0.009	0.014	0.025	0.040	0.057	0.069	0.090	0.103
41	0.006	0.007	0.015	0.025	0.035	0.047	0.063	0.080	0.092	**121**	0.005	0.007	0.012	0.019	0.032	0.042	0.056	0.071	0.081
42	0.003	0.002	0.005	0.010	0.017	0.022	0.033	0.043	0.053	**122**	0.001	0.001	0.002	0.005	0.010	0.016	0.023	0.032	0.039
43	0.007	0.011	0.018	0.024	0.035	0.048	0.066	0.083	0.092	**123**	0.006	0.008	0.011	0.021	0.027	0.042	0.056	0.072	0.080
44	0.003	0.002	0.005	0.007	0.014	0.024	0.031	0.039	0.042	**124**	0.001	0.001	0.003	0.006	0.011	0.015	0.023	0.029	0.036
45	0.007	0.012	0.014	0.026	0.037	0.050	0.068	0.084	0.095	**125**	0.006	0.008	0.011	0.023	0.032	0.045	0.059	0.072	0.081
46	0.009	0.011	0.020	0.030	0.044	0.059	0.074	0.094	0.105	**126**	0.008	0.009	0.013	0.023	0.033	0.051	0.064	0.081	0.091
47	0.005	0.004	0.007	0.012	0.020	0.029	0.041	0.053	0.061	**127**	0.001	0.002	0.006	0.009	0.013	0.015	0.027	0.039	0.045
48	0.008	0.015	0.022	0.036	0.048	0.064	0.084	0.106	0.113	**128**	0.005	0.009	0.015	0.029	0.038	0.056	0.071	0.089	0.101
49	0.001	0.003	0.007	0.010	0.020	0.028	0.039	0.054	0.061	**129**	0.000	0.003	0.003	0.005	0.016	0.021	0.029	0.041	0.049
50	0.018	0.026	0.036	0.050	0.068	0.089	0.103	0.134	0.139	**130**	0.011	0.013	0.021	0.036	0.052	0.064	0.082	0.107	0.114
51	0.006	0.007	0.010	0.024	0.030	0.043	0.058	0.075	0.086	**131**	0.004	0.007	0.010	0.014	0.026	0.039	0.052	0.066	0.076
52	0.000	0.000	0.002	0.002	0.011	0.013	0.017	0.023	0.031	**132**	0.000	0.000	0.001	0.002	0.008	0.011	0.016	0.019	0.025
53	0.007	0.007	0.013	0.021	0.033	0.047	0.062	0.077	0.085	**133**	0.004	0.008	0.014	0.020	0.030	0.038	0.052	0.067	0.076
54	0.000	0.001	0.002	0.003	0.007	0.012	0.017	0.025	0.034	**134**	0.001	0.001	0.001	0.004	0.008	0.014	0.014	0.022	0.025
55	0.005	0.009	0.014	0.022	0.033	0.044	0.060	0.074	0.087	**135**	0.005	0.006	0.011	0.017	0.027	0.039	0.052	0.065	0.076
56	0.008	0.012	0.019	0.028	0.040	0.059	0.071	0.089	0.098	**136**	0.007	0.007	0.015	0.023	0.036	0.046	0.065	0.081	0.091
57	0.000	0.002	0.006	0.011	0.016	0.026	0.035	0.046	0.056	**137**	0.001	0.002	0.001	0.007	0.013	0.015	0.024	0.033	0.041
58	0.010	0.016	0.020	0.035	0.045	0.064	0.082	0.102	0.113	**138**	0.008	0.010	0.018	0.027	0.039	0.055	0.072	0.089	0.102

ID	700-year open terrain 3-second gust wind speed, mph									ID	700-year open terrain 3-second gust wind speed, mph								
	110	115	120	130	140	150	160	170	180		110	115	120	130	140	150	160	170	180
59	0.003	0.001	0.006	0.011	0.019	0.027	0.037	0.050	0.058	**139**	0.001	0.002	0.003	0.009	0.013	0.022	0.029	0.038	0.046
60	0.011	0.013	0.023	0.034	0.048	0.062	0.083	0.104	0.115	**140**	0.008	0.010	0.016	0.023	0.037	0.058	0.071	0.090	0.097
61	0.007	0.008	0.014	0.022	0.033	0.042	0.059	0.073	0.083	**141**	0.004	0.004	0.010	0.016	0.028	0.037	0.048	0.068	0.075
62	0.000	0.000	0.001	0.004	0.005	0.009	0.017	0.023	0.030	**142**	0.000	0.000	0.001	0.002	0.006	0.008	0.014	0.020	0.028
63	0.005	0.009	0.014	0.023	0.036	0.045	0.061	0.078	0.087	**143**	0.003	0.006	0.011	0.019	0.028	0.041	0.052	0.064	0.075
64	0.001	0.001	0.003	0.005	0.008	0.011	0.019	0.023	0.032	**144**	0.000	0.000	0.002	0.003	0.006	0.012	0.017	0.020	0.030
65	0.008	0.010	0.013	0.025	0.036	0.047	0.060	0.077	0.088	**145**	0.004	0.006	0.010	0.019	0.029	0.040	0.054	0.066	0.080
66	0.008	0.011	0.017	0.027	0.043	0.057	0.075	0.092	0.101	**146**	0.006	0.008	0.015	0.025	0.032	0.052	0.062	0.081	0.092
67	0.001	0.001	0.008	0.011	0.016	0.023	0.035	0.043	0.053	**147**	0.000	0.003	0.003	0.004	0.010	0.015	0.026	0.032	0.040
68	0.011	0.015	0.022	0.032	0.046	0.068	0.081	0.101	0.113	**148**	0.005	0.010	0.017	0.026	0.036	0.053	0.070	0.091	0.104
69	0.002	0.003	0.008	0.011	0.020	0.025	0.039	0.048	0.057	**149**	0.001	0.001	0.004	0.011	0.014	0.021	0.031	0.037	0.046
70	0.018	0.024	0.036	0.052	0.064	0.087	0.107	0.133	0.138	**150**	0.011	0.015	0.023	0.032	0.050	0.067	0.083	0.106	0.117
71	0.006	0.008	0.012	0.023	0.033	0.043	0.056	0.074	0.084	**151**	0.006	0.006	0.010	0.019	0.028	0.039	0.052	0.066	0.077
72	0.001	0.000	0.004	0.005	0.007	0.011	0.016	0.023	0.030	**152**	0.000	0.000	0.001	0.002	0.003	0.010	0.015	0.021	0.027
73	0.006	0.006	0.014	0.021	0.033	0.047	0.061	0.076	0.083	**153**	0.007	0.006	0.010	0.019	0.028	0.040	0.051	0.069	0.075
74	0.001	0.001	0.001	0.002	0.007	0.012	0.019	0.020	0.032	**154**	0.001	0.001	0.004	0.003	0.007	0.011	0.012	0.022	0.027
75	0.005	0.008	0.015	0.025	0.033	0.049	0.060	0.078	0.086	**155**	0.005	0.007	0.011	0.018	0.029	0.037	0.050	0.066	0.076
76	0.006	0.012	0.018	0.030	0.042	0.057	0.073	0.093	0.102	**156**	0.006	0.008	0.015	0.025	0.033	0.053	0.063	0.080	0.093
77	0.002	0.001	0.005	0.011	0.018	0.025	0.033	0.046	0.055	**157**	0.001	0.002	0.003	0.008	0.008	0.015	0.023	0.032	0.040
78	0.010	0.016	0.021	0.034	0.047	0.063	0.083	0.103	0.113	**158**	0.009	0.009	0.016	0.024	0.036	0.056	0.071	0.089	0.098
79	0.003	0.001	0.003	0.011	0.019	0.028	0.038	0.049	0.056	**159**	0.001	0.001	0.006	0.008	0.017	0.017	0.028	0.037	0.049
80	0.011	0.011	0.024	0.034	0.046	0.065	0.080	0.104	0.112	**160**	0.008	0.012	0.016	0.026	0.040	0.054	0.068	0.087	0.101

Table B.3 Standard Deviation of Expected Annual Loss of Use (EAL_U), Expressed in Days, Open Terrain, z_0=0.03 m

ID	700-year open terrain 3-second gust wind speed, mph									ID	700-year open terrain 3-second gust wind speed, mph								
	110	115	120	130	140	150	160	170	180		110	115	120	130	140	150	160	170	180
1	10.514	12.239	17.387	26.795	34.074	48.228	58.478	75.753	80.811	**81**	8.949	9.822	15.268	21.008	29.838	41.400	52.117	67.485	74.180
2	7.206	9.878	14.263	19.334	27.926	36.847	45.163	58.485	62.024	**82**	5.591	7.921	11.209	16.549	21.734	30.395	38.589	48.138	54.890
3	9.284	10.113	15.983	24.877	33.436	47.529	57.162	71.200	78.701	**83**	8.074	11.692	15.044	21.040	30.113	40.888	51.384	65.061	73.761
4	6.582	7.612	12.605	17.161	22.017	35.038	41.569	52.502	59.440	**84**	5.454	7.642	10.596	14.841	20.915	29.348	36.731	46.862	51.982
5	9.437	13.283	17.766	26.671	36.231	49.889	61.385	77.261	84.013	**85**	7.939	10.458	15.247	22.497	31.555	43.361	54.342	67.077	77.136
6	10.833	14.055	20.989	29.257	39.299	52.454	64.187	84.203	88.164	**86**	7.373	10.396	16.206	24.685	33.758	45.653	55.163	69.950	77.738
7	6.468	9.816	13.933	21.509	27.336	36.141	46.747	58.526	65.373	**87**	6.099	8.567	11.307	16.228	24.734	32.334	41.587	50.520	55.077
8	12.599	14.291	20.385	30.327	39.880	53.679	66.625	82.863	89.789	**88**	6.639	11.923	14.879	24.059	33.522	45.972	58.115	76.259	80.637
9	6.302	8.248	12.949	17.441	27.275	36.831	46.064	54.567	61.541	**89**	4.765	7.130	10.692	16.219	22.392	30.337	40.096	51.011	54.220
10	17.537	23.158	30.170	41.374	53.907	69.492	84.472	103.605	106.765	**90**	10.046	15.226	19.486	32.733	40.469	52.537	65.615	82.842	89.899
11	6.401	7.983	12.508	17.141	28.544	37.044	46.203	58.931	68.660	**91**	4.691	5.910	10.314	16.883	22.492	30.714	43.695	55.749	62.606
12	3.253	3.741	5.737	8.612	11.847	15.963	25.189	32.552	37.449	**92**	2.514	3.824	5.544	9.065	12.253	16.881	24.170	29.935	34.753
13	5.542	6.678	12.075	18.278	27.346	36.990	47.625	59.455	66.924	**93**	4.510	7.426	10.103	17.212	25.837	33.017	41.621	53.653	59.962
14	2.229	2.681	4.942	7.884	12.722	16.800	23.988	30.275	35.762	**94**	2.409	2.849	6.575	7.791	11.789	16.968	23.943	29.102	35.322
15	4.917	6.707	12.787	19.240	28.092	35.261	45.591	60.455	67.301	**95**	5.034	5.548	11.048	15.533	23.999	34.921	42.179	53.336	58.933
16	9.070	10.128	15.043	23.315	35.039	44.267	59.578	71.415	79.207	**96**	6.455	8.930	13.376	19.354	28.115	43.148	52.133	63.739	71.009
17	2.995	4.366	8.844	12.242	17.681	25.105	33.337	43.498	49.291	**97**	2.324	3.675	6.645	8.904	14.106	20.176	26.069	33.944	40.420
18	9.554	13.744	19.425	26.086	38.646	50.262	62.839	80.021	87.174	**98**	6.507	10.838	14.560	23.148	30.800	43.755	53.689	67.858	75.989
19	2.386	3.554	6.801	10.329	19.212	24.451	33.182	42.505	49.587	**99**	1.999	3.380	7.026	9.325	14.708	20.342	28.000	38.982	42.025
20	9.458	12.986	17.190	25.935	38.229	47.929	61.517	78.891	84.452	**100**	5.894	9.096	13.475	24.237	33.167	41.146	52.756	69.621	75.267
21	7.762	9.406	14.786	24.180	30.606	41.148	55.929	66.151	74.457	**101**	6.814	9.718	14.766	21.657	28.349	37.876	49.183	62.478	69.664
22	6.159	8.162	11.618	16.889	21.294	31.192	38.940	47.427	51.985	**102**	5.483	7.313	11.274	14.716	21.542	28.863	37.621	45.552	50.688
23	6.765	10.895	16.386	23.164	29.659	41.461	54.420	67.976	74.805	**103**	5.669	8.986	12.841	19.746	26.535	38.671	49.010	61.454	66.765
24	5.081	7.665	10.835	16.300	21.285	28.167	35.624	46.280	50.956	**104**	5.091	6.637	10.181	13.822	19.388	30.173	35.414	46.038	49.886
25	8.160	11.460	15.646	20.957	32.207	41.527	54.855	68.820	75.504	**105**	6.881	10.838	14.541	22.559	28.523	39.988	49.464	62.971	68.612
26	9.742	12.566	19.174	28.475	37.195	49.330	63.002	77.723	84.717	**106**	8.804	11.164	17.602	23.533	33.850	44.657	56.416	72.248	77.138
27	6.396	8.875	11.395	18.690	23.456	33.087	42.869	53.335	60.894	**107**	5.786	7.675	11.491	17.727	22.035	30.159	39.606	48.215	54.068
28	9.718	13.010	20.443	30.730	40.831	53.528	64.408	82.567	89.313	**108**	7.460	10.076	16.272	25.142	35.057	47.381	59.315	74.470	81.518
29	5.559	8.032	12.402	16.391	22.430	34.587	42.368	53.964	59.918	**109**	5.407	7.900	10.233	15.673	22.556	28.498	38.216	48.743	53.871
30	17.466	22.812	31.852	42.297	52.370	69.930	83.358	102.693	106.651	**110**	11.798	13.645	19.011	29.298	40.187	52.609	66.466	84.275	89.944
31	5.219	7.940	11.005	15.053	26.978	36.399	48.425	60.987	67.727	**111**	4.524	7.348	11.227	16.488	24.708	34.069	42.156	53.515	61.535
32	3.117	3.521	5.886	9.245	13.655	17.781	25.307	32.122	38.263	**112**	2.233	3.202	5.395	8.575	12.901	17.625	22.590	30.983	35.659
33	6.508	6.992	11.239	19.715	25.356	35.186	49.268	60.168	66.798	**113**	5.100	6.352	12.025	16.948	24.371	32.886	40.307	54.724	61.502
34	2.074	2.352	4.662	7.465	11.656	18.025	23.555	30.458	36.628	**114**	2.314	3.150	4.622	7.718	12.139	19.361	23.509	29.418	34.924
35	5.981	8.669	11.921	18.570	27.681	37.426	48.916	60.068	67.853	**115**	4.844	7.201	10.856	16.744	24.133	32.884	40.022	52.836	61.211
36	8.649	12.092	15.979	23.815	32.919	45.546	57.316	74.639	79.786	**116**	5.466	8.454	13.392	21.195	29.366	40.062	51.664	64.469	71.837
37	3.293	4.332	7.591	11.622	19.101	25.143	32.344	42.135	46.850	**117**	2.621	4.121	6.619	9.677	14.350	20.403	27.530	34.365	41.116
38	9.605	11.729	18.759	27.798	37.671	49.000	63.418	80.774	86.143	**118**	7.099	11.324	13.188	20.668	31.270	40.137	55.605	68.318	74.922
39	3.603	5.481	7.320	12.307	17.908	24.570	31.905	39.931	47.270	**119**	2.013	3.210	5.362	9.154	14.960	18.042	28.132	35.467	42.154
40	8.808	10.007	17.682	28.374	36.320	51.799	60.698	78.969	85.351	**120**	7.672	8.513	14.013	23.853	30.837	42.633	54.950	71.238	76.870
41	7.071	10.836	15.530	24.237	31.460	44.001	54.036	69.960	77.006	**121**	6.099	6.766	10.349	19.214	28.965	39.492	47.959	59.947	66.073
42	5.577	6.811	10.512	15.504	22.097	30.420	40.206	49.185	53.742	**122**	3.489	4.392	7.644	12.415	15.012	21.791	27.759	35.086	41.022
43	8.538	11.381	14.685	24.550	31.477	42.843	52.376	69.585	74.974	**123**	4.849	8.818	12.689	17.246	26.062	36.301	46.355	60.378	66.223
44	4.696	5.818	9.127	13.660	18.698	26.459	32.227	41.960	46.903	**124**	3.060	3.912	6.695	8.603	13.369	17.969	26.261	33.718	37.480
45	8.560	11.591	17.220	25.785	35.566	45.074	55.657	73.361	79.205	**125**	7.113	10.074	14.301	22.310	29.214	38.561	51.256	64.376	72.192
46	10.159	13.028	18.618	27.031	34.124	48.529	63.224	76.189	84.763	**126**	5.501	9.325	13.376	22.293	28.064	40.832	50.889	67.152	71.936
47	4.825	7.272	11.464	15.665	23.331	30.856	40.906	50.614	56.479	**127**	3.680	5.130	7.447	12.430	15.335	22.086	29.247	35.273	42.520
48	9.887	12.613	19.168	27.416	39.028	52.323	64.362	81.195	86.686	**128**	7.335	8.866	15.361	21.675	32.648	41.500	54.275	69.566	77.594
49	5.408	6.549	9.130	14.211	20.369	29.739	37.351	46.592	53.483	**129**	3.221	4.321	7.445	10.139	15.255	21.569	27.296	37.564	45.388
50	14.831	21.744	28.212	40.385	51.756	68.436	84.343	99.552	106.701	**130**	9.374	12.672	21.816	28.671	39.623	50.999	64.334	81.261	85.052
51	5.462	7.798	11.828	18.333	24.376	34.127	46.612	58.640	65.637	**131**	4.257	6.708	10.566	15.362	24.208	31.420	40.908	52.777	61.529
52	1.629	2.151	3.697	4.814	7.766	11.827	16.857	21.723	25.655	**132**	1.737	3.135	3.494	5.715	7.248	10.175	16.248	19.839	25.028
53	5.389	8.384	9.953	19.282	26.493	36.174	45.968	56.941	65.774	**133**	5.590	6.928	10.287	15.654	24.080	27.916	42.605	50.774	57.711
54	1.556	1.734	2.434	5.608	7.815	13.859	17.207	21.678	28.942	**134**	1.675	1.927	3.083	5.303	8.614	10.598	16.863	22.053	26.198
55	6.872	7.851	12.034	19.577	27.620	33.998	48.448	60.036	66.072	**135**	4.439	5.801	10.123	14.559	22.219	32.609	40.263	53.791	59.564
56	8.605	11.173	17.247	24.391	31.644	41.472	56.330	70.502	75.736	**136**	5.601	8.365	11.889	20.973	25.278	36.754	49.901	63.630	67.515
57	2.378	3.747	5.846	9.907	15.125	23.326	29.594	36.607	42.397	**137**	2.726	3.547	5.380	6.912	10.514	16.192	20.966	29.309	35.405
58	7.409	12.977	18.296	26.847	37.240	47.829	64.491	76.955	84.032	**138**	7.812	7.849	13.384	21.701	29.942	41.057	54.379	70.041	73.973

ID	700-year open terrain 3-second gust wind speed, mph									ID	700-year open terrain 3-second gust wind speed, mph								
	110	115	120	130	140	150	160	170	180		110	115	120	130	140	150	160	170	180
59	3.395	3.415	6.423	10.080	15.372	21.174	30.165	38.565	45.276	**139**	1.965	2.689	4.909	7.837	12.457	17.024	23.901	31.554	35.078
60	9.561	11.331	18.554	25.619	37.674	47.221	66.937	78.106	84.578	**140**	6.752	8.889	14.786	21.218	29.860	42.139	52.146	67.359	74.136
61	6.351	7.694	11.209	18.261	25.850	37.703	46.005	59.474	66.145	**141**	5.815	6.671	10.914	17.542	24.050	31.800	42.116	52.380	59.585
62	2.420	3.642	4.960	6.671	10.438	13.671	20.623	25.145	28.860	**142**	2.711	3.662	5.312	8.294	10.111	13.457	18.334	22.483	26.541
63	5.962	9.083	13.134	19.407	27.855	38.185	48.388	58.342	65.879	**143**	5.789	7.920	10.504	15.467	24.610	32.823	43.134	52.923	58.622
64	2.169	2.881	4.069	6.623	9.619	14.500	21.486	25.296	31.106	**144**	2.638	3.344	4.719	7.396	9.084	14.251	18.782	24.047	27.058
65	6.509	8.921	12.632	20.023	27.166	37.286	48.873	62.781	65.911	**145**	6.161	7.240	12.294	17.790	25.168	35.817	44.241	53.124	60.116
66	8.811	11.716	17.931	22.908	33.517	45.097	56.940	72.520	78.865	**146**	7.592	9.068	13.542	21.824	29.095	39.316	52.231	61.305	71.661
67	4.005	4.440	7.116	9.981	16.213	21.633	29.358	38.179	44.650	**147**	3.211	4.257	5.864	8.660	13.206	15.859	24.691	28.876	35.166
68	9.566	11.219	17.229	26.373	36.829	48.507	61.785	78.309	84.470	**148**	7.004	9.945	14.549	20.572	30.157	41.118	54.428	68.494	75.191
69	3.214	4.609	6.039	10.215	16.159	25.163	30.491	39.955	47.327	**149**	3.142	4.181	5.899	8.518	12.689	20.609	23.794	33.752	39.114
70	16.689	21.464	28.747	39.035	50.529	66.740	80.988	101.176	107.089	**150**	9.152	13.895	18.961	28.286	37.877	49.510	60.673	78.849	87.168
71	5.585	7.364	11.318	16.756	25.954	33.430	45.689	56.642	63.139	**151**	4.945	7.122	10.901	15.640	23.379	32.420	40.953	50.955	59.655
72	1.614	2.811	3.102	4.605	7.713	12.468	15.895	20.362	26.556	**152**	2.124	2.578	3.528	6.517	8.633	11.590	14.718	19.721	22.989
73	5.557	7.536	11.064	17.893	25.706	35.415	45.948	58.138	64.445	**153**	5.643	6.806	9.293	16.345	21.879	30.118	42.275	50.626	60.021
74	1.166	1.820	3.297	4.243	7.875	10.159	15.675	19.779	25.895	**154**	1.468	2.127	3.112	4.695	9.320	11.495	15.922	20.796	25.259
75	4.981	7.428	10.948	16.949	25.576	34.964	45.490	57.786	63.866	**155**	4.985	5.851	10.032	16.360	22.140	31.736	41.155	51.864	59.581
76	7.365	11.368	15.649	23.574	34.258	45.822	56.103	69.619	74.882	**156**	6.386	9.258	13.623	18.451	26.750	38.469	47.757	62.950	69.526
77	2.187	3.279	6.250	10.500	15.230	20.517	28.390	37.988	45.080	**157**	2.034	2.740	4.738	6.722	10.983	15.845	22.045	28.333	32.286
78	9.707	12.157	18.223	27.495	36.987	48.812	59.061	76.988	85.149	**158**	6.436	8.471	13.729	21.032	30.256	40.393	54.345	66.855	74.684
79	1.861	4.038	6.948	9.308	13.616	21.374	29.543	39.452	44.625	**159**	1.816	3.367	4.068	6.184	11.238	17.811	23.634	29.032	36.771
80	8.176	12.080	16.528	25.825	35.148	49.559	61.491	76.384	85.825	**160**	6.055	9.519	13.722	23.369	31.146	42.685	53.825	65.610	74.350

Table B.4 Standard Deviation of Total Expected Annual Loss (EAL_T), as a Ratio of Building Value, Open Terrain, z_0=0.03 m

ID	700-year open terrain 3-second gust wind speed, mph									ID	700-year open terrain 3-second gust wind speed, mph								
	110	115	120	130	140	150	160	170	180		110	115	120	130	140	150	160	170	180
1	0.019	0.025	0.036	0.054	0.079	0.107	0.134	0.170	0.190	**81**	0.017	0.018	0.030	0.046	0.069	0.090	0.123	0.152	0.168
2	0.012	0.016	0.025	0.039	0.054	0.073	0.094	0.121	0.132	**82**	0.009	0.013	0.020	0.031	0.043	0.059	0.079	0.101	0.113
3	0.015	0.022	0.037	0.052	0.077	0.106	0.131	0.170	0.185	**83**	0.015	0.020	0.030	0.046	0.066	0.091	0.116	0.148	0.167
4	0.011	0.014	0.023	0.031	0.047	0.064	0.085	0.106	0.123	**84**	0.008	0.012	0.017	0.028	0.040	0.058	0.076	0.095	0.106
5	0.019	0.025	0.040	0.058	0.082	0.112	0.137	0.174	0.190	**85**	0.016	0.019	0.033	0.048	0.069	0.097	0.125	0.157	0.171
6	0.022	0.029	0.042	0.064	0.088	0.120	0.149	0.191	0.205	**86**	0.017	0.024	0.037	0.055	0.077	0.104	0.133	0.166	0.181
7	0.012	0.017	0.027	0.040	0.054	0.075	0.099	0.128	0.141	**87**	0.011	0.015	0.019	0.029	0.049	0.064	0.086	0.102	0.120
8	0.025	0.030	0.047	0.070	0.094	0.125	0.156	0.199	0.216	**88**	0.016	0.025	0.036	0.055	0.081	0.108	0.141	0.172	0.191
9	0.011	0.016	0.021	0.037	0.053	0.070	0.094	0.123	0.141	**89**	0.008	0.013	0.021	0.030	0.045	0.062	0.083	0.105	0.120
10	0.038	0.050	0.068	0.098	0.127	0.164	0.199	0.245	0.260	**90**	0.022	0.031	0.047	0.068	0.096	0.124	0.160	0.197	0.217
11	0.012	0.017	0.028	0.044	0.063	0.084	0.114	0.143	0.159	**91**	0.009	0.012	0.022	0.036	0.054	0.075	0.100	0.128	0.146
12	0.005	0.007	0.010	0.015	0.027	0.036	0.052	0.066	0.081	**92**	0.004	0.006	0.008	0.015	0.023	0.030	0.045	0.060	0.072
13	0.010	0.013	0.025	0.043	0.065	0.087	0.116	0.144	0.162	**93**	0.011	0.014	0.023	0.038	0.057	0.079	0.101	0.126	0.140
14	0.004	0.005	0.009	0.017	0.024	0.034	0.052	0.063	0.080	**94**	0.004	0.005	0.009	0.014	0.024	0.035	0.049	0.060	0.072
15	0.012	0.017	0.026	0.043	0.064	0.082	0.111	0.143	0.162	**95**	0.010	0.014	0.025	0.036	0.054	0.076	0.096	0.127	0.144
16	0.016	0.022	0.035	0.053	0.078	0.105	0.135	0.171	0.189	**96**	0.014	0.019	0.028	0.047	0.065	0.095	0.118	0.156	0.169
17	0.006	0.008	0.015	0.025	0.041	0.055	0.076	0.097	0.113	**97**	0.005	0.007	0.009	0.018	0.029	0.044	0.060	0.076	0.090
18	0.022	0.026	0.038	0.062	0.089	0.119	0.152	0.190	0.204	**98**	0.015	0.019	0.032	0.051	0.071	0.104	0.131	0.167	0.181
19	0.006	0.009	0.015	0.025	0.038	0.056	0.076	0.097	0.117	**99**	0.005	0.006	0.010	0.022	0.034	0.044	0.061	0.084	0.097
20	0.020	0.028	0.042	0.062	0.085	0.115	0.150	0.189	0.207	**100**	0.013	0.020	0.032	0.052	0.072	0.102	0.132	0.164	0.179
21	0.017	0.021	0.032	0.047	0.072	0.096	0.124	0.150	0.176	**101**	0.012	0.017	0.026	0.046	0.062	0.084	0.110	0.138	0.159
22	0.009	0.014	0.021	0.030	0.040	0.059	0.076	0.094	0.109	**102**	0.009	0.013	0.017	0.026	0.039	0.053	0.072	0.087	0.103
23	0.014	0.023	0.034	0.050	0.071	0.096	0.122	0.157	0.174	**103**	0.012	0.017	0.026	0.043	0.061	0.084	0.110	0.139	0.156
24	0.009	0.012	0.017	0.029	0.039	0.053	0.071	0.092	0.110	**104**	0.009	0.012	0.016	0.025	0.036	0.054	0.069	0.087	0.103
25	0.019	0.022	0.032	0.050	0.073	0.098	0.125	0.155	0.175	**105**	0.015	0.021	0.028	0.047	0.065	0.088	0.110	0.141	0.161
26	0.021	0.029	0.042	0.060	0.085	0.115	0.144	0.184	0.201	**106**	0.015	0.024	0.035	0.054	0.071	0.101	0.130	0.165	0.180
27	0.012	0.014	0.023	0.037	0.051	0.071	0.093	0.117	0.134	**107**	0.011	0.012	0.021	0.029	0.044	0.063	0.080	0.099	0.115
28	0.024	0.029	0.046	0.069	0.092	0.126	0.153	0.201	0.211	**108**	0.015	0.022	0.036	0.053	0.082	0.110	0.134	0.174	0.196
29	0.010	0.013	0.024	0.035	0.047	0.070	0.091	0.117	0.135	**109**	0.009	0.013	0.018	0.032	0.045	0.060	0.079	0.102	0.115
30	0.035	0.048	0.068	0.100	0.126	0.166	0.200	0.249	0.260	**110**	0.023	0.031	0.046	0.069	0.096	0.129	0.159	0.199	0.214
31	0.010	0.018	0.026	0.040	0.059	0.085	0.112	0.139	0.161	**111**	0.012	0.014	0.023	0.037	0.052	0.077	0.099	0.128	0.146
32	0.005	0.008	0.010	0.016	0.026	0.036	0.050	0.066	0.080	**112**	0.005	0.006	0.010	0.015	0.026	0.032	0.047	0.062	0.076
33	0.014	0.017	0.027	0.043	0.063	0.086	0.111	0.142	0.163	**113**	0.011	0.015	0.025	0.037	0.055	0.074	0.096	0.126	0.142
34	0.003	0.005	0.009	0.017	0.026	0.036	0.049	0.063	0.081	**114**	0.004	0.006	0.007	0.015	0.022	0.035	0.048	0.061	0.075
35	0.012	0.019	0.028	0.046	0.063	0.085	0.115	0.143	0.162	**115**	0.008	0.015	0.025	0.038	0.056	0.077	0.099	0.128	0.142
36	0.016	0.024	0.036	0.055	0.079	0.109	0.134	0.171	0.190	**116**	0.014	0.021	0.030	0.048	0.068	0.093	0.117	0.150	0.168
37	0.007	0.009	0.014	0.027	0.038	0.054	0.078	0.095	0.109	**117**	0.005	0.006	0.010	0.020	0.027	0.041	0.057	0.074	0.087
38	0.020	0.030	0.040	0.065	0.088	0.116	0.153	0.194	0.206	**118**	0.014	0.022	0.032	0.050	0.074	0.099	0.131	0.165	0.185
39	0.007	0.009	0.015	0.026	0.038	0.054	0.076	0.099	0.109	**119**	0.004	0.007	0.011	0.022	0.031	0.041	0.062	0.081	0.098
40	0.020	0.025	0.044	0.066	0.089	0.120	0.149	0.190	0.207	**120**	0.016	0.018	0.031	0.050	0.076	0.099	0.129	0.168	0.187
41	0.015	0.021	0.034	0.053	0.071	0.099	0.127	0.164	0.181	**121**	0.013	0.016	0.027	0.042	0.063	0.083	0.112	0.138	0.159
42	0.010	0.012	0.020	0.029	0.045	0.062	0.080	0.103	0.119	**122**	0.006	0.008	0.012	0.020	0.031	0.042	0.060	0.075	0.091
43	0.016	0.021	0.033	0.053	0.072	0.096	0.126	0.157	0.174	**123**	0.013	0.016	0.026	0.041	0.059	0.081	0.110	0.137	0.155
44	0.009	0.010	0.017	0.026	0.038	0.055	0.071	0.091	0.102	**124**	0.005	0.007	0.011	0.020	0.029	0.039	0.054	0.070	0.084
45	0.019	0.025	0.038	0.056	0.079	0.102	0.131	0.166	0.183	**125**	0.015	0.018	0.028	0.047	0.063	0.090	0.119	0.146	0.166
46	0.023	0.026	0.040	0.064	0.082	0.111	0.144	0.179	0.201	**126**	0.013	0.020	0.029	0.049	0.071	0.092	0.121	0.156	0.172
47	0.010	0.014	0.021	0.031	0.048	0.069	0.088	0.114	0.129	**127**	0.008	0.010	0.014	0.022	0.032	0.045	0.062	0.081	0.095
48	0.020	0.029	0.045	0.064	0.090	0.123	0.154	0.194	0.208	**128**	0.014	0.020	0.034	0.050	0.077	0.104	0.131	0.166	0.184
49	0.009	0.011	0.020	0.031	0.044	0.063	0.084	0.105	0.122	**129**	0.006	0.009	0.013	0.019	0.034	0.047	0.062	0.082	0.098
50	0.035	0.049	0.069	0.096	0.123	0.163	0.195	0.244	0.257	**130**	0.022	0.029	0.045	0.068	0.096	0.120	0.155	0.194	0.208
51	0.013	0.013	0.024	0.043	0.057	0.082	0.104	0.135	0.156	**131**	0.009	0.013	0.021	0.032	0.051	0.075	0.098	0.123	0.142
52	0.003	0.005	0.006	0.009	0.019	0.026	0.035	0.048	0.063	**132**	0.003	0.005	0.006	0.010	0.017	0.021	0.033	0.040	0.052
53	0.011	0.014	0.027	0.044	0.058	0.085	0.112	0.140	0.154	**133**	0.010	0.015	0.023	0.036	0.057	0.071	0.098	0.120	0.138
54	0.003	0.003	0.006	0.010	0.016	0.026	0.037	0.050	0.065	**134**	0.003	0.004	0.007	0.009	0.018	0.024	0.033	0.043	0.056
55	0.014	0.016	0.025	0.042	0.060	0.081	0.110	0.138	0.159	**135**	0.008	0.015	0.022	0.036	0.051	0.074	0.097	0.123	0.139
56	0.017	0.022	0.036	0.053	0.073	0.103	0.134	0.168	0.184	**136**	0.013	0.016	0.029	0.043	0.063	0.087	0.119	0.148	0.166
57	0.004	0.006	0.015	0.023	0.031	0.048	0.068	0.086	0.102	**137**	0.004	0.006	0.009	0.014	0.023	0.034	0.046	0.065	0.077
58	0.018	0.026	0.036	0.063	0.086	0.117	0.149	0.186	0.204	**138**	0.015	0.019	0.032	0.050	0.073	0.100	0.126	0.167	0.181

ID	700-year open terrain 3-second gust wind speed, mph									ID	700-year open terrain 3-second gust wind speed, mph								
	110	115	120	130	140	150	160	170	180		110	115	120	130	140	150	160	170	180
59	0.005	0.006	0.012	0.020	0.035	0.048	0.074	0.091	0.106	**139**	0.003	0.006	0.009	0.017	0.027	0.038	0.055	0.074	0.084
60	0.020	0.024	0.042	0.062	0.085	0.119	0.151	0.187	0.204	**140**	0.016	0.021	0.031	0.049	0.070	0.102	0.126	0.162	0.179
61	0.013	0.016	0.027	0.042	0.060	0.082	0.110	0.138	0.158	**141**	0.012	0.015	0.021	0.037	0.055	0.073	0.096	0.125	0.143
62	0.005	0.006	0.008	0.013	0.018	0.028	0.041	0.051	0.064	**142**	0.005	0.007	0.009	0.013	0.019	0.024	0.035	0.045	0.056
63	0.012	0.017	0.029	0.045	0.062	0.089	0.112	0.138	0.160	**143**	0.011	0.016	0.022	0.039	0.053	0.080	0.099	0.123	0.141
64	0.005	0.005	0.008	0.014	0.020	0.029	0.040	0.053	0.066	**144**	0.004	0.006	0.008	0.012	0.016	0.027	0.039	0.047	0.058
65	0.012	0.019	0.028	0.045	0.067	0.086	0.111	0.145	0.159	**145**	0.011	0.016	0.023	0.038	0.055	0.078	0.101	0.125	0.144
66	0.018	0.022	0.036	0.050	0.080	0.107	0.134	0.169	0.185	**146**	0.013	0.020	0.028	0.046	0.067	0.095	0.117	0.152	0.172
67	0.006	0.009	0.017	0.024	0.034	0.047	0.067	0.087	0.101	**147**	0.006	0.009	0.011	0.017	0.025	0.038	0.053	0.065	0.079
68	0.022	0.027	0.043	0.062	0.085	0.120	0.147	0.188	0.202	**148**	0.014	0.020	0.033	0.051	0.070	0.099	0.130	0.165	0.182
69	0.006	0.007	0.013	0.023	0.037	0.050	0.070	0.092	0.108	**149**	0.007	0.007	0.012	0.022	0.029	0.043	0.056	0.076	0.089
70	0.036	0.048	0.066	0.093	0.119	0.158	0.194	0.241	0.255	**150**	0.023	0.028	0.045	0.065	0.090	0.122	0.152	0.192	0.211
71	0.012	0.015	0.026	0.041	0.061	0.082	0.104	0.137	0.152	**151**	0.012	0.014	0.021	0.038	0.053	0.074	0.099	0.123	0.142
72	0.003	0.005	0.008	0.012	0.016	0.025	0.035	0.049	0.057	**152**	0.003	0.005	0.006	0.010	0.014	0.023	0.031	0.043	0.050
73	0.014	0.015	0.025	0.041	0.061	0.081	0.110	0.139	0.155	**153**	0.010	0.015	0.021	0.035	0.050	0.072	0.096	0.124	0.139
74	0.003	0.004	0.005	0.008	0.016	0.022	0.035	0.044	0.061	**154**	0.003	0.004	0.007	0.009	0.016	0.025	0.031	0.045	0.056
75	0.011	0.017	0.025	0.043	0.059	0.087	0.108	0.139	0.155	**155**	0.009	0.013	0.024	0.033	0.055	0.071	0.094	0.122	0.142
76	0.017	0.022	0.037	0.056	0.077	0.103	0.132	0.169	0.188	**156**	0.014	0.016	0.030	0.043	0.061	0.092	0.119	0.150	0.164
77	0.006	0.007	0.015	0.022	0.034	0.049	0.064	0.089	0.102	**157**	0.004	0.006	0.009	0.015	0.022	0.035	0.045	0.063	0.079
78	0.017	0.029	0.041	0.060	0.087	0.112	0.145	0.186	0.207	**158**	0.017	0.019	0.032	0.050	0.074	0.099	0.128	0.161	0.178
79	0.007	0.006	0.013	0.019	0.036	0.053	0.068	0.089	0.107	**159**	0.004	0.005	0.009	0.017	0.030	0.038	0.053	0.071	0.088
80	0.023	0.024	0.044	0.063	0.087	0.117	0.146	0.188	0.207	**160**	0.015	0.020	0.034	0.050	0.075	0.101	0.129	0.160	0.183

APPENDIX C: EXPECTED ANNUAL LOSS FOR BUILDING, CONTENT, AND LOSS OF USE IN REFERENCE NON-OPEN TERRAIN

Table C.1 Fractional Expected Annual Building Loss for Reference Non-Open Terrain (EAL_{BR}) as a Ratio of Building Value (10^{-3}), z_0=0.15 m

ID	700-year open terrain 3-second gust wind speed, mph									ID	700-year open terrain 3-second gust wind speed, mph								
	110	115	120	130	140	150	160	170	180		110	115	120	130	140	150	160	170	180
1	1.08	1.79	2.05	3.14	4.21	7.23	9.66	15.98	17.62	**81**	0.92	1.35	1.75	2.61	3.68	5.89	8.21	12.75	14.36
2	1.05	1.63	1.83	2.55	3.37	5.53	7.38	10.87	12.63	**82**	0.77	1.26	1.49	2.03	2.69	4.40	6.06	9.86	10.64
3	0.80	1.28	1.62	2.42	3.71	6.13	8.28	13.62	14.32	**83**	0.65	1.03	1.28	2.00	3.08	5.14	7.32	12.23	12.58
4	0.73	1.18	1.37	1.95	2.58	4.70	6.10	10.34	10.53	**84**	0.56	0.94	1.15	1.64	2.24	3.78	5.13	8.76	9.52
5	0.90	1.53	1.80	2.73	3.95	6.76	9.39	14.55	15.23	**85**	0.69	1.21	1.46	2.36	3.21	5.66	8.01	12.42	14.07
6	1.28	2.17	2.66	4.45	5.66	10.05	13.75	22.08	22.69	**86**	0.93	1.56	1.92	2.97	4.16	7.13	9.63	15.85	17.22
7	0.98	1.70	1.80	2.66	3.26	5.50	7.86	12.52	13.65	**87**	0.82	1.31	1.49	2.17	2.82	4.83	6.80	10.47	11.26
8	0.92	1.50	1.91	3.24	5.00	7.84	11.27	17.28	20.74	**88**	0.68	1.08	1.38	2.20	2.94	5.70	8.34	13.50	14.68
9	0.73	1.13	1.37	2.14	2.86	5.17	7.21	11.12	12.30	**89**	0.59	0.96	1.08	1.68	2.24	3.95	5.89	9.04	10.19
10	1.17	1.76	2.45	4.27	6.08	10.26	14.78	23.14	24.32	**90**	0.70	1.30	1.63	2.82	4.08	6.62	9.63	15.76	17.37
11	0.40	0.64	0.97	1.40	2.22	4.05	5.75	9.41	10.69	**91**	0.30	0.49	0.67	1.34	2.04	3.35	5.49	8.82	10.27
12	0.31	0.50	0.59	0.87	1.30	1.80	3.04	4.84	5.42	**92**	0.19	0.34	0.46	0.76	1.06	1.83	2.88	4.46	5.14
13	0.32	0.49	0.81	1.29	2.25	3.73	5.63	9.62	10.11	**93**	0.24	0.37	0.69	1.13	1.81	3.37	4.99	8.85	9.87
14	0.22	0.37	0.47	0.70	1.00	1.72	2.81	4.41	5.29	**94**	0.16	0.25	0.34	0.62	0.95	1.63	2.64	4.30	5.07
15	0.30	0.57	0.81	1.38	2.03	3.53	5.32	9.41	10.72	**95**	0.23	0.37	0.58	1.11	1.95	3.66	5.12	8.49	9.73
16	0.57	0.99	1.42	3.12	4.93	7.59	11.91	17.64	19.42	**96**	0.30	0.52	0.96	1.73	3.03	5.81	8.11	12.88	14.84
17	0.33	0.51	0.65	1.08	1.67	3.01	4.50	7.40	8.47	**97**	0.22	0.35	0.47	0.90	1.21	2.47	3.34	5.83	6.52
18	0.45	0.64	1.23	2.14	3.60	6.40	9.44	14.01	17.20	**98**	0.26	0.43	0.63	1.36	2.33	4.47	6.40	10.42	12.49
19	0.23	0.43	0.54	0.99	1.49	2.65	4.29	6.75	8.05	**99**	0.15	0.25	0.41	0.61	1.11	2.07	3.23	5.12	6.60
20	0.42	0.82	1.21	2.21	3.77	5.88	9.18	15.09	17.23	**100**	0.22	0.45	0.70	1.36	2.22	4.05	6.26	10.42	12.42
21	1.04	1.60	1.90	2.88	3.63	5.85	8.90	12.92	13.52	**101**	0.82	1.34	1.63	2.64	3.50	5.46	7.81	12.33	12.87
22	0.95	1.52	1.67	2.33	2.88	4.69	6.29	9.72	10.09	**102**	0.78	1.22	1.45	2.11	2.55	4.17	5.90	8.83	9.71
23	0.79	1.29	1.55	2.45	3.11	5.28	7.85	11.98	13.40	**103**	0.64	1.03	1.28	2.05	2.76	5.05	7.16	11.26	12.46
24	0.69	1.12	1.32	1.83	2.21	3.71	5.18	8.54	9.04	**104**	0.57	0.92	1.10	1.60	2.12	3.93	5.06	8.17	9.13
25	0.87	1.39	1.70	2.69	3.33	5.61	8.32	12.73	14.18	**105**	0.68	1.10	1.60	2.36	3.15	5.36	7.47	11.70	12.74
26	1.20	2.00	2.55	4.29	5.72	9.43	13.41	21.22	22.17	**106**	0.85	1.51	1.84	2.75	4.13	6.88	9.84	15.63	16.87
27	1.00	1.57	1.78	2.41	3.18	5.14	7.29	11.38	12.06	**107**	0.78	1.25	1.51	2.17	2.84	4.59	6.51	9.94	10.96
28	0.97	1.56	1.94	3.08	4.62	7.97	10.76	17.87	18.91	**108**	0.69	1.03	1.46	2.35	3.67	5.99	8.61	13.53	15.35
29	0.71	1.23	1.38	1.97	2.65	4.70	6.39	10.31	11.10	**109**	0.59	0.93	1.16	1.75	2.35	3.73	5.52	8.85	9.70
30	1.09	1.78	2.61	4.21	5.88	10.28	14.29	23.09	23.91	**110**	0.75	1.17	1.56	2.75	4.17	6.54	9.78	15.87	16.56
31	0.37	0.61	0.87	1.60	2.23	3.96	6.24	9.87	10.67	**111**	0.26	0.48	0.74	1.22	2.03	3.72	5.22	8.58	9.80
32	0.30	0.48	0.58	0.90	1.20	2.02	3.12	4.77	5.76	**112**	0.20	0.36	0.44	0.71	1.02	1.92	2.71	4.51	5.36
33	0.32	0.55	0.71	1.29	2.19	3.52	5.98	9.29	10.26	**113**	0.23	0.41	0.62	1.09	2.00	3.41	4.82	8.10	9.81
34	0.23	0.37	0.47	0.71	1.05	1.80	2.64	4.25	5.42	**114**	0.15	0.26	0.38	0.64	0.95	1.84	2.53	4.05	4.77
35	0.28	0.56	0.78	1.22	2.04	3.85	5.91	9.53	10.87	**115**	0.24	0.41	0.57	1.20	2.06	3.35	4.74	7.87	9.57
36	0.58	1.05	1.68	2.80	4.47	7.85	11.48	18.11	19.80	**116**	0.33	0.55	0.85	1.82	2.79	5.31	8.02	13.23	14.26
37	0.31	0.52	0.69	1.10	1.64	2.97	4.32	7.11	8.50	**117**	0.22	0.36	0.55	0.83	1.22	2.45	3.64	5.89	6.63
38	0.40	0.75	1.19	2.30	3.85	6.30	9.78	15.56	17.14	**118**	0.26	0.46	0.76	1.43	2.36	3.98	6.95	11.34	12.71
39	0.24	0.43	0.59	0.87	1.45	2.68	3.97	6.68	8.20	**119**	0.15	0.29	0.42	0.64	1.08	1.79	3.17	5.35	6.59
40	0.41	0.82	1.18	2.16	3.86	6.83	9.21	15.83	17.60	**120**	0.29	0.40	0.67	1.64	2.64	4.30	6.77	11.52	13.22
41	1.01	1.68	2.04	2.76	3.98	6.44	8.69	13.98	15.57	**121**	0.79	1.34	1.60	2.35	3.13	5.63	7.46	12.04	12.79
42	0.95	1.48	1.62	2.27	2.82	4.49	6.38	9.51	10.26	**122**	0.71	1.17	1.31	1.73	2.16	3.47	4.47	7.32	7.87
43	0.76	1.26	1.46	2.23	3.21	5.26	7.16	11.33	13.14	**123**	0.59	0.97	1.25	1.89	2.67	4.45	6.32	10.26	11.40
44	0.67	1.05	1.14	1.48	2.02	3.41	4.42	7.61	8.44	**124**	0.52	0.84	0.96	1.33	1.66	2.58	3.84	5.87	6.96
45	0.87	1.32	1.68	2.65	3.39	5.76	7.94	13.17	14.41	**125**	0.63	1.05	1.39	2.01	2.95	4.81	7.37	11.59	12.66
46	1.19	2.01	2.61	4.08	5.59	9.36	13.71	20.23	22.58	**126**	0.89	1.38	1.72	2.75	3.67	6.53	9.11	14.34	16.29
47	0.98	1.54	1.70	2.39	2.74	4.71	6.75	10.51	11.12	**127**	0.73	1.19	1.36	1.77	2.32	3.72	5.04	7.71	8.55
48	0.85	1.41	1.92	2.72	4.40	7.55	10.61	17.15	18.45	**128**	0.68	0.99	1.40	2.13	3.34	5.01	7.56	12.40	13.79
49	0.68	1.07	1.18	1.77	2.32	4.05	5.61	9.50	9.62	**129**	0.52	0.86	0.93	1.37	1.82	2.92	4.02	6.87	7.67
50	1.07	1.82	2.45	4.05	5.69	10.03	14.86	21.56	24.15	**130**	0.73	1.13	1.66	2.62	3.82	6.35	9.40	15.42	16.37
51	0.36	0.59	0.93	1.48	2.16	3.69	5.94	8.98	10.97	**131**	0.26	0.47	0.62	1.18	2.11	3.45	5.13	8.11	9.29
52	0.29	0.47	0.54	0.83	0.95	1.67	2.37	3.61	4.42	**132**	0.20	0.33	0.42	0.66	0.89	1.47	2.30	3.57	4.04
53	0.29	0.49	0.69	1.20	2.06	3.66	5.42	8.69	10.39	**133**	0.26	0.45	0.65	1.10	2.01	2.79	5.22	8.27	9.63
54	0.21	0.35	0.42	0.64	0.86	1.59	2.19	3.71	3.78	**134**	0.15	0.24	0.33	0.53	0.78	1.28	2.11	3.33	4.25

ID	700-year open terrain 3-second gust wind speed, mph									ID	700-year open terrain 3-second gust wind speed, mph								
	110	115	120	130	140	150	160	170	180		110	115	120	130	140	150	160	170	180
55	0.28	0.53	0.73	1.24	2.07	3.33	5.88	8.57	10.01	**135**	0.21	0.38	0.57	1.11	1.84	3.38	4.84	8.25	9.65
56	0.51	1.03	1.54	2.68	4.32	7.11	11.37	17.30	19.76	**136**	0.30	0.55	0.89	1.82	2.76	4.77	7.72	11.86	13.83
57	0.29	0.51	0.65	1.01	1.55	2.84	4.09	6.26	7.40	**137**	0.19	0.34	0.51	0.81	1.40	2.17	3.14	5.36	6.18
58	0.43	0.68	1.25	2.12	3.22	5.99	10.01	14.96	17.63	**138**	0.27	0.45	0.72	1.48	2.51	4.02	6.67	9.99	11.79
59	0.25	0.41	0.51	0.92	1.31	2.37	3.95	5.64	7.55	**139**	0.16	0.25	0.38	0.62	1.18	1.88	2.89	4.78	5.58
60	0.39	0.78	1.21	2.41	3.56	5.90	10.73	14.76	16.89	**140**	0.23	0.41	0.61	1.22	2.43	4.24	6.17	10.41	12.16
61	0.95	1.56	1.70	2.28	3.25	5.18	6.78	11.15	11.14	**141**	0.85	1.28	1.50	2.20	2.88	4.65	6.57	10.57	10.45
62	0.87	1.36	1.39	1.68	1.84	2.80	3.89	5.70	6.09	**142**	0.73	1.17	1.26	1.65	1.79	2.83	3.63	5.70	5.93
63	0.70	1.18	1.38	2.03	2.72	4.70	6.64	10.08	11.67	**143**	0.59	1.01	1.22	1.84	2.59	4.36	6.25	10.21	11.24
64	0.65	1.00	1.01	1.31	1.46	2.38	3.48	5.01	5.57	**144**	0.49	0.84	0.92	1.28	1.50	2.40	3.17	4.93	5.35
65	0.80	1.26	1.55	2.17	3.05	4.88	7.06	11.24	12.22	**145**	0.62	1.02	1.30	2.10	2.73	4.94	6.68	10.26	11.26
66	1.17	1.84	2.29	3.61	5.27	8.86	12.62	19.19	21.36	**146**	0.84	1.38	1.82	2.84	3.89	6.22	9.43	14.09	15.70
67	0.89	1.45	1.49	1.94	2.47	3.76	5.15	7.89	9.07	**147**	0.72	1.18	1.28	1.76	2.16	3.25	4.76	7.21	7.88
68	0.83	1.43	1.74	2.77	4.23	6.91	10.18	16.72	18.11	**148**	0.61	1.01	1.27	2.23	3.28	5.02	7.69	12.42	13.24
69	0.66	1.05	1.11	1.45	2.19	3.55	4.54	6.94	8.35	**149**	0.52	0.84	1.01	1.29	1.76	3.08	3.76	6.45	7.35
70	1.06	1.79	2.43	3.90	5.96	9.56	13.72	21.81	23.73	**150**	0.71	1.14	1.46	2.79	3.37	5.98	8.42	15.01	15.98
71	0.38	0.63	0.92	1.45	2.43	3.66	5.82	8.93	10.42	**151**	0.26	0.45	0.74	1.21	2.09	3.52	5.12	8.35	9.68
72	0.28	0.46	0.58	0.78	0.98	1.70	2.31	3.65	4.21	**152**	0.20	0.34	0.44	0.67	0.97	1.54	2.17	3.35	4.14
73	0.32	0.51	0.70	1.14	2.06	3.56	5.50	8.66	10.79	**153**	0.20	0.38	0.61	1.12	1.91	3.08	5.25	8.24	9.10
74	0.21	0.34	0.41	0.62	0.76	1.37	2.07	3.36	4.23	**154**	0.14	0.27	0.32	0.51	0.73	1.40	2.04	3.38	4.06
75	0.30	0.53	0.80	1.24	2.06	3.54	5.39	8.59	10.09	**155**	0.25	0.38	0.62	1.13	1.89	3.35	5.12	7.77	9.14
76	0.62	0.96	1.65	2.89	4.28	7.89	11.12	16.57	19.61	**156**	0.31	0.57	0.98	1.92	2.81	5.12	7.26	11.91	13.75
77	0.31	0.49	0.67	1.01	1.56	2.52	3.86	6.15	7.09	**157**	0.20	0.34	0.52	0.81	1.15	2.13	3.21	5.24	6.12
78	0.47	0.73	1.24	2.29	3.84	6.41	8.89	15.55	17.20	**158**	0.31	0.41	0.67	1.33	2.50	4.03	6.76	10.30	12.28
79	0.24	0.36	0.50	0.90	1.26	2.33	3.78	6.09	7.35	**159**	0.17	0.27	0.40	0.70	1.01	1.89	2.84	4.46	5.10
80	0.42	0.83	1.23	2.22	3.59	6.47	9.43	15.86	16.91	**160**	0.28	0.42	0.71	1.43	2.47	4.42	6.59	10.22	12.34

Table C.2 Fractional Expected Annual Content Loss for Reference Non-Open Terrain (EAL_{CR}), as a Ratio of Content Value (10^{-4}), z_0=0.15 m

ID	700-year open terrain 3-second gust wind speed, mph									**ID**	700-year open terrain 3-second gust wind speed, mph								
	110	115	120	130	140	150	160	170	180		110	115	120	130	140	150	160	170	180
1	1.31	2.38	5.31	10.08	19.54	32.61	53.38	85.83	100.79	**81**	1.25	1.27	3.02	7.76	14.98	26.28	46.75	69.05	82.12
2	0.39	0.88	1.56	4.39	7.42	15.43	23.32	38.84	52.58	**82**	0.17	0.30	0.81	2.26	4.95	8.66	17.28	28.97	34.80
3	1.04	1.84	3.96	10.37	16.32	32.85	51.91	84.21	101.96	**83**	0.92	1.75	3.45	9.28	18.76	29.33	49.22	73.55	84.28
4	0.26	0.59	1.23	3.13	5.66	10.13	21.67	35.61	45.38	**84**	0.15	0.36	0.86	1.95	4.92	8.34	14.99	24.98	32.25
5	1.66	2.45	5.56	12.17	20.39	36.00	60.28	90.42	109.16	**85**	1.24	1.97	4.15	9.46	15.62	30.00	51.74	78.21	98.13
6	3.31	4.59	11.13	23.37	38.38	70.80	106.12	165.23	185.46	**86**	1.36	2.38	5.01	12.12	24.84	43.48	66.82	115.23	126.86
7	0.36	1.13	2.82	7.64	11.36	19.77	35.26	55.58	69.11	**87**	0.23	0.79	1.29	2.82	7.71	15.89	23.67	38.02	49.91
8	2.15	4.51	7.93	16.74	34.09	58.01	86.42	145.15	165.70	**88**	0.92	1.96	4.32	8.95	20.48	35.71	63.31	97.80	115.10
9	0.67	0.87	2.21	5.56	9.90	22.71	32.31	53.02	67.67	**89**	0.18	0.45	1.12	2.79	6.86	13.51	21.51	41.09	46.44
10	3.95	6.93	14.45	26.02	47.82	84.49	115.24	193.23	204.21	**90**	1.35	2.73	7.03	13.76	26.71	47.65	75.72	122.06	149.65
11	0.74	1.90	3.45	9.57	16.15	31.37	49.64	75.27	99.44	**91**	0.69	1.18	2.87	7.26	12.85	23.84	43.11	61.38	78.04
12	0.12	0.20	0.52	1.37	2.61	4.44	10.79	17.46	26.11	**92**	0.04	0.10	0.31	0.95	2.13	4.84	8.86	16.20	22.62
13	1.05	1.49	5.03	8.24	15.12	30.20	46.73	76.35	95.59	**93**	0.82	1.66	3.39	8.20	15.71	29.08	41.79	72.90	80.63
14	0.04	0.14	0.43	1.43	2.24	6.02	10.52	17.62	26.51	**94**	0.03	0.07	0.35	0.76	2.21	4.66	10.06	15.69	23.36
15	0.82	1.81	4.36	8.14	14.50	30.64	47.69	76.09	94.96	**95**	0.83	1.60	2.98	7.26	12.51	26.19	39.97	63.69	81.94
16	2.14	5.71	11.13	20.90	34.63	69.49	101.88	158.70	182.43	**96**	1.99	2.06	5.03	10.96	20.47	37.95	65.28	104.32	128.64
17	0.52	0.51	2.22	3.73	8.67	16.29	28.29	46.16	62.36	**97**	0.26	0.24	0.49	2.67	4.71	10.15	18.87	29.32	40.02
18	1.92	3.54	7.64	18.04	32.80	59.34	89.33	134.81	158.29	**98**	1.60	2.00	4.25	9.53	22.08	35.55	58.96	94.86	114.52
19	0.35	0.48	1.43	4.16	8.08	18.28	29.91	42.85	57.75	**99**	0.10	0.27	1.15	2.52	4.67	10.33	19.45	34.58	40.65
20	1.71	3.77	7.06	18.64	33.50	59.88	85.79	137.97	152.81	**100**	1.46	1.74	3.89	10.18	20.71	38.36	56.94	94.12	115.69
21	1.14	1.81	4.53	7.49	16.71	29.46	50.45	78.11	96.91	**101**	0.94	1.18	3.45	6.25	15.38	27.13	45.14	72.45	78.79
22	0.33	0.57	0.90	2.55	5.18	8.56	15.38	27.62	34.28	**102**	0.12	0.51	0.78	1.46	3.83	7.73	12.67	22.16	27.14
23	0.82	2.30	4.01	9.62	17.30	29.17	51.42	80.32	92.22	**103**	1.18	1.37	2.81	7.73	16.04	25.79	42.92	72.90	85.90
24	0.32	0.49	1.01	2.32	5.61	9.60	16.33	24.86	35.73	**104**	0.13	0.36	0.58	2.34	3.92	7.24	13.28	24.94	30.41
25	1.25	2.56	4.54	10.70	19.45	34.11	54.21	85.45	98.46	**105**	1.11	1.84	4.40	9.16	16.91	28.88	46.29	73.48	87.79
26	3.30	5.11	11.26	23.91	37.00	69.26	105.10	161.77	183.65	**106**	1.01	2.90	3.98	14.04	23.44	44.08	67.12	108.19	121.83
27	0.65	0.58	2.02	5.06	11.44	17.50	33.96	47.58	72.80	**107**	0.29	0.40	1.49	3.18	7.12	12.88	22.34	37.70	49.84
28	2.90	4.26	8.15	18.52	31.39	61.34	90.36	136.51	163.31	**108**	1.38	1.68	5.06	9.45	18.34	39.26	62.06	96.55	121.90
29	0.43	0.83	1.81	4.65	10.70	16.70	32.33	48.79	65.38	**109**	0.18	0.51	1.11	3.22	7.57	13.61	21.55	35.73	45.74
30	3.86	7.15	15.19	29.16	47.81	79.08	116.50	186.22	215.46	**110**	2.01	3.37	6.73	15.17	23.43	47.08	74.21	119.63	143.19
31	0.68	1.46	3.15	7.90	16.16	29.76	48.30	76.33	88.47	**111**	0.80	1.57	2.81	6.30	14.60	25.22	40.42	64.32	78.84
32	0.08	0.11	0.26	1.02	2.65	5.89	11.76	18.41	22.88	**112**	0.15	0.07	0.66	1.29	1.71	5.11	9.81	13.75	22.15
33	1.13	1.93	4.39	8.21	15.30	27.53	46.71	77.52	97.18	**113**	0.70	1.92	3.47	7.25	13.82	27.43	43.26	73.69	83.18
34	0.10	0.16	0.32	0.99	1.78	5.21	11.03	20.20	27.27	**114**	0.09	0.11	0.17	1.16	2.26	5.22	9.89	15.95	24.07
35	0.97	2.13	4.16	8.20	16.13	31.63	49.75	77.65	89.27	**115**	1.12	1.33	3.38	8.64	14.68	26.46	43.41	67.30	85.34
36	2.64	5.51	10.38	21.53	38.79	63.88	102.32	157.24	180.12	**116**	1.26	2.99	5.10	11.08	21.78	42.05	67.89	108.84	125.20
37	0.30	0.48	1.37	3.37	7.91	16.22	24.81	40.63	58.67	**117**	0.19	0.17	0.66	1.82	5.17	10.64	19.76	35.59	41.07
38	2.40	5.21	10.05	18.90	29.95	59.57	89.37	146.03	157.55	**118**	1.41	2.31	4.70	9.48	22.23	36.89	56.77	91.47	114.31
39	0.40	0.47	1.52	3.72	9.50	15.69	26.06	44.37	59.03	**119**	0.09	0.41	0.88	2.44	5.40	10.17	19.21	33.13	41.94
40	2.15	4.14	10.47	19.07	29.20	56.56	87.38	139.15	149.77	**120**	1.81	1.79	4.94	10.19	16.32	37.03	62.63	96.95	114.26
41	0.83	1.70	4.01	9.16	18.39	31.47	52.48	82.42	97.45	**121**	0.58	1.55	3.74	7.39	12.85	28.51	41.84	70.30	85.96
42	0.17	0.43	1.14	2.78	5.36	11.67	19.57	32.91	42.84	**122**	0.10	0.15	0.40	1.37	2.60	5.92	11.07	21.23	30.45
43	0.98	2.38	4.08	9.64	17.52	31.92	50.76	82.62	98.47	**123**	0.81	1.91	3.00	7.65	15.32	25.85	43.30	71.66	81.88
44	0.25	0.27	0.77	2.38	4.52	9.29	14.59	24.70	34.87	**124**	0.05	0.10	0.48	1.21	2.66	5.54	9.82	18.99	29.19
45	1.23	2.82	5.04	10.23	20.20	37.93	55.59	86.92	100.10	**125**	0.87	2.22	4.12	8.36	16.92	29.29	49.59	80.74	90.01
46	3.00	5.32	11.77	22.92	38.06	61.90	105.86	164.01	185.70	**126**	1.34	2.42	4.31	11.83	22.55	38.74	64.72	109.66	126.70
47	0.38	0.70	1.71	5.21	8.75	19.30	31.72	50.66	63.84	**127**	0.51	0.30	0.82	3.06	5.26	10.20	18.99	31.31	41.43
48	2.13	4.25	9.03	18.56	29.63	58.21	86.61	142.06	165.06	**128**	1.13	1.76	4.28	10.86	19.84	37.00	58.98	97.01	118.05
49	0.26	0.59	1.72	4.94	9.85	17.48	30.08	50.25	64.03	**129**	0.13	0.36	0.95	2.10	5.50	10.37	21.26	32.56	39.56
50	3.94	7.68	14.95	29.03	45.48	81.56	122.35	186.37	214.17	**130**	1.41	2.52	8.00	14.32	24.84	49.30	70.59	117.46	147.25
51	0.86	1.47	3.45	7.67	15.19	27.89	48.38	78.06	97.78	**131**	0.80	1.35	2.49	7.19	13.90	25.60	43.84	65.76	76.83
52	0.03	0.06	0.57	0.88	2.32	4.22	7.97	14.23	21.33	**132**	0.02	0.05	0.36	0.52	1.86	3.69	8.10	13.11	19.86
53	0.94	1.54	3.91	8.77	17.17	29.29	47.40	75.81	89.14	**133**	0.62	1.93	3.81	7.78	13.54	27.78	40.58	71.69	83.46
54	0.07	0.10	0.25	1.31	2.10	4.42	10.98	17.69	25.67	**134**	0.11	0.11	0.38	0.81	1.38	4.46	9.22	13.31	19.46
55	0.90	1.86	4.17	7.42	15.70	31.71	48.27	76.31	88.44	**135**	0.99	1.49	3.19	6.94	13.07	26.45	43.65	63.81	83.80
56	3.38	5.32	10.16	20.76	40.63	65.12	97.30	155.28	180.13	**136**	1.03	1.67	6.00	11.14	23.02	37.15	60.21	109.51	125.54
57	0.31	0.66	1.12	3.73	8.78	15.79	25.42	42.55	53.50	**137**	0.17	0.28	0.92	2.12	5.30	9.43	20.28	30.09	38.49
58	2.12	4.45	7.24	17.49	31.03	57.65	85.49	142.12	163.76	**138**	1.40	1.88	4.42	9.81	18.17	34.33	56.08	92.79	115.93

ID	700-year open terrain 3-second gust wind speed, mph									ID	700-year open terrain 3-second gust wind speed, mph								
	110	115	120	130	140	150	160	170	180		110	115	120	130	140	150	160	170	180
59	0.37	0.37	1.61	4.00	7.51	15.91	28.10	43.43	56.68	**139**	0.27	0.39	0.65	1.95	4.64	9.67	16.16	29.56	44.37
60	2.21	3.76	8.48	16.59	32.66	58.32	87.14	139.52	152.53	**140**	1.40	1.92	4.06	10.43	20.67	33.71	57.48	97.46	117.32
61	0.92	1.78	3.95	6.51	16.19	27.59	45.41	73.76	88.89	**141**	0.81	1.01	2.85	6.82	13.46	24.92	39.59	68.34	75.45
62	0.08	0.08	0.18	1.08	2.92	5.38	8.96	14.50	22.58	**142**	0.04	0.06	0.23	0.75	1.71	3.55	6.83	12.58	19.53
63	0.70	1.76	4.41	8.80	16.15	30.26	46.71	77.33	94.08	**143**	0.98	1.63	3.24	6.41	16.68	27.54	41.04	69.56	83.10
64	0.08	0.10	0.28	0.83	2.10	5.18	11.38	15.76	25.28	**144**	0.07	0.06	0.24	0.79	1.86	4.23	8.24	14.09	21.75
65	1.21	2.78	4.97	8.97	16.53	31.86	48.01	77.86	94.28	**145**	1.15	1.84	3.81	8.90	14.68	28.98	43.70	71.00	83.49
66	2.25	5.06	12.10	21.77	39.10	68.72	104.31	170.10	185.91	**146**	0.83	2.18	4.22	12.17	23.83	39.73	67.18	110.80	123.06
67	0.38	0.33	1.17	3.50	8.31	15.50	27.47	47.48	55.71	**147**	0.10	0.38	0.77	2.44	5.08	9.89	17.75	27.97	44.34
68	2.31	4.60	7.88	16.92	28.67	55.56	86.11	138.33	158.48	**148**	1.02	1.89	3.59	12.47	20.63	35.26	58.22	100.12	114.59
69	0.32	0.53	1.56	3.54	6.75	14.74	28.09	43.99	59.01	**149**	0.15	0.20	0.76	1.83	6.58	9.70	18.86	30.01	44.48
70	3.98	6.49	13.23	28.11	46.59	79.22	125.98	186.45	212.93	**150**	1.59	2.98	6.72	14.67	26.20	45.42	71.57	119.57	141.18
71	1.20	1.58	3.95	8.13	14.19	28.10	44.33	74.10	84.53	**151**	0.95	1.47	3.03	6.61	14.09	24.79	41.61	67.65	82.57
72	0.10	0.07	0.27	0.88	2.42	4.02	9.82	15.71	21.44	**152**	0.05	0.07	0.11	0.89	2.03	4.06	6.91	12.53	19.08
73	1.15	1.46	3.89	7.76	14.32	29.10	45.26	73.98	94.64	**153**	0.91	1.68	3.34	7.93	13.67	25.43	44.97	70.71	86.78
74	0.04	0.12	0.23	0.52	2.54	4.70	9.19	15.98	21.52	**154**	0.08	0.11	0.23	0.70	1.84	5.15	8.63	14.58	19.74
75	0.81	1.60	4.19	7.97	17.54	28.53	45.36	75.00	93.41	**155**	0.80	1.56	3.57	7.62	13.30	25.74	44.50	68.04	86.69
76	2.96	4.91	10.83	21.53	40.76	69.00	93.15	162.78	176.51	**156**	1.37	1.93	4.69	11.87	21.51	39.07	65.57	105.72	123.10
77	0.54	0.31	1.72	3.15	7.68	15.68	28.38	40.82	55.59	**157**	0.21	0.25	0.39	1.95	4.32	10.06	16.81	30.44	38.76
78	2.16	5.03	8.77	17.73	32.24	55.75	88.20	146.73	162.68	**158**	0.97	1.87	3.80	8.41	20.96	35.99	58.33	99.88	109.46
79	0.30	0.34	1.52	4.13	8.83	13.89	26.70	40.91	58.93	**159**	0.09	0.12	1.21	2.04	4.28	9.19	17.78	30.26	41.99
80	1.69	3.38	8.07	17.74	34.23	55.01	90.78	140.01	150.86	**160**	1.37	2.40	4.70	8.62	19.73	37.26	56.81	94.34	113.58

Table C.3 Fractional Expected Annual Loss of Use for Reference Non-Open Terrain (EAL_{UR}), Expressed in Days, z_0=0.15 m

ID	700-year open terrain 3-second gust wind speed, mph									ID	700-year open terrain 3-second gust wind speed, mph								
	110	115	120	130	140	150	160	170	180		110	115	120	130	140	150	160	170	180
1	0.46	0.76	1.03	1.80	2.82	5.00	6.85	10.87	12.37	**81**	0.36	0.58	0.77	1.57	2.31	3.79	6.00	9.16	10.71
2	0.34	0.58	0.76	1.40	2.17	3.46	5.20	8.66	9.07	**82**	0.27	0.42	0.64	1.10	1.56	2.83	4.29	6.55	7.45
3	0.32	0.48	0.89	1.48	2.32	4.06	5.89	9.65	10.52	**83**	0.28	0.46	0.66	1.21	1.99	3.52	5.15	8.37	10.02
4	0.25	0.41	0.54	0.97	1.69	2.93	4.37	6.54	7.86	**84**	0.18	0.32	0.46	0.84	1.38	2.34	3.44	5.85	6.84
5	0.39	0.60	0.99	1.76	2.58	4.64	6.71	10.44	11.81	**85**	0.26	0.48	0.84	1.47	2.15	3.88	5.73	9.69	10.82
6	0.57	0.98	1.63	2.71	4.25	7.00	9.96	16.38	16.70	**86**	0.34	0.64	0.97	1.81	2.69	4.89	7.45	11.55	13.00
7	0.34	0.58	0.88	1.44	2.18	3.99	5.59	9.07	9.56	**87**	0.26	0.49	0.70	1.11	1.73	2.90	4.55	6.80	8.31
8	0.38	0.77	1.11	1.98	3.23	5.54	8.22	13.62	14.90	**88**	0.27	0.46	0.78	1.57	2.23	3.83	6.09	9.68	10.88
9	0.26	0.46	0.58	1.09	1.85	2.98	4.62	7.92	8.74	**89**	0.20	0.32	0.48	0.94	1.50	2.70	3.94	6.56	7.05
10	0.50	1.00	1.61	2.76	4.47	7.46	10.26	16.29	17.52	**90**	0.32	0.57	0.99	1.85	2.60	5.05	7.02	11.07	12.30
11	0.16	0.27	0.48	0.99	1.63	2.58	4.59	6.77	8.10	**91**	0.12	0.23	0.46	0.81	1.45	2.52	4.04	6.15	7.90
12	0.09	0.14	0.23	0.44	0.68	1.21	2.14	3.13	3.78	**92**	0.06	0.11	0.16	0.36	0.66	1.17	1.64	3.02	3.51
13	0.14	0.23	0.46	0.86	1.53	2.54	4.11	6.91	8.34	**93**	0.10	0.18	0.42	0.80	1.30	2.54	3.86	6.36	7.35
14	0.06	0.11	0.16	0.39	0.57	1.14	1.97	2.99	3.74	**94**	0.05	0.08	0.17	0.31	0.68	1.03	1.78	2.77	3.51
15	0.13	0.24	0.41	0.84	1.56	2.71	4.09	6.89	7.76	**95**	0.09	0.18	0.36	0.68	1.44	2.34	3.71	6.33	7.46
16	0.31	0.59	1.06	2.06	3.26	5.74	8.59	13.01	14.66	**96**	0.17	0.25	0.54	1.05	2.00	3.59	5.79	9.08	10.57
17	0.13	0.21	0.30	0.61	1.10	2.01	3.21	4.93	6.10	**97**	0.06	0.13	0.24	0.46	0.87	1.40	2.47	3.97	4.99
18	0.26	0.46	0.82	1.67	2.88	4.74	6.86	11.65	12.87	**98**	0.15	0.23	0.46	1.07	1.66	3.33	4.78	8.06	8.64
19	0.09	0.16	0.28	0.61	0.94	1.87	3.14	4.92	5.87	**99**	0.06	0.12	0.20	0.37	0.68	1.34	2.23	3.63	4.77
20	0.21	0.43	0.74	1.82	2.53	4.61	7.36	11.51	12.28	**100**	0.13	0.23	0.48	1.00	1.63	3.25	5.09	7.72	9.28
21	0.39	0.62	0.97	1.55	2.28	4.29	5.87	9.49	10.21	**101**	0.32	0.58	0.75	1.36	2.28	3.88	6.08	8.93	9.85
22	0.33	0.52	0.69	1.13	1.63	2.92	4.00	6.65	7.17	**102**	0.25	0.42	0.65	1.05	1.65	2.58	3.78	6.24	6.94
23	0.27	0.46	0.72	1.33	2.28	3.69	5.42	8.99	9.71	**103**	0.24	0.38	0.64	1.19	1.89	3.28	5.31	7.98	9.06
24	0.26	0.40	0.58	0.86	1.48	2.59	3.87	6.02	6.97	**104**	0.19	0.32	0.48	0.85	1.38	2.22	3.66	5.54	6.27
25	0.31	0.63	0.87	1.43	2.29	3.67	5.76	9.27	10.46	**105**	0.29	0.48	0.84	1.35	2.09	3.89	5.62	8.97	9.50
26	0.54	1.00	1.37	2.64	3.85	6.99	9.33	15.42	16.05	**106**	0.36	0.60	0.94	1.69	2.77	4.56	7.13	10.81	12.27
27	0.32	0.56	0.73	1.30	1.83	3.29	4.94	8.04	8.97	**107**	0.26	0.44	0.71	1.09	1.71	3.11	4.62	6.87	7.72
28	0.38	0.77	1.19	1.94	3.26	5.58	8.18	12.89	13.70	**108**	0.26	0.46	0.77	1.27	2.25	4.12	6.32	9.44	10.58
29	0.25	0.42	0.58	1.10	1.81	2.88	4.30	7.32	7.80	**109**	0.18	0.33	0.47	0.87	1.38	2.45	3.83	5.79	7.13
30	0.64	1.04	1.63	3.04	4.70	7.43	10.42	17.94	18.69	**110**	0.34	0.47	0.91	1.57	2.59	4.79	6.86	11.57	12.19
31	0.16	0.28	0.47	0.94	1.53	2.44	4.32	6.82	7.98	**111**	0.12	0.28	0.41	0.90	1.58	2.58	4.06	6.52	7.46
32	0.09	0.14	0.21	0.35	0.71	1.29	2.05	3.26	4.09	**112**	0.08	0.12	0.20	0.35	0.62	1.16	1.75	3.09	3.68
33	0.13	0.27	0.44	0.79	1.49	2.71	3.99	6.38	7.79	**113**	0.10	0.23	0.36	0.72	1.53	2.54	3.87	6.40	7.17
34	0.08	0.11	0.16	0.30	0.53	1.06	1.78	2.95	3.75	**114**	0.05	0.10	0.14	0.33	0.55	1.05	1.79	2.90	3.35
35	0.13	0.22	0.39	0.81	1.42	2.68	4.31	6.88	8.09	**115**	0.08	0.19	0.37	0.80	1.41	2.48	3.90	6.07	7.28
36	0.30	0.50	1.07	1.87	3.19	5.77	8.25	13.44	14.89	**116**	0.19	0.30	0.56	1.07	2.13	3.73	5.62	9.14	10.45
37	0.11	0.17	0.27	0.67	0.98	1.92	2.91	4.78	5.99	**117**	0.06	0.12	0.20	0.46	0.88	1.45	2.54	3.98	5.06
38	0.24	0.41	0.81	1.65	2.84	4.84	7.27	12.14	12.83	**118**	0.10	0.23	0.48	1.00	1.69	3.06	5.22	7.96	9.33
39	0.08	0.14	0.23	0.53	1.04	1.80	3.17	4.64	5.69	**119**	0.06	0.10	0.20	0.35	0.66	1.35	2.31	3.67	4.66
40	0.24	0.43	0.80	1.62	2.62	4.94	6.92	11.47	12.92	**120**	0.12	0.26	0.53	0.96	1.76	3.23	4.88	8.17	9.69
41	0.41	0.58	0.91	1.60	2.51	4.34	6.35	10.35	10.97	**121**	0.31	0.48	0.75	1.25	1.77	3.47	5.26	8.41	9.20
42	0.28	0.50	0.60	1.05	1.59	2.67	4.01	6.32	7.44	**122**	0.22	0.35	0.46	0.73	1.15	1.89	2.69	4.41	5.26
43	0.26	0.47	0.65	1.29	1.94	3.90	5.36	8.42	10.03	**123**	0.22	0.39	0.57	1.09	1.74	2.84	4.45	7.22	8.35
44	0.19	0.33	0.49	0.77	1.26	2.16	2.98	4.99	6.16	**124**	0.17	0.25	0.32	0.55	0.85	1.40	2.24	3.79	4.46
45	0.30	0.53	0.80	1.56	2.42	4.26	5.68	9.41	10.92	**125**	0.28	0.45	0.70	1.24	2.06	3.69	4.79	7.96	9.49
46	0.52	0.94	1.42	2.44	3.93	6.72	8.73	14.83	16.12	**126**	0.33	0.60	0.92	1.55	2.35	4.36	6.40	10.78	11.31
47	0.31	0.53	0.69	1.18	1.69	2.87	4.38	7.07	8.30	**127**	0.22	0.37	0.43	0.75	1.25	2.15	3.23	5.11	6.21
48	0.36	0.55	0.99	1.98	3.10	5.20	7.69	12.67	13.01	**128**	0.23	0.37	0.73	1.23	2.06	3.42	5.37	8.93	9.66
49	0.22	0.31	0.48	0.82	1.41	2.45	3.75	6.08	7.27	**129**	0.15	0.24	0.35	0.57	0.96	1.70	2.75	4.52	5.05
50	0.51	0.88	1.63	2.61	4.00	7.12	10.42	16.01	17.13	**130**	0.28	0.51	0.78	1.53	2.88	4.60	6.68	11.03	12.12
51	0.14	0.28	0.42	0.81	1.72	2.87	4.06	6.53	7.93	**131**	0.13	0.22	0.39	0.76	1.48	2.54	3.78	6.01	7.24
52	0.09	0.13	0.19	0.28	0.50	0.84	1.39	2.34	2.81	**132**	0.06	0.10	0.17	0.29	0.48	0.89	1.42	2.20	2.83
53	0.12	0.23	0.43	0.85	1.25	2.76	3.84	6.86	7.50	**133**	0.11	0.16	0.33	0.71	1.34	2.39	3.52	5.71	7.03
54	0.07	0.09	0.13	0.24	0.36	0.82	1.43	2.31	2.65	**134**	0.04	0.08	0.15	0.20	0.41	0.80	1.22	2.15	2.74
55	0.15	0.21	0.36	0.77	1.37	2.59	3.66	6.65	8.21	**135**	0.10	0.20	0.34	0.74	1.25	2.35	3.63	6.03	7.21
56	0.34	0.60	1.13	1.97	3.44	5.97	8.51	13.39	14.56	**136**	0.14	0.31	0.51	1.22	1.89	3.81	5.57	9.17	10.24
57	0.08	0.14	0.28	0.52	0.90	1.74	2.77	4.45	5.35	**137**	0.07	0.11	0.18	0.39	0.80	1.25	2.09	3.45	4.46
58	0.24	0.42	0.77	1.57	2.68	4.48	6.91	11.02	12.33	**138**	0.14	0.24	0.50	1.05	1.66	3.06	4.74	7.79	9.02

ID	700-year open terrain 3-second gust wind speed, mph									ID	700-year open terrain 3-second gust wind speed, mph								
	110	115	120	130	140	150	160	170	180		110	115	120	130	140	150	160	170	180
59	0.08	0.14	0.24	0.49	0.94	1.60	2.47	4.82	5.29	**139**	0.04	0.09	0.17	0.33	0.73	1.18	2.04	3.26	4.00
60	0.27	0.41	0.70	1.59	2.75	4.69	6.76	10.98	12.33	**140**	0.13	0.26	0.52	0.95	1.78	3.06	4.51	8.20	8.92
61	0.31	0.52	0.65	1.20	1.74	3.17	4.57	7.44	8.41	**141**	0.28	0.46	0.64	1.06	1.84	3.15	4.74	7.05	8.02
62	0.23	0.38	0.40	0.60	0.84	1.30	2.00	3.38	3.71	**142**	0.20	0.32	0.38	0.58	0.86	1.48	1.99	3.14	3.69
63	0.26	0.39	0.59	1.07	1.67	2.99	4.60	7.12	7.95	**143**	0.23	0.36	0.59	0.99	1.65	2.70	4.27	7.04	7.53
64	0.17	0.28	0.30	0.48	0.66	1.25	1.71	3.11	3.51	**144**	0.14	0.23	0.32	0.50	0.75	1.40	1.92	2.91	3.46
65	0.30	0.50	0.68	1.16	1.93	3.39	5.11	7.93	8.92	**145**	0.26	0.41	0.65	1.17	1.83	3.13	4.43	7.74	8.63
66	0.46	0.87	1.34	2.42	3.75	6.05	9.09	14.14	15.32	**146**	0.34	0.51	0.88	1.38	2.41	4.47	6.10	10.01	11.37
67	0.25	0.42	0.47	0.81	1.15	2.20	2.97	5.31	6.35	**147**	0.21	0.34	0.45	0.79	1.09	1.98	2.78	4.27	5.27
68	0.34	0.60	1.11	1.77	2.86	4.92	7.38	11.43	13.50	**148**	0.21	0.35	0.64	1.18	1.99	3.23	5.49	9.11	10.00
69	0.18	0.32	0.37	0.72	1.13	2.04	3.01	4.93	5.98	**149**	0.16	0.24	0.34	0.61	0.99	1.51	2.80	4.07	4.91
70	0.51	0.89	1.45	2.66	4.05	6.77	9.99	15.97	16.93	**150**	0.27	0.49	0.83	1.51	2.50	4.38	6.46	10.42	12.51
71	0.16	0.26	0.42	0.83	1.52	2.65	4.21	6.42	7.47	**151**	0.13	0.25	0.38	0.77	1.40	2.58	3.90	6.26	7.09
72	0.07	0.14	0.17	0.27	0.44	0.81	1.46	2.19	2.92	**152**	0.06	0.09	0.15	0.27	0.48	0.94	1.51	2.15	2.70
73	0.11	0.20	0.41	0.81	1.40	2.63	3.82	6.47	7.41	**153**	0.11	0.21	0.39	0.67	1.32	2.46	3.83	5.89	7.18
74	0.06	0.11	0.14	0.28	0.50	0.77	1.31	2.15	2.82	**154**	0.04	0.09	0.12	0.18	0.44	0.73	1.29	2.13	2.75
75	0.11	0.20	0.44	0.79	1.36	2.40	3.84	6.36	7.99	**155**	0.12	0.18	0.33	0.68	1.30	2.54	4.06	6.19	7.29
76	0.33	0.52	1.06	1.97	3.12	5.57	8.52	13.38	14.61	**156**	0.15	0.31	0.68	1.16	2.18	3.48	5.79	8.94	10.92
77	0.10	0.16	0.26	0.49	0.94	1.81	2.56	4.02	5.60	**157**	0.09	0.12	0.19	0.38	0.78	1.22	2.03	3.66	4.47
78	0.24	0.41	0.76	1.68	2.43	4.70	6.83	11.24	13.13	**158**	0.13	0.29	0.49	0.91	1.69	3.06	4.62	7.84	9.38
79	0.08	0.16	0.23	0.47	0.85	1.58	2.53	4.15	5.03	**159**	0.04	0.09	0.12	0.30	0.60	1.07	1.90	3.30	4.03
80	0.22	0.42	0.81	1.53	2.35	4.69	6.99	11.32	13.15	**160**	0.14	0.24	0.46	0.87	1.81	3.25	4.96	7.62	9.67

APPENDIX D: STANDARD DEVIATION OF EXPECTED ANNUAL LOSS FOR BUILDING, CONTENT, LOSS OF USE, AND TOTAL EXPECTED ANNUAL LOSS IN REFERENCE NON-OPEN TERRAIN

Table D.1 Standard Deviation of Expected Annual Building Loss for Reference Non-Open Terrain (EAL_{BR}), as a Ratio of Building Value, z_0=0.15 m

ID	700-year open terrain 3-second gust wind speed, mph									ID	700-year open terrain 3-second gust wind speed, mph								
	110	115	120	130	140	150	160	170	180		110	115	120	130	140	150	160	170	180
1	0.006	0.010	0.015	0.025	0.034	0.048	0.060	0.077	0.091	**81**	0.006	0.009	0.012	0.019	0.031	0.044	0.052	0.071	0.078
2	0.005	0.008	0.011	0.018	0.025	0.035	0.050	0.061	0.071	**82**	0.004	0.004	0.008	0.013	0.020	0.030	0.042	0.052	0.061
3	0.006	0.009	0.013	0.021	0.033	0.046	0.057	0.073	0.078	**83**	0.007	0.009	0.013	0.019	0.029	0.039	0.051	0.065	0.077
4	0.004	0.005	0.011	0.014	0.024	0.031	0.045	0.056	0.062	**84**	0.003	0.005	0.006	0.012	0.019	0.026	0.038	0.050	0.056
5	0.006	0.009	0.014	0.023	0.033	0.046	0.061	0.078	0.087	**85**	0.005	0.007	0.012	0.020	0.030	0.041	0.054	0.071	0.079
6	0.011	0.012	0.021	0.033	0.048	0.064	0.085	0.102	0.114	**86**	0.006	0.011	0.015	0.027	0.041	0.050	0.069	0.086	0.095
7	0.007	0.007	0.010	0.018	0.026	0.038	0.052	0.065	0.074	**87**	0.005	0.006	0.008	0.016	0.021	0.033	0.042	0.054	0.064
8	0.007	0.012	0.020	0.029	0.042	0.060	0.074	0.093	0.102	**88**	0.006	0.009	0.014	0.025	0.031	0.045	0.062	0.074	0.088
9	0.004	0.008	0.010	0.017	0.029	0.038	0.047	0.061	0.073	**89**	0.003	0.005	0.009	0.011	0.022	0.032	0.041	0.054	0.064
10	0.011	0.014	0.024	0.034	0.050	0.067	0.084	0.106	0.119	**90**	0.008	0.011	0.017	0.026	0.036	0.048	0.070	0.084	0.094
11	0.006	0.006	0.011	0.018	0.026	0.033	0.048	0.059	0.070	**91**	0.005	0.006	0.008	0.014	0.022	0.033	0.044	0.057	0.069
12	0.002	0.003	0.005	0.007	0.012	0.019	0.026	0.039	0.043	**92**	0.001	0.002	0.003	0.007	0.012	0.016	0.026	0.029	0.039
13	0.004	0.006	0.009	0.015	0.022	0.035	0.045	0.057	0.069	**93**	0.006	0.005	0.010	0.014	0.023	0.032	0.045	0.057	0.068
14	0.003	0.004	0.004	0.008	0.012	0.019	0.028	0.035	0.044	**94**	0.001	0.002	0.004	0.007	0.011	0.018	0.027	0.032	0.041
15	0.004	0.005	0.009	0.016	0.025	0.034	0.047	0.065	0.068	**95**	0.005	0.006	0.011	0.015	0.024	0.032	0.042	0.060	0.064
16	0.010	0.013	0.018	0.031	0.045	0.061	0.075	0.096	0.106	**96**	0.005	0.009	0.016	0.026	0.035	0.047	0.064	0.078	0.089
17	0.004	0.004	0.007	0.014	0.021	0.029	0.040	0.050	0.059	**97**	0.003	0.004	0.004	0.010	0.017	0.023	0.033	0.043	0.051
18	0.008	0.012	0.017	0.024	0.040	0.053	0.069	0.087	0.098	**98**	0.004	0.009	0.011	0.021	0.031	0.043	0.056	0.072	0.080
19	0.002	0.003	0.007	0.012	0.022	0.031	0.042	0.050	0.062	**99**	0.003	0.002	0.005	0.010	0.016	0.025	0.033	0.041	0.052
20	0.008	0.012	0.020	0.027	0.042	0.056	0.067	0.089	0.099	**100**	0.004	0.007	0.014	0.019	0.030	0.040	0.055	0.070	0.081
21	0.007	0.007	0.013	0.019	0.030	0.043	0.051	0.069	0.078	**101**	0.004	0.007	0.014	0.015	0.026	0.036	0.050	0.065	0.074
22	0.004	0.006	0.008	0.015	0.020	0.028	0.040	0.049	0.055	**102**	0.004	0.006	0.008	0.012	0.021	0.025	0.034	0.046	0.053
23	0.006	0.008	0.012	0.019	0.030	0.041	0.056	0.071	0.078	**103**	0.004	0.007	0.011	0.017	0.025	0.039	0.049	0.065	0.071
24	0.006	0.005	0.007	0.012	0.019	0.027	0.038	0.048	0.052	**104**	0.003	0.004	0.008	0.012	0.018	0.026	0.037	0.043	0.052
25	0.007	0.007	0.011	0.018	0.029	0.041	0.055	0.069	0.077	**105**	0.007	0.009	0.010	0.019	0.027	0.036	0.051	0.067	0.075
26	0.012	0.014	0.021	0.034	0.048	0.063	0.081	0.101	0.111	**106**	0.006	0.010	0.015	0.027	0.038	0.049	0.069	0.086	0.095
27	0.004	0.005	0.010	0.016	0.026	0.036	0.048	0.063	0.069	**107**	0.004	0.006	0.010	0.016	0.024	0.031	0.040	0.052	0.062
28	0.009	0.012	0.017	0.025	0.040	0.056	0.076	0.093	0.102	**108**	0.007	0.008	0.013	0.019	0.034	0.043	0.059	0.075	0.085
29	0.003	0.007	0.011	0.016	0.025	0.037	0.047	0.061	0.068	**109**	0.005	0.004	0.011	0.015	0.021	0.033	0.040	0.051	0.061
30	0.010	0.017	0.023	0.038	0.053	0.067	0.086	0.108	0.117	**110**	0.007	0.010	0.016	0.025	0.035	0.049	0.063	0.083	0.097
31	0.002	0.007	0.010	0.015	0.021	0.036	0.046	0.061	0.070	**111**	0.005	0.006	0.011	0.016	0.025	0.031	0.045	0.055	0.065
32	0.002	0.002	0.005	0.008	0.016	0.020	0.027	0.037	0.044	**112**	0.002	0.002	0.003	0.007	0.010	0.016	0.025	0.033	0.041
33	0.003	0.006	0.009	0.017	0.024	0.034	0.046	0.061	0.068	**113**	0.004	0.005	0.009	0.013	0.023	0.031	0.043	0.055	0.066
34	0.001	0.002	0.004	0.008	0.014	0.019	0.029	0.037	0.044	**114**	0.001	0.001	0.003	0.005	0.011	0.018	0.024	0.034	0.040
35	0.004	0.006	0.009	0.016	0.022	0.034	0.049	0.060	0.070	**115**	0.004	0.005	0.008	0.016	0.022	0.030	0.042	0.057	0.064
36	0.007	0.013	0.020	0.029	0.044	0.061	0.074	0.092	0.109	**116**	0.005	0.008	0.015	0.024	0.030	0.044	0.062	0.079	0.089
37	0.002	0.004	0.005	0.013	0.022	0.028	0.041	0.051	0.060	**117**	0.002	0.004	0.005	0.009	0.017	0.023	0.035	0.045	0.052
38	0.007	0.010	0.017	0.030	0.040	0.053	0.068	0.087	0.097	**118**	0.004	0.009	0.013	0.021	0.032	0.043	0.058	0.069	0.084
39	0.002	0.003	0.006	0.011	0.019	0.031	0.039	0.051	0.062	**119**	0.001	0.003	0.006	0.008	0.013	0.024	0.034	0.040	0.053
40	0.007	0.014	0.019	0.028	0.042	0.056	0.071	0.088	0.098	**120**	0.006	0.007	0.010	0.023	0.029	0.041	0.054	0.068	0.081
41	0.005	0.008	0.013	0.022	0.032	0.041	0.059	0.075	0.087	**121**	0.006	0.008	0.011	0.017	0.027	0.036	0.051	0.064	0.075
42	0.003	0.005	0.009	0.015	0.022	0.033	0.042	0.054	0.064	**122**	0.003	0.005	0.006	0.009	0.017	0.022	0.030	0.042	0.048
43	0.004	0.008	0.011	0.019	0.029	0.039	0.057	0.072	0.082	**123**	0.003	0.005	0.013	0.017	0.025	0.036	0.046	0.059	0.071
44	0.002	0.004	0.008	0.012	0.018	0.026	0.036	0.047	0.057	**124**	0.002	0.003	0.006	0.010	0.015	0.021	0.030	0.036	0.043
45	0.006	0.009	0.015	0.022	0.029	0.043	0.057	0.074	0.084	**125**	0.004	0.008	0.011	0.019	0.024	0.036	0.052	0.065	0.073
46	0.012	0.014	0.020	0.035	0.045	0.059	0.080	0.100	0.112	**126**	0.006	0.008	0.016	0.024	0.036	0.048	0.063	0.082	0.090
47	0.004	0.006	0.009	0.016	0.027	0.034	0.043	0.059	0.068	**127**	0.003	0.004	0.007	0.011	0.020	0.026	0.034	0.046	0.054
48	0.008	0.011	0.020	0.029	0.039	0.054	0.067	0.087	0.103	**128**	0.006	0.007	0.013	0.021	0.029	0.044	0.060	0.070	0.080
49	0.002	0.004	0.008	0.014	0.022	0.032	0.042	0.058	0.064	**129**	0.003	0.003	0.006	0.012	0.017	0.022	0.033	0.044	0.054
50	0.011	0.013	0.024	0.038	0.048	0.065	0.083	0.107	0.111	**130**	0.006	0.010	0.015	0.025	0.036	0.049	0.065	0.082	0.092
51	0.004	0.006	0.012	0.015	0.023	0.035	0.045	0.060	0.072	**131**	0.003	0.005	0.009	0.016	0.024	0.032	0.045	0.055	0.063
52	0.002	0.002	0.003	0.006	0.010	0.014	0.024	0.026	0.034	**132**	0.001	0.002	0.003	0.007	0.008	0.013	0.018	0.026	0.033
53	0.003	0.005	0.008	0.017	0.024	0.035	0.046	0.059	0.067	**133**	0.004	0.005	0.007	0.013	0.023	0.032	0.041	0.053	0.064

ID	700-year open terrain 3-second gust wind speed, mph									ID	700-year open terrain 3-second gust wind speed, mph								
	110	115	120	130	140	150	160	170	180		110	115	120	130	140	150	160	170	180
54	0.002	0.001	0.002	0.006	0.011	0.015	0.021	0.029	0.035	**134**	0.001	0.001	0.003	0.006	0.011	0.015	0.020	0.027	0.033
55	0.002	0.004	0.011	0.015	0.024	0.033	0.045	0.058	0.064	**135**	0.005	0.006	0.008	0.014	0.023	0.030	0.044	0.054	0.064
56	0.010	0.014	0.020	0.030	0.044	0.058	0.076	0.098	0.105	**136**	0.006	0.008	0.012	0.024	0.033	0.047	0.064	0.078	0.085
57	0.006	0.003	0.005	0.012	0.016	0.025	0.038	0.048	0.058	**137**	0.002	0.003	0.004	0.008	0.013	0.020	0.030	0.036	0.046
58	0.007	0.008	0.017	0.025	0.040	0.052	0.069	0.086	0.098	**138**	0.005	0.007	0.013	0.019	0.030	0.042	0.057	0.070	0.079
59	0.004	0.004	0.007	0.013	0.018	0.027	0.038	0.048	0.057	**139**	0.001	0.003	0.004	0.009	0.017	0.023	0.031	0.039	0.048
60	0.008	0.012	0.016	0.028	0.040	0.052	0.068	0.087	0.096	**140**	0.005	0.006	0.013	0.020	0.030	0.042	0.053	0.071	0.078
61	0.005	0.006	0.009	0.016	0.026	0.033	0.047	0.059	0.068	**141**	0.004	0.005	0.008	0.014	0.023	0.033	0.044	0.054	0.065
62	0.003	0.003	0.005	0.007	0.011	0.014	0.026	0.030	0.037	**142**	0.002	0.003	0.004	0.007	0.009	0.014	0.020	0.027	0.033
63	0.004	0.004	0.009	0.017	0.023	0.031	0.048	0.058	0.068	**143**	0.004	0.006	0.008	0.013	0.023	0.033	0.044	0.054	0.068
64	0.002	0.003	0.005	0.006	0.013	0.016	0.024	0.031	0.039	**144**	0.002	0.002	0.003	0.006	0.010	0.015	0.021	0.029	0.035
65	0.004	0.007	0.011	0.016	0.027	0.034	0.049	0.063	0.074	**145**	0.005	0.006	0.010	0.016	0.024	0.034	0.046	0.056	0.066
66	0.009	0.014	0.021	0.030	0.046	0.062	0.079	0.099	0.105	**146**	0.006	0.008	0.016	0.025	0.036	0.052	0.061	0.079	0.093
67	0.003	0.005	0.007	0.011	0.019	0.025	0.039	0.046	0.058	**147**	0.003	0.004	0.006	0.011	0.017	0.022	0.030	0.041	0.048
68	0.008	0.011	0.018	0.025	0.039	0.052	0.067	0.088	0.101	**148**	0.006	0.008	0.010	0.022	0.031	0.044	0.056	0.074	0.084
69	0.004	0.004	0.009	0.012	0.019	0.028	0.037	0.050	0.055	**149**	0.003	0.002	0.005	0.010	0.017	0.023	0.032	0.042	0.050
70	0.012	0.016	0.022	0.036	0.049	0.066	0.083	0.104	0.115	**150**	0.007	0.006	0.017	0.024	0.036	0.049	0.063	0.081	0.093
71	0.006	0.004	0.011	0.016	0.022	0.033	0.048	0.056	0.066	**151**	0.005	0.005	0.007	0.013	0.024	0.029	0.042	0.054	0.065
72	0.001	0.002	0.004	0.005	0.008	0.014	0.022	0.027	0.035	**152**	0.001	0.002	0.003	0.005	0.008	0.012	0.020	0.025	0.030
73	0.004	0.006	0.009	0.015	0.023	0.034	0.047	0.060	0.069	**153**	0.004	0.004	0.008	0.015	0.021	0.031	0.043	0.051	0.063
74	0.002	0.001	0.004	0.006	0.011	0.015	0.022	0.028	0.035	**154**	0.002	0.001	0.002	0.007	0.010	0.014	0.020	0.026	0.032
75	0.003	0.005	0.009	0.015	0.024	0.034	0.046	0.056	0.066	**155**	0.003	0.004	0.009	0.014	0.022	0.030	0.041	0.052	0.063
76	0.012	0.013	0.019	0.031	0.044	0.059	0.076	0.096	0.105	**156**	0.006	0.007	0.014	0.020	0.033	0.049	0.059	0.077	0.090
77	0.003	0.004	0.005	0.012	0.021	0.025	0.036	0.046	0.053	**157**	0.003	0.003	0.006	0.009	0.013	0.020	0.029	0.036	0.044
78	0.006	0.013	0.017	0.025	0.039	0.054	0.069	0.085	0.099	**158**	0.005	0.007	0.011	0.021	0.031	0.041	0.057	0.075	0.081
79	0.002	0.002	0.005	0.013	0.018	0.027	0.036	0.046	0.054	**159**	0.003	0.002	0.004	0.011	0.013	0.022	0.029	0.037	0.048
80	0.008	0.011	0.018	0.028	0.038	0.054	0.068	0.088	0.094	**160**	0.005	0.007	0.014	0.019	0.031	0.039	0.058	0.068	0.079

Table D.2 Standard Deviation of Expected Annual Content Loss for Reference Non-Open Terrain (EAL_{CR}), as a Ratio of Content Value, z_0=0.15 m

ID	700-year open terrain 3-second gust wind speed, mph									ID	700-year open terrain 3-second gust wind speed, mph								
	110	115	120	130	140	150	160	170	180		110	115	120	130	140	150	160	170	180
1	0.004	0.006	0.011	0.015	0.027	0.038	0.052	0.065	0.074	**81**	0.005	0.008	0.009	0.014	0.024	0.031	0.044	0.056	0.067
2	0.001	0.001	0.004	0.010	0.014	0.022	0.029	0.038	0.047	**82**	0.001	0.002	0.003	0.007	0.014	0.016	0.027	0.034	0.040
3	0.002	0.007	0.010	0.016	0.025	0.036	0.046	0.062	0.071	**83**	0.004	0.004	0.010	0.013	0.022	0.033	0.045	0.055	0.064
4	0.002	0.002	0.004	0.006	0.012	0.019	0.027	0.036	0.043	**84**	0.001	0.002	0.002	0.006	0.011	0.014	0.023	0.028	0.034
5	0.003	0.008	0.012	0.017	0.025	0.038	0.051	0.063	0.076	**85**	0.003	0.006	0.010	0.015	0.024	0.036	0.045	0.057	0.067
6	0.008	0.011	0.022	0.030	0.044	0.057	0.077	0.095	0.107	**86**	0.006	0.005	0.013	0.022	0.034	0.047	0.060	0.079	0.090
7	0.002	0.002	0.008	0.012	0.018	0.031	0.037	0.052	0.062	**87**	0.001	0.003	0.006	0.010	0.015	0.019	0.031	0.041	0.048
8	0.008	0.011	0.017	0.028	0.039	0.054	0.068	0.090	0.092	**88**	0.007	0.007	0.013	0.021	0.029	0.042	0.054	0.070	0.082
9	0.002	0.005	0.008	0.010	0.020	0.024	0.041	0.048	0.063	**89**	0.001	0.001	0.004	0.010	0.013	0.021	0.028	0.038	0.047
10	0.010	0.015	0.024	0.033	0.048	0.064	0.085	0.103	0.113	**90**	0.007	0.012	0.014	0.022	0.037	0.047	0.065	0.082	0.092
11	0.002	0.004	0.008	0.016	0.023	0.032	0.046	0.058	0.069	**91**	0.002	0.004	0.008	0.014	0.021	0.030	0.040	0.052	0.062
12	0.000	0.000	0.002	0.004	0.009	0.013	0.019	0.022	0.032	**92**	0.000	0.001	0.002	0.005	0.008	0.009	0.016	0.022	0.029
13	0.006	0.006	0.009	0.014	0.025	0.034	0.044	0.059	0.068	**93**	0.004	0.005	0.010	0.014	0.023	0.031	0.040	0.054	0.062
14	0.003	0.001	0.002	0.005	0.008	0.013	0.021	0.027	0.035	**94**	0.000	0.001	0.003	0.005	0.009	0.012	0.017	0.021	0.032
15	0.003	0.006	0.010	0.017	0.024	0.030	0.044	0.059	0.066	**95**	0.003	0.005	0.009	0.015	0.022	0.031	0.041	0.052	0.061
16	0.009	0.014	0.018	0.031	0.044	0.057	0.075	0.091	0.105	**96**	0.006	0.006	0.013	0.023	0.034	0.045	0.058	0.073	0.086
17	0.001	0.003	0.005	0.013	0.017	0.021	0.035	0.047	0.057	**97**	0.001	0.004	0.004	0.008	0.013	0.019	0.028	0.038	0.044
18	0.006	0.009	0.017	0.026	0.037	0.052	0.068	0.088	0.099	**98**	0.005	0.006	0.013	0.020	0.027	0.042	0.058	0.070	0.081
19	0.003	0.004	0.005	0.011	0.019	0.025	0.035	0.045	0.056	**99**	0.002	0.001	0.005	0.008	0.014	0.018	0.031	0.039	0.046
20	0.008	0.011	0.016	0.029	0.036	0.052	0.070	0.089	0.095	**100**	0.004	0.008	0.010	0.019	0.028	0.041	0.053	0.069	0.083
21	0.006	0.005	0.010	0.015	0.025	0.034	0.046	0.061	0.067	**101**	0.005	0.005	0.009	0.014	0.020	0.029	0.042	0.052	0.061
22	0.001	0.001	0.003	0.005	0.011	0.017	0.022	0.029	0.036	**102**	0.001	0.001	0.005	0.004	0.010	0.012	0.020	0.025	0.029
23	0.003	0.005	0.009	0.015	0.022	0.033	0.046	0.058	0.065	**103**	0.004	0.005	0.008	0.016	0.019	0.033	0.039	0.052	0.064
24	0.001	0.001	0.003	0.005	0.009	0.015	0.025	0.027	0.036	**104**	0.003	0.001	0.002	0.004	0.007	0.015	0.023	0.026	0.032
25	0.004	0.005	0.009	0.017	0.024	0.035	0.048	0.059	0.067	**105**	0.004	0.005	0.010	0.015	0.024	0.031	0.039	0.054	0.061
26	0.009	0.013	0.017	0.031	0.043	0.059	0.078	0.095	0.107	**106**	0.008	0.006	0.015	0.021	0.032	0.047	0.059	0.077	0.088
27	0.004	0.005	0.006	0.012	0.021	0.027	0.037	0.049	0.055	**107**	0.001	0.004	0.005	0.011	0.015	0.020	0.031	0.035	0.048
28	0.006	0.009	0.016	0.029	0.041	0.054	0.068	0.090	0.104	**108**	0.005	0.007	0.011	0.018	0.030	0.044	0.055	0.069	0.082
29	0.003	0.002	0.006	0.011	0.020	0.029	0.036	0.050	0.056	**109**	0.002	0.003	0.006	0.008	0.017	0.020	0.031	0.040	0.047
30	0.010	0.012	0.024	0.035	0.045	0.062	0.081	0.102	0.113	**110**	0.004	0.010	0.014	0.025	0.035	0.046	0.066	0.081	0.093
31	0.003	0.005	0.008	0.016	0.022	0.032	0.047	0.057	0.067	**111**	0.003	0.006	0.009	0.012	0.019	0.031	0.041	0.052	0.060
32	0.001	0.001	0.003	0.004	0.008	0.012	0.020	0.026	0.034	**112**	0.000	0.001	0.005	0.004	0.007	0.012	0.019	0.023	0.027
33	0.003	0.006	0.011	0.013	0.024	0.033	0.043	0.061	0.065	**113**	0.003	0.004	0.008	0.015	0.020	0.031	0.039	0.051	0.062
34	0.000	0.001	0.002	0.005	0.008	0.012	0.020	0.024	0.034	**114**	0.001	0.001	0.001	0.003	0.008	0.011	0.019	0.021	0.032
35	0.004	0.006	0.009	0.016	0.022	0.034	0.045	0.056	0.068	**115**	0.003	0.004	0.008	0.012	0.022	0.028	0.041	0.052	0.063
36	0.009	0.013	0.017	0.030	0.043	0.058	0.073	0.093	0.108	**116**	0.004	0.008	0.012	0.024	0.032	0.043	0.063	0.075	0.088
37	0.004	0.002	0.006	0.010	0.017	0.024	0.034	0.045	0.052	**117**	0.001	0.001	0.005	0.007	0.014	0.022	0.027	0.038	0.045
38	0.005	0.010	0.017	0.028	0.038	0.053	0.066	0.088	0.099	**118**	0.006	0.007	0.011	0.021	0.031	0.041	0.054	0.069	0.081
39	0.001	0.003	0.006	0.011	0.017	0.025	0.034	0.047	0.054	**119**	0.000	0.001	0.006	0.008	0.013	0.020	0.028	0.038	0.048
40	0.006	0.012	0.014	0.028	0.039	0.053	0.069	0.087	0.097	**120**	0.006	0.007	0.013	0.017	0.029	0.041	0.057	0.072	0.081
41	0.006	0.007	0.010	0.016	0.025	0.038	0.050	0.061	0.071	**121**	0.004	0.003	0.006	0.011	0.022	0.032	0.045	0.054	0.064
42	0.002	0.002	0.002	0.007	0.014	0.019	0.027	0.038	0.047	**122**	0.000	0.002	0.004	0.007	0.009	0.013	0.024	0.027	0.038
43	0.002	0.006	0.007	0.018	0.025	0.036	0.046	0.060	0.073	**123**	0.005	0.004	0.009	0.013	0.020	0.031	0.043	0.053	0.063
44	0.001	0.001	0.004	0.008	0.012	0.017	0.025	0.031	0.042	**124**	0.001	0.000	0.002	0.008	0.013	0.016	0.023	0.028	0.035
45	0.005	0.007	0.009	0.018	0.027	0.037	0.052	0.063	0.074	**125**	0.005	0.004	0.009	0.013	0.024	0.033	0.041	0.056	0.067
46	0.009	0.012	0.022	0.033	0.044	0.056	0.073	0.096	0.105	**126**	0.004	0.007	0.014	0.020	0.032	0.045	0.062	0.078	0.085
47	0.002	0.004	0.006	0.012	0.019	0.026	0.037	0.049	0.058	**127**	0.001	0.003	0.006	0.009	0.013	0.018	0.029	0.038	0.047
48	0.007	0.012	0.016	0.023	0.041	0.052	0.066	0.087	0.098	**128**	0.004	0.006	0.009	0.019	0.029	0.043	0.054	0.069	0.078
49	0.002	0.003	0.008	0.012	0.018	0.025	0.037	0.047	0.060	**129**	0.001	0.002	0.002	0.009	0.016	0.023	0.027	0.038	0.044
50	0.011	0.015	0.021	0.033	0.048	0.064	0.082	0.105	0.109	**130**	0.007	0.009	0.015	0.024	0.034	0.050	0.064	0.081	0.088
51	0.005	0.004	0.009	0.016	0.025	0.033	0.043	0.060	0.068	**131**	0.003	0.003	0.008	0.010	0.022	0.030	0.043	0.051	0.063
52	0.000	0.000	0.002	0.004	0.008	0.013	0.019	0.025	0.032	**132**	0.001	0.000	0.001	0.006	0.007	0.010	0.015	0.020	0.026
53	0.006	0.005	0.008	0.017	0.022	0.031	0.046	0.057	0.069	**133**	0.002	0.004	0.009	0.013	0.021	0.029	0.040	0.051	0.061
54	0.000	0.000	0.002	0.004	0.008	0.010	0.017	0.024	0.032	**134**	0.000	0.001	0.002	0.003	0.007	0.012	0.016	0.019	0.027
55	0.004	0.006	0.008	0.015	0.024	0.033	0.045	0.054	0.065	**135**	0.003	0.005	0.008	0.012	0.020	0.031	0.042	0.052	0.062
56	0.011	0.014	0.021	0.030	0.042	0.057	0.074	0.094	0.102	**136**	0.006	0.006	0.015	0.022	0.029	0.047	0.059	0.073	0.087
57	0.001	0.002	0.003	0.011	0.018	0.024	0.035	0.045	0.051	**137**	0.004	0.002	0.003	0.009	0.013	0.019	0.026	0.036	0.043
58	0.009	0.009	0.016	0.025	0.038	0.054	0.067	0.087	0.099	**138**	0.006	0.006	0.013	0.018	0.030	0.040	0.054	0.072	0.079

ID	700-year open terrain 3-second gust wind speed, mph									ID	700-year open terrain 3-second gust wind speed, mph								
	110	115	120	130	140	150	160	170	180		110	115	120	130	140	150	160	170	180
59	0.002	0.001	0.006	0.011	0.019	0.026	0.036	0.047	0.054	**139**	0.001	0.003	0.005	0.007	0.012	0.020	0.031	0.034	0.048
60	0.007	0.008	0.019	0.026	0.040	0.054	0.070	0.088	0.096	**140**	0.004	0.009	0.011	0.020	0.028	0.039	0.054	0.068	0.080
61	0.003	0.005	0.010	0.014	0.026	0.032	0.046	0.059	0.070	**141**	0.002	0.005	0.008	0.012	0.023	0.032	0.039	0.053	0.064
62	0.001	0.000	0.004	0.003	0.007	0.014	0.020	0.026	0.030	**142**	0.000	0.000	0.001	0.004	0.007	0.009	0.014	0.018	0.026
63	0.004	0.005	0.010	0.016	0.022	0.032	0.046	0.059	0.066	**143**	0.005	0.005	0.007	0.013	0.020	0.028	0.040	0.052	0.061
64	0.001	0.000	0.002	0.004	0.008	0.010	0.018	0.023	0.030	**144**	0.000	0.000	0.002	0.004	0.008	0.009	0.019	0.022	0.031
65	0.005	0.005	0.009	0.016	0.024	0.034	0.042	0.056	0.066	**145**	0.003	0.005	0.008	0.014	0.023	0.029	0.041	0.052	0.062
66	0.008	0.011	0.020	0.030	0.043	0.059	0.076	0.096	0.105	**146**	0.005	0.009	0.015	0.018	0.032	0.044	0.061	0.075	0.085
67	0.001	0.002	0.005	0.011	0.016	0.023	0.034	0.045	0.052	**147**	0.001	0.001	0.002	0.006	0.012	0.019	0.028	0.033	0.045
68	0.009	0.009	0.018	0.026	0.040	0.053	0.071	0.084	0.099	**148**	0.005	0.007	0.010	0.018	0.031	0.041	0.057	0.071	0.080
69	0.003	0.004	0.006	0.009	0.017	0.025	0.037	0.046	0.052	**149**	0.002	0.001	0.005	0.008	0.013	0.018	0.026	0.036	0.046
70	0.012	0.016	0.022	0.034	0.046	0.066	0.084	0.104	0.114	**150**	0.005	0.010	0.013	0.024	0.034	0.049	0.062	0.076	0.093
71	0.005	0.005	0.007	0.014	0.022	0.035	0.042	0.061	0.068	**151**	0.003	0.004	0.008	0.012	0.021	0.029	0.042	0.054	0.059
72	0.002	0.001	0.001	0.004	0.008	0.013	0.017	0.024	0.029	**152**	0.000	0.000	0.002	0.002	0.007	0.011	0.013	0.021	0.029
73	0.005	0.006	0.009	0.016	0.024	0.033	0.046	0.056	0.064	**153**	0.003	0.004	0.007	0.013	0.023	0.029	0.040	0.051	0.059
74	0.001	0.001	0.003	0.003	0.008	0.011	0.019	0.023	0.029	**154**	0.001	0.001	0.003	0.004	0.007	0.010	0.018	0.023	0.030
75	0.005	0.005	0.009	0.016	0.023	0.033	0.046	0.057	0.064	**155**	0.005	0.003	0.009	0.015	0.021	0.031	0.039	0.053	0.061
76	0.010	0.010	0.020	0.030	0.043	0.057	0.071	0.093	0.103	**156**	0.007	0.007	0.013	0.023	0.032	0.049	0.060	0.077	0.087
77	0.003	0.003	0.008	0.012	0.016	0.025	0.035	0.044	0.053	**157**	0.001	0.001	0.002	0.005	0.010	0.019	0.028	0.035	0.044
78	0.006	0.009	0.018	0.026	0.036	0.053	0.068	0.087	0.099	**158**	0.005	0.008	0.012	0.017	0.030	0.041	0.051	0.071	0.078
79	0.002	0.003	0.005	0.009	0.016	0.024	0.036	0.044	0.054	**159**	0.002	0.002	0.006	0.005	0.013	0.018	0.028	0.033	0.045
80	0.007	0.012	0.018	0.028	0.039	0.051	0.066	0.083	0.098	**160**	0.005	0.006	0.011	0.022	0.031	0.039	0.055	0.070	0.078

Table D.3 Standard Deviation of Expected Annual Loss of Use for Reference Non-Open Terrain (EAL_{UR}), Expressed in Days, z_0=0.15 m

ID	700-year open terrain 3-second gust wind speed, mph									ID	700-year open terrain 3-second gust wind speed, mph								
	110	115	120	130	140	150	160	170	180		110	115	120	130	140	150	160	170	180
1	4.248	8.790	11.272	19.065	26.180	36.826	47.720	57.626	67.813	**81**	5.645	5.738	9.996	15.604	23.732	30.150	40.481	53.262	59.943
2	3.588	5.854	9.557	14.551	19.261	29.428	36.319	46.121	53.904	**82**	2.336	4.925	8.020	12.175	16.668	22.415	31.007	40.487	45.933
3	3.745	5.631	11.405	17.320	24.226	33.501	44.866	53.605	62.526	**83**	3.791	6.107	10.392	14.949	20.040	28.660	39.834	49.802	56.535
4	3.239	3.187	8.388	13.958	18.629	25.639	34.685	41.384	49.198	**84**	2.837	3.762	7.248	10.048	15.483	23.852	31.066	37.271	43.120
5	4.909	8.071	10.942	16.831	26.327	35.737	43.384	56.853	61.946	**85**	4.556	5.461	11.016	14.666	22.832	31.241	39.509	53.239	56.813
6	9.832	12.352	18.380	26.876	35.343	48.398	62.065	74.953	81.998	**86**	4.801	7.318	13.375	18.974	28.387	37.054	50.874	64.108	70.733
7	3.253	6.012	8.927	15.173	21.421	29.919	39.783	48.366	54.982	**87**	3.741	4.132	7.334	12.944	17.925	23.884	32.801	40.975	48.204
8	6.967	10.687	15.269	21.396	32.663	44.305	53.122	69.710	77.725	**88**	4.758	7.817	11.119	16.299	25.051	34.824	45.189	57.595	62.044
9	3.623	5.355	8.144	13.170	20.178	26.144	36.476	48.745	55.528	**89**	3.387	4.379	7.372	11.570	18.317	25.168	33.841	36.747	46.222
10	9.490	11.438	18.318	29.376	39.611	48.887	63.062	80.105	84.847	**90**	5.786	9.018	13.143	21.112	26.894	39.942	49.436	62.832	68.203
11	3.433	5.037	8.506	14.214	18.994	27.727	35.873	46.053	53.557	**91**	3.320	4.221	7.273	13.715	19.902	23.818	32.714	43.020	48.075
12	1.454	2.512	4.628	5.900	11.156	13.449	23.079	26.920	34.017	**92**	1.232	1.759	4.186	4.868	9.877	12.168	20.799	25.081	29.232
13	4.177	4.651	8.445	11.809	17.337	28.745	35.372	45.657	49.978	**93**	2.411	4.271	6.370	13.358	16.674	23.891	33.694	41.144	48.223
14	1.111	2.245	3.455	4.498	8.732	15.944	19.472	26.858	31.104	**94**	0.924	1.497	2.915	4.229	11.177	13.590	20.923	25.021	29.738
15	2.799	3.745	9.026	11.216	19.180	25.039	36.966	45.226	53.046	**95**	3.047	4.207	7.921	11.980	16.094	24.734	34.215	40.684	49.526
16	7.722	10.118	14.215	23.750	33.411	45.346	57.944	69.426	79.022	**96**	5.942	6.052	11.076	17.210	26.593	34.213	44.133	60.154	63.441
17	2.138	4.140	6.194	10.020	16.464	21.325	30.403	37.616	45.959	**97**	2.000	1.928	4.235	7.605	13.006	17.497	25.025	32.140	39.487
18	5.798	7.922	13.549	20.185	30.432	39.948	50.747	66.067	70.589	**98**	4.851	5.216	8.480	14.518	22.392	31.118	41.291	54.066	60.754
19	2.037	3.988	5.585	9.344	14.936	22.362	29.610	36.781	44.781	**99**	2.366	1.988	3.332	7.740	11.399	17.131	28.246	31.912	40.484
20	5.506	7.744	12.146	18.624	27.517	41.113	49.835	62.636	71.918	**100**	5.233	5.290	9.570	16.382	22.640	31.503	42.913	51.612	61.687
21	4.579	5.717	8.620	14.696	20.830	30.057	38.794	50.898	57.373	**101**	4.781	5.791	8.883	13.885	19.698	30.113	39.568	46.653	54.548
22	2.256	3.784	7.300	10.650	16.032	22.314	28.983	36.471	44.058	**102**	2.657	3.743	6.593	9.301	16.026	20.428	27.399	34.811	40.858
23	4.703	6.939	8.569	15.355	21.262	29.704	39.234	52.159	58.431	**103**	3.992	5.003	9.461	15.850	19.746	26.633	38.379	48.786	53.174
24	3.606	4.287	6.231	9.943	16.259	22.969	28.092	36.048	43.462	**104**	2.166	3.308	6.041	10.421	14.482	20.499	25.869	34.998	41.706
25	3.887	5.934	9.838	15.950	22.613	31.191	40.503	49.451	59.506	**105**	4.702	7.224	8.883	14.486	21.729	28.052	35.142	50.546	54.722
26	8.829	12.476	18.502	25.343	33.002	47.420	61.172	77.267	81.781	**106**	5.191	8.829	11.556	18.330	28.852	36.987	50.300	63.305	66.932
27	4.852	5.028	6.839	12.897	19.347	28.048	39.064	47.372	53.377	**107**	3.221	4.457	6.794	11.513	17.751	24.289	31.342	40.790	47.478
28	6.192	8.525	14.008	21.202	30.916	41.126	55.773	68.139	76.226	**108**	5.289	6.505	9.995	17.578	25.071	33.198	45.079	57.821	64.639
29	3.899	3.794	8.041	12.372	18.376	27.246	35.427	46.027	52.468	**109**	2.615	4.023	6.354	10.378	15.769	23.186	29.482	41.671	47.299
30	7.869	12.200	18.950	26.836	37.043	50.381	63.240	78.865	85.067	**110**	6.604	7.410	13.268	19.348	29.101	36.911	50.381	62.479	70.402
31	2.621	5.981	7.957	12.019	18.943	26.811	35.813	49.181	54.410	**111**	2.532	4.397	6.104	11.978	15.426	22.985	33.462	42.789	49.160
32	0.876	1.764	4.496	7.132	9.334	12.973	20.562	25.674	33.483	**112**	1.911	1.832	2.705	5.162	9.214	14.707	19.968	26.977	28.968
33	3.239	5.368	9.043	11.991	18.946	27.165	35.993	46.757	51.572	**113**	3.095	4.377	7.725	12.943	18.343	25.125	32.147	39.741	49.605
34	1.201	2.003	2.455	5.400	10.120	14.337	21.545	27.205	33.525	**114**	1.243	1.759	3.713	5.122	7.892	12.046	19.258	25.238	31.868
35	3.216	4.156	8.042	13.376	19.051	27.435	34.155	43.938	52.372	**115**	3.238	5.104	8.077	11.900	15.119	26.086	35.070	40.293	48.686
36	8.290	9.933	15.511	23.684	32.458	45.293	55.667	70.975	76.675	**116**	4.264	5.826	11.487	17.453	23.808	33.255	46.204	59.182	66.213
37	2.311	3.151	5.071	10.026	16.469	21.505	30.995	38.830	44.125	**117**	2.215	3.602	4.047	7.819	13.654	19.114	27.537	32.619	37.432
38	6.001	6.103	13.251	21.650	27.135	40.757	52.753	64.310	71.515	**118**	3.475	5.823	7.057	15.778	25.046	32.543	40.759	52.068	60.660
39	1.640	4.436	5.450	9.441	16.071	20.782	29.997	38.194	43.612	**119**	1.704	1.647	4.899	7.867	14.206	15.500	25.723	34.406	39.141
40	6.026	8.914	13.216	20.825	29.459	39.899	51.927	65.291	71.685	**120**	4.698	5.804	11.066	15.676	21.910	31.309	40.784	51.939	57.013
41	6.102	6.735	11.059	15.496	25.727	35.071	44.985	55.776	60.460	**121**	3.109	5.480	7.181	14.792	21.030	29.011	38.413	48.092	54.399
42	3.539	4.558	5.930	8.712	17.217	23.230	30.882	41.681	46.352	**122**	1.828	2.304	5.224	8.313	13.049	18.939	24.577	31.842	37.916
43	4.948	5.587	10.517	16.712	20.945	29.909	40.493	52.513	58.749	**123**	2.762	3.203	7.079	13.780	21.331	28.686	36.317	45.786	54.305
44	2.088	3.847	5.980	9.270	13.801	21.049	29.052	35.343	42.319	**124**	1.912	1.638	4.005	5.571	10.885	15.999	23.318	28.927	34.056
45	6.132	6.450	10.002	15.080	25.199	31.506	41.794	54.440	62.082	**125**	3.420	5.595	8.202	13.176	20.967	27.309	38.400	46.789	56.139
46	7.291	12.607	17.820	26.567	32.903	47.238	57.682	73.934	80.319	**126**	6.088	5.970	13.005	19.003	26.435	34.570	47.306	60.228	66.892
47	3.175	4.930	6.720	13.322	19.062	25.534	35.846	44.672	51.569	**127**	1.629	3.490	6.488	9.844	13.102	19.015	28.463	33.919	42.385
48	8.290	9.125	14.145	20.796	28.520	39.335	52.759	67.136	74.032	**128**	4.938	5.494	9.055	15.306	21.718	32.008	41.337	52.098	60.745
49	5.181	4.103	5.917	10.973	16.059	25.927	33.092	42.544	49.208	**129**	1.700	2.855	4.545	8.922	14.690	17.969	26.905	33.239	39.438
50	9.044	10.766	16.907	27.023	37.216	50.859	62.453	77.049	84.664	**130**	6.016	8.065	10.492	18.241	27.305	39.928	48.234	59.427	69.171
51	3.839	4.037	6.336	10.162	18.534	25.958	34.796	42.751	50.817	**131**	2.516	3.921	8.163	10.872	16.392	24.399	33.489	41.312	46.099
52	0.879	1.359	2.549	5.870	8.301	11.980	15.298	21.675	26.407	**132**	1.175	1.476	2.374	2.979	6.317	12.136	14.679	18.152	26.711
53	2.033	5.543	7.154	11.913	17.178	23.598	34.893	42.759	51.342	**133**	2.164	4.408	7.295	10.708	16.517	24.747	31.720	42.311	47.227
54	1.428	1.681	2.599	3.549	9.670	10.812	17.580	22.297	26.327	**134**	1.366	0.902	2.107	3.614	8.913	10.841	14.448	20.680	25.311
55	4.231	4.211	8.131	11.936	17.555	26.555	33.629	44.236	50.974	**135**	2.964	4.165	6.836	11.584	15.061	24.251	30.810	38.987	47.522
56	6.240	9.861	16.334	24.781	31.546	45.285	56.024	67.915	79.306	**136**	4.762	6.846	9.025	17.919	25.328	33.424	45.077	57.767	63.101
57	2.932	2.355	3.469	9.565	14.316	19.554	27.149	36.456	40.854	**137**	2.320	2.955	3.641	8.035	11.588	16.639	22.041	28.841	35.239
58	7.517	8.747	14.371	21.146	26.772	37.961	50.486	65.703	70.484	**138**	3.343	5.157	9.154	15.477	22.543	30.691	41.084	51.998	58.029

ID	700-year open terrain 3-second gust wind speed, mph									ID	700-year open terrain 3-second gust wind speed, mph								
	110	115	120	130	140	150	160	170	180		110	115	120	130	140	150	160	170	180
59	1.934	2.093	6.762	8.919	13.447	20.701	28.277	36.225	42.411	**139**	1.486	1.555	4.345	7.098	10.935	18.581	23.021	29.527	37.300
60	5.725	9.834	11.993	18.945	28.656	40.534	51.662	64.962	73.078	**140**	3.437	3.854	7.703	13.573	20.689	31.515	42.571	49.332	58.581
61	4.213	4.485	8.560	12.882	19.000	25.467	35.264	45.464	51.553	**141**	4.571	4.153	8.343	12.468	19.242	26.013	32.622	42.668	48.536
62	1.283	1.651	3.168	6.783	9.774	13.749	18.231	22.509	29.880	**142**	1.278	1.839	2.560	5.344	8.265	11.216	15.013	20.637	25.328
63	4.474	3.768	7.695	13.369	19.587	26.748	34.377	44.669	51.134	**143**	4.219	5.577	6.360	12.241	16.764	25.368	33.802	42.387	49.128
64	1.293	1.252	3.125	5.748	9.588	12.099	17.619	25.277	28.603	**144**	1.366	2.171	2.459	4.652	9.051	14.105	17.667	20.923	25.740
65	3.293	5.705	8.866	12.536	19.398	26.147	35.965	46.627	52.109	**145**	2.768	4.727	7.408	11.556	18.592	25.975	33.697	44.326	52.344
66	8.548	11.936	15.407	22.797	34.055	44.606	56.388	70.335	79.194	**146**	3.764	5.977	10.771	18.074	25.696	33.170	44.280	58.922	65.590
67	2.017	2.168	5.587	10.157	15.421	20.745	29.358	35.023	42.739	**147**	2.428	2.191	4.682	7.091	11.300	16.990	24.771	30.381	37.349
68	7.342	8.866	12.611	20.488	31.484	40.368	50.919	66.315	71.239	**148**	5.043	5.831	11.353	15.821	22.765	32.892	43.115	54.830	63.990
69	1.908	3.243	5.652	8.733	15.364	21.135	29.092	35.569	41.504	**149**	2.227	2.403	4.551	7.627	12.311	15.334	23.888	30.329	36.484
70	8.136	11.674	17.142	24.117	35.186	47.479	58.101	75.480	83.516	**150**	4.970	7.158	11.141	19.945	26.976	37.119	47.009	60.823	65.644
71	2.586	4.804	7.130	11.441	19.531	25.505	35.905	45.816	50.481	**151**	2.786	4.789	5.909	11.997	17.507	22.434	31.836	39.762	47.997
72	1.126	1.116	2.337	4.055	7.681	10.884	16.470	22.650	25.725	**152**	0.608	1.121	1.954	4.067	6.496	11.494	15.070	17.115	22.886
73	2.525	4.110	8.593	12.812	18.540	25.701	33.469	43.096	50.525	**153**	2.084	4.297	8.190	10.881	17.489	23.505	33.856	40.273	46.215
74	0.862	1.408	2.798	4.075	7.734	11.076	17.425	21.863	25.882	**154**	0.803	1.138	2.903	2.920	7.847	10.335	16.703	20.322	24.730
75	3.565	4.621	6.605	12.792	17.803	25.109	33.909	43.958	51.551	**155**	1.730	4.408	7.640	10.272	17.179	22.737	32.427	38.901	47.945
76	6.170	11.315	16.813	24.708	31.388	43.133	53.908	70.412	76.031	**156**	4.422	5.088	11.636	15.415	25.364	35.452	45.287	57.625	65.055
77	2.053	1.140	4.643	9.557	14.914	20.525	27.459	34.371	41.255	**157**	1.387	1.887	4.039	6.368	10.539	15.903	23.030	29.812	33.637
78	6.431	8.183	12.351	20.149	27.427	40.563	50.423	63.055	72.197	**158**	4.148	6.536	8.138	14.485	23.598	30.468	42.377	53.383	59.661
79	2.652	2.816	5.540	7.924	13.829	20.626	27.929	34.610	40.774	**159**	1.172	2.339	3.822	6.367	10.587	17.734	23.470	29.211	35.500
80	5.639	7.089	10.802	21.160	30.454	40.328	50.715	65.907	73.909	**160**	4.743	5.598	9.222	15.663	22.194	30.665	41.074	52.706	58.044

Table D.4 Standard Deviation of Total Expected Annual Loss for Reference Non-Open Terrain (EAL_{TR}), as a Ratio of Building Value, z_0=0.15 m

ID	700-year open terrain 3-second gust wind speed, mph									ID	700-year open terrain 3-second gust wind speed, mph								
	110	115	120	130	140	150	160	170	180		110	115	120	130	140	150	160	170	180
1	0.010	0.017	0.024	0.040	0.058	0.082	0.105	0.132	0.154	**81**	0.010	0.015	0.020	0.032	0.053	0.071	0.090	0.120	0.135
2	0.007	0.011	0.017	0.028	0.039	0.057	0.079	0.098	0.115	**82**	0.005	0.007	0.013	0.021	0.033	0.047	0.068	0.085	0.100
3	0.009	0.014	0.022	0.036	0.055	0.078	0.098	0.125	0.138	**83**	0.010	0.014	0.022	0.032	0.047	0.066	0.090	0.111	0.131
4	0.006	0.007	0.016	0.023	0.037	0.050	0.073	0.090	0.102	**84**	0.004	0.007	0.010	0.019	0.030	0.043	0.062	0.079	0.090
5	0.009	0.016	0.025	0.038	0.056	0.078	0.104	0.132	0.149	**85**	0.009	0.013	0.021	0.033	0.051	0.071	0.092	0.120	0.135
6	0.019	0.022	0.039	0.059	0.084	0.111	0.148	0.179	0.200	**86**	0.011	0.017	0.027	0.045	0.069	0.088	0.119	0.150	0.168
7	0.009	0.011	0.017	0.030	0.043	0.065	0.086	0.110	0.126	**87**	0.007	0.009	0.015	0.026	0.035	0.052	0.070	0.091	0.107
8	0.014	0.022	0.035	0.052	0.074	0.104	0.129	0.166	0.179	**88**	0.011	0.016	0.025	0.042	0.055	0.080	0.107	0.132	0.153
9	0.007	0.012	0.017	0.028	0.047	0.060	0.082	0.104	0.126	**89**	0.005	0.008	0.014	0.020	0.036	0.052	0.068	0.087	0.106
10	0.020	0.026	0.043	0.062	0.089	0.118	0.150	0.189	0.209	**90**	0.013	0.021	0.029	0.045	0.065	0.088	0.122	0.149	0.167
11	0.009	0.010	0.018	0.032	0.045	0.060	0.085	0.106	0.126	**91**	0.007	0.010	0.015	0.026	0.040	0.057	0.077	0.100	0.119
12	0.002	0.004	0.007	0.011	0.021	0.031	0.044	0.060	0.073	**92**	0.002	0.003	0.006	0.011	0.020	0.026	0.042	0.050	0.065
13	0.008	0.011	0.017	0.027	0.041	0.063	0.081	0.105	0.122	**93**	0.008	0.009	0.018	0.026	0.042	0.056	0.078	0.100	0.118
14	0.005	0.006	0.006	0.012	0.019	0.032	0.046	0.059	0.074	**94**	0.002	0.003	0.007	0.011	0.020	0.029	0.044	0.052	0.069
15	0.007	0.010	0.018	0.029	0.044	0.059	0.083	0.112	0.122	**95**	0.008	0.010	0.018	0.027	0.041	0.057	0.076	0.102	0.113
16	0.018	0.024	0.033	0.056	0.080	0.108	0.135	0.169	0.190	**96**	0.011	0.014	0.027	0.044	0.062	0.082	0.110	0.138	0.157
17	0.005	0.007	0.012	0.024	0.036	0.048	0.069	0.088	0.105	**97**	0.004	0.006	0.008	0.016	0.028	0.040	0.057	0.075	0.088
18	0.013	0.019	0.031	0.045	0.071	0.094	0.123	0.156	0.176	**98**	0.008	0.014	0.021	0.037	0.053	0.076	0.102	0.128	0.144
19	0.004	0.007	0.012	0.021	0.037	0.052	0.071	0.087	0.107	**99**	0.005	0.003	0.009	0.017	0.027	0.041	0.059	0.073	0.091
20	0.014	0.021	0.033	0.049	0.071	0.098	0.122	0.158	0.174	**100**	0.009	0.014	0.023	0.035	0.053	0.072	0.099	0.125	0.147
21	0.011	0.011	0.021	0.032	0.051	0.072	0.090	0.119	0.133	**101**	0.009	0.012	0.022	0.027	0.043	0.063	0.087	0.109	0.126
22	0.005	0.008	0.012	0.022	0.032	0.045	0.062	0.077	0.091	**102**	0.005	0.008	0.013	0.018	0.032	0.039	0.055	0.072	0.084
23	0.009	0.013	0.020	0.033	0.049	0.069	0.094	0.120	0.134	**103**	0.008	0.012	0.019	0.031	0.043	0.065	0.084	0.110	0.124
24	0.008	0.007	0.011	0.019	0.030	0.043	0.062	0.076	0.087	**104**	0.005	0.006	0.011	0.018	0.027	0.042	0.059	0.070	0.084
25	0.011	0.012	0.020	0.033	0.050	0.071	0.095	0.118	0.134	**105**	0.010	0.015	0.018	0.032	0.047	0.063	0.085	0.114	0.127
26	0.020	0.025	0.037	0.060	0.083	0.112	0.144	0.179	0.197	**106**	0.012	0.016	0.027	0.044	0.065	0.087	0.118	0.150	0.165
27	0.008	0.009	0.015	0.027	0.044	0.060	0.083	0.105	0.117	**107**	0.005	0.010	0.015	0.026	0.038	0.050	0.068	0.085	0.104
28	0.015	0.020	0.031	0.048	0.072	0.099	0.131	0.165	0.184	**108**	0.011	0.014	0.023	0.035	0.059	0.078	0.105	0.132	0.152
29	0.006	0.009	0.017	0.026	0.042	0.061	0.079	0.104	0.117	**109**	0.007	0.007	0.016	0.023	0.036	0.052	0.067	0.087	0.103
30	0.018	0.028	0.042	0.066	0.090	0.117	0.151	0.189	0.207	**110**	0.012	0.018	0.029	0.046	0.064	0.087	0.116	0.148	0.171
31	0.005	0.012	0.017	0.028	0.040	0.063	0.084	0.109	0.125	**111**	0.007	0.011	0.018	0.027	0.041	0.056	0.078	0.098	0.115
32	0.003	0.003	0.008	0.013	0.024	0.032	0.045	0.060	0.074	**112**	0.002	0.004	0.007	0.012	0.018	0.028	0.042	0.055	0.066
33	0.006	0.011	0.018	0.029	0.043	0.061	0.082	0.110	0.121	**113**	0.007	0.008	0.016	0.026	0.040	0.056	0.075	0.096	0.116
34	0.002	0.003	0.006	0.013	0.022	0.031	0.048	0.060	0.074	**114**	0.002	0.003	0.005	0.009	0.018	0.029	0.041	0.054	0.068
35	0.007	0.011	0.017	0.029	0.040	0.061	0.084	0.105	0.124	**115**	0.007	0.009	0.015	0.026	0.039	0.055	0.076	0.098	0.115
36	0.015	0.023	0.035	0.054	0.078	0.108	0.132	0.167	0.193	**116**	0.008	0.014	0.025	0.043	0.055	0.078	0.112	0.139	0.159
37	0.005	0.006	0.010	0.022	0.037	0.049	0.071	0.089	0.103	**117**	0.003	0.006	0.009	0.016	0.029	0.041	0.060	0.076	0.090
38	0.012	0.018	0.031	0.052	0.070	0.095	0.122	0.157	0.175	**118**	0.008	0.014	0.021	0.038	0.057	0.077	0.101	0.124	0.149
39	0.003	0.006	0.012	0.020	0.034	0.052	0.068	0.090	0.106	**119**	0.002	0.004	0.011	0.015	0.025	0.040	0.059	0.072	0.092
40	0.012	0.024	0.031	0.050	0.073	0.098	0.126	0.157	0.174	**120**	0.010	0.013	0.020	0.037	0.052	0.074	0.098	0.124	0.144
41	0.011	0.014	0.022	0.036	0.054	0.074	0.102	0.127	0.146	**121**	0.009	0.011	0.017	0.028	0.047	0.063	0.089	0.110	0.128
42	0.006	0.008	0.013	0.023	0.036	0.051	0.068	0.089	0.105	**122**	0.003	0.006	0.010	0.015	0.027	0.036	0.051	0.068	0.082
43	0.008	0.013	0.018	0.034	0.049	0.069	0.096	0.122	0.141	**123**	0.007	0.008	0.020	0.028	0.043	0.063	0.081	0.104	0.123
44	0.004	0.006	0.012	0.020	0.029	0.043	0.060	0.077	0.095	**124**	0.003	0.004	0.009	0.016	0.026	0.035	0.051	0.061	0.074
45	0.011	0.015	0.023	0.037	0.053	0.074	0.099	0.127	0.146	**125**	0.008	0.013	0.019	0.030	0.044	0.063	0.087	0.111	0.128
46	0.019	0.025	0.038	0.062	0.080	0.106	0.139	0.177	0.196	**126**	0.011	0.014	0.028	0.042	0.063	0.084	0.112	0.145	0.159
47	0.007	0.010	0.014	0.027	0.044	0.057	0.075	0.101	0.117	**127**	0.004	0.007	0.013	0.019	0.032	0.043	0.059	0.079	0.094
48	0.015	0.021	0.034	0.048	0.071	0.095	0.121	0.157	0.180	**128**	0.010	0.012	0.020	0.037	0.052	0.077	0.103	0.125	0.143
49	0.006	0.007	0.014	0.024	0.037	0.054	0.073	0.099	0.113	**129**	0.004	0.006	0.009	0.020	0.030	0.041	0.057	0.076	0.092
50	0.020	0.024	0.041	0.066	0.086	0.117	0.148	0.189	0.199	**130**	0.012	0.018	0.027	0.044	0.064	0.090	0.116	0.146	0.163
51	0.008	0.009	0.018	0.027	0.043	0.061	0.080	0.107	0.126	**131**	0.005	0.008	0.016	0.025	0.041	0.057	0.080	0.097	0.113
52	0.002	0.003	0.005	0.010	0.018	0.025	0.039	0.047	0.060	**132**	0.002	0.003	0.004	0.011	0.014	0.023	0.031	0.043	0.056
53	0.007	0.010	0.015	0.030	0.041	0.060	0.083	0.104	0.122	**133**	0.005	0.009	0.015	0.024	0.040	0.056	0.074	0.095	0.113
54	0.003	0.002	0.005	0.009	0.019	0.024	0.037	0.049	0.061	**134**	0.002	0.002	0.005	0.009	0.018	0.026	0.034	0.045	0.056
55	0.006	0.009	0.018	0.027	0.043	0.060	0.080	0.102	0.117	**135**	0.007	0.011	0.015	0.024	0.039	0.055	0.077	0.095	0.113
56	0.018	0.025	0.037	0.055	0.077	0.104	0.135	0.172	0.186	**136**	0.011	0.014	0.023	0.042	0.057	0.083	0.111	0.137	0.153
57	0.008	0.005	0.008	0.021	0.030	0.045	0.066	0.085	0.099	**137**	0.005	0.005	0.007	0.016	0.024	0.036	0.052	0.066	0.081
58	0.014	0.016	0.030	0.046	0.070	0.093	0.123	0.156	0.175	**138**	0.010	0.012	0.023	0.034	0.054	0.073	0.099	0.127	0.141

ID	700-year open terrain 3-second gust wind speed, mph									ID	700-year open terrain 3-second gust wind speed, mph								
	110	115	120	130	140	150	160	170	180		110	115	120	130	140	150	160	170	180
59	0.005	0.005	0.012	0.022	0.033	0.048	0.067	0.086	0.101	**139**	0.002	0.004	0.008	0.016	0.027	0.040	0.056	0.068	0.086
60	0.013	0.020	0.031	0.048	0.071	0.095	0.123	0.157	0.172	**140**	0.009	0.012	0.022	0.035	0.052	0.074	0.097	0.124	0.141
61	0.008	0.011	0.017	0.028	0.046	0.059	0.084	0.106	0.123	**141**	0.007	0.009	0.016	0.024	0.042	0.059	0.076	0.098	0.115
62	0.004	0.004	0.008	0.011	0.019	0.027	0.043	0.051	0.064	**142**	0.003	0.004	0.005	0.011	0.016	0.023	0.033	0.044	0.056
63	0.008	0.008	0.017	0.030	0.042	0.058	0.084	0.105	0.121	**143**	0.008	0.011	0.014	0.025	0.039	0.057	0.077	0.097	0.117
64	0.003	0.004	0.008	0.011	0.021	0.026	0.040	0.053	0.065	**144**	0.003	0.004	0.005	0.010	0.018	0.025	0.037	0.048	0.060
65	0.008	0.011	0.019	0.029	0.046	0.061	0.084	0.110	0.127	**145**	0.007	0.010	0.017	0.027	0.043	0.059	0.079	0.099	0.118
66	0.017	0.024	0.037	0.054	0.081	0.109	0.139	0.174	0.189	**146**	0.010	0.015	0.028	0.041	0.062	0.087	0.109	0.140	0.161
67	0.004	0.007	0.012	0.021	0.033	0.045	0.068	0.082	0.100	**147**	0.004	0.006	0.009	0.017	0.027	0.038	0.054	0.069	0.085
68	0.015	0.019	0.032	0.046	0.071	0.094	0.123	0.156	0.178	**148**	0.011	0.014	0.020	0.037	0.056	0.077	0.102	0.131	0.149
69	0.006	0.007	0.014	0.020	0.034	0.049	0.066	0.087	0.098	**149**	0.005	0.004	0.010	0.017	0.028	0.038	0.055	0.072	0.087
70	0.021	0.029	0.040	0.062	0.085	0.118	0.148	0.185	0.205	**150**	0.011	0.014	0.029	0.044	0.064	0.088	0.113	0.143	0.165
71	0.009	0.009	0.017	0.028	0.040	0.061	0.083	0.105	0.119	**151**	0.008	0.008	0.014	0.024	0.041	0.053	0.076	0.096	0.113
72	0.003	0.003	0.006	0.008	0.015	0.025	0.037	0.048	0.060	**152**	0.002	0.003	0.005	0.007	0.014	0.022	0.033	0.042	0.053
73	0.008	0.010	0.017	0.027	0.042	0.061	0.083	0.105	0.121	**153**	0.006	0.008	0.014	0.025	0.040	0.055	0.076	0.092	0.110
74	0.002	0.002	0.006	0.009	0.018	0.025	0.039	0.048	0.059	**154**	0.003	0.003	0.005	0.010	0.017	0.024	0.036	0.045	0.056
75	0.007	0.010	0.016	0.028	0.042	0.060	0.082	0.101	0.118	**155**	0.007	0.008	0.016	0.026	0.039	0.055	0.073	0.094	0.112
76	0.019	0.022	0.036	0.056	0.078	0.105	0.133	0.170	0.186	**156**	0.011	0.013	0.025	0.038	0.059	0.087	0.107	0.138	0.159
77	0.005	0.006	0.010	0.022	0.035	0.046	0.064	0.082	0.096	**157**	0.004	0.004	0.008	0.014	0.023	0.036	0.053	0.066	0.079
78	0.012	0.021	0.031	0.046	0.068	0.096	0.123	0.153	0.177	**158**	0.009	0.014	0.020	0.035	0.055	0.073	0.098	0.131	0.144
79	0.004	0.005	0.010	0.021	0.032	0.047	0.066	0.081	0.097	**159**	0.004	0.004	0.008	0.016	0.024	0.038	0.052	0.065	0.084
80	0.013	0.020	0.031	0.050	0.070	0.095	0.121	0.156	0.172	**160**	0.010	0.012	0.023	0.036	0.055	0.071	0.102	0.124	0.141

APPENDIX E: TOTAL EXPECTED ANNUAL LOSS FOR TERRAINS 3, 4, AND 5

Table E.1 Total Expected Annual Loss, (EAL_T), as a Ratio of Building Value (10^{-2}), z_0=0.35 m

ID	700-year open terrain 3-second gust wind speed, mph									ID	700-year open terrain 3-second gust wind speed, mph								
	110	115	120	130	140	150	160	170	180		110	115	120	130	140	150	160	170	180
1	0.078	0.129	0.161	0.259	0.365	0.621	0.949	1.510	1.712	**81**	0.058	0.100	0.127	0.199	0.298	0.504	0.746	1.274	1.374
2	0.072	0.123	0.142	0.211	0.293	0.482	0.727	1.128	1.279	**82**	0.054	0.088	0.109	0.168	0.223	0.387	0.552	0.913	1.026
3	0.058	0.095	0.128	0.185	0.296	0.527	0.773	1.272	1.523	**83**	0.042	0.072	0.100	0.181	0.241	0.415	0.680	1.081	1.345
4	0.054	0.088	0.103	0.153	0.222	0.389	0.559	0.897	1.082	**84**	0.043	0.064	0.081	0.132	0.189	0.337	0.508	0.782	0.863
5	0.061	0.109	0.133	0.218	0.335	0.582	0.899	1.350	1.639	**85**	0.046	0.073	0.104	0.170	0.280	0.475	0.762	1.196	1.422
6	0.089	0.148	0.196	0.336	0.540	0.913	1.348	2.154	2.418	**86**	0.058	0.098	0.127	0.225	0.344	0.616	0.940	1.507	1.737
7	0.075	0.121	0.141	0.223	0.325	0.526	0.821	1.221	1.452	**87**	0.054	0.090	0.118	0.175	0.236	0.405	0.619	0.991	1.103
8	0.063	0.100	0.144	0.251	0.390	0.685	1.075	1.723	2.048	**88**	0.041	0.074	0.104	0.174	0.266	0.482	0.754	1.268	1.546
9	0.055	0.086	0.117	0.163	0.255	0.410	0.627	1.035	1.227	**89**	0.039	0.067	0.087	0.135	0.197	0.330	0.553	0.850	1.042
10	0.075	0.116	0.178	0.321	0.502	0.871	1.310	2.182	2.502	**90**	0.049	0.079	0.118	0.214	0.339	0.592	0.908	1.484	1.695
11	0.024	0.044	0.062	0.112	0.182	0.349	0.530	0.866	1.087	**91**	0.018	0.029	0.046	0.086	0.163	0.273	0.454	0.737	0.924
12	0.019	0.034	0.042	0.065	0.098	0.166	0.267	0.422	0.514	**92**	0.013	0.022	0.031	0.054	0.086	0.143	0.234	0.356	0.446
13	0.019	0.034	0.050	0.091	0.164	0.332	0.468	0.846	0.991	**93**	0.015	0.023	0.045	0.087	0.152	0.299	0.451	0.731	0.962
14	0.015	0.024	0.032	0.047	0.081	0.139	0.233	0.363	0.468	**94**	0.009	0.016	0.024	0.043	0.071	0.123	0.207	0.343	0.407
15	0.019	0.032	0.049	0.093	0.171	0.326	0.536	0.805	1.004	**95**	0.014	0.023	0.041	0.074	0.141	0.263	0.458	0.730	0.963
16	0.030	0.058	0.117	0.198	0.400	0.651	1.118	1.717	2.028	**96**	0.017	0.033	0.060	0.116	0.215	0.425	0.684	1.135	1.410
17	0.021	0.036	0.049	0.086	0.134	0.247	0.405	0.669	0.805	**97**	0.014	0.022	0.033	0.059	0.110	0.176	0.297	0.520	0.601
18	0.025	0.047	0.086	0.183	0.306	0.570	0.870	1.482	1.728	**98**	0.013	0.025	0.048	0.113	0.190	0.340	0.598	0.999	1.236
19	0.017	0.026	0.040	0.066	0.130	0.223	0.371	0.607	0.797	**99**	0.009	0.019	0.026	0.048	0.081	0.182	0.285	0.458	0.585
20	0.027	0.043	0.080	0.171	0.322	0.549	0.937	1.437	1.787	**100**	0.015	0.028	0.048	0.104	0.191	0.350	0.600	1.017	1.239
21	0.073	0.121	0.154	0.221	0.319	0.544	0.755	1.248	1.436	**101**	0.056	0.098	0.120	0.200	0.284	0.464	0.692	1.140	1.305
22	0.069	0.112	0.132	0.187	0.252	0.402	0.559	0.929	1.052	**102**	0.053	0.086	0.113	0.162	0.229	0.376	0.511	0.850	0.959
23	0.056	0.094	0.120	0.188	0.287	0.467	0.719	1.118	1.325	**103**	0.041	0.073	0.095	0.162	0.240	0.410	0.659	1.072	1.224
24	0.052	0.086	0.099	0.153	0.205	0.360	0.497	0.796	0.888	**104**	0.040	0.066	0.080	0.124	0.180	0.305	0.444	0.723	0.826
25	0.060	0.097	0.126	0.197	0.307	0.504	0.801	1.213	1.418	**105**	0.045	0.076	0.101	0.180	0.275	0.509	0.680	1.097	1.296
26	0.086	0.137	0.194	0.311	0.524	0.860	1.268	2.051	2.401	**106**	0.062	0.098	0.135	0.224	0.330	0.565	0.928	1.427	1.719
27	0.073	0.115	0.136	0.210	0.275	0.477	0.662	1.132	1.288	**107**	0.053	0.087	0.114	0.175	0.239	0.417	0.561	0.956	1.096
28	0.064	0.101	0.138	0.243	0.379	0.687	1.084	1.686	1.950	**108**	0.041	0.072	0.104	0.165	0.268	0.510	0.725	1.223	1.470
29	0.053	0.088	0.100	0.163	0.233	0.403	0.621	0.953	1.152	**109**	0.038	0.067	0.084	0.140	0.207	0.354	0.520	0.813	1.016
30	0.078	0.118	0.181	0.323	0.519	0.929	1.364	2.150	2.433	**110**	0.046	0.076	0.111	0.190	0.333	0.558	0.877	1.483	1.737
31	0.024	0.045	0.061	0.105	0.192	0.314	0.510	0.833	1.019	**111**	0.016	0.027	0.048	0.096	0.152	0.294	0.470	0.743	0.924
32	0.020	0.035	0.041	0.066	0.096	0.162	0.247	0.424	0.489	**112**	0.013	0.022	0.031	0.050	0.080	0.145	0.225	0.375	0.437
33	0.018	0.034	0.053	0.092	0.160	0.301	0.490	0.803	0.987	**113**	0.014	0.023	0.039	0.084	0.139	0.268	0.462	0.716	0.895
34	0.015	0.025	0.031	0.045	0.079	0.146	0.231	0.379	0.459	**114**	0.009	0.016	0.024	0.042	0.075	0.131	0.215	0.336	0.405
35	0.021	0.034	0.052	0.097	0.154	0.320	0.516	0.846	1.064	**115**	0.012	0.022	0.037	0.085	0.159	0.265	0.448	0.745	0.976
36	0.029	0.070	0.099	0.216	0.368	0.713	1.095	1.732	2.037	**116**	0.018	0.033	0.064	0.119	0.222	0.392	0.713	1.072	1.402
37	0.021	0.034	0.052	0.083	0.140	0.252	0.402	0.688	0.824	**117**	0.013	0.023	0.035	0.062	0.099	0.194	0.324	0.487	0.628
38	0.028	0.052	0.085	0.167	0.318	0.572	0.928	1.534	1.748	**118**	0.015	0.024	0.048	0.110	0.190	0.367	0.619	0.996	1.201
39	0.017	0.027	0.040	0.079	0.116	0.236	0.368	0.629	0.743	**119**	0.010	0.016	0.026	0.048	0.085	0.174	0.305	0.475	0.602
40	0.032	0.045	0.079	0.158	0.302	0.581	0.974	1.492	1.806	**120**	0.016	0.027	0.050	0.095	0.212	0.368	0.576	1.007	1.248
41	0.077	0.118	0.139	0.231	0.314	0.576	0.805	1.347	1.589	**121**	0.055	0.090	0.111	0.166	0.256	0.454	0.665	1.064	1.284
42	0.067	0.111	0.127	0.173	0.246	0.393	0.575	0.891	1.052	**122**	0.049	0.080	0.094	0.135	0.170	0.291	0.418	0.660	0.729
43	0.053	0.090	0.105	0.182	0.265	0.438	0.714	1.076	1.300	**123**	0.039	0.066	0.084	0.146	0.215	0.376	0.587	0.930	1.107
44	0.051	0.078	0.085	0.128	0.165	0.302	0.426	0.696	0.881	**124**	0.034	0.058	0.069	0.100	0.137	0.228	0.328	0.534	0.604
45	0.059	0.091	0.119	0.199	0.306	0.520	0.766	1.188	1.465	**125**	0.041	0.071	0.100	0.161	0.225	0.430	0.639	1.063	1.186
46	0.080	0.133	0.183	0.316	0.491	0.870	1.252	2.030	2.266	**126**	0.054	0.091	0.120	0.200	0.308	0.529	0.820	1.341	1.518
47	0.068	0.112	0.133	0.183	0.272	0.448	0.636	1.019	1.219	**127**	0.048	0.080	0.097	0.141	0.181	0.320	0.456	0.727	0.848
48	0.064	0.096	0.130	0.219	0.349	0.661	0.990	1.615	1.933	**128**	0.039	0.064	0.090	0.150	0.251	0.452	0.666	1.101	1.395
49	0.054	0.080	0.091	0.139	0.204	0.338	0.517	0.848	1.021	**129**	0.037	0.061	0.068	0.108	0.142	0.245	0.403	0.608	0.785
50	0.065	0.109	0.179	0.291	0.484	0.860	1.311	2.101	2.383	**130**	0.050	0.074	0.106	0.187	0.302	0.553	0.822	1.354	1.584
51	0.023	0.042	0.061	0.110	0.173	0.312	0.485	0.752	0.969	**131**	0.015	0.028	0.045	0.089	0.144	0.247	0.449	0.737	0.900
52	0.018	0.031	0.038	0.055	0.081	0.133	0.191	0.303	0.377	**132**	0.012	0.021	0.029	0.048	0.066	0.118	0.179	0.276	0.342
53	0.021	0.031	0.052	0.097	0.155	0.290	0.473	0.785	0.938	**133**	0.013	0.022	0.042	0.078	0.141	0.276	0.459	0.705	0.881
54	0.015	0.024	0.029	0.041	0.065	0.105	0.156	0.266	0.336	**134**	0.009	0.016	0.022	0.033	0.054	0.102	0.150	0.245	0.317
55	0.020	0.034	0.050	0.096	0.149	0.286	0.481	0.767	0.963	**135**	0.014	0.024	0.038	0.073	0.139	0.255	0.432	0.715	0.877

ID	700-year open terrain 3-second gust wind speed, mph									ID	700-year open terrain 3-second gust wind speed, mph								
	110	115	120	130	140	150	160	170	180		110	115	120	130	140	150	160	170	180
56	0.031	0.061	0.098	0.230	0.354	0.677	1.082	1.762	2.046	**136**	0.016	0.032	0.052	0.121	0.229	0.404	0.651	1.103	1.340
57	0.019	0.034	0.049	0.076	0.121	0.218	0.372	0.577	0.730	**137**	0.013	0.022	0.030	0.060	0.092	0.172	0.262	0.425	0.561
58	0.028	0.046	0.082	0.176	0.296	0.547	0.886	1.446	1.710	**138**	0.015	0.025	0.047	0.092	0.201	0.359	0.587	0.940	1.161
59	0.015	0.025	0.038	0.063	0.116	0.196	0.333	0.589	0.727	**139**	0.010	0.016	0.024	0.045	0.075	0.146	0.258	0.402	0.549
60	0.024	0.043	0.101	0.168	0.318	0.559	0.903	1.435	1.683	**140**	0.014	0.027	0.045	0.103	0.175	0.327	0.579	0.920	1.203
61	0.069	0.109	0.132	0.184	0.233	0.417	0.635	0.981	1.153	**141**	0.053	0.088	0.107	0.167	0.226	0.382	0.565	0.931	1.004
62	0.064	0.103	0.108	0.139	0.152	0.238	0.317	0.498	0.556	**142**	0.048	0.079	0.090	0.122	0.150	0.238	0.312	0.488	0.521
63	0.051	0.083	0.103	0.156	0.225	0.383	0.571	0.912	1.089	**143**	0.040	0.065	0.085	0.142	0.198	0.360	0.570	0.883	1.030
64	0.047	0.075	0.080	0.101	0.120	0.186	0.265	0.417	0.472	**144**	0.035	0.057	0.066	0.094	0.120	0.189	0.265	0.405	0.454
65	0.058	0.091	0.113	0.164	0.233	0.436	0.630	0.967	1.163	**145**	0.041	0.068	0.095	0.144	0.233	0.374	0.568	0.923	1.059
66	0.076	0.136	0.171	0.303	0.433	0.763	1.154	1.824	2.165	**146**	0.055	0.086	0.123	0.198	0.312	0.544	0.812	1.294	1.595
67	0.063	0.106	0.113	0.157	0.194	0.319	0.488	0.738	0.922	**147**	0.048	0.079	0.100	0.134	0.176	0.276	0.412	0.647	0.738
68	0.057	0.095	0.126	0.203	0.332	0.612	0.995	1.497	1.833	**148**	0.041	0.065	0.093	0.152	0.260	0.405	0.635	1.085	1.272
69	0.048	0.076	0.082	0.114	0.155	0.274	0.427	0.656	0.822	**149**	0.036	0.059	0.068	0.106	0.133	0.249	0.346	0.572	0.690
70	0.066	0.114	0.161	0.287	0.468	0.832	1.272	2.019	2.351	**150**	0.044	0.072	0.099	0.186	0.324	0.515	0.796	1.327	1.565
71	0.023	0.040	0.056	0.104	0.172	0.319	0.496	0.794	0.978	**151**	0.016	0.027	0.045	0.090	0.145	0.287	0.437	0.734	0.890
72	0.019	0.031	0.038	0.058	0.074	0.132	0.176	0.304	0.369	**152**	0.011	0.020	0.028	0.047	0.068	0.116	0.170	0.265	0.330
73	0.020	0.031	0.048	0.090	0.143	0.285	0.469	0.774	0.947	**153**	0.013	0.022	0.041	0.078	0.141	0.268	0.446	0.713	0.871
74	0.014	0.023	0.028	0.044	0.063	0.107	0.164	0.262	0.335	**154**	0.009	0.015	0.023	0.035	0.051	0.096	0.165	0.247	0.321
75	0.018	0.031	0.046	0.090	0.152	0.307	0.460	0.752	0.964	**155**	0.012	0.023	0.037	0.076	0.142	0.268	0.424	0.698	0.955
76	0.031	0.060	0.109	0.221	0.379	0.710	1.013	1.711	2.099	**156**	0.019	0.033	0.052	0.119	0.238	0.410	0.658	1.113	1.309
77	0.020	0.036	0.046	0.078	0.121	0.232	0.325	0.573	0.811	**157**	0.012	0.021	0.031	0.053	0.092	0.167	0.263	0.425	0.566
78	0.027	0.041	0.077	0.173	0.309	0.564	0.920	1.401	1.812	**158**	0.014	0.023	0.048	0.097	0.171	0.331	0.584	0.947	1.225
79	0.016	0.027	0.034	0.069	0.118	0.204	0.325	0.535	0.721	**159**	0.010	0.015	0.023	0.041	0.084	0.161	0.253	0.407	0.545
80	0.027	0.051	0.081	0.168	0.297	0.545	0.917	1.446	1.763	**160**	0.014	0.025	0.050	0.103	0.179	0.353	0.560	0.980	1.191

Table E.2 Total Expected Annual Loss (EAL_T), as a Ratio of Building Value (10^{-2}), z_0=0.7 m

ID	700-year open terrain 3-second gust wind speed, mph									ID	700-year open terrain 3-second gust wind speed, mph								
	110	115	120	130	140	150	160	170	180		110	115	120	130	140	150	160	170	180
1	0.051	0.081	0.103	0.158	0.241	0.406	0.593	0.956	1.155	**81**	0.033	0.057	0.078	0.128	0.179	0.335	0.463	0.749	0.905
2	0.048	0.078	0.096	0.145	0.207	0.343	0.517	0.784	0.904	**82**	0.031	0.055	0.071	0.112	0.150	0.267	0.393	0.631	0.725
3	0.034	0.058	0.073	0.117	0.177	0.323	0.476	0.813	0.953	**83**	0.026	0.042	0.055	0.096	0.152	0.271	0.398	0.683	0.825
4	0.035	0.057	0.067	0.109	0.151	0.271	0.388	0.640	0.776	**84**	0.023	0.038	0.053	0.085	0.131	0.212	0.330	0.502	0.633
5	0.038	0.065	0.081	0.117	0.198	0.349	0.516	0.835	1.007	**85**	0.024	0.042	0.062	0.100	0.158	0.272	0.423	0.710	0.812
6	0.049	0.083	0.114	0.172	0.271	0.502	0.786	1.219	1.492	**86**	0.036	0.055	0.079	0.129	0.198	0.359	0.558	0.890	1.080
7	0.048	0.077	0.093	0.142	0.195	0.342	0.542	0.843	0.965	**87**	0.035	0.054	0.069	0.119	0.164	0.287	0.394	0.653	0.802
8	0.039	0.060	0.079	0.130	0.218	0.391	0.634	1.025	1.226	**88**	0.024	0.041	0.055	0.100	0.159	0.295	0.449	0.737	0.947
9	0.036	0.057	0.071	0.104	0.157	0.285	0.447	0.680	0.886	**89**	0.023	0.039	0.052	0.089	0.136	0.231	0.362	0.576	0.703
10	0.040	0.065	0.090	0.168	0.267	0.477	0.792	1.245	1.466	**90**	0.026	0.045	0.061	0.118	0.182	0.324	0.500	0.836	0.998
11	0.013	0.022	0.031	0.059	0.093	0.181	0.280	0.466	0.568	**91**	0.008	0.013	0.023	0.045	0.075	0.153	0.247	0.389	0.516
12	0.012	0.020	0.027	0.043	0.059	0.110	0.159	0.267	0.346	**92**	0.007	0.012	0.018	0.031	0.046	0.085	0.140	0.218	0.274
13	0.010	0.018	0.027	0.046	0.082	0.160	0.257	0.420	0.531	**93**	0.006	0.011	0.019	0.038	0.076	0.140	0.221	0.381	0.507
14	0.009	0.016	0.019	0.031	0.049	0.086	0.138	0.230	0.269	**94**	0.005	0.008	0.013	0.026	0.041	0.077	0.122	0.190	0.238
15	0.010	0.018	0.025	0.049	0.079	0.150	0.254	0.414	0.531	**95**	0.005	0.010	0.017	0.037	0.070	0.130	0.227	0.398	0.482
16	0.015	0.025	0.041	0.095	0.186	0.332	0.597	0.944	1.127	**96**	0.008	0.016	0.032	0.060	0.109	0.194	0.379	0.592	0.751
17	0.013	0.022	0.032	0.050	0.079	0.152	0.238	0.404	0.487	**97**	0.007	0.012	0.020	0.034	0.061	0.114	0.187	0.269	0.415
18	0.012	0.025	0.032	0.077	0.158	0.299	0.478	0.773	1.027	**98**	0.006	0.014	0.025	0.049	0.103	0.168	0.326	0.509	0.695
19	0.009	0.016	0.022	0.040	0.074	0.128	0.250	0.364	0.536	**99**	0.006	0.009	0.014	0.027	0.054	0.102	0.174	0.260	0.362
20	0.011	0.021	0.033	0.078	0.147	0.280	0.476	0.806	1.050	**100**	0.006	0.011	0.023	0.050	0.101	0.171	0.318	0.511	0.698
21	0.047	0.078	0.092	0.140	0.193	0.334	0.472	0.788	0.910	**101**	0.033	0.056	0.073	0.116	0.177	0.285	0.457	0.703	0.836
22	0.046	0.076	0.089	0.129	0.174	0.278	0.416	0.659	0.743	**102**	0.031	0.054	0.067	0.113	0.146	0.254	0.360	0.587	0.699
23	0.034	0.057	0.069	0.105	0.164	0.288	0.447	0.678	0.855	**103**	0.022	0.040	0.056	0.094	0.138	0.255	0.389	0.613	0.782
24	0.035	0.058	0.069	0.102	0.125	0.233	0.350	0.520	0.635	**104**	0.023	0.040	0.048	0.080	0.120	0.203	0.294	0.472	0.576
25	0.038	0.059	0.072	0.120	0.173	0.304	0.446	0.727	0.866	**105**	0.026	0.044	0.058	0.098	0.152	0.273	0.414	0.647	0.805
26	0.052	0.083	0.108	0.165	0.275	0.479	0.751	1.189	1.477	**106**	0.033	0.060	0.074	0.128	0.196	0.342	0.516	0.873	1.008
27	0.046	0.076	0.092	0.133	0.190	0.326	0.470	0.758	0.893	**107**	0.031	0.054	0.070	0.112	0.165	0.267	0.385	0.648	0.721
28	0.040	0.060	0.084	0.129	0.226	0.384	0.613	0.971	1.161	**108**	0.024	0.042	0.058	0.095	0.152	0.289	0.428	0.744	0.877
29	0.035	0.056	0.068	0.100	0.155	0.252	0.398	0.645	0.803	**109**	0.024	0.039	0.051	0.082	0.128	0.230	0.352	0.551	0.682
30	0.042	0.066	0.087	0.156	0.274	0.482	0.763	1.169	1.422	**110**	0.023	0.044	0.062	0.106	0.176	0.339	0.538	0.866	1.009
31	0.013	0.022	0.030	0.056	0.096	0.163	0.272	0.441	0.570	**111**	0.009	0.014	0.024	0.044	0.086	0.139	0.240	0.390	0.496
32	0.012	0.020	0.027	0.042	0.057	0.108	0.164	0.245	0.338	**112**	0.007	0.013	0.020	0.033	0.049	0.094	0.139	0.225	0.278
33	0.011	0.018	0.027	0.048	0.084	0.152	0.265	0.408	0.563	**113**	0.006	0.010	0.018	0.035	0.065	0.134	0.222	0.361	0.507
34	0.009	0.016	0.021	0.032	0.050	0.095	0.144	0.224	0.296	**114**	0.005	0.009	0.014	0.024	0.044	0.073	0.125	0.178	0.274
35	0.010	0.018	0.026	0.050	0.078	0.146	0.268	0.441	0.545	**115**	0.006	0.009	0.020	0.036	0.071	0.139	0.247	0.408	0.501
36	0.014	0.026	0.044	0.097	0.177	0.342	0.552	0.891	1.153	**116**	0.009	0.015	0.026	0.058	0.106	0.209	0.372	0.584	0.791
37	0.012	0.021	0.028	0.050	0.080	0.141	0.252	0.391	0.516	**117**	0.007	0.012	0.020	0.033	0.060	0.099	0.185	0.280	0.365
38	0.015	0.021	0.042	0.076	0.144	0.287	0.529	0.797	1.005	**118**	0.006	0.011	0.023	0.044	0.088	0.173	0.311	0.492	0.704
39	0.009	0.016	0.024	0.040	0.067	0.123	0.220	0.340	0.465	**119**	0.005	0.010	0.015	0.028	0.046	0.099	0.170	0.258	0.371
40	0.012	0.020	0.038	0.078	0.162	0.294	0.512	0.832	1.009	**120**	0.007	0.011	0.026	0.044	0.093	0.191	0.328	0.526	0.666
41	0.046	0.080	0.090	0.139	0.197	0.333	0.512	0.856	0.974	**121**	0.031	0.055	0.066	0.113	0.143	0.259	0.375	0.646	0.741
42	0.046	0.074	0.083	0.123	0.169	0.279	0.391	0.627	0.752	**122**	0.031	0.052	0.062	0.093	0.114	0.198	0.274	0.433	0.489
43	0.034	0.055	0.065	0.101	0.139	0.263	0.415	0.653	0.776	**123**	0.023	0.039	0.048	0.083	0.119	0.210	0.325	0.524	0.648
44	0.033	0.052	0.061	0.085	0.120	0.199	0.303	0.491	0.588	**124**	0.021	0.038	0.045	0.065	0.088	0.153	0.219	0.329	0.404
45	0.034	0.056	0.069	0.105	0.159	0.291	0.451	0.707	0.882	**125**	0.024	0.041	0.051	0.089	0.131	0.221	0.349	0.557	0.698
46	0.049	0.080	0.102	0.174	0.240	0.453	0.746	1.116	1.360	**126**	0.033	0.056	0.069	0.118	0.161	0.323	0.473	0.722	0.900
47	0.046	0.075	0.087	0.126	0.186	0.299	0.430	0.680	0.833	**127**	0.031	0.052	0.066	0.090	0.124	0.207	0.295	0.474	0.562
48	0.033	0.058	0.073	0.126	0.194	0.346	0.529	0.918	1.112	**128**	0.022	0.040	0.050	0.089	0.136	0.260	0.362	0.656	0.800
49	0.032	0.053	0.060	0.087	0.124	0.223	0.342	0.566	0.654	**129**	0.021	0.035	0.045	0.068	0.093	0.162	0.240	0.401	0.510
50	0.037	0.061	0.085	0.159	0.243	0.437	0.714	1.139	1.373	**130**	0.025	0.041	0.056	0.094	0.153	0.298	0.454	0.738	0.912
51	0.013	0.022	0.030	0.048	0.086	0.147	0.260	0.392	0.495	**131**	0.008	0.014	0.023	0.043	0.072	0.135	0.216	0.381	0.464
52	0.012	0.020	0.024	0.034	0.046	0.082	0.115	0.179	0.224	**132**	0.007	0.012	0.017	0.028	0.039	0.070	0.102	0.163	0.184
53	0.010	0.016	0.025	0.045	0.080	0.132	0.244	0.393	0.498	**133**	0.006	0.010	0.017	0.037	0.062	0.136	0.206	0.347	0.449
54	0.008	0.015	0.018	0.028	0.036	0.064	0.093	0.153	0.166	**134**	0.005	0.009	0.013	0.022	0.031	0.056	0.080	0.139	0.161
55	0.010	0.018	0.025	0.044	0.072	0.132	0.234	0.376	0.493	**135**	0.006	0.010	0.018	0.035	0.065	0.117	0.220	0.342	0.459
56	0.016	0.028	0.051	0.097	0.167	0.315	0.537	0.905	1.152	**136**	0.009	0.014	0.025	0.054	0.109	0.182	0.325	0.572	0.700
57	0.012	0.020	0.027	0.047	0.063	0.118	0.221	0.341	0.442	**137**	0.006	0.012	0.019	0.030	0.050	0.088	0.147	0.258	0.330
58	0.011	0.022	0.033	0.073	0.156	0.282	0.478	0.741	0.951	**138**	0.006	0.011	0.023	0.046	0.094	0.177	0.300	0.482	0.647
59	0.009	0.015	0.021	0.037	0.058	0.113	0.199	0.340	0.428	**139**	0.005	0.008	0.015	0.024	0.040	0.081	0.149	0.246	0.317
60	0.013	0.023	0.038	0.069	0.159	0.261	0.498	0.755	0.987	**140**	0.006	0.011	0.023	0.042	0.089	0.168	0.294	0.472	0.702

ID	700-year open terrain 3-second gust wind speed, mph									ID	700-year open terrain 3-second gust wind speed, mph								
	110	115	120	130	140	150	160	170	180		110	115	120	130	140	150	160	170	180
61	0.045	0.073	0.082	0.117	0.146	0.234	0.349	0.572	0.662	**141**	0.031	0.053	0.065	0.097	0.130	0.239	0.337	0.506	0.586
62	0.043	0.069	0.074	0.096	0.109	0.167	0.213	0.337	0.365	**142**	0.030	0.050	0.060	0.085	0.103	0.168	0.216	0.334	0.338
63	0.032	0.055	0.059	0.092	0.126	0.202	0.327	0.508	0.612	**143**	0.022	0.040	0.049	0.078	0.119	0.188	0.308	0.469	0.587
64	0.031	0.050	0.055	0.072	0.083	0.133	0.183	0.274	0.280	**144**	0.022	0.036	0.044	0.061	0.078	0.119	0.166	0.262	0.284
65	0.034	0.056	0.065	0.095	0.128	0.232	0.329	0.538	0.632	**145**	0.023	0.040	0.051	0.083	0.119	0.206	0.318	0.488	0.621
66	0.046	0.074	0.094	0.155	0.232	0.417	0.587	1.005	1.283	**146**	0.030	0.057	0.067	0.105	0.160	0.301	0.446	0.727	0.942
67	0.042	0.070	0.079	0.101	0.127	0.208	0.306	0.496	0.582	**147**	0.030	0.050	0.061	0.087	0.120	0.188	0.270	0.416	0.498
68	0.035	0.056	0.071	0.119	0.181	0.305	0.509	0.854	1.017	**148**	0.022	0.037	0.049	0.087	0.131	0.235	0.384	0.601	0.740
69	0.032	0.051	0.058	0.075	0.097	0.175	0.281	0.437	0.511	**149**	0.021	0.037	0.046	0.065	0.088	0.151	0.230	0.364	0.459
70	0.036	0.061	0.082	0.152	0.226	0.414	0.655	1.086	1.335	**150**	0.024	0.041	0.056	0.098	0.155	0.279	0.470	0.715	0.909
71	0.012	0.022	0.033	0.058	0.085	0.158	0.256	0.425	0.483	**151**	0.009	0.014	0.024	0.043	0.074	0.134	0.236	0.375	0.448
72	0.012	0.020	0.026	0.036	0.050	0.077	0.122	0.185	0.211	**152**	0.007	0.011	0.017	0.028	0.041	0.069	0.102	0.162	0.194
73	0.010	0.016	0.026	0.041	0.069	0.141	0.226	0.377	0.476	**153**	0.007	0.011	0.017	0.037	0.061	0.115	0.201	0.340	0.463
74	0.009	0.014	0.018	0.026	0.035	0.060	0.090	0.143	0.178	**154**	0.005	0.008	0.013	0.021	0.033	0.055	0.085	0.138	0.169
75	0.010	0.017	0.025	0.042	0.076	0.134	0.234	0.378	0.528	**155**	0.006	0.011	0.017	0.032	0.060	0.137	0.201	0.375	0.438
76	0.014	0.027	0.046	0.094	0.169	0.328	0.557	0.903	1.147	**156**	0.008	0.014	0.026	0.057	0.098	0.181	0.340	0.553	0.699
77	0.011	0.020	0.030	0.040	0.072	0.121	0.206	0.368	0.469	**157**	0.007	0.015	0.018	0.030	0.056	0.095	0.160	0.238	0.326
78	0.012	0.021	0.037	0.070	0.136	0.286	0.449	0.798	1.029	**158**	0.007	0.011	0.020	0.044	0.090	0.183	0.301	0.517	0.662
79	0.009	0.015	0.020	0.034	0.074	0.120	0.180	0.314	0.453	**159**	0.005	0.008	0.014	0.022	0.041	0.088	0.146	0.224	0.303
80	0.013	0.021	0.033	0.075	0.140	0.285	0.476	0.793	1.008	**160**	0.007	0.011	0.022	0.047	0.087	0.177	0.302	0.506	0.670

Table E.3 Total Expected Annual Loss (EAL_T), as a Ratio of Building Value (10^{-2}), z_0=1 m

ID	700-year open terrain 3-second gust wind speed, mph									ID	700-year open terrain 3-second gust wind speed, mph								
	110	115	120	130	140	150	160	170	180		110	115	120	130	140	150	160	170	180
1	0.040	0.065	0.081	0.124	0.181	0.318	0.474	0.725	0.897	**81**	0.025	0.043	0.057	0.096	0.149	0.248	0.362	0.595	0.712
2	0.036	0.064	0.075	0.119	0.165	0.275	0.422	0.671	0.774	**82**	0.025	0.042	0.055	0.087	0.125	0.217	0.319	0.508	0.639
3	0.028	0.045	0.055	0.091	0.135	0.240	0.369	0.608	0.722	**83**	0.019	0.032	0.042	0.071	0.117	0.206	0.292	0.507	0.619
4	0.028	0.046	0.055	0.078	0.123	0.216	0.305	0.510	0.651	**84**	0.018	0.032	0.042	0.068	0.097	0.180	0.278	0.447	0.479
5	0.029	0.047	0.062	0.094	0.158	0.244	0.400	0.620	0.793	**85**	0.018	0.032	0.045	0.073	0.113	0.216	0.328	0.535	0.636
6	0.038	0.063	0.087	0.134	0.215	0.372	0.620	0.936	1.142	**86**	0.027	0.043	0.061	0.095	0.150	0.283	0.430	0.658	0.818
7	0.037	0.062	0.078	0.115	0.165	0.284	0.421	0.698	0.829	**87**	0.026	0.044	0.054	0.094	0.130	0.221	0.330	0.520	0.622
8	0.028	0.049	0.059	0.103	0.161	0.311	0.487	0.719	0.941	**88**	0.019	0.031	0.042	0.069	0.122	0.217	0.337	0.534	0.677
9	0.029	0.045	0.056	0.093	0.118	0.230	0.349	0.605	0.709	**89**	0.019	0.031	0.040	0.068	0.111	0.180	0.288	0.454	0.588
10	0.030	0.049	0.071	0.113	0.175	0.332	0.532	0.857	1.156	**90**	0.019	0.033	0.049	0.084	0.132	0.247	0.377	0.631	0.776
11	0.010	0.017	0.023	0.043	0.070	0.127	0.205	0.302	0.445	**91**	0.006	0.010	0.017	0.031	0.055	0.105	0.171	0.269	0.348
12	0.009	0.016	0.022	0.033	0.052	0.087	0.135	0.204	0.267	**92**	0.005	0.009	0.014	0.024	0.042	0.070	0.115	0.179	0.226
13	0.007	0.012	0.020	0.033	0.057	0.105	0.173	0.297	0.392	**93**	0.004	0.008	0.013	0.028	0.046	0.087	0.153	0.250	0.318
14	0.007	0.012	0.015	0.025	0.037	0.067	0.104	0.179	0.213	**94**	0.003	0.006	0.011	0.020	0.031	0.061	0.094	0.147	0.212
15	0.007	0.013	0.019	0.035	0.054	0.109	0.190	0.308	0.385	**95**	0.004	0.007	0.012	0.025	0.045	0.099	0.149	0.263	0.364
16	0.010	0.019	0.033	0.071	0.115	0.228	0.392	0.654	0.844	**96**	0.006	0.010	0.017	0.035	0.077	0.145	0.225	0.389	0.497
17	0.009	0.015	0.024	0.036	0.063	0.117	0.173	0.285	0.416	**97**	0.005	0.009	0.014	0.026	0.045	0.085	0.144	0.233	0.307
18	0.008	0.014	0.023	0.050	0.101	0.168	0.329	0.535	0.700	**98**	0.004	0.008	0.013	0.028	0.056	0.108	0.221	0.364	0.485
19	0.008	0.012	0.017	0.034	0.047	0.091	0.165	0.287	0.408	**99**	0.004	0.007	0.013	0.019	0.050	0.080	0.133	0.198	0.284
20	0.008	0.014	0.023	0.045	0.090	0.187	0.327	0.557	0.730	**100**	0.005	0.007	0.012	0.033	0.064	0.101	0.215	0.330	0.503
21	0.038	0.061	0.076	0.107	0.148	0.261	0.404	0.621	0.707	**101**	0.026	0.042	0.059	0.094	0.141	0.227	0.333	0.554	0.658
22	0.037	0.061	0.071	0.101	0.135	0.223	0.326	0.511	0.601	**102**	0.026	0.044	0.055	0.090	0.123	0.206	0.304	0.475	0.563
23	0.028	0.046	0.055	0.083	0.132	0.213	0.319	0.505	0.599	**103**	0.019	0.030	0.040	0.066	0.111	0.186	0.285	0.467	0.605
24	0.027	0.046	0.054	0.080	0.112	0.181	0.277	0.426	0.513	**104**	0.018	0.031	0.039	0.062	0.100	0.162	0.258	0.388	0.480
25	0.028	0.049	0.057	0.090	0.128	0.227	0.357	0.573	0.683	**105**	0.020	0.032	0.046	0.074	0.114	0.200	0.307	0.474	0.591
26	0.041	0.063	0.079	0.125	0.200	0.336	0.521	0.896	1.058	**106**	0.026	0.046	0.055	0.100	0.150	0.264	0.415	0.655	0.825
27	0.036	0.059	0.072	0.106	0.146	0.264	0.400	0.603	0.746	**107**	0.024	0.042	0.056	0.089	0.120	0.213	0.324	0.527	0.593
28	0.027	0.049	0.060	0.101	0.153	0.293	0.444	0.736	0.950	**108**	0.018	0.030	0.043	0.080	0.117	0.217	0.347	0.528	0.654
29	0.027	0.045	0.054	0.077	0.126	0.221	0.311	0.524	0.657	**109**	0.018	0.031	0.041	0.071	0.104	0.166	0.271	0.445	0.532
30	0.028	0.050	0.068	0.111	0.177	0.366	0.534	0.879	1.082	**110**	0.020	0.034	0.045	0.078	0.124	0.238	0.367	0.606	0.749
31	0.010	0.016	0.024	0.038	0.077	0.123	0.210	0.334	0.404	**111**	0.005	0.011	0.016	0.032	0.051	0.098	0.166	0.271	0.357
32	0.010	0.015	0.020	0.034	0.053	0.088	0.130	0.212	0.249	**112**	0.005	0.009	0.016	0.025	0.043	0.075	0.111	0.182	0.237
33	0.007	0.013	0.019	0.032	0.060	0.098	0.164	0.301	0.388	**113**	0.005	0.008	0.013	0.028	0.050	0.086	0.154	0.261	0.353
34	0.007	0.012	0.015	0.024	0.039	0.066	0.110	0.175	0.223	**114**	0.004	0.007	0.010	0.019	0.030	0.055	0.090	0.155	0.191
35	0.007	0.014	0.018	0.033	0.062	0.112	0.174	0.287	0.386	**115**	0.004	0.007	0.012	0.026	0.045	0.092	0.148	0.251	0.345
36	0.011	0.020	0.031	0.058	0.137	0.234	0.414	0.625	0.849	**116**	0.006	0.012	0.017	0.036	0.069	0.125	0.236	0.399	0.541
37	0.009	0.016	0.022	0.040	0.058	0.112	0.197	0.319	0.401	**117**	0.005	0.009	0.014	0.026	0.048	0.083	0.127	0.224	0.318
38	0.011	0.016	0.033	0.048	0.114	0.194	0.317	0.546	0.744	**118**	0.005	0.008	0.014	0.029	0.053	0.115	0.194	0.354	0.507
39	0.007	0.012	0.018	0.032	0.050	0.103	0.171	0.293	0.380	**119**	0.004	0.008	0.011	0.021	0.039	0.075	0.121	0.197	0.275
40	0.008	0.014	0.026	0.050	0.100	0.184	0.306	0.542	0.769	**120**	0.004	0.007	0.015	0.036	0.065	0.124	0.200	0.369	0.447
41	0.037	0.060	0.071	0.107	0.147	0.252	0.394	0.625	0.819	**121**	0.025	0.043	0.056	0.083	0.116	0.192	0.284	0.459	0.550
42	0.036	0.059	0.069	0.099	0.134	0.212	0.306	0.518	0.596	**122**	0.023	0.041	0.051	0.075	0.095	0.164	0.219	0.362	0.419
43	0.026	0.044	0.051	0.081	0.116	0.187	0.302	0.475	0.601	**123**	0.017	0.030	0.038	0.058	0.092	0.151	0.235	0.382	0.459
44	0.026	0.043	0.048	0.069	0.090	0.154	0.237	0.376	0.463	**124**	0.017	0.028	0.037	0.051	0.071	0.118	0.178	0.274	0.328
45	0.029	0.045	0.055	0.093	0.115	0.210	0.327	0.547	0.713	**125**	0.018	0.031	0.040	0.064	0.097	0.176	0.252	0.396	0.518
46	0.037	0.061	0.078	0.121	0.180	0.313	0.534	0.874	1.032	**126**	0.024	0.042	0.052	0.080	0.126	0.218	0.323	0.563	0.662
47	0.038	0.058	0.069	0.098	0.138	0.244	0.346	0.548	0.638	**127**	0.024	0.040	0.050	0.076	0.094	0.167	0.229	0.378	0.445
48	0.027	0.046	0.056	0.090	0.140	0.244	0.446	0.641	0.801	**128**	0.018	0.028	0.038	0.059	0.093	0.167	0.287	0.433	0.584
49	0.026	0.041	0.051	0.072	0.102	0.195	0.276	0.459	0.563	**129**	0.017	0.030	0.036	0.055	0.079	0.129	0.197	0.314	0.405
50	0.028	0.048	0.064	0.100	0.150	0.292	0.471	0.784	1.047	**130**	0.019	0.030	0.042	0.075	0.113	0.209	0.358	0.507	0.677
51	0.009	0.016	0.023	0.036	0.063	0.106	0.159	0.261	0.346	**131**	0.005	0.010	0.015	0.031	0.049	0.096	0.146	0.243	0.303
52	0.009	0.015	0.020	0.029	0.037	0.061	0.085	0.142	0.164	**132**	0.005	0.009	0.013	0.022	0.033	0.056	0.077	0.126	0.138
53	0.007	0.013	0.019	0.032	0.047	0.093	0.141	0.243	0.326	**133**	0.004	0.008	0.013	0.024	0.042	0.083	0.149	0.222	0.291
54	0.006	0.011	0.014	0.022	0.031	0.049	0.067	0.118	0.145	**134**	0.003	0.006	0.010	0.017	0.026	0.045	0.068	0.107	0.126
55	0.007	0.013	0.018	0.034	0.054	0.099	0.148	0.243	0.336	**135**	0.005	0.007	0.012	0.022	0.044	0.081	0.133	0.214	0.292
56	0.010	0.018	0.030	0.061	0.114	0.219	0.369	0.615	0.827	**136**	0.005	0.010	0.018	0.030	0.073	0.126	0.232	0.384	0.473
57	0.009	0.016	0.020	0.032	0.052	0.091	0.149	0.250	0.353	**137**	0.005	0.009	0.014	0.025	0.040	0.073	0.113	0.181	0.224
58	0.008	0.014	0.023	0.050	0.092	0.177	0.294	0.514	0.684	**138**	0.004	0.007	0.014	0.030	0.056	0.123	0.205	0.346	0.442
59	0.007	0.012	0.016	0.029	0.047	0.089	0.154	0.235	0.347	**139**	0.004	0.007	0.010	0.020	0.031	0.055	0.096	0.180	0.239
60	0.008	0.014	0.021	0.053	0.096	0.185	0.297	0.485	0.713	**140**	0.004	0.007	0.013	0.026	0.055	0.100	0.199	0.325	0.452

ID	700-year open terrain 3-second gust wind speed, mph									ID	700-year open terrain 3-second gust wind speed, mph								
	110	115	120	130	140	150	160	170	180		110	115	120	130	140	150	160	170	180
61	0.035	0.059	0.066	0.092	0.109	0.185	0.262	0.421	0.487	**141**	0.023	0.039	0.051	0.080	0.102	0.171	0.236	0.386	0.433
62	0.034	0.056	0.060	0.080	0.092	0.143	0.187	0.275	0.289	**142**	0.023	0.039	0.050	0.069	0.085	0.139	0.177	0.277	0.283
63	0.026	0.043	0.049	0.071	0.090	0.150	0.242	0.342	0.415	**143**	0.018	0.030	0.037	0.060	0.081	0.142	0.211	0.317	0.385
64	0.025	0.041	0.045	0.059	0.069	0.108	0.143	0.219	0.242	**144**	0.017	0.028	0.036	0.051	0.063	0.105	0.140	0.219	0.233
65	0.027	0.046	0.052	0.073	0.099	0.170	0.243	0.394	0.472	**145**	0.018	0.030	0.040	0.061	0.084	0.152	0.218	0.350	0.431
66	0.036	0.058	0.077	0.106	0.179	0.281	0.502	0.709	0.943	**146**	0.026	0.042	0.054	0.084	0.116	0.208	0.331	0.535	0.653
67	0.034	0.055	0.063	0.086	0.108	0.173	0.226	0.385	0.490	**147**	0.024	0.041	0.050	0.072	0.086	0.149	0.202	0.323	0.375
68	0.027	0.046	0.054	0.085	0.129	0.239	0.394	0.600	0.798	**148**	0.017	0.028	0.037	0.062	0.091	0.173	0.269	0.418	0.549
69	0.025	0.041	0.047	0.063	0.086	0.129	0.235	0.341	0.439	**149**	0.017	0.028	0.034	0.053	0.076	0.119	0.168	0.292	0.348
70	0.027	0.045	0.060	0.092	0.163	0.300	0.453	0.734	0.952	**150**	0.019	0.032	0.043	0.068	0.105	0.189	0.294	0.518	0.603
71	0.009	0.016	0.022	0.037	0.058	0.101	0.166	0.271	0.361	**151**	0.005	0.010	0.016	0.030	0.049	0.095	0.154	0.228	0.318
72	0.009	0.015	0.019	0.028	0.038	0.063	0.085	0.138	0.163	**152**	0.005	0.009	0.013	0.023	0.032	0.054	0.083	0.135	0.143
73	0.007	0.012	0.017	0.031	0.047	0.096	0.152	0.261	0.342	**153**	0.004	0.007	0.012	0.023	0.041	0.084	0.131	0.218	0.288
74	0.006	0.011	0.014	0.021	0.028	0.048	0.071	0.115	0.145	**154**	0.003	0.006	0.009	0.017	0.025	0.044	0.064	0.105	0.127
75	0.007	0.011	0.018	0.029	0.050	0.087	0.154	0.269	0.352	**155**	0.004	0.007	0.012	0.022	0.043	0.085	0.129	0.223	0.314
76	0.010	0.018	0.030	0.065	0.116	0.220	0.384	0.606	0.802	**156**	0.005	0.010	0.016	0.034	0.070	0.132	0.219	0.389	0.507
77	0.010	0.014	0.022	0.035	0.060	0.099	0.153	0.249	0.344	**157**	0.005	0.009	0.012	0.024	0.043	0.070	0.118	0.178	0.246
78	0.010	0.015	0.026	0.049	0.091	0.180	0.321	0.526	0.709	**158**	0.004	0.008	0.013	0.029	0.051	0.127	0.198	0.326	0.474
79	0.007	0.012	0.017	0.024	0.049	0.084	0.151	0.270	0.359	**159**	0.004	0.006	0.012	0.017	0.032	0.057	0.111	0.178	0.231
80	0.008	0.013	0.024	0.045	0.106	0.188	0.315	0.541	0.681	**160**	0.004	0.008	0.014	0.029	0.057	0.114	0.206	0.312	0.453

APPENDIX F: STANDARD DEVIATION OF TOTAL EXPECTED ANNUAL LOSS FOR TERRAINS 3, 4, AND 5

Table F.1 Standard Deviation of Total Expected Annual Loss (EAL_T), as a Ratio of Building value, z_0=0.35 m

ID	700-year open terrain 3-second gust wind speed, mph									ID	700-year open terrain 3-second gust wind speed, mph								
	110	115	120	130	140	150	160	170	180		110	115	120	130	140	150	160	170	180
1	0.006	0.008	0.016	0.025	0.039	0.058	0.075	0.096	0.114	**81**	0.007	0.007	0.011	0.021	0.033	0.049	0.062	0.084	0.102
2	0.005	0.006	0.011	0.019	0.029	0.042	0.056	0.075	0.088	**82**	0.003	0.006	0.007	0.013	0.023	0.034	0.051	0.060	0.076
3	0.005	0.007	0.013	0.025	0.036	0.050	0.069	0.088	0.106	**83**	0.005	0.006	0.011	0.021	0.032	0.044	0.061	0.081	0.096
4	0.004	0.005	0.009	0.015	0.025	0.036	0.054	0.066	0.085	**84**	0.004	0.004	0.006	0.012	0.021	0.031	0.047	0.059	0.073
5	0.007	0.007	0.016	0.023	0.040	0.056	0.075	0.092	0.116	**85**	0.006	0.007	0.015	0.022	0.032	0.044	0.064	0.085	0.097
6	0.012	0.012	0.020	0.036	0.060	0.081	0.109	0.135	0.153	**86**	0.006	0.008	0.017	0.027	0.042	0.061	0.083	0.107	0.123
7	0.007	0.007	0.011	0.021	0.034	0.046	0.068	0.084	0.098	**87**	0.004	0.006	0.010	0.019	0.026	0.038	0.050	0.072	0.083
8	0.008	0.012	0.021	0.032	0.049	0.070	0.094	0.119	0.134	**88**	0.004	0.006	0.016	0.024	0.034	0.054	0.076	0.092	0.111
9	0.006	0.005	0.011	0.019	0.029	0.043	0.060	0.080	0.099	**89**	0.004	0.006	0.009	0.014	0.027	0.034	0.048	0.067	0.083
10	0.012	0.015	0.026	0.042	0.062	0.082	0.105	0.142	0.159	**90**	0.005	0.009	0.015	0.027	0.046	0.063	0.083	0.106	0.125
11	0.005	0.004	0.010	0.016	0.030	0.040	0.058	0.074	0.091	**91**	0.004	0.005	0.010	0.014	0.022	0.034	0.051	0.061	0.079
12	0.001	0.002	0.004	0.008	0.013	0.020	0.032	0.041	0.052	**92**	0.001	0.002	0.004	0.006	0.013	0.019	0.028	0.033	0.046
13	0.003	0.004	0.010	0.015	0.024	0.041	0.055	0.070	0.086	**93**	0.003	0.004	0.009	0.014	0.027	0.038	0.053	0.067	0.081
14	0.001	0.001	0.004	0.007	0.012	0.019	0.031	0.040	0.051	**94**	0.001	0.002	0.003	0.007	0.012	0.019	0.027	0.036	0.045
15	0.002	0.005	0.008	0.016	0.027	0.041	0.057	0.072	0.089	**95**	0.003	0.004	0.008	0.017	0.025	0.039	0.053	0.066	0.080
16	0.007	0.012	0.019	0.035	0.052	0.070	0.100	0.124	0.144	**96**	0.004	0.005	0.012	0.024	0.038	0.057	0.073	0.097	0.116
17	0.003	0.002	0.005	0.013	0.024	0.036	0.050	0.062	0.082	**97**	0.002	0.004	0.006	0.008	0.022	0.028	0.044	0.053	0.068
18	0.007	0.011	0.018	0.034	0.051	0.063	0.089	0.111	0.132	**98**	0.003	0.006	0.009	0.024	0.032	0.052	0.063	0.088	0.110
19	0.002	0.005	0.007	0.014	0.021	0.035	0.050	0.063	0.081	**99**	0.002	0.002	0.005	0.010	0.020	0.029	0.041	0.053	0.069
20	0.008	0.012	0.018	0.034	0.047	0.064	0.089	0.113	0.131	**100**	0.004	0.007	0.013	0.019	0.035	0.049	0.069	0.088	0.106
21	0.004	0.008	0.011	0.021	0.033	0.045	0.061	0.084	0.098	**101**	0.005	0.005	0.010	0.019	0.029	0.044	0.059	0.074	0.091
22	0.004	0.004	0.006	0.014	0.023	0.031	0.047	0.056	0.073	**102**	0.003	0.005	0.007	0.014	0.018	0.030	0.042	0.050	0.065
23	0.004	0.007	0.012	0.023	0.031	0.048	0.062	0.081	0.097	**103**	0.004	0.005	0.010	0.018	0.029	0.042	0.060	0.076	0.090
24	0.004	0.004	0.008	0.011	0.020	0.031	0.043	0.056	0.069	**104**	0.004	0.004	0.008	0.010	0.021	0.028	0.041	0.052	0.066
25	0.005	0.007	0.012	0.022	0.031	0.043	0.066	0.085	0.096	**105**	0.005	0.006	0.011	0.017	0.031	0.045	0.059	0.078	0.093
26	0.010	0.013	0.023	0.036	0.055	0.077	0.103	0.131	0.149	**106**	0.008	0.010	0.015	0.024	0.044	0.060	0.081	0.101	0.119
27	0.005	0.007	0.011	0.017	0.030	0.042	0.061	0.078	0.095	**107**	0.003	0.004	0.008	0.016	0.025	0.035	0.051	0.068	0.081
28	0.006	0.010	0.019	0.032	0.047	0.071	0.091	0.116	0.135	**108**	0.005	0.007	0.013	0.026	0.037	0.052	0.072	0.094	0.110
29	0.004	0.006	0.009	0.018	0.029	0.040	0.059	0.078	0.092	**109**	0.005	0.005	0.008	0.015	0.023	0.037	0.053	0.069	0.081
30	0.011	0.017	0.024	0.037	0.059	0.083	0.112	0.140	0.157	**110**	0.006	0.011	0.014	0.028	0.044	0.062	0.083	0.107	0.122
31	0.003	0.004	0.007	0.015	0.029	0.040	0.057	0.072	0.089	**111**	0.003	0.003	0.009	0.013	0.024	0.034	0.052	0.063	0.079
32	0.002	0.002	0.004	0.006	0.011	0.021	0.031	0.039	0.050	**112**	0.001	0.002	0.004	0.007	0.012	0.017	0.027	0.034	0.042
33	0.003	0.005	0.007	0.014	0.027	0.040	0.053	0.073	0.086	**113**	0.003	0.006	0.009	0.013	0.025	0.038	0.049	0.067	0.082
34	0.001	0.002	0.004	0.006	0.014	0.021	0.031	0.036	0.051	**114**	0.001	0.001	0.003	0.006	0.012	0.017	0.029	0.036	0.046
35	0.003	0.005	0.009	0.013	0.029	0.039	0.057	0.074	0.093	**115**	0.003	0.004	0.007	0.016	0.023	0.035	0.051	0.066	0.084
36	0.009	0.011	0.021	0.036	0.051	0.074	0.099	0.127	0.143	**116**	0.005	0.008	0.013	0.025	0.041	0.053	0.076	0.097	0.113
37	0.002	0.005	0.010	0.012	0.026	0.033	0.049	0.067	0.081	**117**	0.001	0.003	0.004	0.014	0.018	0.026	0.040	0.050	0.063
38	0.006	0.009	0.018	0.031	0.047	0.065	0.091	0.115	0.132	**118**	0.002	0.008	0.011	0.022	0.037	0.050	0.069	0.093	0.106
39	0.003	0.003	0.006	0.012	0.022	0.036	0.048	0.063	0.080	**119**	0.001	0.003	0.007	0.011	0.019	0.028	0.042	0.054	0.069
40	0.005	0.012	0.019	0.031	0.045	0.065	0.089	0.115	0.130	**120**	0.004	0.006	0.012	0.021	0.032	0.047	0.071	0.091	0.106
41	0.005	0.008	0.014	0.025	0.034	0.054	0.073	0.088	0.112	**121**	0.005	0.006	0.009	0.018	0.028	0.042	0.057	0.082	0.095
42	0.003	0.006	0.008	0.015	0.024	0.035	0.049	0.064	0.080	**122**	0.003	0.004	0.006	0.012	0.017	0.025	0.037	0.047	0.058
43	0.005	0.006	0.013	0.020	0.031	0.047	0.064	0.084	0.100	**123**	0.005	0.005	0.010	0.017	0.025	0.041	0.056	0.072	0.086
44	0.002	0.003	0.006	0.011	0.019	0.031	0.041	0.054	0.070	**124**	0.002	0.003	0.006	0.010	0.016	0.022	0.035	0.042	0.058
45	0.006	0.009	0.013	0.023	0.034	0.048	0.068	0.091	0.104	**125**	0.004	0.006	0.008	0.017	0.028	0.042	0.057	0.077	0.089
46	0.010	0.015	0.024	0.039	0.055	0.078	0.098	0.130	0.148	**126**	0.007	0.007	0.015	0.025	0.041	0.056	0.078	0.102	0.118
47	0.004	0.006	0.008	0.015	0.029	0.041	0.059	0.070	0.092	**127**	0.002	0.003	0.009	0.011	0.018	0.027	0.045	0.056	0.073
48	0.006	0.009	0.018	0.030	0.045	0.066	0.089	0.117	0.129	**128**	0.004	0.008	0.010	0.022	0.035	0.048	0.068	0.088	0.103
49	0.004	0.005	0.010	0.015	0.027	0.038	0.054	0.068	0.083	**129**	0.002	0.003	0.006	0.009	0.021	0.028	0.043	0.052	0.068
50	0.013	0.013	0.024	0.037	0.058	0.079	0.110	0.137	0.153	**130**	0.009	0.009	0.015	0.022	0.039	0.057	0.077	0.101	0.120
51	0.002	0.006	0.008	0.013	0.024	0.036	0.056	0.067	0.084	**131**	0.003	0.004	0.007	0.013	0.024	0.034	0.050	0.063	0.082
52	0.001	0.004	0.002	0.006	0.009	0.015	0.022	0.030	0.037	**132**	0.001	0.001	0.003	0.005	0.011	0.013	0.019	0.027	0.032
53	0.003	0.004	0.008	0.014	0.027	0.037	0.053	0.068	0.084	**133**	0.003	0.004	0.009	0.013	0.025	0.033	0.050	0.064	0.076
54	0.001	0.002	0.003	0.005	0.009	0.015	0.024	0.033	0.042	**134**	0.001	0.002	0.002	0.005	0.009	0.013	0.019	0.027	0.034
55	0.002	0.004	0.009	0.015	0.027	0.039	0.050	0.068	0.083	**135**	0.002	0.004	0.008	0.014	0.020	0.033	0.050	0.064	0.075
56	0.009	0.013	0.022	0.035	0.052	0.077	0.097	0.124	0.143	**136**	0.007	0.006	0.014	0.023	0.037	0.055	0.074	0.094	0.113
57	0.002	0.003	0.006	0.009	0.020	0.032	0.047	0.058	0.074	**137**	0.001	0.003	0.004	0.010	0.012	0.025	0.035	0.047	0.059

ID	700-year open terrain 3-second gust wind speed, mph									ID	700-year open terrain 3-second gust wind speed, mph								
	110	115	120	130	140	150	160	170	180		110	115	120	130	140	150	160	170	180
58	0.006	0.009	0.015	0.029	0.043	0.065	0.088	0.110	0.129	**138**	0.004	0.006	0.011	0.020	0.035	0.045	0.065	0.091	0.103
59	0.002	0.002	0.008	0.012	0.024	0.034	0.047	0.062	0.076	**139**	0.001	0.001	0.006	0.007	0.018	0.021	0.036	0.047	0.063
60	0.004	0.012	0.017	0.029	0.044	0.065	0.084	0.113	0.130	**140**	0.003	0.006	0.009	0.022	0.032	0.046	0.070	0.085	0.103
61	0.004	0.005	0.009	0.015	0.029	0.038	0.055	0.072	0.086	**141**	0.004	0.006	0.008	0.015	0.024	0.034	0.052	0.063	0.079
62	0.002	0.003	0.003	0.008	0.011	0.019	0.027	0.032	0.044	**142**	0.002	0.003	0.004	0.006	0.011	0.015	0.020	0.025	0.035
63	0.004	0.007	0.008	0.015	0.024	0.040	0.056	0.068	0.083	**143**	0.004	0.004	0.008	0.014	0.024	0.036	0.054	0.064	0.078
64	0.001	0.002	0.003	0.006	0.011	0.017	0.022	0.032	0.041	**144**	0.002	0.002	0.004	0.006	0.012	0.015	0.023	0.026	0.038
65	0.004	0.006	0.011	0.017	0.027	0.039	0.058	0.074	0.090	**145**	0.005	0.006	0.009	0.016	0.024	0.035	0.048	0.069	0.082
66	0.010	0.009	0.023	0.033	0.052	0.073	0.097	0.123	0.142	**146**	0.004	0.009	0.011	0.023	0.036	0.054	0.079	0.099	0.116
67	0.003	0.003	0.007	0.013	0.023	0.034	0.051	0.058	0.079	**147**	0.004	0.004	0.005	0.010	0.018	0.024	0.036	0.048	0.061
68	0.005	0.011	0.019	0.030	0.045	0.064	0.089	0.112	0.130	**148**	0.003	0.008	0.014	0.022	0.034	0.051	0.068	0.088	0.105
69	0.003	0.004	0.007	0.013	0.023	0.034	0.048	0.060	0.077	**149**	0.002	0.003	0.005	0.011	0.017	0.027	0.038	0.048	0.064
70	0.010	0.014	0.023	0.036	0.056	0.076	0.106	0.135	0.153	**150**	0.005	0.009	0.013	0.027	0.041	0.060	0.079	0.102	0.119
71	0.002	0.004	0.007	0.017	0.021	0.039	0.053	0.069	0.080	**151**	0.002	0.004	0.008	0.012	0.023	0.034	0.046	0.063	0.075
72	0.001	0.002	0.002	0.004	0.009	0.016	0.019	0.030	0.037	**152**	0.001	0.001	0.002	0.004	0.008	0.012	0.020	0.026	0.031
73	0.003	0.004	0.010	0.016	0.026	0.037	0.051	0.069	0.081	**153**	0.003	0.005	0.006	0.013	0.023	0.032	0.053	0.065	0.079
74	0.001	0.001	0.002	0.004	0.009	0.015	0.023	0.030	0.040	**154**	0.001	0.001	0.002	0.005	0.008	0.012	0.020	0.030	0.037
75	0.003	0.004	0.011	0.012	0.024	0.037	0.054	0.068	0.084	**155**	0.003	0.005	0.009	0.013	0.025	0.035	0.051	0.064	0.081
76	0.009	0.013	0.019	0.034	0.049	0.071	0.096	0.121	0.144	**156**	0.005	0.007	0.013	0.022	0.036	0.051	0.072	0.094	0.118
77	0.002	0.003	0.008	0.009	0.021	0.031	0.047	0.057	0.075	**157**	0.001	0.004	0.004	0.007	0.014	0.024	0.036	0.049	0.057
78	0.007	0.011	0.018	0.030	0.046	0.064	0.085	0.110	0.127	**158**	0.005	0.005	0.010	0.019	0.034	0.052	0.068	0.080	0.104
79	0.002	0.004	0.007	0.012	0.021	0.033	0.053	0.057	0.075	**159**	0.002	0.001	0.003	0.011	0.018	0.026	0.038	0.051	0.062
80	0.009	0.010	0.016	0.031	0.047	0.064	0.089	0.112	0.128	**160**	0.003	0.007	0.012	0.021	0.034	0.048	0.065	0.084	0.104

Table F.2 Standard Deviation of Total Expected Annual Loss (EAL_T), as a Ratio of Building Value, z_0=0.7 m

ID	700-year open terrain 3-second gust wind speed, mph									ID	700-year open terrain 3-second gust wind speed, mph								
	110	115	120	130	140	150	160	170	180		110	115	120	130	140	150	160	170	180
1	0.005	0.005	0.011	0.013	0.027	0.039	0.053	0.073	0.086	**81**	0.006	0.003	0.008	0.012	0.020	0.033	0.044	0.055	0.072
2	0.003	0.004	0.007	0.012	0.023	0.031	0.045	0.056	0.070	**82**	0.002	0.003	0.005	0.011	0.016	0.024	0.036	0.049	0.057
3	0.003	0.005	0.008	0.013	0.025	0.033	0.050	0.065	0.081	**83**	0.002	0.003	0.006	0.012	0.020	0.030	0.041	0.054	0.070
4	0.003	0.004	0.008	0.011	0.021	0.029	0.039	0.052	0.064	**84**	0.002	0.003	0.005	0.009	0.017	0.023	0.032	0.046	0.053
5	0.003	0.006	0.008	0.015	0.024	0.040	0.054	0.068	0.083	**85**	0.003	0.003	0.008	0.014	0.020	0.032	0.044	0.059	0.074
6	0.004	0.010	0.012	0.025	0.039	0.055	0.077	0.095	0.116	**86**	0.003	0.006	0.009	0.017	0.027	0.043	0.059	0.072	0.090
7	0.003	0.005	0.010	0.013	0.023	0.034	0.053	0.064	0.077	**87**	0.002	0.003	0.007	0.011	0.019	0.028	0.039	0.050	0.062
8	0.003	0.006	0.011	0.020	0.033	0.047	0.067	0.088	0.100	**88**	0.003	0.003	0.006	0.015	0.026	0.038	0.051	0.065	0.083
9	0.002	0.003	0.007	0.012	0.021	0.033	0.051	0.059	0.075	**89**	0.002	0.004	0.006	0.009	0.018	0.026	0.039	0.050	0.064
10	0.005	0.007	0.014	0.026	0.039	0.058	0.076	0.097	0.115	**90**	0.004	0.005	0.011	0.020	0.028	0.041	0.056	0.075	0.092
11	0.002	0.002	0.005	0.010	0.019	0.025	0.035	0.046	0.059	**91**	0.002	0.003	0.005	0.008	0.013	0.021	0.033	0.038	0.051
12	0.001	0.001	0.002	0.004	0.006	0.016	0.020	0.027	0.038	**92**	0.001	0.001	0.002	0.004	0.006	0.013	0.017	0.022	0.029
13	0.002	0.002	0.003	0.010	0.018	0.022	0.038	0.048	0.059	**93**	0.002	0.003	0.005	0.009	0.012	0.021	0.032	0.042	0.055
14	0.001	0.003	0.002	0.004	0.009	0.013	0.019	0.026	0.035	**94**	0.001	0.001	0.002	0.003	0.007	0.011	0.018	0.021	0.029
15	0.001	0.002	0.006	0.008	0.014	0.022	0.037	0.048	0.060	**95**	0.001	0.002	0.004	0.008	0.017	0.022	0.035	0.040	0.053
16	0.005	0.006	0.012	0.023	0.033	0.045	0.070	0.088	0.108	**96**	0.002	0.005	0.005	0.015	0.025	0.035	0.050	0.064	0.083
17	0.001	0.002	0.003	0.006	0.016	0.025	0.035	0.046	0.060	**97**	0.001	0.001	0.002	0.007	0.012	0.018	0.029	0.035	0.049
18	0.004	0.007	0.009	0.018	0.029	0.042	0.061	0.078	0.095	**98**	0.004	0.002	0.008	0.013	0.019	0.031	0.048	0.059	0.073
19	0.001	0.002	0.004	0.010	0.016	0.027	0.035	0.047	0.062	**99**	0.001	0.001	0.003	0.005	0.011	0.020	0.029	0.038	0.048
20	0.002	0.005	0.011	0.018	0.032	0.042	0.062	0.074	0.102	**100**	0.002	0.003	0.006	0.012	0.018	0.033	0.046	0.061	0.076
21	0.003	0.004	0.007	0.012	0.020	0.031	0.042	0.058	0.071	**101**	0.002	0.003	0.006	0.011	0.020	0.026	0.042	0.052	0.062
22	0.002	0.003	0.007	0.009	0.014	0.024	0.033	0.041	0.054	**102**	0.003	0.003	0.005	0.009	0.016	0.023	0.030	0.037	0.048
23	0.002	0.003	0.009	0.012	0.023	0.029	0.043	0.058	0.071	**103**	0.003	0.004	0.006	0.011	0.020	0.028	0.041	0.052	0.066
24	0.002	0.003	0.006	0.009	0.017	0.021	0.032	0.039	0.052	**104**	0.002	0.002	0.004	0.008	0.012	0.020	0.029	0.035	0.049
25	0.004	0.005	0.007	0.011	0.020	0.031	0.043	0.055	0.072	**105**	0.003	0.004	0.007	0.013	0.018	0.029	0.040	0.052	0.064
26	0.005	0.007	0.014	0.024	0.036	0.054	0.074	0.096	0.112	**106**	0.003	0.007	0.006	0.016	0.027	0.038	0.057	0.072	0.086
27	0.004	0.003	0.007	0.012	0.019	0.029	0.043	0.058	0.069	**107**	0.002	0.004	0.005	0.010	0.017	0.023	0.037	0.050	0.063
28	0.004	0.006	0.012	0.021	0.034	0.044	0.066	0.082	0.100	**108**	0.002	0.005	0.010	0.014	0.024	0.035	0.049	0.067	0.079
29	0.002	0.003	0.006	0.014	0.019	0.031	0.048	0.059	0.073	**109**	0.002	0.003	0.004	0.010	0.018	0.028	0.038	0.052	0.062
30	0.008	0.007	0.012	0.023	0.040	0.055	0.079	0.094	0.113	**110**	0.003	0.003	0.009	0.018	0.028	0.039	0.058	0.072	0.086
31	0.002	0.002	0.004	0.007	0.015	0.022	0.037	0.045	0.059	**111**	0.002	0.002	0.003	0.006	0.014	0.021	0.031	0.043	0.053
32	0.001	0.001	0.002	0.004	0.010	0.012	0.022	0.025	0.036	**112**	0.002	0.001	0.002	0.003	0.008	0.011	0.017	0.025	0.032
33	0.002	0.002	0.005	0.009	0.014	0.026	0.039	0.047	0.057	**113**	0.002	0.002	0.005	0.007	0.014	0.021	0.033	0.043	0.055
34	0.001	0.001	0.003	0.003	0.007	0.014	0.019	0.025	0.034	**114**	0.001	0.001	0.001	0.003	0.007	0.012	0.018	0.024	0.034
35	0.002	0.002	0.004	0.009	0.017	0.024	0.037	0.048	0.060	**115**	0.001	0.002	0.004	0.010	0.014	0.022	0.032	0.042	0.057
36	0.002	0.006	0.013	0.020	0.032	0.048	0.070	0.085	0.103	**116**	0.001	0.004	0.005	0.013	0.025	0.036	0.051	0.064	0.084
37	0.001	0.003	0.004	0.009	0.016	0.023	0.034	0.047	0.062	**117**	0.001	0.001	0.002	0.006	0.012	0.017	0.029	0.038	0.048
38	0.002	0.004	0.010	0.017	0.027	0.042	0.063	0.078	0.095	**118**	0.002	0.002	0.009	0.013	0.022	0.032	0.049	0.056	0.076
39	0.001	0.001	0.004	0.006	0.017	0.027	0.038	0.049	0.062	**119**	0.001	0.001	0.002	0.006	0.012	0.020	0.029	0.037	0.047
40	0.005	0.004	0.009	0.018	0.025	0.041	0.062	0.080	0.098	**120**	0.001	0.005	0.007	0.014	0.023	0.030	0.047	0.055	0.075
41	0.003	0.004	0.009	0.016	0.022	0.036	0.052	0.068	0.079	**121**	0.003	0.003	0.005	0.010	0.018	0.028	0.042	0.051	0.063
42	0.003	0.003	0.006	0.010	0.018	0.023	0.039	0.050	0.065	**122**	0.002	0.002	0.004	0.007	0.013	0.018	0.027	0.033	0.045
43	0.002	0.004	0.006	0.011	0.021	0.028	0.044	0.056	0.073	**123**	0.002	0.003	0.005	0.009	0.016	0.026	0.035	0.050	0.058
44	0.002	0.002	0.004	0.007	0.014	0.022	0.035	0.042	0.057	**124**	0.001	0.002	0.003	0.004	0.011	0.013	0.024	0.031	0.039
45	0.002	0.004	0.006	0.017	0.025	0.032	0.051	0.063	0.079	**125**	0.002	0.004	0.004	0.010	0.017	0.027	0.042	0.051	0.064
46	0.006	0.005	0.014	0.021	0.039	0.053	0.074	0.093	0.112	**126**	0.003	0.003	0.007	0.016	0.024	0.038	0.051	0.068	0.084
47	0.002	0.003	0.008	0.011	0.022	0.032	0.041	0.060	0.071	**127**	0.002	0.002	0.005	0.006	0.014	0.019	0.029	0.037	0.054
48	0.002	0.004	0.008	0.020	0.029	0.045	0.059	0.082	0.099	**128**	0.002	0.006	0.006	0.011	0.021	0.031	0.046	0.063	0.075
49	0.002	0.004	0.004	0.015	0.018	0.028	0.041	0.054	0.069	**129**	0.002	0.002	0.002	0.008	0.012	0.019	0.028	0.036	0.050
50	0.006	0.008	0.011	0.025	0.040	0.051	0.072	0.091	0.114	**130**	0.003	0.002	0.006	0.015	0.022	0.037	0.053	0.069	0.084
51	0.001	0.002	0.004	0.009	0.014	0.022	0.033	0.042	0.054	**131**	0.001	0.002	0.005	0.007	0.012	0.017	0.029	0.036	0.050
52	0.001	0.001	0.002	0.003	0.005	0.009	0.014	0.018	0.027	**132**	0.001	0.001	0.002	0.003	0.004	0.007	0.010	0.014	0.017
53	0.001	0.002	0.004	0.010	0.014	0.023	0.032	0.040	0.053	**133**	0.002	0.001	0.004	0.007	0.010	0.020	0.031	0.036	0.049
54	0.001	0.001	0.002	0.002	0.006	0.007	0.012	0.016	0.023	**134**	0.000	0.001	0.002	0.002	0.004	0.007	0.011	0.016	0.018
55	0.002	0.002	0.006	0.008	0.016	0.021	0.031	0.043	0.055	**135**	0.001	0.002	0.003	0.007	0.012	0.018	0.030	0.039	0.051
56	0.005	0.004	0.013	0.020	0.037	0.046	0.064	0.085	0.104	**136**	0.002	0.004	0.008	0.015	0.022	0.034	0.048	0.060	0.081
57	0.001	0.001	0.003	0.009	0.015	0.021	0.033	0.046	0.056	**137**	0.001	0.001	0.003	0.007	0.009	0.016	0.026	0.030	0.041
58	0.003	0.005	0.008	0.016	0.029	0.043	0.058	0.077	0.096	**138**	0.001	0.003	0.008	0.011	0.021	0.030	0.047	0.060	0.071
59	0.001	0.002	0.004	0.006	0.016	0.021	0.034	0.046	0.059	**139**	0.001	0.001	0.004	0.004	0.012	0.014	0.030	0.033	0.046
60	0.003	0.004	0.010	0.019	0.031	0.043	0.059	0.075	0.096	**140**	0.001	0.002	0.009	0.011	0.020	0.034	0.044	0.061	0.079
61	0.002	0.003	0.005	0.009	0.016	0.023	0.038	0.039	0.056	**141**	0.002	0.003	0.005	0.008	0.015	0.021	0.029	0.039	0.047
62	0.002	0.002	0.003	0.005	0.007	0.011	0.017	0.021	0.029	**142**	0.002	0.002	0.003	0.004	0.007	0.010	0.013	0.016	0.021

ID	700-year open terrain 3-second gust wind speed, mph									ID	700-year open terrain 3-second gust wind speed, mph								
	110	115	120	130	140	150	160	170	180		110	115	120	130	140	150	160	170	180
63	0.002	0.003	0.004	0.009	0.015	0.025	0.035	0.044	0.059	**143**	0.003	0.002	0.004	0.009	0.014	0.021	0.029	0.040	0.050
64	0.001	0.002	0.002	0.005	0.006	0.009	0.015	0.019	0.024	**144**	0.001	0.002	0.002	0.004	0.007	0.008	0.014	0.015	0.021
65	0.002	0.003	0.005	0.008	0.016	0.025	0.039	0.048	0.060	**145**	0.002	0.003	0.004	0.008	0.015	0.021	0.032	0.041	0.054
66	0.004	0.005	0.011	0.023	0.034	0.051	0.067	0.088	0.106	**146**	0.003	0.003	0.008	0.016	0.025	0.037	0.049	0.064	0.081
67	0.002	0.002	0.003	0.007	0.014	0.022	0.032	0.042	0.052	**147**	0.002	0.003	0.003	0.006	0.010	0.015	0.028	0.033	0.041
68	0.003	0.005	0.009	0.019	0.030	0.044	0.060	0.079	0.091	**148**	0.002	0.002	0.005	0.010	0.019	0.032	0.045	0.059	0.073
69	0.001	0.003	0.004	0.009	0.016	0.020	0.034	0.045	0.057	**149**	0.001	0.001	0.003	0.006	0.012	0.020	0.027	0.037	0.046
70	0.004	0.007	0.013	0.024	0.037	0.051	0.074	0.094	0.114	**150**	0.002	0.003	0.006	0.013	0.025	0.037	0.055	0.069	0.086
71	0.003	0.002	0.004	0.009	0.017	0.020	0.034	0.042	0.052	**151**	0.001	0.002	0.002	0.007	0.013	0.019	0.028	0.038	0.049
72	0.001	0.001	0.001	0.003	0.005	0.009	0.013	0.017	0.025	**152**	0.001	0.001	0.001	0.002	0.004	0.006	0.011	0.013	0.018
73	0.001	0.002	0.003	0.007	0.016	0.022	0.032	0.044	0.056	**153**	0.001	0.001	0.004	0.009	0.012	0.019	0.029	0.042	0.049
74	0.001	0.001	0.001	0.002	0.006	0.008	0.012	0.016	0.023	**154**	0.001	0.001	0.001	0.002	0.004	0.006	0.011	0.015	0.023
75	0.001	0.002	0.003	0.008	0.014	0.022	0.034	0.043	0.055	**155**	0.001	0.002	0.003	0.007	0.012	0.022	0.029	0.041	0.049
76	0.002	0.004	0.009	0.021	0.031	0.045	0.067	0.085	0.104	**156**	0.001	0.003	0.006	0.014	0.023	0.034	0.045	0.061	0.078
77	0.001	0.003	0.003	0.009	0.014	0.019	0.034	0.044	0.055	**157**	0.001	0.001	0.003	0.005	0.009	0.013	0.024	0.030	0.043
78	0.003	0.004	0.009	0.016	0.029	0.044	0.060	0.078	0.092	**158**	0.002	0.002	0.005	0.013	0.021	0.027	0.044	0.058	0.075
79	0.001	0.001	0.005	0.007	0.012	0.023	0.036	0.043	0.061	**159**	0.001	0.001	0.002	0.007	0.012	0.018	0.027	0.033	0.047
80	0.003	0.005	0.009	0.018	0.028	0.044	0.060	0.078	0.097	**160**	0.001	0.004	0.005	0.009	0.021	0.034	0.044	0.059	0.074

Table F.3 Standard Deviation of Total Expected Annual Loss (EAL_T), as a Ratio of Building Value, z_0=1 m

ID	700-year open terrain 3-second gust wind speed, mph									ID	700-year open terrain 3-second gust wind speed, mph								
	110	115	120	130	140	150	160	170	180		110	115	120	130	140	150	160	170	180
1	0.003	0.003	0.006	0.015	0.023	0.035	0.046	0.061	0.073	**81**	0.002	0.004	0.005	0.010	0.015	0.025	0.036	0.049	0.060
2	0.002	0.003	0.005	0.010	0.019	0.027	0.038	0.049	0.062	**82**	0.002	0.002	0.004	0.008	0.012	0.020	0.029	0.040	0.051
3	0.002	0.003	0.006	0.014	0.019	0.029	0.040	0.051	0.071	**83**	0.002	0.003	0.004	0.009	0.016	0.023	0.036	0.046	0.056
4	0.003	0.003	0.005	0.009	0.015	0.024	0.033	0.045	0.058	**84**	0.001	0.003	0.003	0.006	0.012	0.019	0.028	0.037	0.048
5	0.002	0.003	0.005	0.013	0.022	0.030	0.045	0.055	0.068	**85**	0.002	0.003	0.007	0.009	0.017	0.026	0.036	0.048	0.056
6	0.004	0.008	0.008	0.018	0.030	0.046	0.064	0.078	0.099	**86**	0.002	0.006	0.006	0.010	0.021	0.034	0.048	0.061	0.071
7	0.002	0.003	0.006	0.011	0.023	0.030	0.042	0.055	0.070	**87**	0.002	0.003	0.004	0.009	0.020	0.020	0.031	0.041	0.057
8	0.003	0.005	0.009	0.016	0.026	0.041	0.053	0.068	0.091	**88**	0.003	0.002	0.009	0.011	0.023	0.031	0.040	0.052	0.070
9	0.002	0.003	0.006	0.011	0.019	0.029	0.043	0.056	0.064	**89**	0.002	0.002	0.004	0.008	0.017	0.021	0.033	0.046	0.056
10	0.002	0.007	0.009	0.022	0.033	0.044	0.063	0.080	0.099	**90**	0.002	0.004	0.007	0.014	0.023	0.033	0.046	0.060	0.072
11	0.001	0.002	0.003	0.006	0.013	0.015	0.024	0.034	0.044	**91**	0.001	0.002	0.002	0.006	0.010	0.014	0.025	0.029	0.041
12	0.001	0.001	0.001	0.003	0.007	0.010	0.016	0.019	0.026	**92**	0.001	0.001	0.001	0.003	0.005	0.009	0.012	0.019	0.025
13	0.001	0.001	0.004	0.007	0.011	0.016	0.030	0.032	0.047	**93**	0.001	0.001	0.003	0.005	0.011	0.017	0.024	0.032	0.039
14	0.001	0.001	0.001	0.003	0.006	0.012	0.016	0.019	0.029	**94**	0.000	0.001	0.002	0.003	0.006	0.009	0.012	0.017	0.023
15	0.001	0.001	0.003	0.006	0.010	0.018	0.027	0.034	0.048	**95**	0.001	0.002	0.003	0.007	0.010	0.018	0.023	0.030	0.040
16	0.002	0.005	0.009	0.015	0.027	0.037	0.059	0.075	0.085	**96**	0.006	0.002	0.006	0.006	0.016	0.025	0.042	0.054	0.066
17	0.001	0.002	0.006	0.006	0.012	0.018	0.031	0.040	0.051	**97**	0.001	0.001	0.003	0.005	0.008	0.014	0.024	0.031	0.041
18	0.002	0.002	0.005	0.010	0.025	0.032	0.049	0.063	0.079	**98**	0.001	0.002	0.002	0.009	0.016	0.025	0.036	0.049	0.058
19	0.001	0.001	0.003	0.010	0.016	0.022	0.031	0.041	0.055	**99**	0.000	0.001	0.002	0.007	0.009	0.016	0.022	0.030	0.044
20	0.003	0.006	0.005	0.016	0.024	0.034	0.051	0.064	0.075	**100**	0.001	0.001	0.004	0.007	0.015	0.025	0.038	0.047	0.058
21	0.002	0.004	0.005	0.010	0.016	0.024	0.033	0.045	0.059	**101**	0.002	0.003	0.005	0.007	0.014	0.022	0.032	0.040	0.051
22	0.003	0.003	0.005	0.010	0.013	0.019	0.028	0.036	0.045	**102**	0.002	0.003	0.004	0.008	0.010	0.019	0.024	0.035	0.043
23	0.003	0.003	0.006	0.011	0.018	0.025	0.038	0.045	0.054	**103**	0.001	0.002	0.004	0.007	0.014	0.022	0.032	0.041	0.053
24	0.001	0.002	0.004	0.006	0.013	0.019	0.028	0.034	0.047	**104**	0.001	0.002	0.005	0.007	0.011	0.017	0.026	0.034	0.043
25	0.002	0.003	0.006	0.010	0.017	0.024	0.037	0.048	0.053	**105**	0.002	0.003	0.004	0.008	0.015	0.023	0.033	0.042	0.052
26	0.003	0.005	0.008	0.017	0.030	0.042	0.058	0.076	0.094	**106**	0.003	0.003	0.006	0.014	0.021	0.030	0.045	0.060	0.075
27	0.002	0.003	0.005	0.009	0.018	0.025	0.037	0.048	0.060	**107**	0.002	0.002	0.004	0.008	0.014	0.022	0.030	0.040	0.053
28	0.002	0.003	0.008	0.016	0.025	0.036	0.053	0.071	0.084	**108**	0.002	0.002	0.006	0.011	0.019	0.028	0.036	0.052	0.064
29	0.002	0.002	0.005	0.011	0.018	0.024	0.037	0.048	0.067	**109**	0.002	0.002	0.004	0.007	0.016	0.024	0.033	0.043	0.056
30	0.003	0.006	0.012	0.015	0.028	0.045	0.063	0.079	0.099	**110**	0.003	0.003	0.006	0.012	0.020	0.031	0.048	0.058	0.074
31	0.001	0.001	0.003	0.007	0.014	0.016	0.023	0.034	0.046	**111**	0.001	0.001	0.003	0.005	0.012	0.014	0.025	0.029	0.039
32	0.001	0.001	0.002	0.003	0.007	0.013	0.016	0.021	0.029	**112**	0.001	0.001	0.001	0.004	0.005	0.009	0.015	0.018	0.025
33	0.001	0.001	0.002	0.006	0.012	0.019	0.028	0.034	0.046	**113**	0.001	0.002	0.002	0.005	0.011	0.015	0.024	0.028	0.039
34	0.001	0.001	0.001	0.002	0.006	0.009	0.014	0.019	0.026	**114**	0.001	0.001	0.001	0.003	0.006	0.011	0.012	0.019	0.026
35	0.001	0.001	0.003	0.007	0.010	0.017	0.024	0.035	0.047	**115**	0.001	0.001	0.003	0.004	0.009	0.017	0.022	0.031	0.041
36	0.003	0.002	0.007	0.011	0.027	0.040	0.058	0.071	0.090	**116**	0.001	0.001	0.003	0.010	0.015	0.025	0.039	0.051	0.069
37	0.001	0.001	0.003	0.007	0.014	0.022	0.030	0.040	0.054	**117**	0.001	0.001	0.002	0.006	0.008	0.015	0.023	0.030	0.043
38	0.002	0.005	0.007	0.014	0.023	0.033	0.049	0.063	0.081	**118**	0.001	0.001	0.005	0.009	0.017	0.024	0.035	0.046	0.062
39	0.001	0.001	0.002	0.006	0.014	0.017	0.032	0.039	0.055	**119**	0.000	0.001	0.003	0.003	0.010	0.016	0.025	0.032	0.043
40	0.002	0.002	0.006	0.016	0.022	0.034	0.048	0.066	0.079	**120**	0.001	0.001	0.006	0.005	0.016	0.024	0.037	0.050	0.063
41	0.002	0.003	0.006	0.011	0.019	0.029	0.041	0.054	0.068	**121**	0.002	0.002	0.004	0.007	0.014	0.020	0.032	0.042	0.051
42	0.002	0.005	0.005	0.007	0.015	0.020	0.031	0.042	0.050	**122**	0.001	0.002	0.003	0.005	0.010	0.013	0.021	0.029	0.039
43	0.002	0.002	0.004	0.009	0.015	0.024	0.037	0.044	0.058	**123**	0.001	0.002	0.003	0.006	0.011	0.018	0.029	0.033	0.045
44	0.002	0.002	0.003	0.007	0.011	0.017	0.028	0.034	0.046	**124**	0.001	0.001	0.002	0.004	0.008	0.013	0.018	0.024	0.038
45	0.002	0.003	0.005	0.010	0.019	0.027	0.037	0.051	0.065	**125**	0.001	0.002	0.003	0.008	0.013	0.021	0.030	0.039	0.054
46	0.004	0.006	0.009	0.017	0.032	0.044	0.055	0.075	0.091	**126**	0.002	0.002	0.005	0.012	0.018	0.028	0.038	0.055	0.068
47	0.002	0.003	0.004	0.007	0.018	0.027	0.037	0.046	0.057	**127**	0.002	0.002	0.004	0.006	0.011	0.018	0.025	0.034	0.043
48	0.005	0.003	0.008	0.016	0.021	0.038	0.051	0.066	0.081	**128**	0.001	0.002	0.005	0.011	0.015	0.026	0.039	0.048	0.061
49	0.002	0.002	0.003	0.010	0.017	0.023	0.036	0.044	0.060	**129**	0.001	0.002	0.002	0.007	0.011	0.014	0.025	0.032	0.042
50	0.003	0.004	0.007	0.015	0.028	0.042	0.058	0.080	0.093	**130**	0.002	0.004	0.005	0.009	0.019	0.030	0.041	0.052	0.068
51	0.001	0.001	0.002	0.007	0.011	0.014	0.022	0.031	0.039	**131**	0.001	0.001	0.002	0.004	0.011	0.012	0.021	0.025	0.033
52	0.001	0.001	0.001	0.002	0.003	0.005	0.009	0.013	0.016	**132**	0.000	0.001	0.001	0.002	0.004	0.005	0.007	0.010	0.013
53	0.001	0.002	0.003	0.005	0.010	0.017	0.022	0.030	0.040	**133**	0.001	0.001	0.002	0.005	0.009	0.015	0.019	0.025	0.037
54	0.000	0.001	0.001	0.001	0.003	0.006	0.009	0.011	0.016	**134**	0.000	0.001	0.001	0.001	0.003	0.005	0.006	0.010	0.014
55	0.001	0.002	0.003	0.007	0.009	0.015	0.027	0.031	0.041	**135**	0.001	0.001	0.002	0.005	0.010	0.014	0.023	0.026	0.035
56	0.002	0.003	0.010	0.012	0.025	0.038	0.054	0.070	0.085	**136**	0.001	0.001	0.009	0.007	0.016	0.023	0.036	0.048	0.065
57	0.001	0.001	0.002	0.004	0.013	0.017	0.028	0.035	0.046	**137**	0.001	0.001	0.001	0.003	0.004	0.011	0.018	0.024	0.034
58	0.001	0.002	0.006	0.014	0.020	0.030	0.048	0.061	0.078	**138**	0.001	0.002	0.004	0.009	0.018	0.022	0.037	0.046	0.059
59	0.000	0.001	0.002	0.009	0.012	0.016	0.027	0.038	0.050	**139**	0.000	0.001	0.001	0.004	0.009	0.012	0.020	0.028	0.037
60	0.002	0.004	0.005	0.012	0.023	0.031	0.046	0.063	0.076	**140**	0.001	0.002	0.003	0.009	0.016	0.020	0.036	0.047	0.056
61	0.002	0.002	0.003	0.006	0.011	0.018	0.025	0.031	0.042	**141**	0.002	0.002	0.003	0.005	0.008	0.015	0.021	0.027	0.035
62	0.001	0.002	0.002	0.004	0.006	0.008	0.012	0.016	0.021	**142**	0.001	0.002	0.003	0.004	0.005	0.007	0.010	0.011	0.017

ID	700-year open terrain 3-second gust wind speed, mph									ID	700-year open terrain 3-second gust wind speed, mph								
	110	115	120	130	140	150	160	170	180		110	115	120	130	140	150	160	170	180
63	0.001	0.002	0.004	0.006	0.014	0.017	0.023	0.030	0.039	**143**	0.002	0.002	0.002	0.006	0.011	0.015	0.023	0.029	0.037
64	0.001	0.001	0.002	0.003	0.004	0.007	0.011	0.014	0.018	**144**	0.001	0.001	0.002	0.003	0.004	0.006	0.010	0.012	0.017
65	0.001	0.002	0.003	0.005	0.014	0.017	0.027	0.034	0.044	**145**	0.002	0.002	0.003	0.005	0.012	0.016	0.021	0.028	0.039
66	0.003	0.004	0.007	0.015	0.030	0.040	0.057	0.072	0.087	**146**	0.001	0.003	0.005	0.010	0.015	0.023	0.039	0.052	0.066
67	0.001	0.002	0.003	0.005	0.012	0.018	0.028	0.035	0.048	**147**	0.001	0.002	0.003	0.004	0.009	0.009	0.020	0.024	0.034
68	0.002	0.002	0.007	0.014	0.019	0.032	0.049	0.063	0.077	**148**	0.001	0.002	0.004	0.007	0.017	0.025	0.035	0.046	0.058
69	0.001	0.001	0.004	0.004	0.012	0.021	0.030	0.041	0.051	**149**	0.001	0.002	0.003	0.004	0.009	0.013	0.023	0.033	0.041
70	0.003	0.003	0.011	0.015	0.026	0.043	0.058	0.075	0.092	**150**	0.002	0.003	0.004	0.013	0.017	0.031	0.043	0.056	0.067
71	0.001	0.001	0.002	0.005	0.011	0.015	0.023	0.031	0.042	**151**	0.001	0.001	0.002	0.004	0.010	0.015	0.019	0.024	0.034
72	0.001	0.001	0.001	0.002	0.003	0.005	0.008	0.014	0.019	**152**	0.001	0.001	0.001	0.002	0.003	0.005	0.009	0.010	0.013
73	0.002	0.001	0.002	0.005	0.008	0.015	0.022	0.031	0.043	**153**	0.001	0.001	0.002	0.004	0.009	0.015	0.021	0.025	0.036
74	0.000	0.001	0.001	0.001	0.003	0.005	0.007	0.012	0.017	**154**	0.000	0.001	0.001	0.002	0.004	0.005	0.009	0.009	0.013
75	0.001	0.001	0.003	0.004	0.008	0.015	0.025	0.031	0.042	**155**	0.001	0.001	0.002	0.004	0.009	0.012	0.021	0.027	0.036
76	0.002	0.003	0.011	0.015	0.027	0.040	0.051	0.072	0.088	**156**	0.001	0.004	0.003	0.011	0.020	0.028	0.037	0.048	0.062
77	0.001	0.001	0.002	0.006	0.016	0.017	0.029	0.034	0.046	**157**	0.001	0.002	0.002	0.002	0.009	0.012	0.022	0.020	0.036
78	0.003	0.003	0.007	0.012	0.023	0.034	0.049	0.060	0.079	**158**	0.001	0.002	0.006	0.007	0.013	0.027	0.036	0.049	0.057
79	0.001	0.001	0.002	0.004	0.014	0.021	0.027	0.038	0.051	**159**	0.001	0.001	0.001	0.005	0.007	0.013	0.020	0.029	0.037
80	0.002	0.003	0.005	0.013	0.023	0.033	0.049	0.062	0.078	**160**	0.001	0.001	0.004	0.006	0.016	0.023	0.036	0.049	0.061

VITA

Fatemeh (Mahtab) Orooji was born in Tehran, Iran, in 1982. She received B.S. and M.S. degrees in Architecture from Sooreh University in 2006, and from the University of Tehran in 2009, respectively. She joined Louisiana State University (LSU) in Baton Rouge, Louisiana in August 2011 to pursue a Ph.D. in Engineering Science with concentration in Construction Management. She obtained an M.S. in Construction Management from LSU in 2014. Fatemeh Orooji worked as a graduate research and teaching assistant at LSU from 2011 to present.