DUKE
ENERGY.

Thomas D. Ray, P.E.
Site Vice President
McGuire Nuclear Station

Duke Energy
MG01VP | 12700 Hagers Ferry Road
Huntersville, NC 28078

o: 980.875.4805
f: 980.875.4809
Tom.Ray@duke-energy.com

July 3, 2018
Serial No. MNS-18-036

10 CFR 50.90

U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001
ATTENTION: Document Control Desk

Duke Energy Carolinas, LLC
McGuire Nuclear Station, Units 1 and 2
Docket Nos. 50-369 and 50-370
Renewed License Nos. NPF-9 and NPF-17

Subject: Response to the Request for Additional Information regarding the License Amendment Request to Revise the Licensing Bases for Protection from Tornado-Generated Missiles

By letter dated December 8, 2017 (ADAMS Accession No. ML17352A364), Duke Energy requested changes to the McGuire Nuclear Station, Units 1 and 2 (McGuire) Updated Final Safety Analysis Report (UFSAR). The proposed License Amendment will revise the McGuire licensing bases for protection from tornado-generated missiles.

This letter provides the additional information requested by the NRC staff via electronic mail from Michael Mahoney dated May 18, 2018 (ADAMS Accession No. ML18138A466). The NRC staff's questions and Duke Energy's responses are provided in Attachment 1. Revised UFSAR mark-ups are provided in Attachment 2.

The conclusions reached in the original determination that the LAR contains No Significant Hazards Considerations and the basis for the categorical exclusion from performing an Environmental Impact Statement have not changed as a result of these responses to the request for additional information.

Please contact Lee A. Hentz at 980-875-4187 if additional questions arise regarding this RAI response.

A001
NRR

I declare under penalty of perjury that the foregoing is true and correct. Executed on July 3, 2018.

Sincerely,

Thomas D. Ray

Thomas D. Ray
Vice President
McGuire Nuclear Station

Attachments

cc w/ Attachments:

C. Haney, Administrator, Region II
U.S. Nuclear Regulatory Commission
Marquis One Tower
245 Peachtree Center Ave., NE, Suite 1200
Atlanta, GA 30303-1257

A. Hutto, NRC Senior Resident Inspector
McGuire Nuclear Station

M. Mahoney, Project Manager
U.S. Nuclear Regulatory Commission
11555 Rockville Pike
Mail Stop O-8 G9A
Rockville, MD 20852-2738

W. L. Cox, III, Section Chief
North Carolina Department of Environment and Natural Resources
Division of Environmental Health
Radiation Protection Section
1645 Mail Service Center
Raleigh, NC 27699-1645

ATTACHMENT 1

By letter to the U.S. Nuclear Regulatory Commission (NRC) dated December 8, 2017 (Agencywide Documents Access Management System (ADAMS) Accession No. ML17352A364), Duke Energy, (the licensee), requested changes to the McGuire Nuclear Station, Units 1 and 2 (McGuire) Updated Final Safety Analysis Report (UFSAR). The proposed amendment will revise the McGuire licensing bases for protection from tornado-generated missiles.

The NRC requires that nuclear power plants be designed to withstand the effects of tornado and high-wind-generated missiles so as not to adversely impact the health and safety of the public in accordance with the requirements of General Design Criterion (GDC) 2, "Design Bases for Protection against Natural Phenomena," and GDC 4, "Environmental and Dynamic Effects Design Bases," of Appendix A, "General Design Criteria for Nuclear Power Plants," to Title 10 of the Code of Federal Regulations (10 CFR) Part 50, "Domestic Licensing of Production and Utilization Facilities."

The safety evaluation report (SER) approving the TORMIS methodology dated October 26, 1983 (ADAMS Accession No. ML080870291) requires licensees using the methodology to consider and address five points in their applications.

In accordance with Regulatory Issue Summary (RIS) 2008-14 dated June 16, 2008 (ADAMS Accession No. ML080230578), the TORMIS methodology is an NRC-approved method for addressing identified deficiencies in complying with a plant's current licensing basis for tornado missile protection. It provides licensees the option of revising the plant's licensing basis for tornado missile protection from a purely deterministic methodology to one that includes limited use of a probabilistic approach. In RIS 2008-14, the TORMIS methodology is approved for situations where (1) a licensee identifies existing plant structures, systems, and components (SSCs) that do not comply with the current licensing basis for positive tornado missile protection of the plant and (2) it would require costly modifications to bring the plant into compliance with the current licensing basis.

The NRC staff has reviewed the application and, based upon this review, determined that additional information is needed to complete our review. Please provide a response on the docket within 45 days of this correspondence.

ATTACHMENT 1

Request for Additional Information (RAI)-01

The proposed UFSAR, Section 3.5.2.8 markup included in Enclosure 2 does not appear to be consistent with current UFSAR Section 3.3.

The proposed UFSAR, Section 3.5.2.8 markup states:

> "Table 3-8 provides a summary of the design basis tornado-generated missiles. The integrity of all Category 1 structures is not impaired by these missiles. This is accomplished either deterministically by designing the exposed structure of steel reinforced concrete capable of withstanding the impact of tornado-generated missiles, or probabilistically by showing that the structure will not be impacted or will not be damaged beyond an acceptable criteria if impacted as discussed in Section 3.5.2.8.1.3"

Current UFSAR Section 3.3 states, "All Category 1 structures, except those structures not exposed to wind, are designed for tornado wind loads."

The proposed UFSAR Section 3.5.2.8 markup seems to imply that some Category 1 structures are not deterministically designed to withstand missiles, which appears to be at inconsistent with current UFSAR, Section 3.3.

RAI-01a: The NRC staff requests the licensee to clarify the application of the proposed USFAR, Section 3.5.2.8 markup with respect to Category 1 structures.

RIS 2008-14 states:

> The TORMIS methodology is not currently approved for the following:
>
> - Justifying not providing positive tornado missile protection (i.e., barrier) for plant modifications
> - removing existing tornado missile barriers
> - eliminating or relaxing of TS [Technical Specifications] requirements that have been established for tornado missile barriers and safety-related equipment
> - promoting operational flexibility or convenience

The current wording in the proposed UFSAR, Section 3.5.2.8 markups stating, in part, "… accomplished either deterministically by designing the exposed structure of steel reinforced concrete capable of withstanding the impact of tornado-generated missiles, or probabilistically by showing that the structure will not be impacted or will not be damaged beyond an acceptable criteria… " appears to support such applications of the future use of TORMIS.

RAI-01b: The NRC staff requests the licensee to clarify its application of proposed UFSAR, Section 3.5.2.8, with regard to future use of TORMIS.

Duke Energy Response for RAI-01a:

UFSAR Section 3.3 only addresses wind loads on Category 1 structures. UFSAR Section 3.5 addresses missile protection. Section 3.5.1.3 in particular is for tornado-generated missiles. This section has a proposed UFSAR change as shown in the LAR Enclosure 2, page 5. A revised version is given below.

Change the proposed UFSAR change to Section 3.5.2.8 from:

> Table 3-8 provides a summary of the design basis tornado-generated missiles. The integrity of all Category 1 structures is not impaired by these missiles. This is accomplished either deterministically by designing the exposed structure of steel reinforced concrete capable of withstanding the impact of tornado-generated missiles, or probabilistically by showing that the structure will not be impacted or will not be damaged beyond an acceptable criteria if impacted as discussed in Section 3.5.2.8.1.3.

To:

> Table 3-8 provides a summary of the design basis tornado-generated missiles. The integrity of ~~all~~ Category 1 structures is not impaired by these missiles. This is accomplished by designing the exposed structure of steel reinforced concrete capable of withstanding the impact of design basis tornado-generated missiles. Modifications to existing or the design of new Category 1 structures shall conform to the requirements of NRC RIS 2008-14.
>
> Table 3-63 provides a list of Category 1 structures, systems, and components that have not been designed to withstand the impact of design basis tornado-generated missiles. These SSCs were probabilistically shown that they will not be impacted or will not be damaged beyond an acceptable criteria if impacted as discussed in Section 3.5.2.8.1.3.

Also, change the proposed UFSAR change to Section 3.5.1.3 from:

> All Category 1 structures exposed to these design basis missiles are designed to withstand their effect with the exception of those Structures Systems and Components included in the TORMIS probabilistic tornado risk analysis listed in Table 3-63 and as discussed in Section 3.5.2.8.1.1. A tabulation of the design basis tornado generated missiles is given in Table 3-8

To:

> ~~All~~ Category 1 structures exposed to these design basis missiles are designed to withstand their effect with the exception of those Category 1 Structures Systems and Components included in the TORMIS probabilistic tornado risk analysis listed in Table 3-63 and as discussed in Section 3.5.2.8.1.1. A tabulation of the design basis tornado generated missiles is given in Table 3-8.

ATTACHMENT 1

Duke Energy Response for RAI-01b:

MNS's intention is to use TORMIS in the future if additional existing Category 1 structures are discovered that do not meet the protection requirement from design basis tornado-generated missiles as listed in UFSAR Table 3-8. Designs of future new SSCs and modification to existing SSCs will meet the requirements of UFSAR Section 3.5.1.3, "Tornado Generated Missiles" and Section 3.5.4, "Barrier Design Procedure." The proposed UFSAR changes are modified below to include a reference to the above stated RIS 2008-14 TORMIS methodology limitations.

Change the proposed UFSAR change to Section 3.5.2.8 from:

> Table 3-8 provides a summary of the design basis tornado-generated missiles. The integrity of all Category 1 structures is not impaired by these missiles. This is accomplished either deterministically by designing the exposed structure of steel reinforced concrete capable of withstanding the impact of tornado-generated missiles, or probabilistically by showing that the structure will not be impacted or will not be damaged beyond an acceptable criteria if impacted as discussed in Section 3.5.2.8.1.3.

To:

> Table 3-8 provides a summary of the design basis tornado-generated missiles. The integrity of ~~all~~ Category 1 structures is not impaired by these missiles. This is accomplished by designing the exposed structure of steel reinforced concrete capable of withstanding the impact of design basis tornado-generated missiles. Modifications to existing or the design of new Category 1 structures shall conform to the requirements of NRC RIS 2008-14.
>
> Table 3-63 provides a list of Category 1 structures, systems, and components that have not been designed to withstand the impact of design basis tornado-generated missiles. These SSCs were probabilistically shown that they will not be impacted or will not be damaged beyond an acceptable criteria if impacted as discussed in Section 3.5.2.8.1.3.

Revised UFSAR mark-ups showing the above are provided in Attachment 2.

RAI-02

The LAR provides discussion on each of the five attributes of TORMIS SER. One of the five review points in the TORMIS SER specifies users should provide sufficient information to justify the assumed missile density based on site specific missile sources and dominant tornado paths of travel.

The LAR includes a brief statement on page 18, "The plant site is described by specifying the geometry, location, and material properties of the structures/components and the location of potential missile sources. Missile sources (buildings, houses, storage areas, vehicles, etc.) are modeled to a distance of approximately 2,500 feet. This process includes the development of missile origin zones around the plant and surveying the types and quantities of missiles in each zone."

The LAR neglects potential shielding effects by stating in Enclosure 1, page 14, "In TORMIS, the effects of local obstructions, buildings, and structures are neglected in simulating the tornado winds. Thus, for example, tornado winds flow through the Turbine Building without consideration of either terrain/site roughness or blockage/interference of the reinforced concrete and heavy steel frame structures."

Bases on its review of the submittal, the NRC staff is unable to locate details or layouts of the development missile origin zones depicting the type, quantity or density of missile in each zone. The LAR also does not appear to include list of targets, shields and buildings (missile source), which are typically provided in TORMIS submittals. In addition, it is unclear what buildings are used for deconstruction to derive 214,000 missiles.

Therefore, the NRC staff requests the licensee to justify how the TORMIS SER was met and provide details of the assumed missile density based on location-specific missile counts and provide the list of targets, shields and buildings (missile source) used in the analysis.

Duke Energy Response:

TORMIS SER review point 4 states:

"The assumptions concerning the locations and numbers of potential missiles presented at a specific site are not well established in the EPRI studies. However, the EPRI methodology allows site specific information on tornado missile availability to be incorporated in the risk calculation. Therefore, users should provide sufficient information to justify the assumed missile density based on site specific missile sources and dominant tornado paths of travel."

LAR Enclosure 1, page 18 discusses the walk-downs undertaken to characterize the site-specific population of potential missiles located throughout the MNS site, and the total number of potential missiles considered for each level of tornado intensity. The following provides additional details regarding the development of the zone and structure missile populations at the site, and the complete listing of safety, missile shielding, and missile source targets in the MNS TORMIS model.

ATTACHMENT 1

Zone Missile Details

Missiles source zones were defined based on review of overall site plans and aerial photos of the plant. Zone boundaries were defined by features such as roads, fence lines, edges of buildings, changes in land use, and homogeneity of areas. The missile zones cover an area that extends out a minimum of 2500 feet in all directions from the safety-related targets. This distance is based on a sensitivity study performed in the original TORMIS research (LAR References 3 and 4). The sensitivity study concluded that missiles beyond 2,000 feet did not need to be considered in the risk assessment. This value was factored up to 2500 feet in modern TORMIS analyses to be conservative. This distance from the safety-related targets is maintained in all directions and not just along the most likely tornado paths.

Figure ***1*** shows the location of the 33 missile zones defined for the analysis overlaid onto an aerial photo of the plant. ***Figure 2*** shows a 3-D AutoCAD rendering of the TORMIS model that shows the missile source zones in green, safety-related targets in red, missile shielding targets in gray and missile source targets in orange. Only the 2-D footprints of the missile source structures are shown in this rendering.

ATTACHMENT 1

[redacted]

Figure 1. Zone Layout for MNS TORMIS Analysis

ATTACHMENT 1

[redacted]

Figure 2. 3-D AutoCAD Representation of MNS TORMIS Model – Southwest Isometric

ATTACHMENT 1

The total number of missiles was surveyed by missile type for each missile source zone. **Table 1** summarizes the number of missiles observed by missile type for each of the 33 zones.

Table 1. Number of Missiles Surveyed by Missile Source Zone

Subset	**Missile Description**	**ZoneNumber**																
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**
1	Rebar	0	0	8	0	0	0	0	0	94	0	0	30	0	0	0	47	0
2	GasCylinder	0	0	10	0	0	0	0	97	13	2	0	2	0	0	1	10	0
3	DrumTank	0	0	0	0	0	0	3	26	0	0	0	2	2	0	2	21	0
4	UtilityPole	0	8	0	7	0	0	0	0	0	4	2	0	3	0	0	7	0
5	CableReel	0	0	0	0	0	0	1	7	25	0	0	11	0	0	0	4	0
6	Pipe_3in	78	51	138	44	160	145	83	340	203	263	128	270	56	0	81	481	0
7	Pipe_6in	0	0	0	4	0	0	0	50	0	18	0	67	0	0	0	76	0
8	Pipe_12in	0	0	1	0	0	0	0	0	1	6	0	7	0	0	0	78	0
9	StorageBin	4	0	2	0	0	7	1	56	11	10	1	2	0	0	19	34	0
10	Pavers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	ConcreteFragment	0	0	0	0	0	12	0	0	150	0	0	100	0	0	0	12	0
12	WoodBeam	0	6	0	0	0	0	0	24	7	9	0	170	98	0	32	207	0
13	WoodPlank	0	10	22	0	0	0	0	942	116	0	0	1,040	0	0	510	233	0
14	MetalSiding	5	21	10	0	8	5	0	29	35	5	0	32	0	0	50	177	0
15	PlywoodSheet	0	0	0	0	0	0	0	84	2	0	0	10	0	0	0	6	0
16	WideFlange	0	0	0	0	10	13	0	0	5	0	0	0	0	0	0	5	0
17	ChannelSection	0	0	0	0	0	0	0	19	4	4	0	0	0	0	0	117	0
18	SmallEquipment	0	0	1	0	0	0	0	1	19	0	0	0	0	0	6	19	0
19	LargeEquipment	0	0	0	3	0	0	0	0	0	0	0	14	0	0	0	0	0
20	SteelFrameGrating	1	1	0	30	0	144	0	108	20	0	0	23	0	0	1	71	0
21	LargeSteelFrame	0	1	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0
22	Vehicle	0	1	11	0	0	0	2	21	15	2	1	24	20	0	745	64	528
23	Tree	0	0	0	0	0	0	0	0	0	0	42	0	35	56	4,900	980	523
Total Missiles		**88**	**99**	**203**	**88**	**178**	**326**	**90**	**1,808**	**720**	**323**	**174**	**1,804**	**214**	**56**	**6,347**	**2,649**	**1,051**

Subset	**Missile Description**	**ZoneNumber**																
		18	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**TOTAL**
1	Rebar	0	0	0	0	0	0	0	0	0	0	0	30	0	0	0	0	**209**
2	GasCylinder	11	0	0	0	0	0	1	0	0	0	0	0	17	0	21	7	**192**
3	DrumTank	4	0	0	0	0	0	0	0	0	0	0	0	11	0	1	7	**79**
4	UtilityPole	11	5	3	0	4	1	5	0	0	4	0	27	0	0	0	40	**131**
5	CableReel	1	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	**59**
6	Pipe_3in	11,346	0	44	60	439	352	113	213	156	194	105	168	255	175	208	117	**16,466**
7	Pipe_6in	0	0	0	0	0	0	0	0	0	0	0	0	28	0	0	15	**258**
8	Pipe_12in	0	0	0	0	0	0	0	0	0	0	0	0	12	0	0	15	**120**
9	StorageBin	3	0	0	0	0	3	1	6	10	0	0	0	10	0	2	9	**191**
10	Pavers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
11	ConcreteFragment	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**274**
12	WoodBeam	10	34	0	0	0	0	0	0	0	0	0	0	168	0	2	0	**767**
13	WoodPlank	400	18	0	7	0	0	0	0	0	0	0	0	273	0	216	0	**3,787**
14	MetalSiding	8	8	8	0	0	0	12	12	0	0	0	0	51	0	72	130	**678**
15	PlywoodSheet	62	0	0	0	0	0	0	15	0	0	0	0	20	0	86	10	**295**
16	WideFlange	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**33**
17	ChannelSection	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	40	**184**
18	SmallEquipment	0	1	0	0	0	0	0	2	6	0	0	0	1	0	2	4	**62**
19	LargeEquipment	0	1	0	30	0	0	1	2	6	0	0	0	1	0	2	9	**69**
20	SteelFrameGrating	132	0	0	0	0	0	1	4	0	0	0	0	36	0	2	4	**578**
21	LargeSteelFrame	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	8	**14**
22	Vehicle	9	65	357	457	1	2	28	0	1	0	0	0	550	0	50	78	**3,032**
23	Tree	626	267	0	162	112	868	796	149	6,834	8,879	4,372	5,644	2,981	4,039	3,487	2,478	**48,230**
Total Missiles		**12,623**	**399**	**412**	**716**	**566**	**1,226**	**958**	**403**	**7,013**	**9,077**	**4,477**	**5,869**	**4,414**	**4,214**	**4,152**	**2,971**	**75,708**

The number of trees over 3 inches in diameter were counted within a 100 foot by 100 foot treed area to estimate a tree density of 70 trees per 10,000 square feet (sf) of treed area. The number of trees within each outlying missile zone was estimated by multiplying the observed tree density (i.e. 70 trees / 10,000 sf) by the total treed area within each zone as determined from a georeferenced aerial photo.

Structure Missile Details

The three-dimensional plant model assumes that all structures, except reinforced concrete buildings and the frames of heavy steel buildings, will break up into component missiles.

Buildings that are expected to experience wind failure include warehouses, trailers and other non- or marginally engineered buildings. Structures with fully-engineered steel or concrete building frames will experience roof system failures and opening failures (windows, doors), followed by wall and roof deck failures at much higher wind speeds. Frame failures are unlikely for fully-engineered structures, but are expected for non- or marginally-engineered buildings.

The total number of missiles produced by structural failure is based on the expected damage states of various building types based on near-ground wind speeds. This approach includes: (1) defining the inventory of all potential missiles generated by failure of structures, and (2) determining the fraction of the missile inventory that will be produced by each level of tornado intensity (Enhanced Fujita Scale).

Table ***2*** lists the total number of potential missiles by missile type from each of the missile source structures (i.e. result of step (1) discussed above). The "Missile Source Target Number" in **Table 2** can be mapped to the structure name with the "TORMIS Target #" from the complete table of safety-related, missile shielding, and missile source targets presented in the **Complete List of Targets** (**Table 3**) portion of this response.

The total number of missiles available by EF scale from each missile source structure is then determined on a source by source basis as described in on page 19 of the LAR. This approach does not necessarily result in every missile becoming available in all tornadoes. As such, the average number of structure missiles for EF5 tornadoes (214,766) is less than the total number of potential structure missiles shown in **Table 2** (229,288).

Table 2. Total Number of Missiles Modeled for Each Missile Source Structure

Subset	Missile Description	Missile Source Target Number																			
		274	275	276	277	278	279	280	281	282	283	284	285	286	287	288	289	290	291	292	293
1	Rebar	40	35	13	3,225	3	364	42	536	10	0	24	32	1,118	6,176	4,300	320	14	3,976	3	54
2	GasCylinder	0	0	0	0	1	0	18	0	1	0	2	0	0	37	0	0	0	99	0	8
3	DrumTank	0	0	0	0	1	0	2	38	2	0	5	0	0	52	0	0	0	139	0	12
4	UtilityPole	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	CableReel	0	0	0	0	1	0	0	27	3	2	6	1	0	0	0	0	0	0	0	5
6	Pipe_3in	0	0	0	0	0	0	0	9	0	11	0	0	0	0	0	0	0	0	0	0
7	Pipe_6in	0	0	0	0	0	0	0	0	0	0	0	9	0	66	0	0	0	179	0	11
8	Pipe_12in	0	0	0	0	0	0	0	0	0	0	0	0	0	22	0	0	0	60	0	4
9	StorageBin	24	3	1	225	2	26	5	16	5	23	11	0	78	424	300	23	1	258	1	10
10	Pavers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	ConcreteFragment	3,375	0	0	0	0	3,510	0	0	1,688	0	0	0	0	52	0	0	0	139	288	9
12	WoodBeam	10	10	19	900	11	102	11	75	2	0	3	5	312	1,716	1,200	325	24	1,088	1	11
13	WoodPlank	44	44	92	4,050	55	457	47	985	12	0	29	209	1,404	7,724	5,400	1,792	119	4,906	4	62
14	MetalSiding	40	20	24	700	19	216	85	1,957	18	194	113	261	849	2,354	1,576	15	34	1,855	2	218
15	PlywoodSheet	0	5	20	450	12	51	0	40	11	0	26	0	156	833	600	768	23	475	1	21
16	WideFlange	7	10	1	377	0	43	13	215	2	38	13	45	183	712	458	15	1	632	1	32
17	ChannelSection	13	16	0	250	0	57	21	490	6	12	26	23	314	803	612	0	0	643	1	58
18	SmallEquipment	11	2	1	100	1	13	6	53	3	4	6	15	52	278	150	12	1	307	1	17
19	LargeEquipment	0	1	1	25	0	5	0	9	0	0	0	0	26	101	50	4	1	119	1	5
20	SteelFrameGrating	0	0	0	0	1	0	0	4	3	8	6	1	0	205	0	0	0	554	0	39
21	LargeSteelFrame	0	0	0	0	1	0	0	208	1	0	2	0	0	8	0	0	0	20	0	3
22	Vehicle	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0
23	Tree	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Missiles		**3,564**	**146**	**172**	**10,302**	**108**	**4,844**	**250**	**4,665**	**1,767**	**292**	**272**	**601**	**4,492**	**21,563**	**14,646**	**3,274**	**218**	**15,449**	**304**	**579**

ATTACHMENT 1

Table 2. Total Number of Missiles Modeled for Each Missile Source Structure (continued)

Subset	Missile Description	Missile Source Target Number																			
		294	295	296	297	298	299	300	301	302	303	304	305	306	307	308	309	310	311	312	313
1	Rebar	20	522	56	259	13	39	39	59	11	1	587	457	35	15	0	7	2	138	78	1,116
2	GasCylinder	2	90	4	17	4	3	3	0	1	1	0	0	0	3	1	0	1	0	0	14
3	DrumTank	4	126	11	49	0	42	8	0	3	1	0	0	0	4	0	0	1	0	0	19
4	UtilityPole	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	CableReel	5	0	14	65	2	0	10	0	3	1	0	0	0	0	0	0	0	0	0	0
6	Pipe_3in	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	Pipe_6in	0	162	0	0	0	0	0	0	0	0	0	0	0	5	0	0	1	0	0	25
8	Pipe_12in	0	54	0	0	0	0	0	0	0	0	0	0	0	2	0	0	1	0	0	9
9	StorageBin	9	18	25	114	11	5	17	5	5	1	41	32	0	1	1	1	1	12	6	76
10	Pavers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	ConcreteFragment	1,890	126	0	14,907	945	4,725	3,375	2,700	2,025	0	0	0	0	2,029	0	0	316	0	0	19
12	WoodBeam	3	126	7	33	4	7	5	17	2	1	164	128	116	4	0	14	1	165	80	309
13	WoodPlank	23	576	67	307	16	109	46	73	13	2	738	574	356	16	0	66	2	834	418	1,390
14	MetalSiding	35	1,083	265	469	8	65	70	36	20	10	328	22	130	20	211	20	2	180	78	987
15	PlywoodSheet	21	0	60	275	0	56	41	9	12	1	82	64	69	0	0	12	0	222	126	145
16	WideFlange	4	225	30	49	2	8	8	8	3	2	124	107	3	5	51	1	1	9	4	204
17	ChannelSection	11	410	61	146	3	21	22	14	7	2	123	96	0	10	51	0	1	0	0	296
18	SmallEquipment	5	180	14	65	11	3	10	3	3	1	28	22	4	5	1	1	1	9	4	76
19	LargeEquipment	0	72	0	0	3	1	0	2	0	0	14	11	0	2	0	1	1	6	2	35
20	SteelFrameGrating	5	504	14	65	0	0	10	0	3	1	0	0	3	14	2	0	2	0	0	76
21	LargeSteelFrame	2	18	4	17	3	13	3	0	1	1	0	0	0	1	0	0	1	0	0	3
22	Vehicle	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	Tree	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Missiles		**2,039**	**4,292**	**632**	**16,837**	**1,025**	**5,098**	**3,667**	**2,926**	**2,112**	**26**	**2,229**	**1,513**	**716**	**2,136**	**318**	**123**	**335**	**1,575**	**796**	**4,799**

Subset	Missile Description	Missile Source Target Number																			
		314	315	316	317	318	319	320	321	322	323	324	325	326	327	328	329	330	331	332	333
1	Rebar	516	516	8,389	504	232	868	41	48	20	11	35	3,793	20	195	516	0	0	0	0	0
2	GasCylinder	2	65	31	0	25	1	3	14	33	0	0	0	2	0	0	0	0	0	0	0
3	DrumTank	2	91	17	0	6	9	8	20	21	0	0	0	4	0	0	0	0	0	0	0
4	UtilityPole	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	CableReel	0	0	11	0	2	0	11	0	4	0	0	0	5	0	0	0	0	0	0	0
6	Pipe_3in	14	0	63	0	3	4	0	800	210	0	0	0	0	0	0	0	0	0	0	0
7	Pipe_6in	0	117	4	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	Pipe_12in	0	39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	StorageBin	4	23	552	36	45	69	18	59	24	1	3	265	9	15	36	0	0	0	0	0
10	Pavers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	51	51	51	51
11	ConcreteFragment	0	91	84	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	WoodBeam	144	130	2,263	141	38	228	6	0	0	3	10	1,059	3	207	544	0	0	0	0	0
13	WoodPlank	624	590	13,356	633	248	1,091	49	22	0	14	44	4,763	23	1,074	2,836	0	0	0	0	0
14	MetalSiding	531	584	4,186	282	479	645	180	50	0	6	20	1,252	35	9	24	1,137	0	0	0	0
15	PlywoodSheet	0	20	1,115	71	3	107	44	0	0	2	5	530	21	501	1,160	0	0	0	0	0
16	WideFlange	104	206	986	178	142	227	49	2	0	6	16	412	3	9	24	0	0	0	0	0
17	ChannelSection	120	292	1,580	118	166	253	26	0	110	3	8	294	13	0	0	0	0	0	0	0
18	SmallEquipment	26	137	385	24	33	50	11	7	12	1	2	118	5	9	20	0	0	0	0	0
19	LargeEquipment	16	56	123	12	0	29	0	6	2	1	1	30	0	6	8	0	0	0	0	0
20	SteelFrameGrating	2	363	5	0	24	0	11	132	97	0	0	0	5	0	0	0	0	0	0	0
21	LargeSteelFrame	4	13	243	0	39	0	3	4	4	0	0	0	2	0	0	0	0	0	0	0
22	Vehicle	1	0	4	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
23	Tree	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Missiles		**2,110**	**3,333**	**33,397**	**1,999**	**1,485**	**3,583**	**460**	**1,164**	**539**	**48**	**144**	**12,516**	**150**	**2,025**	**5,168**	**1,137**	**51**	**51**	**51**	**51**

ATTACHMENT 1

Table 2. Total Number of Missiles Modeled for Each Missile Source Structure (continued)

Subset	Missile Description	Missile Source Target Number																			
		334	335	336	337	338	339	340	341	342	343	344	345	346	347	348	349	350	351	352	353
1	Rebar	0	0	0	20	48	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	GasCylinder	0	0	0	33	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	DrumTank	0	0	0	21	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	UtilityPole	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	CableReel	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	Pipe_3in	0	0	0	210	800	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	Pipe_6in	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	Pipe_12in	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	StorageBin	0	0	0	24	59	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	Pavers	51	51	51	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	ConcreteFragment	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	WoodBeam	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	WoodPlank	0	0	0	0	22	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	MetalSiding	0	0	0	0	50	0	204	497	702	156	182	120	594	594	120	1,656	1,418	1,514	204	497
15	PlywoodSheet	0	0	0	0	0	56	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	WideFlange	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	ChannelSection	0	0	0	110	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	SmallEquipment	0	0	0	12	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	LargeEquipment	0	0	0	2	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	SteelFrameGrating	0	0	0	97	132	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	LargeSteelFrame	0	0	0	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	Vehicle	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	Tree	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Missiles		**51**	**51**	**51**	**539**	**1,164**	**83**	**204**	**497**	**702**	**156**	**182**	**120**	**594**	**594**	**120**	**1,656**	**1,418**	**1,514**	**204**	**497**

Subset	Missile Description	Missile Source Target Number																	
		354	355	356	357	358	359	360	361	362	363	364	365	366	367	368	369	370	371	TOTAL
1	Rebar	0	0	0	0	0	0	0	0	0	0	0	255	0	0	0	0	0	0	**39,766**
2	GasCylinder	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**533**
3	DrumTank	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**738**
4	UtilityPole	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
5	CableReel	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**182**
6	Pipe_3in	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**2,124**
7	Pipe_6in	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**581**
8	Pipe_12in	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**191**
9	StorageBin	0	0	0	0	0	0	0	0	0	0	0	18	0	0	0	0	0	0	**3,077**
10	Pavers	0	0	0	0	0	0	0	0	0	0	51	0	0	0	0	0	0	0	**408**
11	ConcreteFragment	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**42,293**
12	WoodBeam	0	0	0	0	0	0	0	0	0	0	0	71	0	0	0	0	0	0	**11,864**
13	WoodPlank	0	0	0	0	0	0	0	0	0	0	0	320	0	0	0	0	0	0	**58,791**
14	MetalSiding	702	156	182	120	594	594	120	1,656	1,418	1,514	0	249	35	69	79	139	20	58	**40,222**
15	PlywoodSheet	0	0	0	0	0	0	0	0	0	0	0	36	0	0	0	0	0	0	**8,358**
16	WideFlange	0	0	0	0	0	0	0	0	0	0	0	43	0	9	10	17	4	8	**6,103**
17	ChannelSection	0	0	0	0	0	0	0	0	0	0	0	72	0	16	18	32	8	16	**7,874**
18	SmallEquipment	0	0	0	0	0	0	0	0	0	0	0	12	0	0	0	0	0	0	**2,350**
19	LargeEquipment	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	**802**
20	SteelFrameGrating	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**2,388**
21	LargeSteelFrame	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**630**
22	Vehicle	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**13**
23	Tree	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Total Missiles		**702**	**156**	**182**	**120**	**594**	**594**	**120**	**1,656**	**1,418**	**1,514**	**51**	**1,082**	**35**	**94**	**107**	**188**	**32**	**82**	**229,288**

Complete List of Targets

Table 3 lists all 87 safety-related targets, 63 missile pass through targets (representing the Utility Port Barriers), 123 missile shielding targets, and 98 missile source targets. The comment cited in RAI #2 from page 14 of Enclosure 1 of the LAR pertains only to the effect of shielding on the tornado winds, and not tornado missiles. As such, the missile shielding targets all represent portions of reinforced concrete, Category I structures that have been designed to resist the design basis missiles in the MNS UFSAR. However, as described in item 2 on page 14 of Enclosure 1:

> 2. *In TORMIS, the effects of local obstructions, buildings, and structures are neglected in simulating the tornado winds. Thus, for example, tornado winds flow through the Turbine Building without consideration of either terrain/site roughness or blockage/interference of the reinforced concrete and heavy steel frame structures.*

These structures have no effect on the tornado wind fields simulated in TORMIS.

ATTACHMENT 1

Table 3. Sequential Numbering of Safety-related, MPT, Shielding, and Missile Source Targets

TORMIS Target #	Target Group	TORMIS Target Description	I_{safety}	I_{MPT}	I_{shield}	I_{source}
1	U1 D Steam Line	D - PORV 1SV1AB Exhaust Above Roof	1			
2		D - PORV 1SV1AB Exhaust Above Roof -- PP	2			
3	U1 A Steam Line	A - PORV 1SV19AB Exhaust Above Roof	3			
4		A - PORV 1SV19AB Exhaust Above Roof -- PP	4			
5	U1 D Steam Line	D - MSSV Ext DH Exhausts Above roof	5			
6		D - MSSV in Ext DH Exhaust Above Roof -- PP	6			
7	U1 A Steam Line	A - MSSV Ext DH Exhausts Above Roof	7			
8		A - MSSV in Ext DH Exhaust Above Roof -- PP	8			
9	U1 C Steam Line	C - Class B Piping to PORV 1SV-7ABC Int DH	9			
10		C - Class B Piping to PORV 1SV-7ABC Int DH Pipe Hanger	10			
11		C - Pnuematic PORV 1SV7ABC - Int DH	11			
12		C - PORV 1SV7ABC Exhaust - Int DH	12			
13		C - PORV 1SV7ABC Exhaust - Int DH -- NorthWest sway strut -- lower	13			
14		C - PORV 1SV7ABC Exhaust - Int DH -- NorthEast sway strut -- lower	14			
15		C - PORV 1SV7ABC Exhaust Above Roof - Int DH	15			
16		C - PORV 1SV7ABC Exhaust Above Roof -- PP	16			
17	U1 B Steam Line	B - Class B Piping to PORV 1SV-13ABC - Int DH	17			
18		B - Class B Piping to PORV 1SV-13ABC - Int DH Pipe Hanger	18			
19		B - 1" Schedule 80 Off Class B Piping to B PORV	19			
20		B - Pnuematic PORV 1SV13AB - Int DH	20			
21		B - PORV 1SV13AB Exhaust - Int DH	21			
22		B - PORV 1SV13AB Exhaust - Int DH -- SE Sway Strut -- Lower	22			
23		B - PORV 1SV13AB Exhaust - Int DH -- SW Sway Strut -- Lower	23			
24		B - PORV 1SV13AB Exhaust Above Roof	24			
25		B - PORV 1SV13AB Exhaust Above Roof -- PP	25			
26	U1 C Steam Line	C - MSSV - Int DH Exhaust Pipes Inside DH	26			
27		C - MSSV - Int DH Exhaust Pipes Above Roof	27			
28		C - MSSV - Int DH -- Exhaust Above Roof -- PP	28			
29	U1 B Steam Line	B - MSSV - Int DH -- Exhaust Pipes	29			
30		B - MSSV - Int DH Above Roof -- Exhaust Pipes	30			
31		B - MSSV Exhaust Above Roof -- PP	31			
32	Unit 1 TE	TE System Pipe -- U1 Int DH	32			
33	U2 D Steam Line	D - Class B piping to PORV 1SV1AB -- U2 Ext DH	33			
34		D - Class B piping to PORV 1SV1AB -- Hanger	34			
35		D - Pnuematic PORV 2SV1AB above floor	35			
36		D - PORV 2SV1AB Exhaust	36			
37		D - PORV 2SV1AB Exhaust -- West Hanger	37			
38		D - PORV 2SV1AB Exhaust -- East Hanger	38			
39		D - PORV 2SV1AB Exhaust -- Sway Strut SW - Lower	39			
40		D - PORV 2SV1AB Exhaust -- Sway Strut SE - Lower	40			
41		D - PORV 2SV1AB Exhaust Above Roof -- PP	41			
42		D - PORV 2SV1AB Exhaust Above Roof	42			
43	U2 A Steam Line	A - Class B Piping to PORV 2SV19AB -- U2 Ext DH	43			
44		A - Class B Piping to PORV 2SV19AB -- U2 Ext DH Pipe Hanger	44			
45		A - Pnuematic PORV 2SV1AB -- Above Floor	45			
46		A - PORV 2SV1AB Exhaust	46			
47		A - PORV 2SV1AB Exhaust -- West Hanger	47			
48		A - PORV 2SV1AB Exhaust -- East Hanger	48			
49		A - PORV 2SV1AB Exhaust -- Sway Strut SW - Lower	49			
50		A - PORV 2SV1AB Exhaust -- Sway Strut SE - Lower	50			
51		A - PORV 2SV19AB Exhaust Above Roof -- PP	51			
52		A - PORV 2SV19AB Exhaust Above Roof	52			
53	U2 D Steam Line	D - MSSV in Ext DH Exhaust Inside	53			
54		D - MSSV in Ext DH Exhaust Above Roof	54			
55		D - MSSV in Ext DH -- Exhaust Above Roof -- PP	55			
56	U2 A Steam Line	A - MSSV in Ext DH Exhaust Inside	56			
57		A - MSSV in Ext DH Exhaust Above Roof	57			
58		A - MSSV Exhaust Above Roof -- PP	58			

ATTACHMENT 1

TORMIS Target #	Target Group	TORMIS Target Description	I_{safety}	I_{MPT}	I_{shield}	I_{source}
59	U2 C Steam Line	C - Class B Piping to PORV 1SV-7ABC Int DH U2	59			
60		C - Class B Piping to PORV 1SV-7ABC Pipe Hanger U2	60			
61		C - Pnuematic PORV 1SV7ABC - Int DH U2	61			
62		C - PORV 1SV7ABC Exhaust - Int DH U2	62			
63		C - PORV 1SV7ABC Exhaust - Int DH U2 -- Sway Strut NW Lower	63			
64		C - PORV 1SV7ABC Exhaust - Int DH U2 -- Sway Strut NE Lower	64			
65		C - PORV 1SV7ABC Exhaust Above Roof -- PP	65			
66		C - PORV 1SV7ABC Exhaust Above Roof	66			
67	U2 B Steam Line	B - Class B Piping to PORV 1SV-13ABC Int DH U2	67			
68		B - Class B Piping to PORV 1SV-13ABC Pipe Hanger U2	68			
69		B - Pnuematic PORV 1SV13AB - Int DH U2	69			
70		B - PORV 1SV13AB Exhaust - Int DH U2	70			
71		B - PORV 1SV13AB Exhaust - Int DH U2 -- Sway Strut SW Lower	71			
72		B - PORV 1SV13AB Exhaust - Int DH U2 -- Sway Strut SE Lower	72			
73		B - PORV 1SV13AB Exhaust Above Roof -- PP	73			
74		B - PORV 1SV13AB Exhaust Above Roof	74			
75	U2 C Steam Line	C - MSSV - Int DH Exhaust Inside DH	75			
76		C - MSSV - Int DH Exhaust Above Roof	76			
77		C - MSSV Exhaust Above Roof -- PP	77			
78	U2 B Steam Line	B - MSSV - Int DH Exhaust Inside DH	78			
79		B - MSSV - Int DH Exhaust Above Roof	79			
80		B - MSSV Exhaust Above Roof -- PP	80			
81	Unit 2 TE	TE System Pipe -- U2 Int DH	81			
82	Unit 1 VC/YC	VC/YC Air Intake 1A and 1B -- Vertical Pipe	82			
83		VC/YC Air Intake 1A and 1B -- Horizontal Pipe	83			
84	Unit 2 VC/YC	VC/YC Air Intake 2A and 2B -- Vertical Pipe	84			
85		VC/YC Air Intake 2A and 2B -- Horizontal Pipe	85			
86	Spent Fuel Pools	Unit 1 Spent Fuel Pool	86			
87		Unit 2 Spent Fuel Pool	87			
88	Missile Pass Through Targets	U1 Int UPB South Opening West (small)		1		
89		U1 Int UPB South Opening Middle (large) -- corner		2		
90		U1 Int UPB South Opening Middle (large) -- Center - High		3		
91		U1 Int UPB South Opening East (large) -- Corners		4		
92		U1 Int UPB South Opening East (large) -- Center - High		5		
93		U1 Int UPB East Opening South (large) -- corners		6		
94		U1 Int UPB East Opening South (large) -- Center - High		7		
95		U1 Int UPB East Opening Middle (large) -- corners		8		
96		U1 Int UPB East Opening Middle (large) -- Center - High		9		
97		U1 Int UPB East Opening North(large) -- corners		10		
98		U1 Int UPB East Opening North(large) -- Center - High		11		
99		U1 Int UPB North Opening West (small)		12		
100		U1 Int UPB North Opening Middle (small)		13		
101		U1 Int UPB North Opening East (large) -- corners		14		
102		U1 Int UPB North Opening East (large) -- Center - High		15		
103		U2 Int UPB South Opening WEST (large) -- corners		16		
104		U2 Int UPB South Opening WEST (large) -- Center - High		17		
105		U2 Int UPB South Opening Middle (large) -- corners		18		
106		U2 Int UPB South Opening Middle (large) -- Center - High		19		
107		U2 Int UPB South Opening East (small)		20		
108		U2 Int UPB West Opening South (large) -- corners		21		
109		U2 Int UPB West Opening South (large) -- Center - High		22		
110		U2 Int UPB West Opening Middle (large) -- corners		23		
111		U2 Int UPB West Opening Middle (large) -- Center - High		24		
112		U2 Int UPB West Opening North (large) -- corners		25		
113		U2 Int UPB West Opening North (large) -- Center - High		26		
114		U2 Int UPB North Opening WEST (large) -- corners		27		
115		U2 Int UPB North Opening WEST (large) -- Center - High		28		
116		U2 Int UPB North Opening Middle (small)		29		

ATTACHMENT 1

TORMIS Target #	Target Group	TORMIS Target Description	I_{safety}	I_{MPT}	I_{shield}	I_{source}
117	Missile Pass Through Targets (cont)	U2 Int UPB North Opening East (small)		30		
118		U2 Ext UPB South Opening West (small)		31		
119		U2 Ext UPB South Opening Middle (large) -- corners		32		
120		U2 Ext UPB South Opening Middle (large) -- Center - High		33		
121		U2 Ext UPB South Opening East (large) -- corners		34		
122		U2 Ext UPB South Opening East (large) -- Center - High		35		
123		U2 Ext UPB East Opening South (large) -- corners		36		
124		U2 Ext UPB East Opening South (large) -- Center - High		37		
125		U2 Ext UPB East Opening Middle (large) -- corners		38		
126		U2 Ext UPB East Opening Middle (large) -- Center - High		39		
127		U2 Ext UPB East Opening North (large) -- corner		40		
128		U2 Ext UPB East Opening North (large) -- Center - High		41		
129		U2 Ext UPB North Opening West (small)		42		
130		U2 Ext UPB North Opening Middle (small)		43		
131		U2 Ext UPB North Opening East (large) -- corners		44		
132		U2 Ext UPB North Opening East (large) -- Center - High		45		
133		U1 Int UPB South Opening Middle (large) -- Center -Low		46		
134		U1 Int UPB South Opening East (large) -- Center - Low		47		
135		U1 Int UPB East Opening South (large) -- Center - Low		48		
136		U1 Int UPB East Opening Middle (large) -- Center - Low		49		
137		U1 Int UPB East Opening North(large) -- Center - Low		50		
138		U1 Int UPB North Opening East (large) -- Center - Low		51		
139		U2 Int UPB South Opening WEST (large) -- Center - Low		52		
140		U2 Int UPB South Opening Middle (large) -- Center - Low		53		
141		U2 Int UPB West Opening South (large) -- Center - Low		54		
142		U2 Int UPB West Opening Middle (large) -- Center - Low		55		
143		U2 Int UPB West Opening North (large) -- Center - Low		56		
144		U2 Int UPB North Opening WEST (large) -- Center - Low		57		
145		U2 Ext UPB South Opening Middle (large) -- Center - Low		58		
146		U2 Ext UPB South Opening East (large) -- Center - Low		59		
147		U2 Ext UPB East Opening South (large) -- Center - Low		60		
148		U2 Ext UPB East Opening Middle (large) -- Center - Low		61		
149		U2 Ext UPB East Opening North (large) -- Center - Low		62		
150		U2 Ext UPB North Opening East (large) -- Center - Low		63		
151	Missile Shielding Targets	U1 Int DH S Gull Wing 2			1	
152		U1 Int DH S Gull Wing 3			2	
153		U1 Int DH E Gull Wing 2			3	
154		U1 Int DH E Gull Wing 3			4	
155		U1 Int DH N Gull Wing 2			5	
156		U1 Int DH N Gull Wing 3			6	
157		U2 Int DH S Gull Wing 2			7	
158		U2 Int DH S Gull Wing 3			8	
159		U2 Int DH W Gull Wing 2			9	
160		U2 Int DH W Gull Wing 3			10	
161		U2 Int DH N Gull Wing 2			11	
162		U2 Int DH N Gull Wing 3			12	
163		U2 Ext DH S Gull Wing 2			13	
164		U2 Ext DH S Gull Wing 3			14	
165		U1 Int DH Grating Floor at 807' -- NORTH			15	
166		U1 Int DH Grating Floor at 807' -- SOUTH			16	
167		U2 Ext DH Grating Floor at 807' -- NORTH			17	
168		U2 Ext DH Grating Floor at 807' -- SOUTH			18	
169		U2 Int DH Grating Floor at 807' -- NORTH			19	
170		U2 Int DH Grating Floor at 807' -- SOUTH			20	
171		U1 Blockage on AB Roof			21	
172		U2 Blockage on AB Roof			22	
173		Column DD51.8			23	
174		Column GG52.2			24	
175		Column DD59.5			25	

ATTACHMENT 1

TORMIS Target #	Target Group	TORMIS Target Description	I_{safety}	I_{MPT}	I_{shield}	I_{source}
176	Missile Shielding Targets (continued)	Column GG59.5			26	
177		Column DD66.8			27	
178		Column GG68.2			28	
179		Unit 1 TB Mezzanine			29	
180		Unit 1 TB Turbine Deck			30	
181		Unit 2 TB Mezzanine			31	
182		Unit 2 TB Turbine Deck			32	
183		Unit 1 RB			33	
184		Unit 2 RB			34	
185		Unit 1 DG Bldg			35	
186		Unit 2 DG Bldg			36	
187		Aux Bldg -- CR Area			37	
188		Aux Building -- between RBs			38	
189		Aux Bldg -- U1 N of DH to FHB			39	
190		Aux Bldg -- U2 N of DH to FHB			40	
191		Int DH South Wall			41	
192		Int DH East Wall			42	
193		Int DH North Wall			43	
194		Int DH West N-S Beam			44	
195		Int DH Column DD53			45	
196		Int DH Column DD53.2			46	
197		Int DH Column EE53.2			47	
198		Int DH Column FF53.2			48	
199		Int DH Column GG53.2			49	
200		Int DH Column GG53			50	
201		Int DH Roof			51	
202		Int DH South Gull Wing			52	
203		Int DH East Gull Wing			53	
204		Int DH North Gull Wing			54	
205		U1 Ext DH Main Volume (protected)			55	
206		Ext DH Roof			56	
207		U2 Ext DH E Gull Wing 2			57	
208		U2 EXt DH N Gull Wing 2			58	
209		U2 Ext DH N Gull Wing 3			59	
210		DG Concrete Exhaust Plenum			60	
211		Slab Over SG Exhaust Plenum			61	
212		DG Exhaust Gull Wing			62	
213		DG Barrier North End			63	
214		DG Barrier South End			64	
215		Unit 1 Condensers			65	
216		AB up to 767 under air intakes U1			66	
217		AB up to 767 under air intakes U2			67	
218		RWST missile barrier base			68	
219		U2 Int DH South Wall			69	
220		U2 Int DH West Wall			70	
221		U2 Int DH North Wall			71	
222		U2 Int DH Column DD58.5			72	
223		U2 Int DH Column DD59.2			73	
224		U2 Int DH Column EE58.5			74	
225		U2 Int DH Column FF58.5			75	
226		U2 Int DH Column GG58.5			76	
227		U2 Int DH Column GG59.2			77	
228		U2 Int DH Roof			78	
229		U2 Int DH South Gull Wing			79	
230		U2 Int DH West Gull Wing			80	
231		U2 Int DH North Gull Wing			81	

ATTACHMENT 1

TORMIS Target #	Target Group	TORMIS Target Description	I_{safety}	I_{MPT}	I_{shield}	I_{source}
232	Missile Shielding Targets (continued)	U2 Int DH N-S Beam East			82	
233		U2 Int DH N-S Beam Center			83	
234		U2 Int DH E-W Beam South			84	
235		U2 Int DH E-W Beam North			85	
236		U2 Ext DH South Wall			86	
237		U2 Ext DH East Wall			87	
238		U2 Ext DH North Wall			88	
239		U2 Ext DH Column DD 68.5			89	
240		U2 Ext DH Column DD 69.2			90	
241		U2 Ext DH Column EE 69.2			91	
242		U2 Ext DH Column FF 69.2			92	
243		U2 Ext DH Column GG 69.2			93	
244		U2 Ext DH Column GG 68.5			94	
245		U2 Ext DH Roof			95	
246		U2 Ext DH South Gull Wing			96	
247		U2 Ext DH East Gull Wing			97	
248		U2 Ext DH North Gull Wing			98	
249		U2 Ext DH N-S Beam West			99	
250		U2 Ext DH N-S Beam Center			100	
251		U2 Ext DH E-W Beam South			101	
252		U2 Ext DH E-W Beam North			102	
253		U1 Int DH N-S Beam			103	
254		U1 Int DH E-W Beam South			104	
255		U1 Int DH E-W Beam North			105	
256		U1 FHB West Wall			106	
257		U1 FHB East Wall			107	
258		U1 FHB Roof South			108	
259		U1 FHB South Wall Upper			109	
260		U1 FHB Roof North			110	
261		U1 FHB West Wall Upper			111	
262		U1 FHB East Wall Upper			112	
263		U1 FHB Concrete --Cask Area			113	
264		U1 FHB Concrete --Decon Area			114	
265		U2 FHB West Wall			115	
266		U2 FHB East Wall			116	
267		U2 FHB Roof South			117	
268		U2 FHB South Wall Upper			118	
269		U2 FHB Roof North			119	
270		U2 FHB West Wall Upper			120	
271		U2 FHB East Wall Upper			121	
272		U2 FHB Concrete --Cask Area			122	
273		U2 FHB Concrete --Decon Area			123	
274	Missile Source Targets	Valve Shop				1
275		RT Booth Building				2
276		Z2 Trailer Building				3
277		7455 - OSF				4
278		Z3 Paint Storage				5
279		CSB				6
280		YM Processing Facility				7
281		Warehouse 1A				8
282		Chemical Storage Building				9
283		7430 - TSB				10
284		Combustible Storage				11
285		Metal Building				12
286		7427 - Admin Building				13
287		7405 - Envrionmental Services				14

ATTACHMENT 1

TORMIS Target #	Target Group	TORMIS Target Description	I_{safety}	I_{MPT}	I_{shield}	I_{source}
288	Missile Source Targets (continued)	7408 - Technical Solution Center				15
289		7414 - Energy Explorium				16
290		Z15 Trailer Building				17
291		7403 - National Academy for Nuclear Training				18
292		Guard House				19
293		7402				20
294		7415				21
295		7412 - Boat Storage 1				22
296		7410 - Boat Storage 2				23
297		Large Concrete Building				24
298		7425 - Old Carpenter Shop				25
299		Z16 Paint Storage				26
300		Misc Discarded Materials Building				27
301		7432 - Medical Facility				28
302		7436 - Hazmat Building				29
303		Misc Site Comm				30
304		Z20 Admin Building				31
305		7438				32
306		7486 - LLRW				33
307		7481 - Chemical Mix House				34
308		7490 - Water Treatment Plant				35
309		Z25 Small Office Trailer				36
310		WT Blower House				37
311		Z30 Office Trailer Group 1				38
312		Z30 Larger Office Trailer				39
313		McGuire Training Facility				40
314		7420 - ATF				41
315		Fleet Garage				42
316		MOC				43
317		SB North Section (Work Control)				44
318		SB Warehouse/Tool Crib Area				45
319		SB Office Extension (South)				46
320		SB Receiving Bay				47
321		U1 TB Turbine Deck				48
322		U1 TB Mezzanine				49
323		7417				50
324		Z32 Elongated Brick Building				51
325		COW				52
326		Z9 Gas Bottle Storage Building				53
327		Z32 1 Story House Group				54
328		Z32 2 Story House Group				55
329		Aux Srvcs Bldg				56
330		AB SW Pavers				57
331		AB SE Pavers				58
332		DG 2 NE Paver				59
333		DG 2 SE Pavers				60
334		DG 1 NW Pavers				61
335		DG 1 SW Pavers				62
336		SB NW Pavers				63
337		U2 TB Mezzanine				64
338		U2 TB Turbine Deck				65
339		Z14 Pavillion Structure				66
340		U1 TB Roof North Edge				67
341		U1 TB Roof North Mid				68
342		U1 TB Roof South				69
343		U1 TB Wall Zone 1				70

ATTACHMENT 1

TORMIS Target #	Target Group	TORMIS Target Description	I_{safety}	I_{MPT}	I_{shield}	I_{source}
344	Missile Source Targets (continued)	U1 TB Wall Zone 9				71
345		U1 TB Wall Zone 13				72
346		U1 TB Wall Zone 14				73
347		U1 TB Wall Zone 15				74
348		U1 TB Wall Zone 16				75
349		U1 TB West Wall South				76
350		U1 TB East Wall South				77
351		U1 TB Wall South				78
352		U2 TB Roof North Edge				79
353		U2 TB Roof North Mid				80
354		U2 TB Roof South				81
355		U2 TB Wall Zone 1				82
356		U2 TB Wall Zone 9				83
357		U2 TB Wall Zone 13				84
358		U2 TB Wall Zone 14				85
359		U2 TB Wall Zone 15				86
360		U2 TB Wall Zone 16				87
361		U2 TB West Wall South				88
362		U2 TB East Wall South				89
363		U2 TB South Wall				90
364		SB NE Pavers				91
365		Work Control Bldg on AB Roof				92
366		Vent Structure on AB Roof				93
367		Walkway NE				94
368		Walkway S of Aux Svcs				95
369		Walkway N-S North of WC				96
370		Walkway E-W North of WC				97
371		Walkway West of WC Bldg				98

RAI-03

The LAR references RIS 2008-14, which includes reference to the TORMIS SER. RIS 2008-14 specifically identified items licensees should address to confirm the TORMIS methodology and computer code have been applied and implemented properly.

RIS 2008-14, Item 1, advises the licensee to provide "adequate justification that the analysis used the most conservative value for tornado frequency"

The site specific analysis for development of the tornado hazard curve for McGuire is based on data from the National Oceanic and Atmospheric Administration (NOAA) Storm Prediction Center. As shown in Figure 3-2 of the submittal, the TORMIS developed McGuire tornado hazard curves, i.e., the TORRISK 200 x 200 curve, are used and compared to NUREG/CR-4461, Revision 2, "Tornado Climatology of the Contiguous United States" (ADAMS Accession No. ML070810400), to demonstrate conservatism. However, in Enclosure 1, page 21 of the LAR, it states "It can be seen that the NUREG EF [Enhanced Fujita] curve is below the TORRISK 200 x 200 curve until 180 mph, where they intersect." As such, tornado frequency shown in the tornado hazard curve appears non-conservative beyond 180 miles per hour (mph).

The NRC staff requests the licensee to confirm that values used above 180 mph are conservative and bounding values and provide justification.

Duke Energy Response:

The values used in the MNS TORMIS tornado hazard curve is addressed in two parts: sensitivity of the tornado missile damage results and justification of the data used to develop the plant safety envelop curve (hazard curve).

LAR Figure clarification. The plant safety envelop curve (labeled as MNS DH EF Plant in Enclosure 1, Figure 3-2 of the LAR) was used for the MNS TORMIS plant tornado missile simulations. This curve crosses the NUREG EF MNS curve (NUREG/CR-4461) at about 193 miles per hour (mph) as opposed to 180 mph. Figure 3-2 of the LAR compared the MNS DH EF 200 foot (ft) by 200 ft curve and the MNS DH EF Plant curve to the NUREG EF MNS curve however the 200 ft by 200 ft curve was not used in the MNS simulations.

Sensitivity of the Tornado Missile Damage Results. In order to evaluate the sensitivity of the hazard curve values on the missile damage results, a comparison was made between the results from using the hazard curve simulated in the MNS TORMIS analysis to the results from using the NUREG EF MNS curve. This comparison is shown in **Table 4** and compares wind speed exceedance frequencies of the NUREG curve to those of the MNS hazard curve for each EF scale. The frequencies used were taken directly from their respective documents (NUREG/CR-4461 and MNS TORMIS analysis) and interpreted for the EF scale wind speeds. For comparison the last column shows the MNS to NUREG ratios. For the EF5 tornadoes at 201mph, the TORMIS frequency is about 13% lower than the NUREG, but all other frequencies are considerably higher for the other tornado EF scales (i.e. 4.23 times higher for EF3, 2.65 times higher for EF4 tornadoes, etc.).

Intensity	Peak Gust Wind Speed (mph)			NUREG Exc. Frequency	MNS DH EF Plant Freq.	MNS/NUREG
	min	max	MidPt			
EF1	86	110	98	2.98E-04	4.01E-04	1.35
EF2	111	135	123	6.54E-05	1.92E-04	2.94
EF3	136	165	150.5	1.44E-05	6.08E-05	4.23
EF4	166	200	183	2.51E-06	6.66E-06	2.65
EF5	201	230	215.5	2.51E-07	2.20E-07	0.87

Table 4: MNS TORMIS and NUREG Tornado Hazard EF Scale Wind Speed Exceedance Frequencies

The TORMIS equations that relate tornado occurrence rates to missile damage frequency were used to quantify the sensitivity of the computed MNS missile damage frequencies to the tornado hazard curve. These results are given below:

1. The first sensitivity analysis is to quantify the effect of the NUREG EF MNS curve on the MNS TORMIS missile damage frequencies. This is illustrated in **Figure 3** using the NUREG EF MNS curve with extrapolations to lower wind speeds. Just as TORMIS simulates individual EF intensities and aggregates the results to get the overall missile damage frequencies, the contribution by EF scale was computed using the NUREG EF frequencies. This approach provides an analytical quantification using the TORMIS results with the NUREG EF MNS curve. As illustrated in **Table 5**, missile damage frequency results that are more than a factor of three lower than the MNS DH EF Plant curve results as documented in the LAR. The significantly higher TORMIS frequencies for EF1-EF4 (as shown in **Table 4**) contribute to this result. Hence, by virtue of comparing these results, the MNS DH EF Plant curve produces MNS missile damage frequencies that are approximately 300% higher than those that would be produced using the NUREG EF curve.

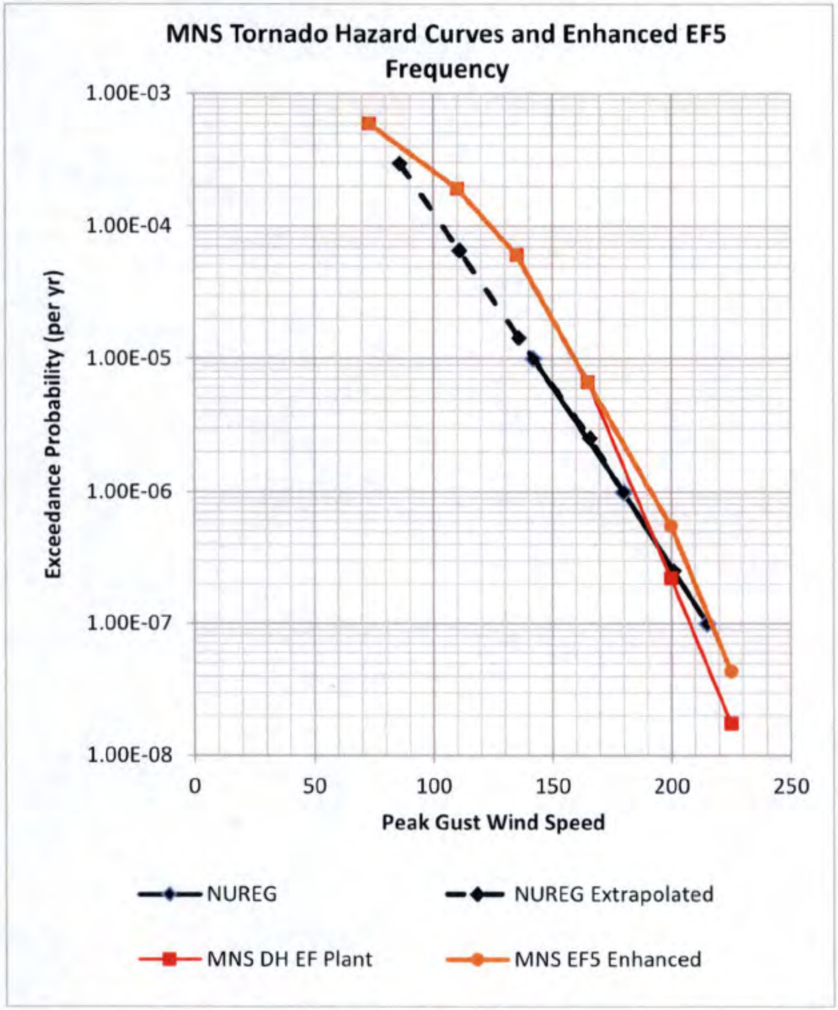


Figure 3: **MNS Tornado Hazard Curves and Illustration of Enhanced EF5 Frequency**

2. The second sensitivity evaluates the EF5 frequencies, which corresponds to wind speeds greater than 201 mph. The TORMIS EF5 frequency was multiplied by a factor of 2.5 in order to create a TORMIS hazard curve that is above the NUREG for the full range of EF5 wind speeds, then updated damage frequencies were produced keeping all other TORMIS frequencies the same (see the orange curve in **Figure 3** labeled "MNS EF5 Enhanced"). For this case, the aggregate damage frequency increased by about 4% for each Unit, as shown in **Table 5.** Hence, the effect of increasing EF5 frequencies produced a minimal impact on the MNS missile damage frequencies. This result follows from the previous results illustrate that the contributions to the missile damage frequencies from much more frequent, but lower intensity tornadoes, dominates the tornado missile risk for MNS.

Target Group and Ratio	MNS Damage Frequency (yr^{-1}) for Different Tornado Hazard Curves					
	MNS DH EF Plant (Base)		NUREG		MNS EF5 Enhanced	
	Unit 1	Unit 2	Unit 1	Unit 2	Unit 1	Unit 2
Main Steam Boolean	2.42E-07	7.13E-07	7.54E-08	2.17E-07	2.50E-07	7.36E-07
TE System Pipe	6.29E-08	4.27E-08	2.05E-08	1.93E-08	6.60E-08	4.56E-08
VC/YC Air Intake and SFP Boolean	5.41E-08		1.71E-08		5.72E-08	
Arithmetic Sum over all Target Groups	3.59E-07	8.10E-07	1.13E-07	2.54E-07	3.73E-07	8.39E-07
Ratio to Base	1.00	1.00	0.31	0.31	1.04	1.04

Table 5: Sensitivity Analysis Comparison of MNS Tornado Missile Damage Frequencies

Justification of Data Used. See the following regarding the justification of the MNS frequencies for high wind speeds.

1. The LAR discusses the hazard curve for the smaller 200' x 200' target, which was not used to perform the TORMIS simulations. The hazard curve used in the simulations is the curve developed for the plant safety envelope that is shown as the red curve in Figure 3-2 of the LAR, reproduced in **Figure 3** herein. There is clearly very little difference in the frequencies of the NUREG curve and the TORMIS curve at 200 mph.

2. **Figure 4** shows the starting region and the 1.4 x 1.4 degree grid used for the development of the MNS subregion from which the tornado frequencies were developed. The starting region covers most of the Eastern US and extends into portions of the Midwest. The location of reported tornadoes for the years 1950-2016 is shown in **Figure 5**. The MNS subregion was developed using multi-variate statistical methods to determine how the cells grouped (or clustered) to form subregions within the larger, starting region. The variables considered in the subregion analysis and computed for each 1.4 x 1.4 degree grid cell included: latitude and longitude; mean and standard deviation of elevation; number of tornado days per year; fraction of land within the cell to the total area of the cell (considering large bodies of water like the Atlantic Ocean); tornado path direction; moderate occurrence rate (EF2/3); strong occurrence rate (EF4/5); and point strike probability.

ATTACHMENT 1

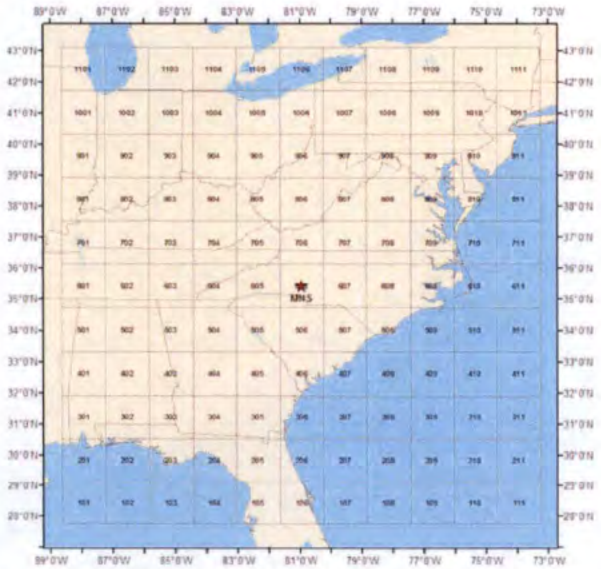


Figure 4: 15.4° x 15.4° Region Centered on MNS

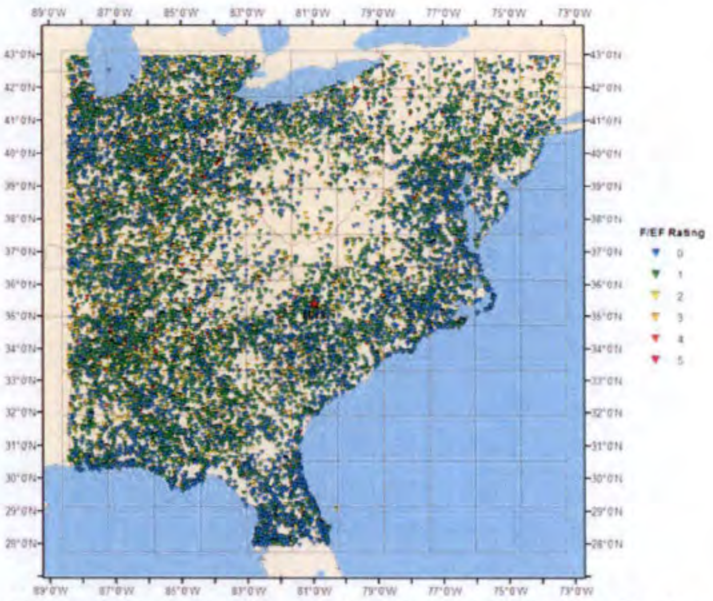


Figure 5: Reported Tornadoes in MNS Starting Region

3. The MNS subregion was developed from multiple plots of cluster groups around the plant and selected the final subregion shown in **Figure 6**, which encompasses an area of 73,377 square miles. MNS is in the eastern shadow of the Appalachian Mountains. The subregion extends in directions away from the Appalachian Mountains and broadly follows the Piedmont topography of the Carolinas. The subregion also extends into Virginia and down into eastern Georgia. In comparing the MNS subregion with the tornado map in **Figure 5**, the cluster analysis associated the MNS home cell with cells in a broad area with similar tornado and physiographic metrics from Georgia to Virginia. MNS did not associate with regions of higher tornado risk, such as areas from Alabama westward or up into the Midwest portion of **Figure 5**.

ATTACHMENT 1

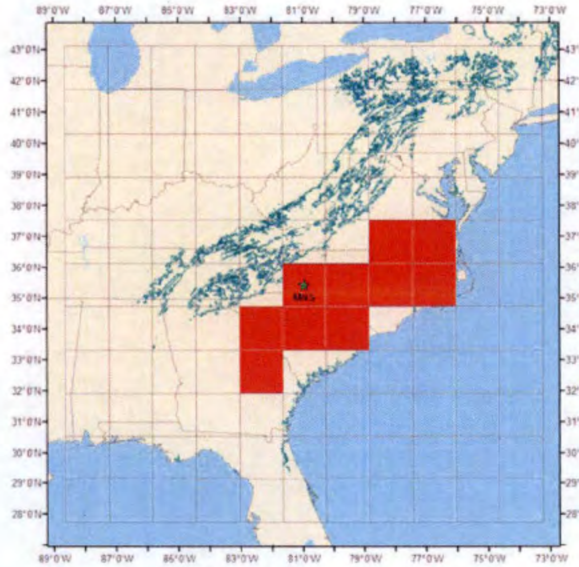
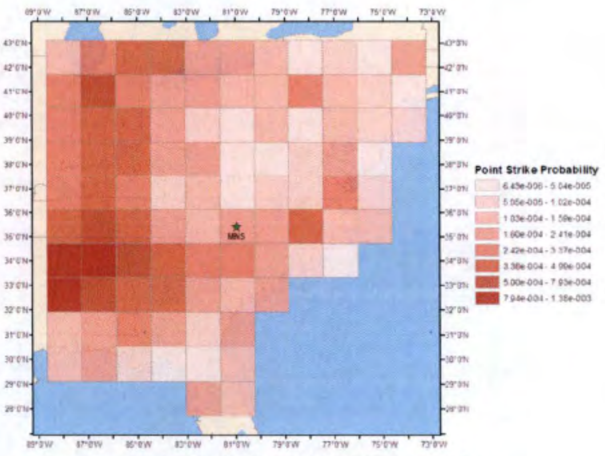
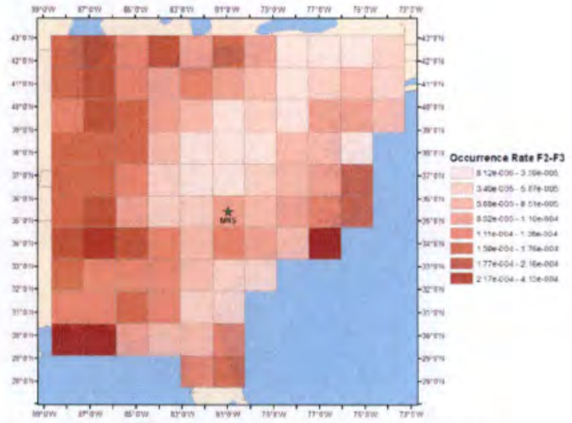


Figure 6: MNS Subregion

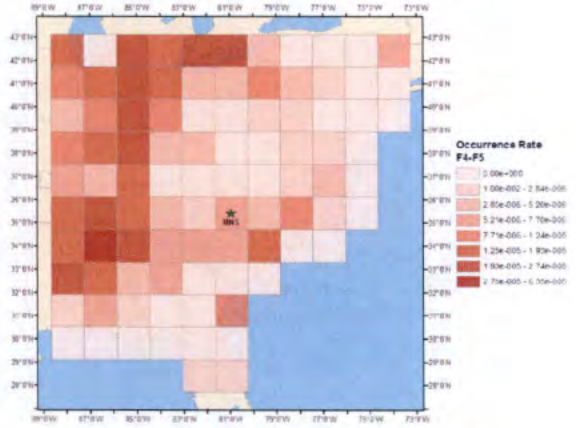
4. **Figures 7a**, **b**, and **c** show the point strike probability, the moderate (EF2/3) and the strong (EF4/5) occurrence rates for 1 degree cells used in the MNS region analysis. The cell statistics were compared for these metrics within the MNS subregion. Seven of the nine cells in the subregion were found to have a higher point strike probability than the MNS home cell. Five cells have higher moderate or strong occurrence rates than the home MNS cell.



a. Point Strike Probability per Year



b. Moderate Occurrence Rate (F2-F3)



c. Strong Occurrence Rate (F4-F5)

Figure 7: 1.4° Cell Metric Plots

5. The occurrence rate adjustments for MNS included a time trend adjustment occurrence rate increase of 164%, an 18% occurrence rate increase for unreported events in the modern era (1995-2016), and a conservative reallocation of 15% of the reported EF0 tornadoes across all intensities to reflect the NWS modern era practice of reporting all unknown intensities as EF0s. No EF5 tornadoes were reported in the MNS subregion.

6. The use of a large MNS subregion encompasses a consistent physiographic region and the application of the adjustments noted above produced a reasonably conservative hazard curve for the MNS site. A systematic method was used to develop the hazard curve that is consistent with the TORMIS methodology. The hazard curve used for MNS clearly produces higher damage frequencies by hundreds of percent over the data in NUREG CR-4461 and the results are not particularly sensitive to EF5 frequencies for this plant.

7. Since the EF scale wind speeds are allowed for tornado missile LAR analyses, conservatism was applied to the resulting exceedance frequency values in the hazard curve at these EF scale wind speeds, rather than to the EF scale wind speeds.

RAI-04:

One of the five review items in the TORMIS SER is to justify any deviation from the calculation approach. In addition, RIS 2008-14 (Item 2.d) includes the concern with taking credit for non-structural members. The unique McGuire configuration of the safety-related targets within the doghouses necessitated the use of the TORMIS ricochet routine to ensure conservatism in the TORMIS analysis. The doghouse openings contain non safety-related barriers (utility port barriers (UPBs)) to protect internal components from missiles. The UPBs consist of vertical and horizontal 5/8 inch diameter (No. 5) rebar spaced at five inches to six inches, on center. They are welded together at rebar intersection points and are welded to a structural steel angle frame which is either anchor bolted to doghouse concrete or welded to steel plates embedded in the doghouse concrete. As specified in the LAR, these UPBs in the openings at the top of the McGuire doghouses are credited for their ability to resist or slow down missiles impacting them. UFSAR, Chapter 3, Table 3-8 describes velocity values for tornado missiles.

As indicated in the LAR, missile ricochet has been an option in the TORMIS computer code dating back to Electric Power Research Institute (EPRI) NP-769, "Tornado Missile Risk Analysis – Appendixes" dated May 1978, however, it has not previously been used in a TORMIS analysis supporting an LAR. To accomplish modeling of barriers, the ricochet routine within the TORMIS software was modified to include a missile-pass-through option to credit the barrier. The LAR states on page 7, "The original TORMIS missile ricochet routine (References 3 and 4) redirects missiles that impact rigid surfaces with a reduced velocity." RIS 2008-14 (Item 2.d) raises a concern about taking credit for non-structural members, and the UPBs used for the dog house design appear to be non-structural.

The NRC staff requests the licensee to clarify if the ricochet model showing a reduced impact velocity is intended to mitigate the concern about crediting non-structural members, and discuss how the UPB can withstand the reduced velocity. Also explain the meaning of the missile velocities in USFAR, Table 3-8 with respect to the reduced velocity.

Duke Energy Response:

Use of Ricochet Routine

The majority of the safety-related targets at MNS are located inside the Main Steam Doghouses and are exposed to missiles through openings at the top level. These openings are bounded by large concrete columns and are partially protected by angled, "gull wing" reinforced concrete type missile barriers as shown in **Figure 8.** Missiles can ricochet off of these concrete surfaces and be directed towards the safety related targets inside the Doghouses.

[redacted]

Figure 8: MNS Unit 2 Exterior Doghouse

The unique configuration of safety related targets within the Doghouses necessitated the use of the TORMIS ricochet routine to ensure conservatism in the TORMIS analysis. Missile ricochet has been an option in the TORMIS computer code dating back to EPRI NP-769 (LAR Reference 4). Instead of terminating a missile history when a missile strikes a missile shielding or safety-related target, the TORMIS missile ricochet routine continues the missile history at a new angle and velocity away from the surface it just impacted. The result is that the missile keeps flying and can still impact and possibly damage targets following the initial impact. Missile histories are continued following impacts on all missile shielding and safety target surfaces that are not perforated by the missile. Missile source targets are conservatively modeled with "imaginary surfaces" that allow missiles to fly through them unimpeded. Missiles are allowed to ricochet up to three times before the missile history is terminated by the TORMIS code.

Utility Port Barriers (UPBs) in Doghouse Openings

The UPBs were not designed or constructed to stop design basis tornado-generated missiles nor are they credited for any ability to resist or slow down the design basis tornado-generated missiles, as described in UFSAR Table 3-8. This table will not change with the LAR. **Figure 9** shows an example of a UPB adjacent to the Main Steam Safety Valve (MSSV) exhausts from the inside of the Doghouse. While these barriers are not qualified to resist the MNS design basis tornado-generated missiles, they do offer considerable resistance to the lightweight TORMIS-generated tornado missiles that most commonly enter the doghouse openings, including metal siding, wood plank, wood beam, and plywood missiles.

[redacted]

Figure 9: UPB in Doghouse Wall Opening Adjacent to MSSV Exhausts

The TORMIS missile ricochet routine redirects missiles with a reduced velocity. A TORMIS code change was made to credit the ability of nonqualified barriers (i.e., the MNS UPBs) to resist or slow down missiles. This change was implemented within the existing TORMIS ricochet routine to perform the following steps when the missile velocity at impact exceeds a user-analyzed critical missile velocity:

1. Continue the missile trajectory through the barrier, instead of ricocheting it off of the surface.
2. Calculate the residual missile velocity based on the change in kinetic energy.

Critical missile velocity is determined based on the minimum amount of kinetic energy that is lost for a given missile type that penetrates a given barrier. The critical missile velocities for wood planks, metal siding, and plywood missiles was determined using a deterministic Finite Element Analysis (FEA) and used as input to TORMIS. Critical missile velocities for the wood beam missile were determined using the kinetic energy results for the wood plank missile.

These critical velocities consider the size of the UPB, the impact location, and the minimum expected change in kinetic energy for a missile passing through the UPB. A reduction factor of 0.9 was applied to the critical velocities determined from the FEA for additional conservatism. **Table 6** shows the missile velocities input to TORMIS for the UPBs. The critical missile velocities for the other 19 TORMIS missile types was set to 0 ft/s, which allows all of these missile types to pass through the UPBs unimpeded with no reduction in velocity.

UPB Impact Location	***TORMIS Input Critical Velocity (ft/s)***			
	Wood Plank	***Metal Siding***	***Plywood Sheet***	***Wood Beam***
Corner of Large UPBs	51	68	32	19
Center of Large UPBs	70	102	72	26
Side of Large UPBs	51	94	45	19
Anywhere on Small UPBs	36	68	32	13

Table 6: Missile Pass Through Velocities for UPBs (from FEA)

This missile pass through option was implemented without modifying the TORMIS physics engine that flies missiles within a tornado wind field. As such, this change does not deviate from the EPRI methodology, but improves the functionality of the ricochet routine to account for missiles that have the ability to pass through non-qualified missile barriers, like the UPBs. Targets representing the UPBs are referred to as "Missile Pass Through" targets in the listing of all targets provided in the response to RAI-02.

RAI-05

The LAR, Enclosure 1, page 8 states: "Target missile hit frequencies are the frequency of at least one tornado missile hitting a target over a period of one year. For very large targets, tornado generated missiles are likely to hit the target for almost every tornado strike and hence the missile hit frequency may approach or be essentially equal to the tornado strike frequency for such targets. As the target size reduces, as the target is shielded by other structures, or if only one surface of the target is exposed, the missile hit frequency reduces accordingly. In general, tornado missile hit frequencies are dependent on many geometrical factors as well as missile types, numbers, and proximity. The degree to which the elevation of the target is above the elevation of the nearby missile sources can also be a critical factor."

The frequencies presented in Enclosure 1, Table 3-2 of the LAR represent the average frequency produced over 60 replications representing all outage and non-outage conditions modeled. According to that table, the four targets with the highest hit frequencies are the VC/YC (Control Room Area Ventilation) Air Intakes (targets 82-85) located outside of the doghouses next to the Reactor Buildings.

The NRC staff requests the licensee to provide additional information on the "geometrical factors, missile types, numbers, proximity" etc., which explains this result.

Duke Energy Response:

The VC/YC Air Intakes for both units at MNS are located outside between the Reactor Buildings to the South and the Turbine Buildings to the North. The Unit 1 Intakes are located West of the Auxiliary Building and the Unit 2 Intakes are located East of the Auxiliary Building. **Figure10** shows an AutoCAD representation of the TORMIS model for the VC/YC air intakes and the immediate proximity. In the figure, safety-related targets are shown in red, missile shielding targets are shown in gray, and missile source targets are shown in orange. The location of these targets causes them to have the highest missile hit frequency of all targets in the MNS TORMIS analysis for several reasons, including:

1. They are located outside of any Category 1 structure. The majority of the targets in the MNS TORMIS analysis are located within the Main Steam Doghouses and missiles must pass through the openings at the upper level of the doghouses to impact the targets. Further, to enter the Doghouses, missiles must have a horizontal or upward trajectory to pass through the openings that are partially protected by concrete gull-wing barriers. Conversely, the VC/YC Air Intakes are located outside and can be impacted from most directions and angles, including by falling missiles. As a result, the VC/YC air intakes are expected to have higher missile hit frequencies due to their location outside of all buildings.

2. They are located at a lower elevation. The VC/YC Air Intakes are located on top of the Diesel Generator Rooms at an elevation of about 7 feet above plant grade. This is a much lower elevation than the openings in the Main Steam Doghouses that start 48 feet above grade, and the exposed MSSV and PORV tailpipes above the doghouse roofs that start 64 feet above grade. Targets at a lower elevation are more likely to be impacted by missiles because all missiles must come down, but they do not have to reach higher elevations. As a result, the VC/YC Air Intakes are expected to have higher missile impact frequencies due to their elevation.

3. Their proximity to missile sources. The VC/YC Air Intakes are located immediately adjacent to missile sources such as the Unit 1 and 2 Turbine Buildings, as well as the metal-clad work control building and enclosed walkways on the roof of the Auxiliary Building. We also note that the intakes are located at a lower elevation than the missiles being generated from these missile sources. The net result is that the air intakes are closer to and located below the point where missiles are generated from these sources. This is especially significant for the VC/YC Air Intakes because it was conservatively assumed that any missile hit on the intakes renders them inoperable. As a result, the VC/YC Air Intakes are expected to have higher missile impact frequencies due to their proximity to these missile sources.

[redacted]

Figure 10: AutoCAD Representation of TORMIS Model for VC/YC Air Intakes and Proximity

RAI-06

NUREG-0800, "Standard Review Plan [SRP] for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition," Chapter 3, Sections 3.5.1.4 and 3.5.2, contain the current acceptance criteria governing tornado missile protection. These criteria generally specify that SSCs that are important to safety be provided with sufficient, positive tornado missile protection (i.e., barriers) to withstand the maximum credible tornado threat. SRP, Chapter 3, Section 3.5.1.4 permits relaxation of the above deterministic criteria if it can be demonstrated that the probability of damage to unprotected essential safety-related features is sufficiently small.

RIS 2008-14 describes identified items that licensees should address when performing an approved TORMIS methodology per the TORMIS SER. The SER found that once the EPRI methodology has been chosen, justification should be provided for any deviations from the calculational approach. Enclosure 1, Section 3.2 of the LAR describes how the licensee complies with the TORMIS SER criteria. Enclosure 1, Section 3.1.5, page 11 of the LAR states "Boolean logic is applied to targets to account for redundancy in the structural or system design or TORMIS modeling of a component as multiple targets."

Enclosure 1, Section 3.1.5, page 11 of the LAR states "... the Unit can sustain damage to one Main steam line, and it can be in multiple places (PORVs [power operated relief valves], MSSVs [main steam safety valves], or associated components) on the same Main Steam line." Proposed USFAR changes in Enclosure 2, Section 3.5.2.8.1.3d states "[t]he failure logic for redundancy of the Main Steam lines when missile damage to the PORVs and MSSVs is beyond acceptable criteria, is that the Unit can sustain damage to one of four Main Steam line and the damage can be in multiple places on the same Main Steam line (PORVs, MSSVs, or associated components)." The basis for failure criteria is unclear. The NRC staff requests the following:

a. **Describe the basis for all failure criteria used in the McGuire TORMIS analysis where Boolean logic is used. Examples include failure criteria for Main Steam line and PORVs or the failure criteria for Control Room Area Ventilation (VC/YC) air intakes and spent fuel pools (SFPs).**

Duke Energy Response for RAI-06a:

Basis for the failure criteria used for Main Steam line, PORVs and MSSVs

The failure criteria used for the Main Steam line (including the MSSVs and the PORVs) Boolean logic in the MNS TORMIS analysis was defined in a Main Steam line redundancy analysis performed in support of this LAR. This analysis determined an acceptable level of tornado missile damage to the Main Steam lines such that the plant response to the resulting damage and loss of function was bounded by the applicable MNS UFSAR Chapter 15 accident analyses.

The failure criteria resulting from this analysis can generally be stated that if a Unit does not have the system/component configuration required to mitigate a tornado event, concurrent with a loss of offsite power, and complete a controlled unit cooldown, then it fails. In order to not fail, this requires that three of the Unit's four Main Steam lines remain intact and at least one of the PORVs associated with any of the three intact Main Steam lines is undamaged and fully functional. If this is not the case, then the failure criteria is met.

A Main Steam line is defined as not intact, or damaged, by any one of the following:

- A missile strike to any MSSV downstream exhaust pipe that crimps it beyond its crimping limit, or causes the downstream exhaust pipe support to fail so as not to perform its design function, or causes the end of the downstream exhaust pipe to displace enough to strike the process piping attached to an MSSV.
- A missile strike to any PORV valve body or its actuator would result in it not being able to perform its design function.
- A missile strike to the downstream PORV exhaust pipe that crimps it beyond its crimping limit, or punctures the wall or failures of any the downstream exhaust pipe supports so as not to perform its design function.
- A missile strike to the process piping upstream of a PORV that causes it to crimp beyond its limit, or a puncture or to fail any upstream process piping supports so as not to perform its design function.

To determine crimping limits, tornado missile target strike/damage analysis was performed to determine how much damage these targets could take due to a missile strike and still perform their design functions. The damage evaluated was the local reduction in internal flow area due to pipe deformation resulting from a tornado missile strike, also called pipe crimping.

Basis for the failure criteria used for Control Room Area Ventilation (VC/YC) Air Intakes and Spent Fuel Pools

The four VC/YC Air Intakes are located on top of the Auxiliary Building roof, two near the south end of the Unit 1 Reactor Building, and two near the south end of the Unit 2 Reactor Building. Based on their location, the Air Intakes are susceptible to tornado missile damage. The Air Intakes for each Unit consist of 2 side-by-side "candy cane" pipes. See Figure 11 below. Given their close proximity to each other, both pipes for each unit are modeled together in TORMIS (i.e. a missile hitting either pipe hits both pipes). The candy-cane shape for each unit is represented in TORMIS as two targets, one representing the vertical pipe, and a second representing the curved section (as a horizontal target). As discussed above, both of these targets represent both pipes for the respective unit. The Boolean logic described in the LAR states that a missile hit on either the vertical or horizontal section results in damage to both intakes for the unit. In other words, any missile impact on either target results in failure of the Unit 1 VC/YC Air Intakes. Unit 2 is treated in the same way.

Each MNS Spent Fuel Pool is housed in a concrete and steel superstructure. The concrete superstructure encloses the Spent Fuel Pool except for the North end of the structure, which is enclosed by a steel structure with siding. The concrete structure provides protection from tornado winds and tornado missiles, but the North end of the Spent Fuel Building does not provide tornado missile protection. As such, the only credible missile paths to the Spent Fuel Pools of each unit are from the North end.

In order to meet the failure criteria for this Boolean combination, a tornado would need to produce missiles that impact and damage the VC/YC Intakes of both Units (that are separated by about 250 feet) on the south side of the Reactor Buildings and have a damaging missile from the same tornado entering at least one of the Spent Fuel Pools from the North end.

As documented in the MNS UFSAR, the analyzed tornado missile accident postulates a tornado missile penetrating the North end of one of the Spent Fuel Fool Buildings and rupturing spent fuel assemblies in Region 2 of the Spent Fuel Pool. In the worst case scenario of this accident, only one of four VC/YC Air Intakes remains intact to provide air intake to the Control Room filtration system (VC). Despite this worst case scenario, the resulting doses to the Control Room are well within the 10 CFR 50.67 limits.

Additional details regarding the failure criteria for the VC/YC Air Intakes is also provided in the response to RAI-06e.

[redacted]

Figure 11: Control Room Area Ventilation Air Intake 'Candy Canes'

b. Considering that the criteria in SRP, Section 3.5.1.4 is compared against the probability per year of damage to all SSCs important to safety that are not designed to withstand tornado missile damage, justify comparing McGuire results using selected failure criteria against the criteria in UFSAR and SRP. Also, describe how the use of failure criteria is consistent with the application of the approved TORMIS methodology.

Duke Energy Response for RAI-06b:

In addition to the discussion on the basis for the failure criteria provided in the response to RAI-06a, additional clarity is provided in the RAI-06d response for the VC/YC Air Intakes and Spent Fuel Pool failure criteria. Also, specific discussion is presented in the RAI-06e response on the individual target results and how the target group damage frequencies were derived. The damage frequency values given in Table 3-2 of the LAR are TORMIS results for individual targets which do not include the effects of the Boolean logic. The damage frequencies that include the effects of the Boolean logic are given in LAR Table 3-4 for the Main Steam system and in new **Table 7** below for the VC/YC Air Intakes / Spent Fuel Pools. These tables represent the damage frequencies for the possible combinations of targets within the group and indicate whether the applicable system fails for each combination. The results of these tables are then included in the aggregate damage frequencies for the MNS target groups in the LAR Table 3-5.

Boolean logic is applied to targets to account for redundancy in the structural or system design or TORMIS modeling of a component as multiple targets. With redundancy in the design, the system function could be met even with one or more individual targets damaged by postulated tornado missiles.

Missile hit and damage frequencies for groups of targets evaluated in TORMIS are commonly combined using Boolean operators (U and ∩). The union (U) operator means that if any one of the targets is damaged in a tornado, the system is assumed to fail. The intersection (∩) operator means that all the intersected components must be damaged in a tornado strike for the system to fail. Combinations of union and intersection operators can be put together to describe multi-component system failure logic for plant systems and subsystems. For union groups, summation of the frequencies is often accurate for small frequencies.

Preliminary analyses determined that the summation of damage frequencies for the individual targets in the LAR Table 3-2 approached or exceeded the 1.0E-06 per year threshold. However, these analyses did not consider any redundancies between the Main Steam lines or the VC/YC Air Intakes. LAR Section 3.1.5 discusses the approach to the Boolean logic developed using the TORSCR code to account for the redundancies. TORSCR is a FORTRAN computer code that is used to post-process TORMIS output files. Its primary function is to compute Boolean combinations of target hit and damage probabilities over multiple targets.

Total risk assessment for multi-target combinations are discussed in the original TORMIS documentation in Section 2.2.4.3 of EPRI NP-768, and Section II of EPRI NP-2005. NP-2005 documents the TORMIS function that provides the Boolean union combination over all targets considered in the analysis as well as the union and intersection combinations for 2 user specified targets. The TORSCR post-processor uses the methodology discussed in these references to produce union and intersection results for any number of targets specified.

TORSCR was initially developed to support the TORMIS analysis performed for the Limerick Generating Station. The TORSCR post-processing computer code and use of the Boolean Logic approach was also previously reviewed and approved by the NRC for the Byron Station TORMIS License Amendment.

Combination Number	*Unit 1 VC/YC Failure*	*Unit 2 VC/YC Failure*	*U1 SFP Failure*	*U2 SPF Failure*	*System Survive or Fail*	*Frequency (yr $^{-1}$)*
1	0	0	0	0	Survive	3.52E-04
2	1	0	0	0	Survive	7.72E-05
3	0	1	0	0	Survive	1.15E-04
4	0	0	1	0	Survive	4.39E-09
5	0	0	0	1	Survive	3.18E-08
6	1	1	0	0	Survive	1.04E-04
7	1	0	1	0	Survive	1.45E-09
8	1	0	0	1	Survive	2.01E-08
9	0	1	1	0	Survive	3.10E-09
10	0	1	0	1	Survive	2.58E-08
11	0	0	1	1	Survive	2.58E-11
12	**1**	**1**	**1**	**0**	**Fail**	**4.04E-09**
13	**1**	**1**	**0**	**1**	**Fail**	**5.00E-08**
14	1	0	1	1	Survive	4.48E-11
15	0	1	1	1	Survive	1.41E-11
16	**1**	**1**	**1**	**1**	**Fail**	**8.51E-11**
Overall Failure Frequency						**5.41E-08**

Table 7. Failure Combinations for VC/YC Air Intakes and Spent Fuel Pools

Enclosure 1, Section 3.1.5, page 13 of the LAR states "The Boolean logic for the Unit 1 and 2 Spent Fuel Pools and the Unit 1 and 2 VC/YC Air Intakes is that failure is defined as both VC/YC Air Intakes failing by wind missile and missile damage to fuel assemblies in either of the Spent Fuel Pools." Proposed USFAR changes in Enclosure 2, Section 3.5.2.8.1.3d states "The failure logic for the Control Room Air Ventilation System (CRAVS) Intakes (VC/YC Air Intakes and Spent Fuel Pools (SFP) is simultaneous tornado generated missile impacts to all the Unit 1 and Unit 2 VC/YC Air Intakes AND the entry of a tornado generated missile into either the Unit 1 or Unit 2 SFP that would impact and Spent Fuel assemblies above acceptable critical velocities." The NRC staff requests the following:

c. **Define acceptable critical velocities, their basis, and their effect on SSCs.**

Duke Energy Response for RAI-06c:

Acceptable critical velocities for tornado generated missiles entering the SFP is defined as the velocities at which tornado missiles can enter the spent fuel pool and not cause damage to spent fuel assemblies. For wood plank, metal siding, and plywood type missiles the acceptable critical missile velocities set at 528 ft/sec. These three missile types were analyzed for entry into the SFPs at the given velocity for damage to spent fuel assemblies. The analysis shows that they will not cause any damage to spent fuel assemblies. For conservatism in the TORMIS analysis, the failure velocity values used for these three missile types are taken as 90% of the acceptable critical velocities. For all other missile types, entry at any speed into the SFP is considered a failure in TORMIS.

The overall damage probability Boolean logic in Enclosure 1, Page 13 of the submittal seems to define the failure criteria as a single Unit 1 and a single Unit 2 VC/YC Air Intake Failure and a failure of either SFP results in damage, but the text on Enclosure 2, Page 8 seems to differ from the Boolean logic shown. The NRC staff requests the following:

d. **Clarify the failure criteria for VC/YC air intakes and SFPs and address any discrepancies between the failure criteria in Enclosure 1, Page 13 and Enclosure 2, Page 8.**

Duke Energy Response for RAI-06d:

The apparent discrepancy between the failure criteria for the VC/YC air intakes as described on Enclosure 1, Page 13 and Enclosure 2, page 8 seems to be due to the wording used in Enclosure 1, Page 13. The following changes in red will make it more consistent:

> *The Boolean logic for the Unit 1 and 2 Spent Fuel Pools and the Unit 1 and 2 VC/YC Air Intakes is that failure is defined as ~~both~~ the VC/YC Air Intakes of both Units failing by wind missile and missile damage to fuel assemblies in either of the Spent Fuel Pools. The three main pieces of this logic can then be expressed as the following independent failure events:*

To clarify further, **Figure 12** is a photograph of the Unit 1 VC/YC Air Intakes and shows that the Intakes for each Unit consist of 2 side-by-side "candy cane" pipes. Given their close proximity to each other, both pipes for each unit are modeled together in TORMIS (i.e. a missile hitting either pipe hits both pipes). The candy-cane shape for each unit is represented in TORMIS as two targets – one representing the vertical pipe, and a second representing the curved section (as a horizontal target). As discussed above, both of these targets represent both pipes for the respective unit. The Boolean logic described on Enclosure 1, Page 13 states that a missile hit on either the vertical or horizontal section results in damage to both intakes for the unit. In other words, any missile impact on either target results in failure of the U1 VC/YC air intakes. Unit 2 is treated in the same way. As such, the language in Enclosure 1, p.13 is consistent with Enclosure 2, page 8.

[redacted]

Figure 12. Photo of Unit 1 VC/YC Air Intakes

e. **The individual target damage frequencies for VC/YC air intakes and SFPs in Enclosure 1, Table 3-2 do not seem to result in the value given in Enclosure 1, Page 13. Provide details on how the damage frequency for this event was derived, and explain the apparent discrepancy between Table 3-2 and Enclosure 1.**

Duke Energy Response for RAI-06e:

The individual target damage frequencies in Table 3-2 of LAR Enclosure 1 do not include any effects of the Boolean logic discussed at the end of Section 3.1.5 on page 13 of Enclosure 1. To reconcile the relatively high damage frequencies for targets 82-85 (VC/YC air intakes) from Table 3-2 with the relatively low Boolean frequency (i.e. 5.41E-08 yr^{-1}) reported on page 13 of Enclosure 1, the location of the targets with respect to each other needed to be taken into consideration.

Figure 13 shows that the VC/YC Air Intakes for the two Units are located on the south side of the Reactor Buildings and that the Spent Fuel Pools are on the north side of the Reactor Buildings.

Figure 14 shows that the only credible missile paths to the Spent Fuel Pools of each Unit are from the north. In order to meet the failure criteria for this Boolean combination, a tornado would need to produce missiles that impact the VC/YC Intakes of both Units (that are separated by about 250 feet) on the south side of the Reactor Buildings and have damaging missiles entering at least one of the Spent Fuel Pools from the north. Based on these locations, it is expected to be a substantial reduction from the individual target damage frequencies (from Table 3-2) to the Boolean logic defined on Page 13 of Enclosure 1.

The differences were quantitatively resolved by considering the 16 possible combinations of the following four failure events:

1. Missile impact on either portion of the Unit 1 VC/YC Air Intakes (82 U 83)
2. Missile impact on either portion of the Unit 2 VC/YC Air Intakes (84 U 85)
3. Damaging missile impact on fuel assemblies in Unit 1 Spent Fuel Pool (86)
4. Damaging missile impact on fuel assemblies in Unit 2 Spent Fuel Pool (87)

Table 8 shows the damage frequency for each possible combination of events that would lead to failure based on the failure criteria defined on Page 13 of Enclosure 1. Each combination in the table represents a Boolean intersection (∩) of the events listed with 0 indicating no failure and 1 indicating failure. For example, combination 12 (the first of three that lead to system failure) is interpreted as "U1 VC/YC Fails AND U2 VC/YC Fails AND U1 SFP Survives AND U2 SFP Fails". The overall failure frequency for the system is then computed as the arithmetic sum of the three event combinations that are labeled "Fail" in the 5th column. This sum is shown in the bottom row of **Table 8**.

[redacted]

Figure 13: Plan View of Location of VC/YC Air Intakes and Spent Fuel Pools

[redacted]

Figure 14: 3-D View of Required Missile Path to Spent Fuel Pools

Combination Number	*Unit 1 VC/YC Failure*	*Unit 2 VC/YC Failure*	*U1 SFP Failure*	*U2 SPF Failure*	*System Survive or Fail*	*Frequency (yr $^{-1}$)*
1	0	0	0	0	Survive	3.52E-04
2	1	0	0	0	Survive	7.72E-05
3	0	1	0	0	Survive	1.15E-04
4	0	0	1	0	Survive	4.39E-09
5	0	0	0	1	Survive	3.18E-08
6	1	1	0	0	Survive	1.04E-04
7	1	0	1	0	Survive	1.45E-09
8	1	0	0	1	Survive	2.01E-08
9	0	1	1	0	Survive	3.10E-09
10	0	1	0	1	Survive	2.58E-08
11	0	0	1	1	Survive	2.58E-11
12	**1**	**1**	**1**	**0**	**Fail**	**4.04E-09**
13	**1**	**1**	**0**	**1**	**Fail**	**5.00E-08**
14	1	0	1	1	Survive	4.48E-11
15	0	1	1	1	Survive	1.41E-11
16	**1**	**1**	**1**	**1**	**Fail**	**8.51E-11**
Overall Failure Frequency						**5.41E-08**

Table 8: Failure Combinations for VC/YC Air Intakes and Spent Fuel Pools

ATTACHMENT 2

UFSAR PROPOSED CHANGES
(With revisions from RAI-01a&b responses)

Spring, summer and autumn storms, phenomena of widespread consequence, are the major bearers of severe weather. For the area of North Carolina, South Carolina and their coastal waters, an average of one tropical storm per year and one hurricane every other year has been computed based on a period of record of 63 years (1901-1963). Within this period, seven years were void of any activity while nine years produced a combined total of three storms per year. Highest winds over the area are 110 miles per hour (fastest mile, Cape Hatteras, N.C., September, 1944) along the coast and 80 miles per hour (fastest mile for inland maxima, Wilmington, N.C., October, 1954). Maximum 24 hour rainfalls, again higher for coastal stations, have been recorded near 15 inches along the coast (Cape Hatteras, N.C., June, 1949) to near 9 inches inland (Wilmington, N.C., September, 1938). Figure 2-37 relates tornado frequency to two degree squares for the period 1916-1955. For the site area a total of 50 tornados are shown per two degree square (square area about 125 miles by 125 miles). To put in terms of probability for a point (nuclear station), such a translation predicts a recurrence interval of 4405 years. Thunderstorms with greater frequencies during the summer occur 45-50 days per year (from Charlotte, N.C., period of record 73 years). Associated hail can be expected about one day per year in coastal areas and one or more days per year over inland areas from the period of record 1955-1967 (Reference 3).

The tornado parameters and tornado frequency values used in the probabilistic tornado risk analysis (TORMIS) described in Section 3.5.2.8.1 are found in Reference 5.

Meteorological conditions assumed for design bases are addressed in Section 3.5.2.1 for tornado loadings and in Section 3.8.1.4 for general wind and snow loadings. Criteria for design tornados include a rotational speed of 300 mph, a translational speed of 60 mph and a vacuum pressure differential of 3 psi in 3 seconds. Design speed for general wind loading is 95 mph (fastest mile). Snow loading for design purposes is 20 pounds per square foot.

Air pollution over the Carolinas is of greatest potential during the fall. An average of ten episode - days per year has been computed for a period of five years (from upper air observations at area Weather Service Stations, i.e., Athens, Georgia; Greensboro, N.C.; Cape Hatteras, N.C. and Charleston, S.C.).

2.3.2 Local Meteorology

2.3.2.1 Data Sources

Climatic Atlas of the United States, United States Department of Commerce, Environmental Science Services Administration, Environmental Data Service, June, 1968.

Climate of the States, North Carolina, Climatography of the United States, No. 60-31, United States Department of Commerce, Weather Bureau, February, 1960.

Local Climatological Data, Annual Summary with Comparative Data, North Carolina, United States Department of Commerce, National Oceanic and Atmospheric Administration, Environmental Data Service, 1971.

2.3.2.2 Normal and Extreme Values of Meteorological Parameters

Table 2-9 depicts normal and extreme values for the following parameters: temperature, rain, sleet and snow, fog, relative humidity, dew point and wind direction and speed.

Thunderstorm occurrence by season is: 11 for spring (March-May), 29 for summer (June-August), 5 for fall (September-November) and 1 for winter (December-February). (Reference 4)

2.3.2.3 Potential Influence of the Plant and Its Facilities on Local Meteorology

Consideration has been given to possible environmental effects associated with heat dissipation from the cooling pond (Lake Norman, vicinity of McGuire Nuclear Station). A review of the literature and operating experience to date would suggest that effects of fogging and icing are minimal for the properly *the basis for judging the representativeness of data for the year October 17, 1970 - October 16, 1971, with regard to long-term conditions (e.g., five year period). Consideration of wind speed by stability type for the two periods shows a lower speed in general for the period October 17, 1970 October 16, 1971; the occurrence of calms and winds less than 4 knots are up four percentage points from 15% for the period January, 1969 - December, 1973. A slight shift in stability frequencies is noted for the period October 17, 1970 - October 16, 1971: "G" increases, "F" and "E" decrease, "D" increases and "C", "B", and "A" decrease.*

Some change in wind direction frequencies, also minor, is noted for the period October 17, 1970 - October 16, 1971: easterly, westerly and southwesterly directions increase while southerly, northerly and northeasterly directions decrease. On balance, the period is taken as reasonably representative of long-term conditions in the vicinity of the site with some conservatism with respect to accident relative concentration estimates as indexed by the joint distribution of wind direction and speed by stability type.

An additional year of onsite data have been collected using a measurement system which conforms to the recommendations of Regulatory Guide 1.23. The location of instrumentation is shown in Figure 2-41 marked permanent meteorological facility. Other discussion relating to instrument accuracy and sensitivity at this facility is included in Section 2.3.3. Dispersion estimates have been developed from this data base and are presented in the following summary.

Table 2-14 displays the joint frequencies of wind direction and speed by atmospheric stability type as they were observed on site for the period February, 1976 - January, 1977. Figure 2-49 represents the distribution of hourly dispersion factors at the Exclusion Area Boundary (2500 feet). Frequencies result from cumulative summation of percentage values in Table 2-14 in decreasing order of relative concentration computed for selected wind speed class intervals. All calm wind occurrences are considered in the distribution. Data recovery for this period was 94% of total observations.

Annual average dispersion factors were also calculated for the period of record using the calculational model in Section 2.3.5. The resulting areal distribution of annual average relative concentration is portrayed in Table 2-15.

2.3.7 References

1. *Meteorology and Atomic Energy, 1968, United States Atomic Energy Commission, Division of Technical Information, July, 1968.*
2. *Workbook of Atmospheric Dispersion Estimates, D. Bruce Turner, United States Department of Health, Education and Welfare, 1969.*
3. *"Severe Local Storm Occurrence, 1955-1967", U.S. Weather Bureau Technical Memorandum WBTM-FCST #12, September, 1969.*
4. *Mean Number of Thunderstorm Days in the United States, U.S. Department of Commerce, Weather Bureau, Technical Paper #19, September, 1952.*
5. ***MCC-1139.01-00-0298, "MNS Tornado Missile TORMIS Analysis".***

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Table of Contents (cont'd)

List of Tables (cont'd)

3.5 Missile Protection

3.5.1 Missile Barriers and Loadings

3.5.1.1 Internal Missiles

The interior structural elements of all Category 1 structures, except those structural elements shielded from internal missiles are designed to withstand the internal missiles effect. For internal missiles characteristics refer to Section 3.5.2.9

3.5.1.2 Turbine-Generator Missiles

All Category 1 structures, with the exception of the New Fuel Storage Vault exposed to these missiles are designed to withstand their effect and meet Regulatory Guide 1.115, Rev. 1. The credible turbine-generator missiles are low trajectory and the associated properties are given in Section 3.5.2.

3.5.1.3 Tornado Generated Missiles

~~All~~ Category 1 structures exposed to these **design basis** missiles are designed to withstand their effect **with the exception of those Structures Systems and Components included in the TORMIS probabilistic tornado risk analysis listed in Table 3-63 and as discussed in Section 3.5.2.8.1.1**. A tabulation of the **design basis** tornado generated missiles is given in Table 3-8.

3.5.1.4 Site Proximity Missiles

For the McGuire Station, aircrafts are not considered as credible missiles due to the established flying patterns close to the station.

Table 3-9 provides a summary of the major Category 1 structures that are designed for missile protection, along with the types of missiles they are protected against.

3.5.1.5 Diesel Generator Missiles

Each Diesel Generator shall be protected against missiles produced by the adjacent diesel generator by the appropriate section of the block wall separating Diesel Generator rooms A from B. The credible diesel generator missiles are given in Section 3.5.2.9.

3.5.2 Missile Selection

The specific missiles and the basis for selection as credible missiles are discussed in this Section. Some missiles which are not credible are pointed out and justified as prescribed below.

3.5.2.1 Reactor Coolant Pump Flywheel

The following precautionary measures, taken to preclude missile formation from the reactor coolant pump flywheel, assure that the flywheel will not produce missiles under any anticipated accident conditions.

1. The flywheel is fabricated from rolled, vacuum-degassed, ASME SA-533.
2. Flywheel blanks are flame-cut from the plate, with allowance for exclusion of flame-affected metal.
3. A minimum of three Charpy tests are made from each plate parallel and normal to the rolling direction to determine that each blank satisfies design requirements.
4. An NDTT less than 10°F is specified.
5. The finished flywheel is subjected to 100 percent volumetric ultrasonic inspection.

valves in the relief line, the air operated relief valves, the air operated spray valves, instrumentation assemblies and associated piping.

Supports for these lines should be capable of restraining movement of components and piping, under action of reaction and jet forces from circumferential pipe rupture, in accordance with the criteria of Section 3.6.2.

Characteristics of valve bonnet missiles are given in Table 3-14. Pressurizer instrumentation assembly missile characteristics are included in Section 3.5.2.5.

3.5.2.7 Turbine-Generator Missiles

Turbine missiles can be generated by a turbine overspeed. The credible low-trajectory turbine missiles and the associated properties are defined in Table 3-15 and Figure 3-4. Basis for selecting these missiles is given in Section 10.2.3.

3.5.2.8 Tornado Generated Missiles

Table 3-8 provides a summary of the **design basis** tornado-generated missiles. The integrity of ~~all~~ Category 1 structures is not impaired by these missiles. This is accomplished by designing the exposed structure of steel reinforced concrete capable of withstanding the impact of tornado-generated missiles. **Modifications to existing or the design of new Category 1 structures shall conform to the requirements of NRC RIS 2008-14.**

Table 3-63 provides a list of Category 1 structures, systems, and components that have not been designed to withstand the impact of design basis tornado-generated missiles. These SSCs were probabilistically show that they will not be impacted or will not be damaged beyond an acceptable criteria if impacted as discussed in Section 3.5.2.8.1.3.

(HISTORICAL INFORMATION NOT REQUIRED TO BE REVISED)

The following was added as part of a NRC request for additional information in order to perform a comparability review. The request was to determine penetration velocities for 2 missiles which were not part of the design basis missiles used during the Construction Permit (CP) stage (Table 3-8). The requested velocities are for category 1 structures with wall or roofs less than 2 feet thick.

In order to assess the degree of comparability of protection against tornado missiles provided in the CP stage with that presently under review by the NRC, an additional investigation has been performed to evaluate the following missiles:

1. *Steel rods, one inch diameter by three feet long, weight eight pounds.*
2. *Utility pole, 13-1/2 inch diameter, 35 feet long, weight 1490 pounds.*

Structural concrete barriers designed to provide missile protection having thicknesses less than two feet are as follows:

1. *Slabs - None*
2. *Walls:*
    a. *1'- 0" thick located on column line AA between column lines 53 to 59 constructed to elevation 782 feet.*
    b. *1'- 6" thick, location on column lines 49 and 63 between column line AA (Turbine Building) and Reactor Building shield building constructed to elevation 782 feet.*

The maximum horizontal velocities required to penetrate the barrier or generate secondary missiles within the wall elevations are as follows:

1	*186*	*232*
2	*184*	*229*

The horizontal velocity (ft./sec) required for penetration or generation of secondary missiles is based upon a constructed thickness equal to three times the penetration depth.

Separation of redundant components is not considered in the design of barriers for tornado missiles.

3.5.2.8.1 Probabilistic Tornado Missile Risk Analysis

New Section

A probabilistic tornado missile risk analysis (Reference 7) was completed using the TORMIS computer code which is based on the NRC approved methodology detailed in References 8, 9, and 10. The TORMIS analysis was performed in accordance with the guidance described in NRC TORMIS Safety Evaluation Report (Reference 11) and as clarified by Regulatory Issue Summary (RIS) 2008-14 (Reference 12).

3.5.2.8.1.1 Scope

New Section

The TORMIS analysis (Reference 7) includes plant components identified as necessary to safely shutdown the plant and maintain a shutdown condition that are located in areas not fully protected by missile barriers designed to resist impact from design basis tornado generated missiles. The plant components (also referred to as, targets) included in the analysis are listed in Table 3-63 and additional details regarding these targets (i.e. specific identification, description, location, and portion) are included in Reference 7, Volume 3.

3.5.2.8.1.2 TORMIS Computer Code

New Section

The TORMIS (TORnado MISsile Risk Analysis Methodology) computer code uses a Monte Carlo simulation method that simulates tornado strikes on a plant. For each tornado strike the tornado field is simulated; missiles are injected and flown; and the missile impacts on structures, systems, and components (SSCs) are analyzed. These models are linked to form an integrated time history simulation methodology. By repeating these simulations, the frequencies of missiles impacting and damaging individual plant components (targets) and groups of targets are estimated. Statistical convergence of the results is achieved by performing multiple replications with different random number seeds.

3.5.2.8.1.3 Analysis

New Section

The TORMIS results show that the arithmetic sum of damage frequencies for all target groups affecting the individual Units are lower than the acceptable threshold frequency of 1.0E-06 per year per Unit as established in Reference 13.

The following limiting inputs and assumptions were used in the analysis (Reference 7):

a. **A site specific tornado hazard curve and data set for McGuire was developed using statistical analysis of the NOAA/National Weather Service Storm Prediction Center tornado data for the years 1950 through 2016. The analysis utilizes the Enhanced Fujita (EF) Scale wind speeds in the TORMIS simulations.**

b. **The missile characteristics and locations are based on plant walk down surveys and plant drawings. The plant walk downs were conducted during both non-outage and outage periods to capture both conditions. A stochastic (time dependent) model of the missile population is implemented in TORMIS. The stochastic approach to the missile population varies the missile populations in each of the TORMIS replications to account for**

predictable changes in plant conditions (i.e. increased missiles during outages) and the randomness inherent in the total number of missiles present at the plant at any given time.

c. **Finite element analysis calculations were performed to determine the missile damage threshold velocity for tornado generated missiles that would cause unacceptable damage to selected targets which is then used as an input in the TORMIS model.**

d. **Boolean combinations of targets were developed, and the logic was applied to targets or target groups to account for redundancies in the system design or for the TORMIS modeling of a component as multiple targets. The failure logic for redundancy of the MainSteam lines when missile damage to the PORVs and MSSVs is beyond acceptable criteria, is that the Unit can sustain damage to one of four MainSteam line and the damage can be in multiple places on the same MainSteam line (PORVs, MSSVs, or associated components). Damage, beyond the acceptable criteria, on more than one line is considered a failure in TORMIS space. The failure logic for the Control Room Air Ventilation System (CRAVS) Intakes (VC/YC Air Intakes) and Spent Fuel Pools (SPF) is simultaneous tornado generated missile impacts to all the Unit 1 and Unit 2 VC/YC Air Intakes AND the entry of a tornado generated missile into either the Unit 1 or Unit 2 SFP that would impact any Spent Fuel assemblies above acceptable critical velocities.**

e. **Any tornado generated missile strikes to the VC/YC Air Intakes were conservatively assumed to crimp the Intakes closed.**

f. **The Utility Port Barriers in the Doghouse Upper Openings are conservatively taken into account for their resistance to a conservative selection of tornado generated missiles entering the Doghouse Upper Openings.**

g. **All tornado generated missiles are conservatively assumed to strike with an end-on, co-linear impact.**

3.5.6 References

1. Ernest L. Robinson, "Bursting Tests of Steam-Turbine Disc Wheels," Transactions of the ASME, July, 1944.
2. A. Amirikan, "Design of Protective Structures,"NAVDOCKS P-51, Bureau of Yards and Docks, Department of the Navy, Washington, D. C., August, 1950.
3. R. C. Gwaltney, "Missile Generation and Protection in Light-Water-Cooled Power Reactor Plants," USAEC Report ORNL-NSIC-22, Oak Ridge National Laboratory, September, 1968.
4. Westinghouse Report No. 296/281 - B of December 1973, Revised April 1974, "The Effects of a High Pressure Turbine Rotor Fracture and Low Pressure Turbine Disc Fracture at Design Overspeed."
5. R. A. Wiliamson and R. R. Alvy, "Impact Effects of Fragments Striking Structural Elements," Holmes and Narver, Inc., Anahelm, California Revised January 1975.
6. NRC Letter to Duquesne Light Company, September 12, 1996, "Acceptance for Referencing of Topical Report WCAP-14535, Topical Report on Reactor Coolant Pump Flywheel Inspection Elimination."
7. **MCC-1139.01-00-0298, "MNS Tornado Missile TORMIS Analysis".**
8. **Electric Power Research Institute Report, EPRI NP-768, "Tornado Missile Risk Analysis", May 1978.**
9. **Electric Power Research Institute Report, EPRI NP-769, "Tornado Missile Risk Analysis - Appendices", May 1978.**
10. **Electric Power Research Institute Report, EPRI NP-2005, Volumes 1 and 2, "Tornado Missile Risk Evaluation Methodology", August 1981.**
11. **NRC Safety Evaluation Report, "Electric Power Research Institute (EPRI) Topical Reports Concerning Tornado Missile Probabilistic Risk Assessment (PRA) Methodology", October 26, 1983 (Adams ML080870291)**
12. **NRC Regulatory Issue Summary 2008-14, "Use of TORMIS Computer Code for Assessment of Tornado Missile Protection", June 16, 2008 (Adams ML080230578)**
13. **Memorandum from Harold Denton, NRR Director, to Victor Stello, Deputy Executive Director for Regional Operations and Generic Requirements, "Position of use of Probabilistic Risk Assessment in Tornado Licensing Action," dated November 7, 1983 (Adams ML030020331).**

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Table 3-63. Structures, Systems and Components Included in TORMIS Analysis Not Designed for Design Basis Tornado Generated Missiles[3]

Category 1 SSC
Unit 1 & 2 Main Steam Safety Valves (MSSVs) Exhaust Piping and associated supports[1 2]
Unit 1 & 2 Steam Generator Power Operated Relief Valves (PORVs) and associated piping and supports[1 2]
Unit 1 & 2 Turbine Driven Auxiliary Feedwater (TD AFW) Exhaust (TE) Pipe[2]
Unit 1 & 2 Control Room Air Ventilation System (CRAVS) Intakes (VC/YC Intakes)[2]
Unit 1 & 2 Spent Fuel Building (north facing wall)

Notes:

1. The SSCs located in the Unit 1 Exterior Doghouse are not included as they have positive tornado missile protection.
2. Only the portion of the Structure that is not protected from the Design Basis tornado generated missiles are included. The Design Basis tornado generated missiles have a horizontal only projection.
3. Additional details and target areas can be found in Section 3.5.6 Reference 7.