Progress Energy

Serial: NPD-NRC-2010-048
June 18, 2010

10CFR52.79

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

LEVY NUCLEAR PLANT, UNITS 1 AND 2
DOCKET NOS. 52-029 AND 52-030
RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION LETTER NO. 089 RELATED TO PROBABLE MAXIMUM FLOOD (PMF) ON STREAMS AND RIVERS

Reference: Letter from Brian C. Anderson (NRC) to John Elnitsky (PEF), dated May 7, 2010, "Request for Additional Information Letter No. 089 Related to SRP Section 2.4.3 for the Levy County Nuclear Plant, Units 1 and 2 Combined License Application"

Ladies and Gentlemen:

Progress Energy Florida, Inc. (PEF) hereby submits our response to the Nuclear Regulatory Commission's (NRC) request for additional information provided in the referenced letter. A response to the NRC request is addressed in the enclosure.

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 June 18, 2010.

Sincerely,

John Elnitsky
Vice President
New Generation Programs & Projects

Enclosure

cc: U.S. NRC Region II, Regional Administrator
Mr. Brian C. Anderson, U.S. NRC Project Manager

Progress Energy Florida, Inc.
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NRO

Levy Nuclear Plant Units 1 and 2
Response to NRC Request for Additional Information Letter No. 089 Related to SRP Section 2.4.3 for the Combined License Application, dated May 7, 2010

NRC RAI #	Progress Energy RAI #	Progress Energy Response
02.04.03-5	L-0807	Response enclosed – see following pages

NRC Letter No.: LNP-RAI-LTR-089

NRC Letter Date: May 7, 2010

NRC Review of Final Safety Analysis Report

NRC RAI #: 02.04.03-05

Text of NRC RAI:

In response to staff's RAI 2.4.3-03, the applicant stated that application of a UH to predict runoff from the surface of a reservoir is acceptable. However, the UH theory is used to describe the time distribution of surface runoff at the outlet produced by a constant and uniform rainfall excess event over a watershed. The time delay and attenuation in discharge compared to the rainfall excess event occurs because of the physical obstruction to overland flow over the surface of the watershed. Within the watershed, overland flow also accumulates into channels and streams. Both of these characteristics (overland flow and presence of channels and streams) are not present when considering runoff from the surface of a lake or reservoir. Therefore, a UH is not an appropriate tool to describe its response to a rainfall event. The staff requests that the applicant provide a rainfall-runoff response function that is appropriate for the surface of Lake Rousseau, or justify its exclusion.

In response to staff's RAI 2.4.3-03, the applicant includes text quoted from Sivapalan et al. (2002). That same reference (Sivapalan et al., 2002) also states the following, which the applicant did not include in its response: "On the other hand, Robinson et al. [1995], using numerical simulations, showed that nonlinearity at small scales is dominated by the hillslope response, that nonlinearity at large scales is dominated by channel network hydrodynamics, and that nonlinearity does not really disappear at any scale." This statement appears to contradict the applicant's assertion that the response of the Withlacoochee River Basin can be considered linear. The staff requests that the applicant provide UHs that are appropriately representative of overland flow and runoff generation conditions in the basin and conservative in predicting the discharge in the Withlacoochee River at the time a PMP event is likely to occur, or justify their exclusion.

References: Sivapalan, M., C. Jothiyangkoon, and M. Menabde, "Linearity and nonlinearity of basin response as a function of scale: Discussion of alternative definitions," Water Resources Research, Vol. 38, No. 2, 1012, 10.1029/2001WR000482, 2002.

PGN RAI ID #: L-0807

PGN Response to NRC RAI:

The two issues identified in this RAI, (1) method for estimating runoff from precipitation falling on the surface of Lake Rousseau and (2) rainfall-runoff nonlinearity, are addressed separately below.

(1) Method for estimating runoff from precipitation falling on the surface of Lake Rousseau:

As described in the response to LNP FSAR RAI 02.04.03-03, a hydrograph is the stream's response to excess rainfall in its catchment. To predict the hydrograph of a catchment, a unit hydrograph (UH) is used. A UH allows researchers to compare the response of two different catchments to the same runoff or investigate the changes in one catchment. A UH is a mathematical model describing the runoff relationship of excess rainfall over a given catchment.

More precisely, a UH model is a transfer function where excess rainfall is converted into surface runoff. The UH theory is applicable to any basin irrespective of its land-use/type of land-surface, including a water surface such as the surface of Lake Rousseau, as long as the basic assumptions of UH theory are not violated. The assumptions that can limit the application of a unit hydrograph are given below (FSAR Reference 2.4.3-210):

1. *Rainfall is spatially uniform over the drainage basin during the specified period.* In order to ensure reasonably uniform spatial distribution of rainfall, the catchment should not be too large. If the area exceeds approximately 5000 square kilometers (km^2) (1931 square miles [mi^2]), it should be sub-divided into sub-basins with channel routing.

2. *The rainfall rate is constant.* In order to satisfy the requirement of constant rainfall intensity, the rainfall duration should be short.

3. *The time base of the direct runoff hydrograph is constant.*

4. *Discharge at any given time, for the same time base, is directly proportional to the total amount of direct runoff.* The proportionality of ordinates of the direct runoff hydrograph assumes the principle of linearity or superposition, that is, that excess rainfall effects are additive.

5. *The hydrograph reflects all combined physical characteristics of the given drainage basin.* The assumption that the hydrograph reflects the influence of catchment characteristics assumes a time invariance of the catchment.

The area of Lake Rousseau is 16.8 km^2 (6.5 mi^2) (FSAR Subsection 2.4.1.2.6) and uniform rainfall intensity is assumed over the whole Withlacoochee watershed. Rainfall is assumed at a constant intensity for 6 hours, which is longer than the 1 hour interval used in the runoff computation. Physical characteristics of Lake Rousseau remain unchanged during the entire PMP event.

Based on the above assumptions and description of the catchment (Lake Rousseau), no assumption of the UH theory was violated while using the UH for runoff computation. Therefore, the use of the UH method for estimating the runoff from precipitation falling on the surface of Lake Rousseau is justified. In fact, the use of the UH theory is best suited for a small lake surface, as the likelihood of violating the assumptions of the UH theory are minimal. It is worthwhile to mention that several UH methods, such as the Single-Linear Reservoir method and the Nash method, were conceptualized using a reservoir. In addition, a lake surface can be considered a watershed with specific characteristics such as area, flow length, slope, zero loss, friction coefficient (Manning's n), etc. Therefore, utilizing the UH method provides a rainfall-runoff response function that is appropriate for the surface of Lake Rousseau.

An alternative approach to the UH method assumes precipitation falling on the surface of Lake Rousseau is equal to the direct runoff without considering any translation (i.e., lag time = 0). This alternative approach assumes runoff from all areas of Lake Rousseau, including areas approximately 9.2 km (5.7 mi.) upstream of the Inglis Dam, is instantaneously available at the dam. Lag times associated with upstream subbasins reaching Lake Rousseau are more than a day (LNP FSAR Table 2.4.3-221). Therefore, the assumption of a zero lag time for the surface of Lake Rousseau is not conservative, because the peak of the overall inflow hydrograph to the lake is reduced by avoiding superposition of runoff from other upstream subbasins. The assumption of a higher lag time used in the UH approach is conservative as it will increase the peak of the overall inflow hydrograph to Lake Rousseau by superimposing runoff from the lake surface with the runoff contributed from upstream watersheds. Therefore, utilizing the UH method is an appropriate tool to describe a rainfall-runoff response function for the surface of Lake Rousseau.

(2) Rainfall-Runoff Nonlinearity

The citation by Sivapalan et al. (2002) (Reference 02.04.03-05 01), "On the other hand, Robinson et al. [1995] (Reference 02.04.03-05 02), using numerical simulations, showed that nonlinearity at small scales is dominated by the hillslope response, that nonlinearity at large scales is dominated by channel network hydrodynamics, and that nonlinearity does not really disappear at any scale," was not used in the response to LNP FSAR RAI 02.04.03-03 for the reasons stated below.

- Sivapalan et al. (2002) cited multiple studies by researchers including Minshall (1960), Wang et al. (1981), and Robinson et al. (1995). The conclusion cited in the response to LNP FSAR RAI 02.04.03-03 applies to the general results regarding nonlinearity in rainfall-runoff response, including the results of Minshall (1960) and Wang et al. (1981). The conclusion cited above applies only to specific research conducted by Robinson et al. (1995).
- The watershed characteristics of the Withlacoochee River Basin are very different than those used in the study conducted by Robinson et al. (1995). For example, the subbasin areas used by Robinson et al. (1995) were 0.87 km^2 (0.336 mi^2), 8.7 km^2 (3.36 mi^2), and 87.0 km^2 (33.6 mi^2) which are smaller than 17 of the 18 subbasin areas within the Withlacoochee River Basin, which range from 56.7 to 595.7 km^2 (21.9 to 230 mi^2) with a median of 251.5 km^2 (97.1 mi^2) as presented in LNP FSAR Table 2.4.3-217. Further, average catchment slope of the watershed used by Robinson et al. (1995) is 30^0 whereas the average catchment slope of the Withlacoochee River Basin is 0.17 meter per kilometer (m/km) [0.9 ft/mi] or 0.00974^0. Thus, the watershed slope of the catchment studied by Robinson et al. (1995) is about 3000 times larger than the slope of the Withlacoochee River Basin. In addition, storage areas such as small intermittent streams, connected lakes and wetlands, sinkholes, and tributaries located in the Withlacoochee River Basin are not present in the catchment studied by Robinson et al. (1995). Therefore, conclusions made by Robinson et al. (1995) are not applicable to the Withlacoochee River Basin.
- Sivapalan et al. (2002) have confirmed the nonlinearity phenomenon described by Minshall (1960). Sivapalan et al. (2002) have not confirmed the findings made by Robinson et al. (1995). For this reason, the conclusion made by Minshall (1960) as quoted by Sivapalan et al. (2002) was referenced in the response to LNP FSAR RAI 02.04.03-03 rather than the conclusion made by Robinson et al. (1995) (as quoted by Sivapalan et al. (2002)).

Therefore, the assertion that the response of the Withlacoochee River Basin can be considered linear made in the response to LNP FSAR RAI 02.04.03-03 has not been contradicted.

In addition, the following analyses were made regarding rainfall-runoff nonlinearity:

a. As discussed in RAI 02.04.03-03, the Withlacoochee River watershed is an ungauged basin for which no historical rainfall and flood records are available. Thus, a direct development of a UH is not possible; instead, a synthetic UH can be developed from measurable basin characteristics. As discussed in LNP FSAR Subsection 2.4.3.3.1, the regional parameter values of the lag and peaking coefficients for Snyder's approach were Ct = 8.0 and CP = 0.6, respectively. Section 5.4.1.6 of ANSI/ANS-2.8-1992 (LNP FSAR Reference 02.04.03-201) supports the application of regional parameters for developing synthetic UHs in ungauged basins.

In order to address the nonlinearity effects under large hypothetical storms such as the PMP as well as to be conservative, the CP values for all subbasins were increased by 33% (literature based CP was 0.6, CP value used for analysis was 0.8) which increases the peak flow of all unit hydrographs by 33%. As discussed in the response to LNP FSAR RAI 02.04.03-03, in order to minimize errors resulting from the assumption of linearity, UHs should be derived from floods with magnitudes as close as possible to those that will be calculated using the derived UH. To verify whether the developed UHs are consistent with extreme events, a comparison was made between peak flows based on the flood frequency analysis of the observed flow data at the U.S. Geological Survey (USGS) station in Holder (LNP FSAR Reference 02.04.03-213) and peak flows obtained by applying the developed unit hydrographs for several extreme events, such as the 100-year, 500-year, and the standard project flood. These comparisons were presented in LNP FSAR Table 02.04.03-222 and on LNP FSAR Figure 02.04.03-216. This comparison shows that the UH-based computed flows for all of these extreme events are 50 percent higher. Therefore, the UHs used to determine runoff provide a conservative estimate for the inflow flood peak and hence are appropriate for computing runoff under PMP conditions. A similar kind of statement was made by the Federal Energy Regulatory Commission (FERC) "if the historical floods used in developing the representative UHs are large enough to be out-of-bank, the non-linear effects should not be significant" (LNP FSAR Reference 2.4.3-207).

b. As described in LNP FSAR Subsection 2.4.3.3.3, several storage areas such as small intermittent streams, connected lakes and wetlands, sinkholes, and tributaries are located upstream of Lake Rousseau. As described in LNP FSAR Subsection 2.4.3.2, the dominant land uses and land coverage in the Withlacoochee Drainage Basin are wetlands, upland forest, rangeland, agriculture, and mining, with some transitional and urban areas. In drainage basins with large floodplains and vegetation or other obstructions within the high banks and on overbank areas, average velocities are likely to remain fairly constant or even decrease to some extent as flow rate increases, reducing the nonlinearity effects. Therefore, the runoff response of the Withlacoochee Drainage Basin will not be significantly nonlinear at Lake Rousseau.

References:

02.04.03-05 01 Sivapalan, M., C. Jothityangkoon, and M. Menabde. *Linearity and Nonlinearity of Basin Response as a Function of Scale: Discussion of Alternative Definitions*. Water Resource Research, Vol. 38, No. 2, 10.1029/2001 WR000482. 2002.

02.04.03-05 02 Robinson, J.S., M. Sivapalan, and J.D. Snell. *On the Relative Roles of Hillslope Processes, Channel Routing and Network Geomorphology in the Hydrologic Response of Natural Catchments*. Water Resource Research, 31(12), 3089-3101. 1995.

Associated LNP COL Application Revisions:

No COLA changes have been identified associated with this response.

Attachments/Enclosures:

None.