Progress Energy

Serial: NPD-NRC-2010-021
March 10, 2010

10 CFR 52.79

U.S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, D.C. 20555-0001

SHEARON HARRIS NUCLEAR POWER PLANT, UNITS 2 AND 3
DOCKET NOS. 52-022 AND 52-023
REVISION TO FINAL SAFETY ANALYSIS REPORT (FSAR) SECTION 2.4.5 – PROBABLE MAXIMUM SURGE AND SEICHE FLOODING

Ladies and Gentlemen:

Progress Energy Carolinas, Inc. (PEC) hereby submits voluntary revisions to FSAR Chapter 2 for the Shearon Harris Nuclear Power Plant Units 2 and 3 (HAR). The specific changes identified in the enclosure to this letter will be included in a future revision of the HAR combined license application.

If you have any further questions, or need additional information, please contact Bob Kitchen at (919) 546-6992, or me at (727) 820-4481.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on March 10, 2010.

Sincerely,

John Elnitsky
Vice President
Nuclear Plant Development

Enclosure

cc : U.S. NRC Region II, Regional Administrator
U.S. NRC Resident Inspector, SHNPP Unit 1
Mr. Brian Hughes, U.S. NRC Project Manager

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D084
NRO

NRC Review of Final Safety Analysis Report

PGN RAI ID #: H-0586

PGN Response to NRC RAI:

Subsequent to previous RAI submittals associated with the probable maximum flood (PMF), PEC decided to enhance the probable maximum hurricane (PMH) analysis using additional methodology and approaches employed for the PMF analysis. The PMF calculation was revised and associated changes to the text and tables of HAR FSAR Section 2.4.5 are shown in the "Associated HAR COL Application Revisions" section below.

The analysis procedure used to calculate the wave runup and wave setup results associated with the PMH event at the HAR site is presented in HAR Calculation Package HAG-0000-X7C-003 (Rev. 4), "Probable Maximum Flood (PMF) on Streams and Rivers ". A copy of this calculation is available for NRC's review in the Progress Energy-provided Reading Room.

Associated HAR COL Application Revisions:

The text of HAR FSAR Rev. 1, Subsection 2.4.5 will be revised as presented below. In addition, two new references are added, one table is replaced and four new tables are added as shown below.

Revised 2.4.5 text is shown below.

HAR COL 2.4-2

2.4.5 PROBABLE MAXIMUM SURGE AND SEICHE FLOODING

A PMH could cause a water level change in the Main Reservoir and the Auxiliary Reservoir. The resulting high water levels, if not considered in the project design, could affect the safety of the Main Dam, Auxiliary Dam, or safety-related structures located at the plant site. The following subsections discuss the design considerations afforded these facilities related to flooding. Preceding the PMH, the assumed stillwater level elevations in the Main Reservoir and Auxiliary Reservoir are 73.2 m (240 ft.) NGVD29 and 76.8 m (252 ft.) NGVD29, respectively.

2.4.5.1 Probable Maximum Winds and Associated Meteorological Parameters

The meteorological characteristics used to calculate the PMH were obtained from NOAA Technical Report NWS 23 (Reference 2.4-234). According to this report, the PMH is a hypothetical steady-state hurricane having a combination of values of meteorological parameters that will give the highest sustained wind speed that can probably occur at a specific coastal location. From values of the parameters, a wind field is specified, which is termed the "PMH wind field." The following are the over-water PMH wind field parameters taken from

NOAA Technical Report NWS 23 corresponding to the Milepost 2200 and Latitude of 35.6 degrees (Figure 1.1 of NOAA, Reference 2.4-234):

- Coriolis parameter (f) = 14.584x10^{-5} Sin(35.6) = 0.31 hr^{-1}
- Peripheral pressure (P_w) = 30.12-in.
- Central pressure (P_0) = 26.4-in.
- Radius of maximum wind (R) = 9 nautical miles for small storms, and 25 nautical miles for large storms
- Forward speed (T) = 10 knots (KT) for small storms, and 34 knots for large storms
- Density coefficient, K = 68.7 KT-in

Using the above parameters, the maximum gradient wind speed (V_{gx}) was calculated for a stationary hurricane using the following relationship (Reference 2.4-234):

$$V_{gx} = K(P_w - P_0)^{\frac{1}{2}} - \frac{fR}{2} \qquad (15)$$

The obtained value of V_{gx} is 128.7 KT (148.2 mph). The value of V_{gx} is adjusted to the maximum 10-meter, 10-minute value (V_{xs}) for a stationary hurricane using the following relationship (Reference 2.4-234):

$$V_{xs} = 0.95V_{gx} \qquad (16)$$

The obtained maximum 10-meter, 10-minute wind speed for a stationary hurricane, V_{xs} is 122.2 KT (140.8 mph). In order to determine wind speed for a moving hurricane, the stationary hurricane wind speed needs to be adjusted for asymmetry due to storm forward speed (T). The asymmetry factor (AF) is given as (Reference 2.4-234):

$$AF = 1.5T^{0.63}T_0^{0.37}Cos(\beta) \qquad (17)$$

Where

AF is the asymmetry factor in KT,

T is the forward wind speed of the storm in KT,

T_0 = 1 when AF and T are in KT,

and β is the angle between track direction and the surface wind direction.

To be conservative, β was assumed to be zero giving $Cos(\beta)$ a value of 1. Substituting values of T_0 and $Cos(\beta)$, the maximum value of asymmetry factor is:

$$AF = 1.5T^{0.63} \tag{18}$$

The maximum value of T is 34 KT (39.2 mph). Substituting T = 34 KT in Equation (18), the maximum value of asymmetry factor (AF) is 13.8 KT (15.9 mph). Adding the stationary hurricane wind speed (V_{xs}) and asymmetry factor (AF) together, the wind speed for a moving hurricane is 136.1 KT (156.8 mph).

When the center of a hurricane crosses the coast, over-water wind speeds are reduced because of filling by a factor that decreases with travel time after landfall. Kaplan and Demaria (Reference 2.4-267) developed a mathematical model for predicting decay of maximum sustained surface winds after storm landfall using a combination of physical and empirical considerations. In the simplest version of this model, the maximum winds inland are a function of the maximum winds at landfall and of the travel time after landfall. With the assumption of a track perpendicular to the coastline, it can be used to estimate the maximum inland penetration of winds of a given speed using the storm's landfall intensity and speed of motion. This decay model is given as (Reference 2.4-267):

$$V(t) = V_b + (R_f V_0 - V_b)\exp(-\alpha t) \tag{19}$$

where

$V(t)$ is the inland storm wind speed on traveling overland for time (t) hours after landfall,

V_b is the background wind speed,

R_f is the initial decay factor just after the landfall,

V_0 is the storm wind speed just before the landfall,

and α is a coefficient.

The values of R_f, V_b, and α are 1.0, 26.7 KT, and 0.095 hr^{-1}, respectively (Reference 2.4-267). Substituting these values in Equation (19), the decay model can be written as:

$$V(t) = 26.7 + (V_0 - 26.7)e^{-0.095t} \quad (20)$$

In the above Equation, V(t) and V_0 are in knots and t is in hours. The HAR site is located about 225.3 km (140 mi.) inland from the coastline. With a forward speed of 34 knots (39.2 mph), the overland travel time is 3.6 hours.

Substituting the value of the overland travel time t = 3.6 hours and V_0 =136.1 KT into Equation (20), the maximum 10-meter, 10-minute overland wind speed at the HAR site is 94.9 KT (109.3 mph).

2.4.5.2 Surge and Seiche Water Levels

For the HAR site, the only dynamic mechanism considered to be credible for the production of high water levels is the probable maximum wind (PMW) discussed in Subsection 2.4.5.1. Subsection 2.4.5.3 discusses the effects of the PMW on the plant reservoirs and the resulting activity.

2.4.5.3 Wave Action

In order to determine impact of wind-wave action due to PMW, straight line fetch distances were used in wave runup and setup calculations. Conservatively, straight line fetch distances shown in Figures 2.4.3-230, 2.4.3-231, 2.4.3-232, and 2.4.3-233 and tabulated in Tables 2.4.3-229, 2.4.3-230, 2.4.3-231, and 2.4.3-232 were used for HAR 2, HAR 3, HNP, the Auxiliary Dam, and the Main Dam locations.

2.4.5.3.1 Wind Speed Corrections

As presented in Subsection 2.4.5.1, the maximum 10-meter, 10-minute overland wind speed at the HAR site is 94.9 KT (109.3 mph). Based on Figure 2.4.3-234, the ratio of wind speed of any duration (V_t) to the 1-hour wind speed (V_{3600}) is given as:

$$\frac{V_t}{V_{3600}} = \begin{cases} 1.277+0.296\tanh\left[0.9\log_{10}\left(\frac{45}{t}\right)\right] & t\leq 3600 \\ -0.15\log_{10}t+1.5334 & 3600<t<36{,}000 \end{cases} \qquad (21)$$

Substituting the maximum 10-meter, 10-minute overland wind speed of 94.9 KT (109.3 mph) into Equation (21), the maximum 10-meter, 1-hour overland wind speed is 90.4 KT (104.1 mph). Before using this wind speed in the calculation of wave runup and wind setup, several adjustments such as corrections for transition from land to water and averaging durations based on various fetch distances needs to be applied using the procedure outlined in the U.S. Army Corps of Engineers' Coastal Engineering Manual, Engineer Manual 1110-2-1100 (Part II) (Reference 2.4-263). Subsection 2.4.3.6.3 provides a step-by-step procedure for calculating over-water wind speed.

Over-water wind speed is determined by applying a correction factor for transition from land to water. Based on Figure 2.4.3-235 and an overland wind speed of 90.4 KT (104.1 mph), the correction factor is 0.9. Therefore, the over-water wind speed is 90.4 KT x 0.9 = 81.3 KT (93.7 mph). Following the procedure presented in Subsection 2.4.3.6.3, the wind speed was corrected for averaging duration. Substituting over-water wind speed of 93.7 mph (150.8 km/hr) and over-water fetch distances for various locations in Equation (9), the averaging time durations ($t_{x,u}$) were determined for various fetch lines directed toward HAR 2, HAR 3, HNP, the Auxiliary Dam, and the Main Dam. Fetch distances corresponding to PMF conditions were used to determine PMH water levels, thus increasing straight line fetch lengths and creating more conservative conditions than those corresponding to normal water levels. The calculated averaging durations for various locations have been listed in Table 2.4.5-201. Using these calculated averaging durations in conjunction with Figure II-2-1 (Figure 2.4.3-234) of *EM 1110-2-1100 (Part II)* (Reference 2.4-263), the appropriate wind speeds for various fetch lines were determined. Table 2.4.5-201 presents both the calculated correction factors for various winds averaging durations and corrected wind speed for various fetch lines directed toward HAR 2, HAR 3, HNP, the Auxiliary Dam, and the Main Dam.

2.4.5.3.2 Wave Runup, Wave Height, and Wave Period

After determining estimates of PMH wind for wave prediction, the wave runup for various fetch lines directed toward HAR 2, HAR 3, HNP, the Auxiliary Dam, and the Main Dam were calculated using the step-by-step procedure given in *EM 1110-2-1100* (Reference 2.4-263) as described in Steps 1 through 4 of Subsection 2.4.3.6.5. Table 2.4.5-202 presents the results of wave runup along with significant wave heights and wave periods.

2.4.5.3.3 Wave Setup

Using the procedure described in Subsection 2.4.3.6.6, wave setups were determined for various fetch lines directed toward HAR 2, HAR 3, HNP, the Auxiliary Dam, and the Main Dam. Table 2.4.5-203 presents results of wave setup.

2.4.5.3.4 Overall PMH Elevation

The values of stillwater elevation, wave runup, and wind setup for various fetch lines were added together to determine the PMH water elevation coincident with wind-wave activity at HAR 2, HAR 3, HNP, the Auxiliary Dam, and the Main Dam. Table 2.4.5-204 presents the overall PMH elevations for these locations.

2.4.5.3.5 Maximum PMH Elevation due to Coincident Wind-Wave Activity

The maximum PMH elevations for HAR 2, HAR 3, HNP, the Auxiliary Dam, and the Main Dam are summarized in Table 2.4.5-205. As indicated by Table 2.4.5-205, none of the PMH elevations exceeded the target elevation of 79.2 m (260 ft. NGVD29). Therefore, no potential hazard exists to the plant's safety-related facilities as a result of the effect of the PMH.

2.4.5.4 Resonance

Wave amplification due to resonance will not occur on either reservoir at the HAR site, because the wind fetch is approximately 100 times longer than the significant wave length. The resonance due to such a high mode, if it does occur, would not have an appreciable effect. Normally, only the first few modes of resonance are of concern, that is, the wave length would have to be at least 152.4 m (500 ft.).

2.4.5.5 Protective Structures

All safety-related structures at the plant site are protected from high water levels up to elevation 79.6 m (261 ft. NGVD29), which is higher than anticipated flood levels due to wave runup in the reservoirs or direct rainfall at the plant site.

The Auxiliary Dam is a safety-related structure for HNP and the Main Dam is built as Seismic Category I. However, the Main Dam and Auxiliary Dam do not serve any safety-related purpose for HAR 2 and HAR 3. Subsection 2.4.1.1 provides additional information pertaining to the dams and spillways.

The upstream face of the Main Dam and both upstream and downstream faces of the Auxiliary Dam are protected by riprap designed for the worst postulated wave action. Subsection 2.5.6 of the HNP FSAR provides an additional description of the riprap design. The downstream face of the Main Dam is protected by a layer of oversized rock. As discussed in Subsection 2.4.2.2, the backwater effects of the Cape Fear River on the downstream face of the Main Dam are not expected to be significant. However, protection of the downstream face, as described in Subsection 2.5.6.4 of the HNP FSAR, serves as an additional safety precaution.

References:

Changes include the addition of two new references to Section 2.4.16:

1. FSAR Reference 2.4-263	U.S. Army Corps of Engineers (USACE), U.S. Army Corps of Engineers' Coastal Engineering Manual, Engineer Manual 1110-2-1100 (Part II), 2006.
2. FSAR Reference 2.4-267	Kaplan, J. and M. Demaria, "On the Decay of Tropical Cyclone Winds after Landfall in the New England Area," Journal of Applied Meteorology, Vol. 40, February 2001.

Changes include the replacement of Table 2.4.5-201 and the addition of Tables 2.4.5-202 through 2.4.5-205 as shown below.

HAR COL 2.4-2

Table 2.4.5-201
Correction for PMH Wind Averaging Duration

Location	Line ID	St. Line Fetch, X (mi)	St. Line Fetch, X (km)	T(X,U) (s)	Correction Factor	Wind Speed Ut (m/s)
HAR 2	1	0.85	1.37	1290	1.02	42.52
	2	0.72	1.17	1160	1.02	42.66
	3	0.61	0.99	1038	1.03	42.81
	4	0.64	1.03	1065	1.03	42.77
	5	0.55	0.89	966	1.03	42.91
HAR 3	1	0.93	1.50	1372	1.02	42.45
	2	0.88	1.42	1323	1.02	42.49
	3	0.87	1.40	1311	1.02	42.50
	4	0.40	0.64	774	1.04	43.26
	5	0.50	0.81	907	1.03	43.01
	6	0.50	0.81	907	1.03	43.00
	7	0.50	0.80	905	1.03	43.01
HNP	1	0.76	1.23	1201	1.02	42.61
	2	4.33	6.96	3841	1.00	41.47
	3	2.73	4.38	2818	1.00	41.79
DAMs	1	4.29	6.91	3821	1.00	41.48
	2	4.29	6.91	3821	1.00	41.48
	3	1.17	1.89	1601	1.02	42.28
	4	1.08	1.74	1517	1.02	42.34

HAR COL 2.4-2

Table 2.4.5-202
Wave Runup Computation Due to PMH Wind at HAR 2, HAR 3, HNP, and the Auxiliary and Main Dams

Reservoir	Stillwater Elevation (ft. NGVD29)	Bottom Elevation (ft. NGVD29)	Water Depth (m)	Limiting Wave Period (sec)
Auxiliary	252.0	240.0	3.66	5.97
Main	240.0	220.0	6.10	7.71

Location	Line ID	Wind Velocity (m/s)	St. Line Fetch, X (km)	Hm0 (m)	Predicted Peak Wave Period, Tp (sec)	Slope = tan (alpha)	Deepwater Wave Steepness, s0	Iribarren Number	Significant Runup, Rus (ft.)	Max Runup (0.1%), Ru (ft.)
HAR 2	1	42.52	1.37	1.05	2.35	0.09	0.12	0.25	0.62	0.96
	2	42.66	1.17	0.98	2.23	0.09	0.13	0.25	0.57	0.88
	3	42.81	0.99	0.90	2.12	0.13	0.13	0.35	0.75	1.16
	4	42.77	1.03	0.92	2.14	0.13	0.13	0.35	0.77	1.19
	5	42.91	0.89	0.86	2.04	0.13	0.13	0.35	0.71	1.10
HAR 3	1	42.45	1.50	1.10	2.42	0.09	0.12	0.25	0.65	1.02
	2	42.49	1.42	1.07	2.38	0.09	0.12	0.25	0.63	0.99
	3	42.50	1.40	1.07	2.37	0.09	0.12	0.25	0.63	0.98
	4	43.26	0.64	0.74	1.84	0.13	0.14	0.34	0.59	0.91
	5	43.01	0.81	0.82	1.98	0.13	0.13	0.34	0.67	1.04
	6	43.00	0.81	0.82	1.98	0.13	0.13	0.34	0.67	1.04
	7	43.01	0.80	0.82	1.98	0.13	0.13	0.34	0.67	1.04
HNP	1	42.61	1.23	1.00	2.27	0.20	0.12	0.57	1.34	2.09
	2	41.47	6.96	2.30	4.00	0.10	0.09	0.33	1.79	2.79
	3	41.79	4.38	1.85	3.44	0.10	0.10	0.32	1.38	2.15
DAMs	1	41.48	6.91	2.30	3.99	0.50	0.09	1.65	8.13	13.28
	2	41.48	6.91	2.30	3.99	0.40	0.09	1.32	7.15	11.11
	3	42.28	1.89	1.23	2.61	0.40	0.12	1.18	3.42	5.32
	4	42.34	1.74	1.18	2.54	0.40	0.12	1.17	3.27	5.08

HAR COL 2.4-2

Table 2.4.5-203
Wave Setup Computation Due to PMH Winds at HAR 2, HAR 3, HNP, and the Auxiliary and Main Dams

Location	Line ID	Wind Velocity (mph)	St. Line Fetch, X (mi.)	Depth (ft.)	Setup (ft.)
HAR 2	1	95.67	0.85	20.00	0.28
	2	95.98	0.72	20.00	0.24
	3	96.32	0.61	12.00	0.34
	4	96.23	0.64	12.00	0.35
	5	96.55	0.55	12.00	0.31
HAR 3	1	95.51	0.93	20.00	0.30
	2	95.61	0.88	20.00	0.29
	3	95.63	0.87	20.00	0.28
	4	97.34	0.40	12.00	0.22
	5	96.76	0.50	12.00	0.28
	6	96.76	0.50	12.00	0.28
	7	96.77	0.50	12.00	0.28
HNP	1	95.88	0.76	12.00	0.42
	2	93.30	4.33	20.00	1.34
	3	94.02	2.73	20.00	0.86
DAMs	1	93.34	4.29	20.00	1.34
	2	93.34	4.29	20.00	1.34
	3	95.13	1.17	12.00	0.63
	4	95.26	1.08	12.00	0.58

HAR COL 2.4-2

Table 2.4.5-204
Overall PMH Elevation at HAR 2, HAR 3, HNP, and the Auxiliary and Main Dams

Location	Line ID	Stillwater EL. (ft. NGVD29)	Max Runup (0.1%), Ru (ft.)	Setup (ft.)	Overall PMH (ft. NGVD29)
HAR 2	1	240	0.96	0.28	241.24
	2	240	0.88	0.24	241.12
	3	252	1.16	0.34	253.50
	4	252	1.19	0.35	253.54
	5	252	1.10	0.31	253.40
HAR 3	1	240	1.02	0.30	241.32
	2	240	0.99	0.29	241.27
	3	240	0.98	0.28	241.26
	4	252	0.91	0.22	253.14
	5	252	1.04	0.28	253.32
	6	252	1.04	0.28	253.32
	7	252	1.04	0.28	253.32
HNP	1	252	2.09	0.42	254.51
	2	240	2.79	1.34	244.14
	3	240	2.15	0.86	243.01
DAMs	1	240	13.28	1.34	254.62
	2	240	11.11	1.34	252.45
	3	252	5.32	0.63	257.95
	4	252	5.08	0.58	257.67

Notes:
240.0 ft. and 252.0 ft. NGVD29 are the stillwater water elevations in the Main and Auxiliary Reservoirs, respectively.

HAR COL 2.4-2

Table 2.4.5-205
Maximum PMH Elevation at HAR 2, HAR 3, HNP, and the Auxiliary and Main Dams

Location	Maximum PMH Elevation (ft. NGVD29)
HAR 2	253.54
HAR 3	253.32
HNP	254.51
DAMs	257.95

Attachments/Enclosures:

None.