Enclosure 3
Staff Responses to Public Comments on Draft Regulatory Guide DG-1143
(Proposed Revision 1 of Regulatory Guide 1.76)
(Public comments have been edited for clarity)

Comments			NRC Comment Resolution
Originator	**DG-1143 Section**	**Specific Comments**	
Consulting Engineer (Public Citizen) 03/23/2006 letter (ML060830478)	general (comment 1)	It is not clear why 10^{-7}/yr tornado probability of exceedance level was chosen. This probability level is significantly less than the earthquake probability levels of 10^{-4}/yr mean or 10^{-5}/yr median design defined for the safe-shutdown earthquake in Regulatory Guide (RG) 1.165.	The regulatory guidance used to review the current fleet of operating power reactors (e.g., Section 2.2.3 of RG 1.70, “Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants,” and Section3.3.2 of the Standard Review Plan (SRP)) sets probabilistic guidelines for considering external initiators that have potential consequences serious enough to affect the safety of the plant to the extent that guidelines Part 100, “Reactor Site Criteria,” of Title 10 the *Code of Federal Regulations* (10 CFR Part 100) could be exceeded. In practice, a conservative interpretation of this criterion has generally meant that the initiating event should have a probability of occurrence of less than 10^{-7} per year. In the case of the design-basis tornado (as defined in the basis document for RG 1.76 (WASH-1300, “Technical Basis for Interim Regional Tornado Criteria,” dated May 1974), the staff’s March 1988 interim position on the design-basis tornado, and SECY-93-087, “Policy, Technical, and Licensing Issues Pertaining to Evolutionary and Advanced Light-Water Reactor (ALWR) Design”), the structural design need not account for the external initiating event if the probability of occurrence of the event is less than 10^{-7} per year. In the staff requirements memorandum (SRM) for SECY-04-200, “A Risk-Informed Approach to Defining the Design-Basis Tornado for New Reactor Licensing,” the Commission endorsed the continued definition of the values of the design-basis tornado parameters as those of a tornado having a mean frequency of 10^{-7} per year.

Comments			NRC Comment Resolution
Originator	DG-1143 Section	Specific Comments	
			Similar to tornadoes, seismic events simultaneously affect many nominally independent structures, systems, and components (SSCs) and are hazards whose frequencies decrease with increasing magnitude. Appendix A, “Seismic and Geologic Siting Criteria for Nuclear Power Plants,” to 10 CFR Part 100 defines a safe-shutdown earthquake (SSE) as an earthquake that is based on an evaluation of the potential maximum earthquake, considering the regional and local geology and seismology and specific characteristics of local subsurface material. A staff review of a set of 29 currently operating plants of recent design (as documented in Appendix B to RG 1.165, “Identification and Characterization of Seismic Sources and Determination of Safe Shutdown Earthquake Ground Motion”) found that 50 percent were designed to survive an SSE that had a frequency of 10^{-5} per year. Consequently, RG 1.165 specifies that new plants should perform a site-specific hazard analysis to define an SSE that has a median reference frequency of 10^{-5} per year. The SRM for SECY-93-087 states that licensees also need to use a seismic margin analysis to demonstrate a low likelihood of seismic-induced failure of SSCs that function to mitigate the consequences of seismic events that have a ground motion acceleration that is up to a factor of approximately 1.667 greater than the ground motion acceleration of the design-basis SSE.

Comments			NRC Comment Resolution
Originator	Section	Specific Comments	
Public Citizen	general (comment 2)	Tornado wind and missile loads have been used to envelop loads for other postulated external hazards such as a small airplane crash not otherwise considered explicitly. It is not obvious that the Region III design-basis tornado criteria (e.g., a 200-mph wind and a 77-mph automobile missile) would encompass the effects of a small airplane crash for typically exposed safety-related equipment such as emergency generators, tanks, and ventilation equipment. If the extreme wind is to be used as a surrogate for other external hazards, consider defining two regions as was done in SECY 93-087 Item II.F, but with Region I at 275 mph and Region II at 230 mph.*	The staff has revised the introduction to this regulatory guide to state that this regulatory guide does not address extreme hazards (e.g., a small airplane crash). Such hazards are beyond the scope of this regulatory guide.
Public Citizen	general (comment 3)	Missile Spectrum B presented in SRP Section 3.5.1.4 (Revision 2, issued July 1981) includes an automobile missile with a velocity of 106 ft/s for Region I. DG-1143 increases this missile's velocity by a factor of 1.6 to 170 ft/s.	Revision 0 of SRP Section 3.5.1.4 (issued November 1975) first introduced Missile Spectrum B, which was subsequently superseded by Missile Spectra I and II, which were introduced in Revision 1 of SRP Section 3.5.1.4 (issued March 1978). Revision 1 (as well as Revision 2, issued July 1981) of SRP Section 3.5.1.4 states that the use of Missile Spectrum B is restricted to those applicants who had already committed to using it as their design -basis in their construction permit stage. Consequently, Missile Spectrum B has not been applicable to any applicant who has applied for a construction permit since 1978. Also see the staff's response to public citizen's Comment 5.
Public Citizen	general (comment 4)	The automobile missile presented in Spectrum B in SRP Section 3.5.1.4 (Revision 2, issued July 1981) is limited to within 30 ft of plant grade. DG-1143 no longer limits the automobile missile to within 30 ft of plant grade.	The staff has revised this regulatory guide to limit the height of the automobile missile to altitudes within 9 m (30 ft) of the highest ground elevation within 0.81 kilometers (km) (0.5 mi) of plant structures consistent with SRP Section 3.5.1.4, Revision 2, issued July 1981. This height is reasonable in that only the more severe and, consequently, less likely tornadoes have the capability to lift the automobile missile to heights greater than 9 m (30 ft) above the point of origin and,

Comments			NRC Comment Resolution
Originator	**DG-1143 Section**	**Specific Comments**	
			when lifted above 9 m (30 ft), only a small fraction of the total trajectory is above this elevation. The penetrating missile is assumed to strike at any elevation of the structure, thereby ensuring some level of protection for all safety-significant SSCs. Therefore, the proposed missile spectrum provides adequate defense by protecting all elevations from missiles to some extent, while limiting the more substantial protection necessary for the automobile missile to credible elevations.
Public Citizen	general (comment 5)	The revised (170 ft/s or 52 m/s) automobile missile will have a very significant impact on increasing the design requirements for new reactor Category I structures, systems, and components (SSCs). It also brings into question the tornado safety of all existing plant SSC structural adequacy outside containment and may have undue severe economic impacts on the private sector with little or no increase in necessary safety.	The staff has selected the tornado missiles based on (1) the likelihood of that missile being present at a particular site, (2) the potential to cause significant damage to SSCs, and (3) the probability of the missile being lofted off the ground by the tornado. Based on these criteria, the staff feels that an automobile is a very appropriate and important consideration. The analysis has recalculated tornado missile speeds using the new Enhanced Fujita (EF) lower wind speed criteria, resulting in a 1810 kilogram (kg) (4,000 pound (lb)) car tornado missile speed of 41 meters per second (m/s) (92 miles per hour (mi/h)) for Region I. This value is lower than the 47 m/s (105 mi/h) 1814 kg (4,000 lb) car tornado missile identified as a Tier 1 site parameter in the AP1000 design control document. Therefore, the newly revised car missile will not increase the design requirements for new reactor Category I SSCs.
Public Citizen	general (comment 6)	Before the new automobile tornado missiles are adopted by the NRC, it is strongly urged that this issue be reviewed by a panel of technically qualified experts before the recommendations of a single set of authors (i.e., Simiu and Scanlan) are adopted for regulatory purposes.	Although the staff adopted the methods of Simiu and Scanlan for this regulatory guide , the staff did consider other studies. An Electric Power Research Institute (EPRI) study (see G.H. Redmann et al., “Windfield and Trajectory Models for Tornado-Propelled Objects,” EPRI NP-2898, March 1983) uses a more sophisticated model for determining the trajectory of tornado-propelled missiles. One of the tornado missiles considered in the EPRI study is the 1814 kg (4000

Comments			NRC Comment Resolution
Originator	DG-1143 Section	Specific Comments	
			lb) car with the dimensions of the design-basis car that was used in Revision 0 of RG 1.76. The EPRI model represents the tornado missile as a rigid body (6 degrees of freedom) subject to drag, lift, and gravity, while many other models (including the model of Simiu and Scanlan) treat the tornado missile as a point mass (3 degrees of freedom), subject only to drag and gravity. For the car, the lift forces can be significant, especially in the early part of the trajectory. In addition, the EPRI model of the tornado wind field is more realistic than that of Simiu and Scanlan in that the wind field satisfies the continuity equation (mass conservation). The initial position of the tornado missile (when it is released into the wind field) is on the loci of maximum tornado rotational velocity at an angle β with respect to the translational direction of the tornado. It is expected that the tornado missile would achieve a relatively high horizontal velocity for β values equal to 270 degrees because this is the location where the tornado's translational and rotational velocities are in the same direction. Although the rotational and translational velocities are in the same direction at β =2 70 degrees, in the Phase III model of the EPRI report, the maximum magnitude of the total velocity (resultant of the rotational, translational, and radial components) is a maximum for β = 225 degrees, not β = 270 degrees. However, it is unlikely that the missile would be released into the tornado wind field on the rear part of the tornado (β between 90 and 270 degrees). The majority of the model results presented in the EPRI report are for β equal to 0 degrees.

Comments			NRC Comment Resolution
Originator	**DG-1143 Section**	**Specific Comments**	
			Revision 1 to RG 1.76 partitions the United States into three distinct tornado regions with maximum probable tornado wind speeds. For each of the three regions, the Simiu and Scanlan model predicts more conservative 1814 kg (4,000 lb) car tornado missile speeds than those listed in the EPRI report. The following table shows a comparison of the 1814 kg (4,000 lb) car missile speed from the Simiu and Scanlan model versus the highest 1814 kg (4,000 lb) car tornado missile speeds reported in the EPRI study for each of the DG-1143 tornado wind speed criteria. **Tornado Wind Speed (DG-1143 Region)** / **Horizontal Missile Speed (Simiu and Scanlan) [a]** / **Horizontal Missile Speed (EPRI) [b]** 103 m/s (230 mi/h) (I) / 41 m/s (92 mi/h) / 13, 28, 34 m/s (29, 63, 76 mi/h) 89 m/s (200 mi/h) (II) / 34 m/s (76 mi/h) / 11, 15, 15 m/s (25, 34, 34, mi/h) 72 m/s (160 mi/h) (III) / 10 m/s (22 mi/h) / 7, 9, 9.5 m/s (16, 20, 21 mi/h) [a] The Simiu and Scanlan missile speeds are based on an injection height of 40 meters (m) (131 feet (ft)) with β equal to 0 degrees. [b] The three EPRI missile speeds provided for each tornado region represent more realistic injection heights of 3 m (10 ft), 6 m (20 ft), and 20 m (66 ft) with β equal to 0 degrees. The EPRI report does not provide horizontal missile speeds for β equal to 270 degrees for the DG-1143 tornado wind speeds. However, for a 134 m/s (300 mi/h) tornado with β equal to 270 degrees, the EPRI study concludes that the maximum justifiable horizontal velocity for the car is 44 m/s (98 mi/h), whereas the Simiu and Scanlan model gives 52 m/s (116 mi/h) with β equal to 0 degrees. The Simiu and Scanlan model produces comparable results in this situation.

Comments			NRC Comment Resolution
Originator	DG-1143 Section	Specific Comments	
			The EPRI study includes only limited sensitivity studies in the modeling of the tornado wind field and does not consider uncertainties and variability in the drag and lift coefficients of the car. The drag and lift coefficients can vary from car to car and, even for the car studied, there are measurement error and curve-fitting errors in estimating the drag and lift as a function of pitch and yaw. Considering these uncertainties, the results of the Simiu and Scanlan model do not appear excessively conservative, while still providing estimates comparable to the EPRI study findings.

Comments			NRC Comment Resolution
Originator	**DG-1143 Section**	**Specific Comments**	
Public Citizen	general (comment 7)	The old Fujita (F) scale (which correlated tornado damage to wind speed) is being replaced by the Enhanced Fujita (EF) scale. The new EF scale significantly reduces the wind speeds at which a particular damage occurs for stronger tornadoes. Use of the new EF scale would significantly reduce the wind pressure design loads as well as missile loads.	This revision implements the new EF scale. The change from F scale to EF scale reduced the 10^{-7} tornado wind speeds presented in DG-1143 for each of the three regions as follows: Region I: 134 m/s (300 mi/h) ➜ 103 m/s (230 mi/h) Region II: 116 m/s (260 mi/h) ➜ 89 m/s (200 mi/h) Region III: 89 m/s (200 mi/h) ➜ 72 m/s (160 mi/h) Because of this reduction in the wind speeds, the analysis also recalculated the resulting missile speeds. The changes from the tornado missile speeds presented in DG-1143 are as follows: **<u>Automobile Missile</u>** Region I: 52 m/s (116 mi/h) ➜ 41 m/s (92 mi/h) Region II: 45 m/s (101 mi/h) ➜ 34 m/s (76 mi/h) Region III: 34 m/s (76 mi/h) ➜ 24 m/s (54 mi/h) (this speed is for a smaller, 1177 kg (2595lb) car for Region III) **<u>Schedule 40 Pipe Missile</u>** Region I: 47 m/s (105 mi/h) ➜ 41 m/s (92 mi/h) Region II: 38 m/s (85 mi/h) ➜ 34 m/s (76 mi/h) Region III: 8 m/s (18 mi/h) ➜ 24 m/s (54 mi/h) **<u>Solid Steel Sphere</u>** Region I: 41 m/s (92 mi/h) ➜ 8 m/s (18 mi/h) Region II: 21 m/s (47 mi/h) ➜ 7 m/s (16 mi/h) Region III: 7 m/s (16 mi/h) ➜ 6 m/s (13 mi/h)

Comments			NRC Comment Resolution
Originator	**DG-1143 Section**	**Specific Comments**	
Public Citizen	general (comment 8)	It is strongly recommended that the ASCE Standard Task Force Committee on Wind Loads (who prepared the wind load portion of ASCE Standard 7-05) be contacted to obtain its input on DG-1143, particularly as it relates to hurricane loads and missile phenomena and the use of the new EF scale. The use of the EF scale would tend to place a greater emphasis on hurricane wind loads. At a very low probability of exceedance rate of 10^{-7}/yr, hurricane wind speeds in the Atlantic and Gulf regions would approach or exceed tornado wind speeds. An extension of the ASCE Standard 7-05 hurricane wind speed methodology to 1000-year return periods would exceed 200 mph; an extension of hurricane wind speeds to the 10^{-7}/yr probability of exceedance level could exceed both the Region III and Region II wind speed levels, particularly if it is recognized that hurricanes typically have damage areas one to two orders of magnitude greater than tornadoes per year.	The staff has revised the introduction to this regulatory guide to state that it does not address extreme winds, such as hurricanes, nor the missiles attributable to such winds. The staff will address these extreme winds and wind-generated missiles on a case-by-case basis.
Public Citizen	general (comment 9)	There is a need to define different wind loads for RISC Category 3 SSCs which are part of a nuclear power plant, but do not involve a potential release from the reactor core or fresh spent fuel storage. This would be consistent with RG 1.143 type facilities where, for example, reduced safe-shutdown basis earthquake loads are defined for design purposes.	The staff has addressed this concern by limiting the scope of SSCs that should be protected from the effects of design-basis tornadoes to the important-to-safety SSCs identified in RG 1.117, "Tornado Design Classification." In general, SSCs that would be classified as Risk-Informed Safety Class (RISC) Category 3 (safety-related equipment with low safety significance) are not included among the set of SSCs identified in RG 1.117 as needing protection from the effects of the design-basis tornado. Therefore, RG 1.117 provides acceptable risk-informed guidance for protection against tornado effects.

Comments			NRC Comment Resolution
Originator	**DG-1143 Section**	**Specific Comments**	
Nuclear Energy Institute (NEI) 03/30/2006 letter (ML060950241)	[illegible]	Consider adding the following after the last sentence of the second paragraph of the section on tornado-generated missile characteristics: However, similar to current operating plants, a limited number of windows of missile vulnerability in otherwise tornado resistant structures can be accepted based on appropriate probabilistic missile strike analysis, provided the aggregate probability of missile damage through these windows is acceptable. Examples of windows of missile vulnerability are unprotected louvers, doors, stacks, penetrations, and exposed portions of piping.	The staff will not add the suggested sentence to this regulatory guide. Defense-in-depth principles are used in determining the initial design protection against tornado missiles. RG 1.117 limits the scope of SSCs that should be protected against the effects of the design-basis tornadoes to those SSCs important to safety, considering the credible effects of a tornado. All SSCs important to safety SSCs should be protected from the effects of the design-basis tornado during the initial design of the facility to compensate for the uncertainty in evaluating the probability of a tornado missile strike on a particular SSC and the absence of alternative protected SSCs to complete the same essential function. In the event that protection of an isolated SSC was overlooked during initial design and construction, the staff has accepted a probabilistic method for evaluating the need to correct that isolated vulnerability.
NEI	general (comment 2)	There does not appear to be a limitation on the height at which the automobile missile may impact the plant. Earlier versions of SRP 3.5.1.4 (e.g., Missile Spectrum II from the 1996 Revision 3) limit the height above grade at which the automobile missile would be considered. The height limitation was invoked during the AP1000 design certification and forms a part of its DCD in Subsection 3.5.1.4 (first bullet).	The staff has revised this regulatory guide to limit the height of the automobile missile to altitudes within 9 m (30 ft) of the highest ground elevation within 0.81 kilometers (km) (0.5 mi) of plant structures consistent with SRP Section 3.5.1.4, Revision 2, issued July 1981. This height is reasonable in that only the more severe and, consequently, less likely tornadoes have the capability to lift the automobile missile to heights greater than 9 m (30 ft) above the point of origin and, when lifted above 9 m (30 ft), only a small fraction of the total trajectory is above this elevation. The penetrating missile is assumed to strike at any elevation of the structure, thereby ensuring some level of protection for all safety-significant SSCs. Therefore, the proposed missile spectrum provides adequate defense by protecting all elevations from missiles to some extent, while limiting the more substantial protection necessary for the automobile missile to credible elevations.

Comments			NRC Comment Resolution
Originator	**DG-1143 Section**	**Specific Comments**	
NEI	general (comment 3)	Figure 1 should be related to a map of the United States with State boundaries as an assist to the reader.	The staff has revised Figure 1 of this regulatory guide to show the tornado regions superimposed over a map of the United States with State boundaries
U.S. Depart-ment of Energy (DOE) 03/31/2006 letter (ML060940648)	general (comment 1)	A graphic representation of what is being described on page 4, Tornado Characteristics, and page 5, Design Basis Tornado Characteristics, may help in making sure that there is a common understanding among the NRC, licensees, and applicants.	The staff has added Figure 2 to this regulatory guide to show the translational and rotational (or tangential) wind velocity components of the Rankine combined vortex.
DOE	general (comment 2)	In order to avoid confusion, clarify that the Regions I, II, and III used in DG-1143 correspond to Regions 3, 2, and 1 as used in NUREG/CR-4461, Revision 1.	NUREG/CR-4461, "Tornado Climatology of the Contiguous United States," Revision 2, identifies its tornado regions as Regions 1, 2, and 3, which correspond to Regions I, II, and III as used in this regulatory guide.
DOE	general (comment 3)	DG-1143 should address the impact of selecting the maximum tornado wind speed as a result of the recent change in the Fujita scale from the National Weather Service.	See the staff's response to public citizen's Comment 7.

* SECY-93-087 suggested that it is acceptable to use a tornado design-basis wind speed of 89 m/s (200 mi/h) for States west of the Rocky Mountains and 134 m/s (300 mi/h) for States east of the Rocky Mountains.