Progress Energy

Serial: NPD-NRC-2009-114 10 CFR 52.79
June 23, 2009

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

LEVY COUNTY NUCLEAR POWER PLANT, UNITS 1 AND 2
DOCKET NOS. 52-029 AND 52-030
RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION LETTER NO. 045 RELATED TO PROBABLE MAXIMUM FLOOD (PMF) ON STREAMS AND RIVERS

Reference: Letter from Brian C. Anderson (NRC) to Garry Miller (PEF), dated May 19, 2009, "Request for Additional Information Letter No. 045 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. The enclosure also identifies changes that will be made in a future revision of the Levy County Nuclear Power Plant Units 1 and 2 application.

If you have any further questions, or need additional information, please contact Bob Kitchen at (919) 546-6992, or me at (919) 546-6107.

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

Executed on June 23, 2009.

Sincerely,

Garry D. Miller
General Manager
Nuclear Plant Development

Enclosure

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

Progress Energy Carolinas, Inc.
P.O. Box 1551
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NRO

Levy Nuclear Power Plant Units 1 and 2
Response to NRC Request for Additional Information Letter No. 045 Related to SRP Section 2.4.3 for the Combined License Application, dated May 19, 2009

NRC RAI #	Progress Energy RAI #	Progress Energy Response
02.04.03-1	L-0216	Response enclosed – see following pages
02.04.03-2	L-0217	Response enclosed – see following pages
02.04.03-3	L-0218	Response enclosed – see following pages
02.03.03-4	L-0219	Response enclosed – see following pages

Attachments/Enclosures	Associated NRC RAI #	Pages Included
Figure 1 Monthly Discharge At USGS Station 02313000 On The Withlacoochee River Near Holder	2.3.3-4	1
Figure 2 Monthly Mean And Mean Annual Discharge At USGS Station 02313000 On The Withlacoochee River Near Holder	2.3.3-4	1
Figure 3 Results Of The Sensitivity Analysis – Impact Of Base Flow On The PMF Elevation	2.3.3-4	1

NRC Letter No.: LNP-RAI-LTR-045

NRC Letter Date: May 19, 2009

NRC Review of Final Safety Analysis Report

NRC RAI NUMBER: 02.04.03-1

Text of NRC RAI:

To meet the requirements of GDC 2, 10 CFR 52.17, and 10 CFR Part 100, estimates of the following characteristics are needed, and should be based on conservative assumptions of hydrometeorologic characteristics in the drainage area: (a) the area of the watershed used to estimate flooding in streams and rivers, (b) the total depth of PMP and the PMP hyetograph, (c) the maximum PMF water surface elevation in streams and rivers with coincident wind-waves, and (d) hydraulic characteristics that describe dynamic effects of PMF on SSC important to safety. Please describe the process followed to determine the conceptual models for floods in streams and rivers and in site drainage system to ensure that the design basis flood is based on the most conservative of plausible conceptual models.

PGN RAI ID #: L-0216

PGN Response to NRC RAI:

The LNP safety-related structures are positioned entirely in the Waccasassa Drainage Basin and are not located directly on or near a water body. As described in FSAR Subsection 2.4.1.2.1, there are no named streams on the LNP site, nor are there are any known water control structures in the Waccasassa Drainage Basin. Therefore, no potential hazard to the LNP safety-related structures exists from the flooding of streams or rivers within the Waccasassa Drainage Basin. Runoff from the site is primarily overland, with storage provided by wetlands. The general direction of overland flow is to the southwest toward the Lower Withlacoochee River and the Gulf of Mexico. The closest major freshwater bodies to the LNP safety-related structures include the Withlacoochee River and Lake Rousseau, which is located approximately 3 (miles) mi. south of the LNP site. These water bodies are located in the Withlacoochee Drainage Basin, which is hydrologically separate from the Waccasassa Drainage Basin.

The hydrometeorologic characteristics of the Withlacoochee River Basin that were used to determine the most conservative of plausible conceptual models for floods in streams and rivers are summarized below.

(a) Area of the watershed used to estimate flooding in streams and rivers

Even though the LNP safety-related structures are positioned entirely in the Waccasassa Drainage Basin and are not located on or near a water body, the Withlacoochee Drainage Basin above the Inglis Dam of Lake Rousseau, which is hydrologically separate from the Waccasassa Drainage Basin, is considered the primary drainage basin used to conservatively estimate flooding in streams and rivers. As mentioned in FSAR Subsection 2.4.3.1, the total drainage area is 5171 square kilometers (km^2) (2020 square miles [mi^2]).

(b) Total depth of PMP and the PMP hyetograph

Total rainfall for the 72-hour duration was found to be 90.9 centimeters (cm) (35.8 [inches] in.). The resulting hourly probable maximum precipitation (PMP) hyetograph is tabulated in FSAR Table 2.4.3-216 and plotted in FSAR Figure 2.4.3-206.

(c) Maximum PMF water surface elevation in streams and rivers with coincident wind-waves

FSAR Subsection 2.4.3.6 identifies the probable maximum flood (PMF) elevation of Lake Rousseau at 29.7 feet North American Vertical Datum of 1988 (NAVD88) and describes how the LNP safety-related structures will not be affected by the coincident wind-wave activity associated with the closest water body, Lake Rousseau. The following bullets summarize why the coincident wind-wave activity will not impact the LNP safety-related structures:

- No safety-related structure is located adjacent to Lake Rousseau. The distance between Lake Rousseau and the LNP site is approximately 3 miles.
- The safety-related structures are located in the Waccasassa Drainage Basin, which is hydrologically separate from the Withlacoochee Drainage Basin where Lake Rousseau is located.
- Fetch distance directing towards the LNP site from Lake Rousseau is very small (approximately 0.35 mi.).
- The elevation difference between the Lake Rousseau PMF elevation (29.7 ft. NAVD88) and the floor elevation of LNP safety-related structures (51 ft. NAVD88) is substantial (21.3 ft).

(d) Hydraulic characteristics that describe dynamic effects of PMF on SSC important to safety

Due to the physical characteristics described in Part C of this response, the LNP safety-related structures will not be affected by dynamic effects of wave action from wind-generated activity that may occur concurrently with the peak PMF water level in Lake Rousseau.

Description of Conceptual Modeling Process for Floods in Streams and Rivers

In order to determine the design basis flood, NRC Regulatory Guides 1.206 and 1.59 along with American National Standards Institute/American Nuclear Society (ANSI/ANS)-2.8-1992 were followed. Therefore, determination of design basis flood in streams and rivers is consistent with the current guidance and standards. A description of the conceptual model development process follows:

1. The Withlacoochee River Drainage Basin above the Inglis Dam on Lake Rousseau was considered the primary drainage area for which PMP was determined. Using the geographic information system (GIS) data obtained from Southwest Florida Water Management District (FSAR Reference 2.4.2-208), the drainage area was delineated and the size of the basin

that contributes to Lake Rousseau was determined. Further, the Withlacoochee River Drainage Basin was divided into 18 sub-basins.

2. The PMP storm hyetograph for the Withlacoochee River Drainage Basin was developed using the criteria and the procedure given in HMR 51 (FSAR Reference 2.4.3-202) and HMR 52 (FSAR Reference 2.4.2-205). The 72-hour total drainage-averaged PMP was determined and distributed according to the guidelines given in ANSI/ANS-2.8-1992 (FSAR Reference 2.4.3-201).
3. The PMP design storm was developed by accounting for the antecedent rainfall that precedes the PMP storm as per ANSI/ANS-2.8-1992 (FSAR Reference 2.4.3-201) guidelines. Based on procedures provided in ANSI/ANS-2.8-1992, Section 9.2.1.1 (FSAR Reference 2.4.3-201), the antecedent 72-hour storm having a volume of 40 percent of the PMP was followed by a period of 72 hours of no rain and then the full 72-hour PMP storm was assumed to follow. Using this pattern, a complete PMP storm of 216 hours was developed.
4. According to ANSI/ANS-2.8-1992 (FSAR Reference 2.4.3-201), unit-hydrograph theory was used as the runoff model for developing runoff hydrographs for various sub-basins. Therefore, various hydrological parameters required for developing unit hydrographs for the sub-basins were determined. Using these parameters, unit hydrographs were developed for each sub-basin.
5. The developed PMP storm hyetographs were applied to respective unit hydrographs of various sub-basins along with the appropriate loss parameters using the Hydrologic Engineering Center-Hydrologic Modeling System (HEC-HMS) model (FSAR References 2.4.3-203 and 2.4.3-204) to develop the inflow flood hydrographs for each sub-basin.
6. Inflow hydrographs from various sub-basins were routed using the HEC-HMS model using the Muskingum routing method for various reaches to determine the combined inflow to Lake Rousseau.
7. After obtaining the combined inflow hydrograph, the PMF hydrograph was routed through the reservoir, spillway, and outlet works to estimate the maximum PMF stillwater level in Lake Rousseau.
8. In order to develop the most conservative of plausible conceptual flood models, the following assumptions were made:
    - As mentioned in FSAR Subsection 2.4.3.3.3, several storage areas are located upstream of Lake Rousseau; however, these storage areas are not considered in the hydrologic modeling.
    - Lake Rousseau was considered completely full with no storage available during PMP and PMF events.
    - All the outlet water control structures associated with Lake Rousseau were assumed to be fully closed and non-operable during the PMP and PMF events.

The process followed to determine the conceptual models for the site drainage system will be discussed in the response to LNP FSAR RAI 02.04.02-1.

References:
None

Associated LNP COL Application Revisions:

In the LNP FSAR (Rev. 0), the last sentence of bullet "c." located on page 2.4-17 will be changed from:

"Using this pattern, a complete PMP storm of 226 hours was developed."

To:

"Using this pattern, a complete PMP storm of 216 hours was developed."

Attachments/Enclosures:
None

NRC Letter No.: LNP-RAI-LTR-045

NRC Letter Date: May 19, 2009

NRC Review of Final Safety Analysis Report

NRC RAI NUMBER: 02.04.03-2

Text of NRC RAI:

To meet the requirements of GDC 2, 10 CFR 52.17, and 10 CFR Part 100, the applicant should include information concerning design basis flooding at the plant site, including consideration of appropriate combinations of individual flooding mechanisms in addition to the most severe effects from individual mechanisms themselves. Please clarify the combined events criterion used to identify the design basis flood at the LNP site and to explicitly state the value of the design basis flood in the FSAR including a description of any adjustment made for long-term sea level rise.

PGN RAI ID #: L-0217

PGN Response to NRC RAI:

The Levy Nuclear Plant (LNP) safety-related structures are positioned entirely in the Waccasassa River Basin and are not located directly on or near a water body that could potentially result in flooding of the structures. However, to determine the design basis flood for the LNP site, various flood scenarios relevant to nearby water bodies were considered. The large water bodies closest to the LNP safety-related structures include:

- Lake Rousseau
- Withlacoochee River
- Cross Florida Barge Canal
- Gulf of Mexico

A detailed hydrologic description of these water bodies is presented in FSAR Subsections 2.4.1.1 and 2.4.1.2. The large water bodies nearest to the LNP site are located in the adjacent Withlacoochee River Basin (with the exception of the Gulf of Mexico), which is hydrologically separate from the Waccasassa River Basin as shown in FSAR Figures 2.4.1-206 and 2.4.1-209. However, to demonstrate that the water bodies in the adjacent Withlacoochee River Basin will not impact the LNP, worst case flood-causing mechanisms related to these water bodies were considered. Further, the mechanisms considered include both the individual flooding mechanisms and combined event criteria, as described in American National Standards Institute/American Nuclear Society (ANSI/ANS)-2.8-1992 (FSAR Reference 2.4.3-201).

Individual Flooding Event

1. Precipitation and Snowmelt Induced Flood

   There are no named streams at the LNP site. Major freshwater bodies in the vicinity of the LNP site include the Withlacoochee River and Lake Rousseau. Lake Rousseau is located approximately 4.8 kilometers (km) (3 miles [mi.]) south of the LNP site. The Gulf of Mexico is located approximately 12.8 km (7.9 mi.) west of the LNP site. Although it is located in a different drainage basin and approximately 3 mi. from the LNP safety-related structures, Lake Rousseau is considered the primary water body for determining probable maximum flood (PMF) elevations produced during a probably maximum precipitation (PMP) event. Snowmelt-induced flood is not considered a potential worst case flood-causing mechanism due to the LNP site's geographical location. A detailed description of the processes used to determine the PMP is discussed in FSAR Subsection 2.4.3.

2. Failure of Dams and Other Man-made Structures from Hydrologic, Seismic, or Other Causes Upstream, Downstream, and Onsite

   The LNP safety-related structures are positioned entirely in the Waccasassa River Basin and are not located directly on or near a water body in that river basin. As described in FSAR Subsection 2.4.1.2.9, there are no known water control structures in the Waccasassa River Basin (FSAR Figure 2.4.1-212). Therefore, no potential hazard to the LNP site or safety-related structures exists within the Waccasassa River Basin that could occur as a result of flood waves from severe breaching of upstream dams or domino-type or cascading failures of dams. The nearest water control structures to the LNP site are located in the adjacent Withlacoochee River Basin, which is hydrologically separate from the Waccasassa River Basin. Water control structures within the Withlacoochee River Basin are discussed in FSAR Subsections 2.4.1.2.7 and 2.4.1.2.8 and in the response to FSAR RAI 02.04.04-2. Failure of the water control structures associated with Lake Rousseau and the flooding impact at the LNP safety-related structures is discussed in the FSAR Subsection 2.4.4.

   As discussed in LNP FSAR Subsection 2.4.1, LNP 1 and LNP 2 are located in the central portion of the plant site. Stormwater on the LNP site will drain by a stormwater sewer system and the peripheral areas of the LNP site will drain through open ditches and culverts to stormwater retention ponds. Stormwater from the retention ponds may at times be pumped to the cooling tower water basins. If the drainage system becomes blocked or fails, the LNP site can be drained by overland flow directly to the Lower Withlacoochee River or the Gulf of Mexico. The effects of local intense precipitation at the safety-related structures are discussed in the FSAR Subsection 2.4.2.3.

3. Landslide

   LNP FSAR Figure 2.4.1-203 presents a topographic map of the site. The topographic gradient at the LNP site is approximately 50 feet per mile (1 percent). Based on the extremely low topographic grade of the LNP site, sub-aerial landslides are considered unlikely.

4. Storm Surge

   The potential maximum surge due to a probable maximum hurricane was considered in this analysis. FSAR Subsection 2.4.5.2 describes the step-by-step calculation procedure used to determine the maximum surge.

5. Seiche

   With the exception of the Gulf of Mexico and Lake Rousseau, no other large water bodies are located near the LNP site, and neither the Gulf nor the lake are located in the immediate vicinity of the LNP safety-related structures. Lake Rousseau is located approximately 4.8 km (3 mi.) to the south and the Gulf of Mexico is located approximately 12.8 km (7.9 mi.) to the west of LNP 1 and LNP 2. Given the distance of the LNP from these water bodies, seiche is not considered to be a controlling influence for these bodies of water. Thus, the potential for flooding at the LNP safety-related structures due to seiche effects is considered insignificant.

6. Wind-wave Action

   Wind-wave action is not considered a potential flood-causing event at the LNP site as the safety-related structures are located approximately 4.8 km (3 mi.) from the nearest large water body (Lake Rousseau).

7. Ice Jam

   As discussed in FSAR Subsection 2.4.7, ice-jam-induced floods are not considered a potential worst case flood-causing mechanism due to the geographical location of the LNP site.

8. Channel Changes and Blockages

   No surface water storage is accounted for within the PMF analysis for the Withlacoochee Drainage Basin in order to create a mechanism for a potential worst case flood as detailed in FSAR Subsection 2.4.3.3.3. Thus, any channel changes due to sedimentation processes or any other causes will not have an adverse impact on the safety-related structures at the LNP site.

   Blockages are included in the PMF assumptions for creating a mechanism for a potential worst case flood. As described in FSAR Subsection 2.4.3.5, all control structures associated with Lake Rousseau are assumed to be completely closed and inoperable during the determination of the PMF elevation in Lake Rousseau. Furthermore, the shoreline water depth is assumed to be equal to the 10 percent exceedance high tide of 2.01 meters (m) (6.59 feet [ft.]) NGVD29 for the purpose of PMF analysis.

9. Tsunami

   Based on the best available scientific information related to the LNP site, the expected impact of the probable maximum tsunami (PMT) was considered. As described in FSAR Subsection 2.4.6.5.3, tsunamigenic threats for the LNP site are negligible.

10. Volcanic Eruption

    The LNP site is not located in a volcanically active region; therefore, no volcanic eruption event was considered in determining the design basis flood.

11. Glacier

    Glacier-induced flooding was not considered as a potential worst case flood causing mechanism due to the geographical location of the LNP site.

Combined Event Criteria

In order to determine adequate design flood bases, the following combined event criteria as described in ANSI/ANS-2.8-1992 (FSAR Reference 2.4.3-201) were considered:

1. Wind Influence

   Wind influence was not considered during the PMF analysis because the LNP site is located approximately 4.8 km (3 mi.) from the nearest large water body (Lake Rousseau). Worst case wind influence was considered during the probable maximum hurricane (PMH) analysis as discussed in FSAR Subsection 2.4.5 and in the response to FSAR RAI 02.04.05-8.

2. Seasonal Compatibility

   No seasonality was considered in the PMF analysis. Instead, worst case flood conditions were considered for various mechanisms.

3. Storm Optimization

   The PMP storm is derived by considering parameters such as centering, distribution with time, and antecedent moisture conditions, as discussed in FSAR Subsection 2.4.3.1.

   The PMH analysis was optimized using hurricane parameters, as discussed in FSAR Subsection 2.4.5 and as shown in FSAR Table 2.4.5-203.

4. Reservoirs

   For much of its length, the Withlacoochee River meanders through a broad flat plain that is dominated by swampland, marshes, ponds, and shallow lakes with very little change in elevation. Because flooding within the Withlacoochee Drainage Basin would spread into marshlands and lowlands adjacent to the Withlacoochee River channel and no reservoirs are near the LNP safety-related structures, no reservoir or water body upstream of Lake Rousseau was considered in the PMF analysis. To further understand reservoirs within the Withlacoochee Drainage Basin, water control structures and associated water bodies within the Withlacoochee River Basin are discussed in FSAR Subsections 2.4.1.2.7 and 2.4.1.2.8 and in the response to FSAR RAI 02.04.04-2. Failure of the water control structures associated with Lake Rousseau and the flooding impact at the LNP safety-related structures is discussed in the FSAR Subsection 2.4.4.

Design Basis Flood

The design basis flood elevation pertaining to the LNP safety-related structures corresponds to the PMH elevation of 47.98 ft. North American Vertical Datum of 1988 (NAVD88). Table 1 represents a summary of the combined event criteria and associated flood elevations.

TABLE 1

Flood Elevations Affecting the LNP Site

Combined Event Criteria	Value of the Design Basis Flood	Remarks
PMF + coincident wind-wave activity	29.7 ft. NAVD88	No storage included in the analysis.
Flooding due to dam break during the PMP and PMF event	23.65 ft. NAVD88 (24.65 ft. NGVD29)	With 10% Exceedance High Tide
Max. storm surge due to PMH + wind induced setup	40.33 (surge) + 7.65 (wave effects) = 47.98 ft. NAVD88	With 10% Exceedance High Tide

In addition, wave run-up during a PMH is discussed in the response to FSAR RAI 02.04.05-8.

Adjustment to Long-term Sea Level Rise

The nearest tidal datum is located at Cedar Key, Florida, which is considered a valid estimate for the determination of long-term sea level rise affecting the coastline in the vicinity of the LNP site. The long-term sea level rise at Cedar Key, Florida, as provided by NOAA is 1.8 millimeters per year (mm/yr) with a 95 percent confidence interval of +/- 0.19 mm/yr. (www.tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=8727520%20Cedar%20 Key,%20FL) Therefore, the upper 95 percent confidence bound of sea level rise is 1.8 + 0.19 = 1.99 mm/yr. Considering a design period of 60 years for LNP 1 and LNP 2, the upper 95 percent estimate of sea level rise will be approximately 119.4 mm (0.39 ft.).

References:

None

Associated LNP COL Application Revisions:

None

Attachments/Enclosures:

None

NRC Letter No.: LNP-RAI-LTR-045

NRC Letter Date: May 19, 2009

NRC Review of Final Safety Analysis Report

NRC RAI NUMBER: 02.04.03-3

Text of NRC RAI:

To meet the requirements of GDC 2, 10 CFR 52.17, and 10 CFR Part 100, estimates of the following characteristics are needed, and should be based on conservative assumptions of hydrometeorologic characteristics in the drainage area: (a) the area of the watershed used to estimate flooding in streams and rivers, (b) the total depth of PMP and the PMP hyetograph, (c) the maximum PMF water surface elevation in streams and rivers with coincident wind-waves, and (d) hydraulic characteristics that describe dynamic effects of PMF on SSC important to safety. Please justify (1) the use of unit hydrograph method for estimating the runoff from precipitation falling on the surface of Lake Rousseau and (2) the appropriateness of Snyder's unit hydrograph under PMP conditions given the assumption of linearity in the unit hydrograph approach of runoff generation.

PGN RAI ID #: L-0218

PGN Response to NRC RAI:

Estimates of the following characteristics are discussed in LNP FSAR RAI 02.04.03-1: (a) the area of the watershed used to estimate flooding in streams and rivers, (b) the total depth of probable maximum precipitation (PMP) and the PMP hyetograph, (c) the probable maximum flood (PMF) water surface elevation in streams and rivers with coincident wind-waves, and (d) hydraulic characteristics that describe dynamic effects of PMF on SSC (structures, systems and components) important to safety. The remaining request for LNP FSAR RAI 02.04.03-3 is addressed below.

(1) Justification of the use of unit hydrograph method for estimating the runoff from precipitation falling on the surface of Lake Rousseau.

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 were 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. Therefore, UH theory being developed using a reservoir should be applicable for runoff estimation from their surfaces.

(2) Appropriateness of Snyder's unit hydrograph under PMP conditions given the assumption of linearity in the unit hydrograph approach of runoff generation.

Numerous methods are available for developing and applying a UH in a given drainage basin. In the case of gauged basins for which historical rainfall and flood records are available, UHs are developed and verified with such data. On the other hand, for ungauged basins (that is, no available historical rainfall and flood records), direct development of a UH is not possible and techniques for estimating a UH from measurable basin characteristics are employed. Such a hydrograph is called a synthetic UH. A number of conceptual and empirical methods have been devised for developing a synthetic UH. Some of these methods are the Single-Linear Reservoir, Nash, Clark, Snyder, and SCS. The choice of a method primarily depends on the availability of information required to develop a synthetic UH. As mentioned in FSAR Subsection 2.4.3.3.1, Snyder's synthetic UH was used to develop UHs for various sub-basins in the Withlacoochee basin as regional parameter values of the lag (Ct = 8.0) and peaking (CP = 0.6) coefficients were available. Section 5.4.1.6 of ANSI/ANS-2.8-1992 (FSAR Reference 2.4.3-201) also supports application of regional parameters for synthetic UHs for ungauged basins.

Based on the assumptions of UH theory, specifically Assumption 4 listed in Part 1 of this RAI response, all UH methods share the basic assumption of linearity. This means that the ratio of peak flow to runoff volume, for unit duration, is constant for a basin. Thus, the question should be about the appropriateness of UH under PMP rather than the appropriateness of Snyder's UH under PMP.

Based on available literature, the following observations support the assumption of linearity inherent in the UH approach and justify its application during PMP conditions:

1. The linearity assumption means that the average velocity in the basin remains constant for all discharges rather than increasing with discharge. As described in the response to FSAR RAI 02.04.04-2 and mentioned in 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. FSAR Subsection 2.4.3.2 describes the land-use in the Withlacoochee Drainage Basin. 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 non-linearity effects. Therefore, the runoff response of the Withlacoochee Drainage Basin will not be significantly non-linear.

2. In order to address the non-linearity effects under large hypothetical storms such as PMP, UHs to be used with large hypothetical storms should, if possible, be derived from data for large historical events. According to Maidment, to minimize errors resulting from the assumption of linearity, UHs should be derived from floods of magnitude as close as possible to those that will be calculated using the derived UH (RAI Reference 02.04.03-3-001). In order 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 (FSAR Reference 2.4.3-213) 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 have been presented in FSAR Table 2.4.3-222 and on FSAR Figure 2.4.3-216. A comparison shows that the UH-based computed flows for all of these extreme events are 50 percent higher. According to 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. Therefore, the UHs used provide a conservative estimate for the inflow flood peak and are appropriate for computing runoff under PMP conditions.

3. Hydrologic response in natural catchments is controlled by a set of complex interactions between storm properties, basin characteristics, and antecedent wetness conditions. Further, based on a study conducted on three basins, scale dependence was identified in internal runoff production and non-linearity (RAI Reference 02.04.03-3-002). Increases in

catchment scale promote the existence of a diverse set of runoff mechanisms, as greater complexity is present in surface-subsurface interactions. Initial conditions modulate runoff production and may lead to runoff linearity for wet cases and large flood events. Ding (2006) (RAI Reference 02.04.03-3-003) reported the following expression for the scale parameter:

$$C_h = 0.18A^{-0.31} \tag{1}$$

where A is the area in km^2. In other words, the larger the watershed, the smaller the scale parameter C_h. The size of the Withlacoochee Drainage Basin is fairly large at 5171 km^2 (2020 mi^2), and further saturated antecedent conditions were assumed for the PMP storm. In addition, the basin contains a fairly large network of streams, wetlands, lakes, and swamp areas. These conditions will modulate the runoff production and its transmission to Lake Rousseau. This statement can be verified by reviewing the inflow hydrograph to Lake Rousseau (FSAR Figure 2.4.3-221) that indicates that the peak flow occurs about 4 weeks after the PMP event.

4. Sivapalan et al. clarified the definition of non-linearity with respect to dynamical rainfall-runoff responses of a catchment (RAI Reference 02.04.03-3-004). A dynamical rainfall-runoff relationship attempts to describe, based on physical considerations, the discharge hydrograph, Q(t) [L^3/T] for a specified climatic input, namely the rainfall hyetograph, R(t) [L/T], and for given catchment properties. This dependence can be symbolically written in the functional form

$$Q(t) = \phi\{R(t), A, \alpha, \beta, ...\} \tag{2}$$

where, α, β, ...are various parameters that characterize the climate, soil, vegetation, and geomorphological properties of the catchment. Equation (2) also includes an explicit representation of Catchment A. The dependence on R(t) of the right-hand side of Equation (1) is, in general, non-linear and is also time and location dependent. The dynamical definition of non-linearity refers to a non-linear dependence of the rainfall response on the magnitude of the rainfall inputs R(t). There have been a number of studies in the past that suggest catchment response in the sense of Equation (1), (that is, the functional forms of ϕ), are non-linear for small catchments (small A) and that the non-linearity decreases and catchments become more linear with increasing Catchment A (RAI Reference 02.04.03-3-004). Based on this information the rainfall-runoff response of the Withlacoochee Drainage Basin (a significantly large watershed) can be approximated to be linear irrespective of the magnitude of R(t), including a hypothetical PMP storm event.

References:

- 02.04.03-3-001, Maidment, David R., Handbook of Hydrology, McGraw-Hill, Inc., ISBN 0 07-039732-5, 1992
- 02.04.03-3-002, Vivoni et. al., "Controls on runoff generation and scale-dependence in a distributed hydrologic model," Hydrology and Earth System Sciences, May 2, 2007

- 02.04.03-3-003, Ding, J.Y., "Interactive comment on 'A measure of watershed nonlinearity: interpreting a variable instantaneous unit hydrograph model on two vastly different sized – watersheds' by J. Y. Ding," Hydrology and Earth System Sciences Discussions, January 13, 2006
- 02.04.03-3-004, Sivapalan, M., et al., "Linearity and nonlinearity of basin response as a function of scale: Discussion of alternative definitions," Water Resources Research, Volume 38, Number 2, pp. 4-1 – 4-5, 2002

Associated LNP COL Application Revisions:
None

Attachments/Enclosures:

None

NRC Letter No.: LNP-RAI-LTR-045

NRC Letter Date: May 19, 2009

NRC Review of Final Safety Analysis Report

NRC RAI NUMBER: 02.04.03-4

Text of NRC RAI:

To meet the requirements of GDC 2, 10 CFR 52.17, and 10 CFR Part 100, estimates of the following characteristics are needed, and should be based on conservative assumptions of hydrometeorologic characteristics in the drainage area: (a) the area of the watershed used to estimate flooding in streams and rivers, (b) the total depth of PMP and the PMP hyetograph, (c) the maximum PMF water surface elevation in streams and rivers with coincident wind-waves, and (d) hydraulic characteristics that describe dynamic effects of PMF on SSC important to safety. Please clarify the estimation of base flow used in the determination of the PMF discharge.

PGN RAI ID #: L-0219

PGN Response to NRC RAI:

Estimates of the following characteristics are discussed in LNP FSAR RAI 02.04.03-1: (a) the area of the watershed used to estimate flooding in streams and rivers, (b) the total depth probable maximum precipitation (PMP) and the PMP hyetograph, (c) the probable maximum flood (PMF) water surface elevation in streams and rivers with coincident wind-waves, and (d) hydraulic characteristics that describe dynamic effects of PMF on SSC (structures, systems and components) important to safety. The remaining request for LNP FSAR RAI 02.04.03-4 is addressed below.

According to American National Standards Institute/American Nuclear Society (ANSI/ANS)-2.8-1992 (FSAR Reference 2.4.3-201), the mean monthly flow during the month of occurrence of the PMF may be used as the base flow at the beginning of an antecedent storm for the PMF analysis. As no seasonality was considered in the PMP calculation, the mean annual flow was assumed as the base flow rate to Lake Rousseau for the PMF calculation. As shown in FSAR Subsection 2.4.3.3.2, the base flow used in the hydrologic modeling is 28.5 cubic meters per second (m^3/s) (1008 cubic feet per second [cfs]). This value is calculated based on the published U.S. Geological Survey (USGS) monthly flow statistics of the Withlacoochee River near Holder (USGS Station 02313000) from 1928 to 2006.

Table 1 and Figure 1 (Monthly Discharge at USGS Station 02313000 on the Withlacoochee River near Holder) present the monthly discharge at USGS Station 02313000 on the Withlacoochee River near Holder. Table 1 also presents the statistical characteristics of the mean monthly flow at this Station. Further, Figure 2 (Monthly Mean and Mean Annual Discharge at USGS Station 02313000 on the Withlacoochee River near Holder) presents the mean monthly discharge and mean annual discharge at USGS Station 02313000 on the

Withlacoochee River near Holder. Data for USGS Station 02313000 was obtained from FSAR Reference 2.4.3-213.

An inspection of Figure 2 shows the mean monthly flow for the months of August, September, October, and November are higher than the base flow used in the hydrologic modeling. In order to determine the impact of these higher monthly base flows, a sensitivity analysis was conducted. The results of the sensitivity analysis are presented in Table 2 and on Figure 3 (Results of the Sensitivity Analysis - Impact of Base flow on the PMF Elevation). Based on these results, it can be concluded that the impact of the higher monthly base flow on the PMF elevation is insignificant since it would increase the PMF level by less than 0.02 foot.

Table 1
Monthly Discharge (cfs) At The USGS Station 02313000
Near Holder On The Withlacoochee River

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1928	--	--	--	--	--	--	--	--	5,041	5,523	2,757	1,436
1929	1,056	--	--	--	--	--	--	--	--	--	--	--
1931	--	--	--	--	--	--	--	--	1,066	858.4	535.2	410.8
1932	345.9	311.5	344.4	245.7	218.5	336	306.5	311.7	511.6	296	310.2	300.7
1933	201.6	211	296.6	400.8	340.4	229.5	800.3	1,565	3,992	3,834	1,538	946.9
1934	689	624.6	586.5	513	828.4	1,970	5,925	3,639	2,347	2,069	1,069	653.7
1935	652.9	614.8	441.8	343.9	314.1	268.7	485.8	835.9	2,342	2,760	1,430	946.1
1936	1,054	2,012	2,607	2,030	1,072	915.5	1,093	1,058	853	930.9	850.3	711.3
1937	607.4	598.7	682.6	941.4	859.1	691.9	589.1	1,263	2,241	2,075	1,571	1,630
1938	1,212	859	643.9	468.9	348.9	544.9	1,175	1,165	1,157	1,349	1,396	917.2
1939	707.9	587	427.2	374.8	377.3	522	1,141	1,977	2,411	1,876	1,055	632.6
1940	601.5	637.1	650.6	579.6	420.1	451	1,053	1,268	1,195	819.5	455	372.7
1941	522.7	833	1,205	1,788	1,231	612.7	800.7	1,390	1,033	781.7	828.4	837.5
1942	1,247	1,094	1,480	1,411	759.1	875.1	1,455	1,305	1,286	903.9	522.7	467.8
1943	427.3	379	391.6	372.4	316.9	282.8	965.2	2,097	2,572	1,674	869.6	563.1
1944	550	391.3	347.1	359.9	215.2	216.8	271.2	887.6	1,251	1,097	1,844	949.3
1945	741	589.2	383	253.7	191.5	274.6	1,884	4,744	4,756	3,395	1,634	1,155
1946	1,319	1,130	1,834	1,079	774.7	627.7	824.9	1,621	1,708	2,190	1,291	825.5
1947	647.6	653.8	979	1,237	868.5	745.4	1,165	2,085	2,519	3,116	2,172	1,475
1948	1,176	1,663	1,528	1,108	700.1	551.5	707.5	2,673	3,440	2,756	1,649	1,155

Table 1
Monthly Discharge (cfs) At The USGS Station 02313000
Near Holder On The Withlacoochee River

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1949	877.3	689.1	507.7	586	427.2	471.3	619.2	1,558	4,037	4,344	2,214	1,330
1950	1,078	779.7	712.2	505.9	417.9	362.1	497.5	555.2	3,551	3,403	1,864	1,282
1951	1,293	1,122	841	718.1	636.1	432.6	432.6	619.2	805	1,187	944.8	1,145
1952	830.9	1,001	1,306	1,351	828.5	745.6	586.4	582.3	715.6	1,013	1,054	726.9
1953	646.1	627	635.3	907.3	1,264	668.6	742.3	1,669	3,309	4,567	2,674	2,483
1954	2,844	1,672	1,169	777.2	642	565.5	568.9	851.1	664.9	534.9	491.3	481.7
1955	479.5	525.1	409.6	328.5	247.8	234	322.8	508.2	1,014	864.7	499.7	377.2
1956	377.3	450.6	281	239.1	163.4	131.6	147.8	206.3	268.5	438	829.3	408.5
1957	222.4	223.4	252.6	450	466	610.7	593.5	1,198	1,648	2,026	977.5	546.2
1958	832.1	1,125	2,495	2,662	1,467	789.7	962.5	1,208	824.4	801.2	1,158	855.7
1959	1,309	1,234	2,160	4,203	2,936	2,240	3,110	3,847	4,054	4,018	2,950	1,807
1960	1,355	1,584	4,197	7,096	2,946	1,819	2,081	5,415	5,221	6,206	3,068	1,708
1961	1,504	1,473	1,083	775.6	566	533.8	645.2	849.7	992.9	605	586.2	478.8
1962	474.7	462.7	382.4	274	169.4	224.8	477.6	507.6	789.4	884.1	628.8	480.8
1963	496.1	729.9	1,252	833.2	447.1	428.9	460.6	558.7	540.7	571	483.5	504.1
1964	948.7	1,955	1,553	1,367	1,124	586.1	687.9	1,274	2,716	3,106	1,284	1,114
1965	1,038	1,028	1,162	793.2	539	638.7	889.5	2,648	2,552	1,822	1,171	983.7
1966	995.9	1,339	2,064	1,453	930.7	1,051	2,132	2,507	2,668	2,886	1,470	910.5
1967	856.7	886.4	797.8	572.8	403.7	452.1	578.5	1,229	2,012	1,099	571.9	515.4
1968	469.2	414.3	468.8	284.3	267.9	521.3	1,355	1,495	2,533	1,595	1,300	1,026
1969	878	921.3	1,403	1,727	778.9	576.5	500	934	1,748	2,039	1,841	1,860
1970	2,849	3,286	2,873	2,094	986.2	825	757.4	1,053	909	822.2	645.2	501.3
1971	579.5	913.2	655	510.8	332.7	371	488.7	1,223	1,717	1,281	837.6	695.5
1972	590.7	775.5	667.7	877.9	560.9	643.7	556.5	590.5	630.2	441.3	420.4	607.8
1973	741.8	1,014	843.8	860.7	608.1	467.3	571.8	744.8	1,078	1,061	598.3	581.6
1974	645.5	545.5	507.8	431.6	326	490.3	1,630	2,502	1,971	1,266	745	633.6
1975	578.9	523	408.7	281.3	236.5	214.8	255.4	403.3	714.1	808.1	759.3	538
1976	506.1	426.6	318.9	282.3	458.1	766.7	1,189	1,367	1,221	1,003	620.2	667.6

Table 1
Monthly Discharge (cfs) At The USGS Station 02313000
Near Holder On The Withlacoochee River

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1977	893	889	775.7	402.1	233.8	255.4	256.9	246.2	419	336.4	211.1	367.4
1978	607.2	1,030	1,877	958.3	576.9	556.8	671.1	1,406	1,053	442.1	319.6	370
1979	504.8	600.2	808.9	666.3	1,055	730.9	509	653.9	1,519	3,729	1,654	1,016
1980	843.1	813.4	759.2	775.3	655.3	603.5	710	557.2	564.7	442.8	602.7	628.6
1981	484.8	513.4	433.5	318.3	214.5	167.2	147.5	193.8	236.3	209.5	203	204.8
1982	345.1	559.7	1,108	1,122	626.2	1,234	2,390	2,272	2,752	3,218	1,734	1,069
1983	867.6	1,403	2,346	2,666	1,690	1,032	1,353	1,705	1,622	1,542	1,075	1,145
1984	1,716	1,613	1,444	1,462	1,359	1,120	1,356	1,444	1,122	781.7	551.8	449.6
1985	396.4	343.5	236.1	189.1	130.3	228.4	278.3	782.9	2,569	1,803	951.6	606.2
1986	1,312	1,618	1,261	789.7	482.6	445.6	486.6	361.5	502.4	480.5	390.4	394.3
1987	524.5	641.9	912.6	2,616	1,915	783.5	693.3	489.6	534.2	531.2	649.8	609.1
1988	650.5	975.6	1,274	1,230	746.8	647.7	504.2	609.4	2,237	2,065	954.1	1,412
1989	1,154	1,021	804.8	460.9	387.7	394.6	497.2	464.9	440.8	412.7	374.3	376.1
1990	532.4	446.9	429.5	356.7	224.8	232.8	284.2	329.5	362	230.5	182.6	160.7
1991	158.8	161.8	262.2	357.4	409.5	538.7	1,186	1,621	792.8	351.4	274	218.3
1992	151.9	154.3	148.9	170.6	128.7	136.9	111.8	149.3	244	632.5	383.3	339.7
1993	334.2	423.2	586.4	657.1	374.6	264.3	351.1	253.9	293.3	275.4	282.1	270
1994	401.8	557.6	465.5	300.2	190	261.4	291.8	741.7	1,350	1,996	1,369	1,019
1995	1,016	829.6	632.3	596.4	386.9	379.9	466.2	810.4	1,940	3,121	2,218	1,004
1996	1,366	1,185	1,082	1,533	1,005	641.7	750.8	826.2	629.5	565.4	448.8	497.8
1997	425.7	387.5	314.7	230.9	154.9	142.8	147.3	269.5	232.3	387.2	694.5	1,499
1998	4,414	4,176	4,869	3,372	1,064	495.7	582.9	715.1	1,000	1,144	827.7	618.7
1999	674.9	604.5	425.1	336.1	247.5	284.1	297.4	256.8	234.2	359.7	364.6	276.1
2000	225.9	200	130.5	106.1	80.4	94.7	101.3	82.8	100.3	72.4	60.4	72.8
2001	79.6	80	80.5	108	83.9	105.3	163.6	183.6	430.2	1,169	512.4	272.4
2002	267.3	228.1	223.2	157.3	137.6	154.1	537.4	1,068	1,466	1,319	725.2	920.2
2003	2,434	1,589	1,891	1,655	776.5	1,193	2,705	3,709	3,525	1,653	1,007	708.8
2004	581.7	695.2	980.1	574.3	316.3	390	398.1	412.4	2,681	5,073	2,474	1,147

Table 1
Monthly Discharge (cfs) At The USGS Station 02313000
Near Holder On The Withlacoochee River

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2005	907.5	661.8	674.3	780.9	683.2	954.9	1,822	2,394	1,550	1,024	1,079	1,088
2006	788.7	901.3	599.5	408.1	249.4	265.3	288.1	211	225.5	163.7	165	170.7

Statistical Characteristics

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean	856.8	882.9	987.6	961.4	634.7	569.5	864.3	1242.8	1626.7	1617.2	1028.6	786.6

Table 2
Results of the Sensitivity Analysis - Impact of Base flow on the PMF Elevation

Month	Mean Discharge (cfs)	PMF Level (ft. NGVD29)
Mean Annual	1008	29.666
8 (August)	1242.8	29.673
9 (September)	1626.7	29.683
10 (October)	1617.2	29.683
11 (November)	1028.6	29.667

Notes:
cfs = cubic feet per second
ft. NGVD29 = elevation in feet, National Geodetic Vertical Datum 1929

References:
None

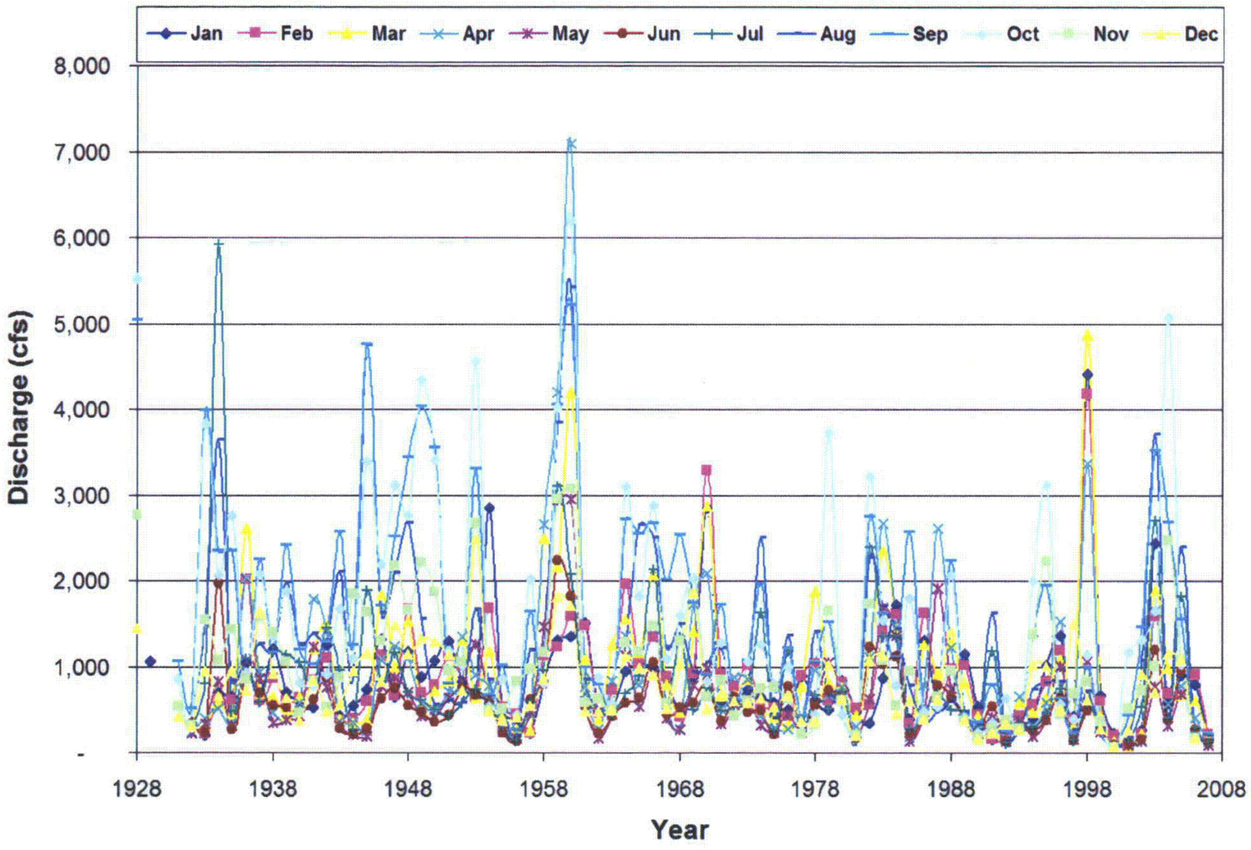
Associated LNP COL Application Revisions:

No COLA revisions have been identified associated with this response.

Attachments/Enclosures:

- Figure 1 - Monthly Discharge at USGS Station 02313000 on the Withlacoochee River near Holder
- Figure 2 - Monthly Mean and Mean Annual Discharge at USGS Station 02313000 on the Withlacoochee River near Holder
- Figure 3 - Results of the Sensitivity Analysis - Impact of Base flow on the PMF Elevation

Attachments To Letter NPD-NRC-2009-114

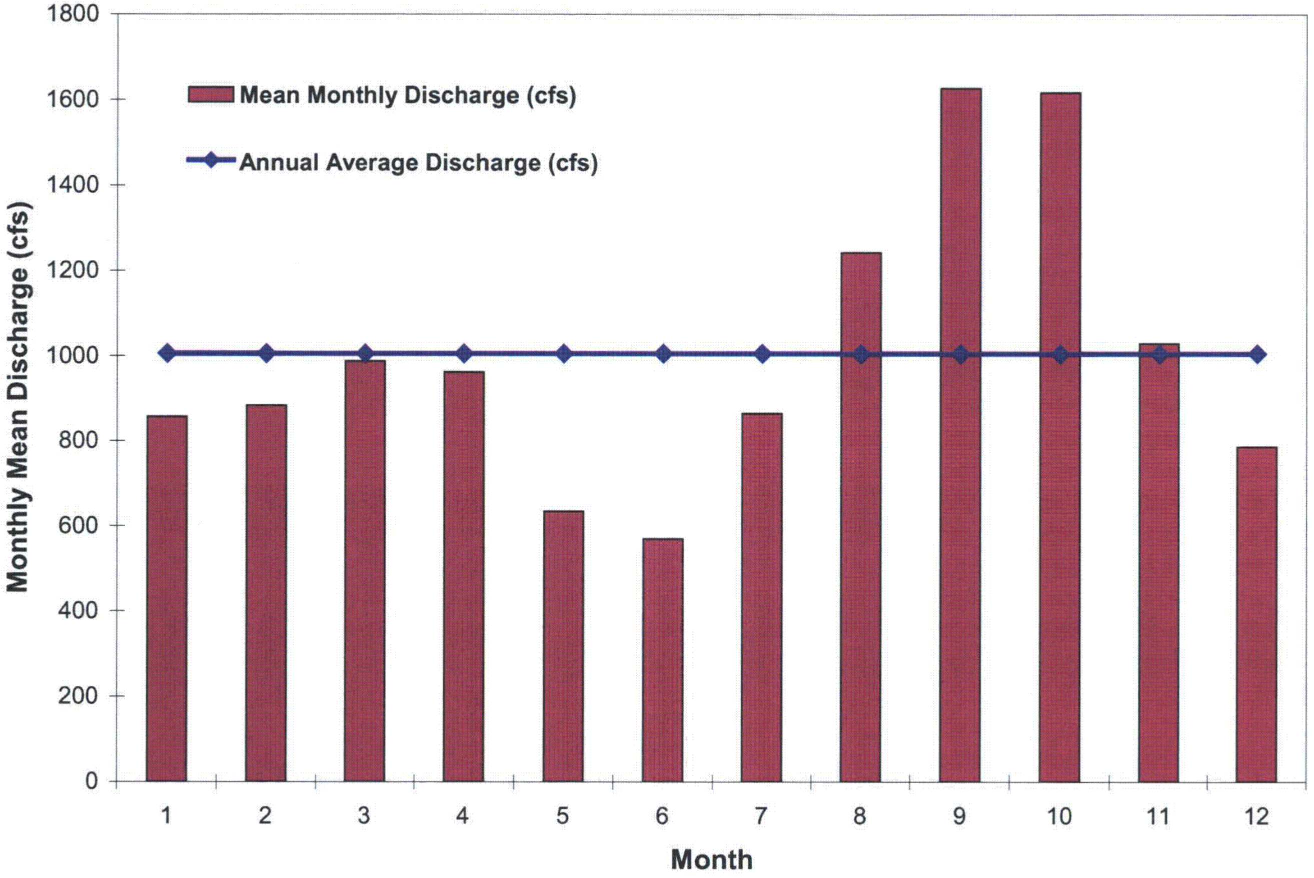


Progress Energy Florida

Levy Nuclear Plant
Units 1 and 2

Monthly Discharge at USGS Station 02313000
on the Withlacoochee River near Holder

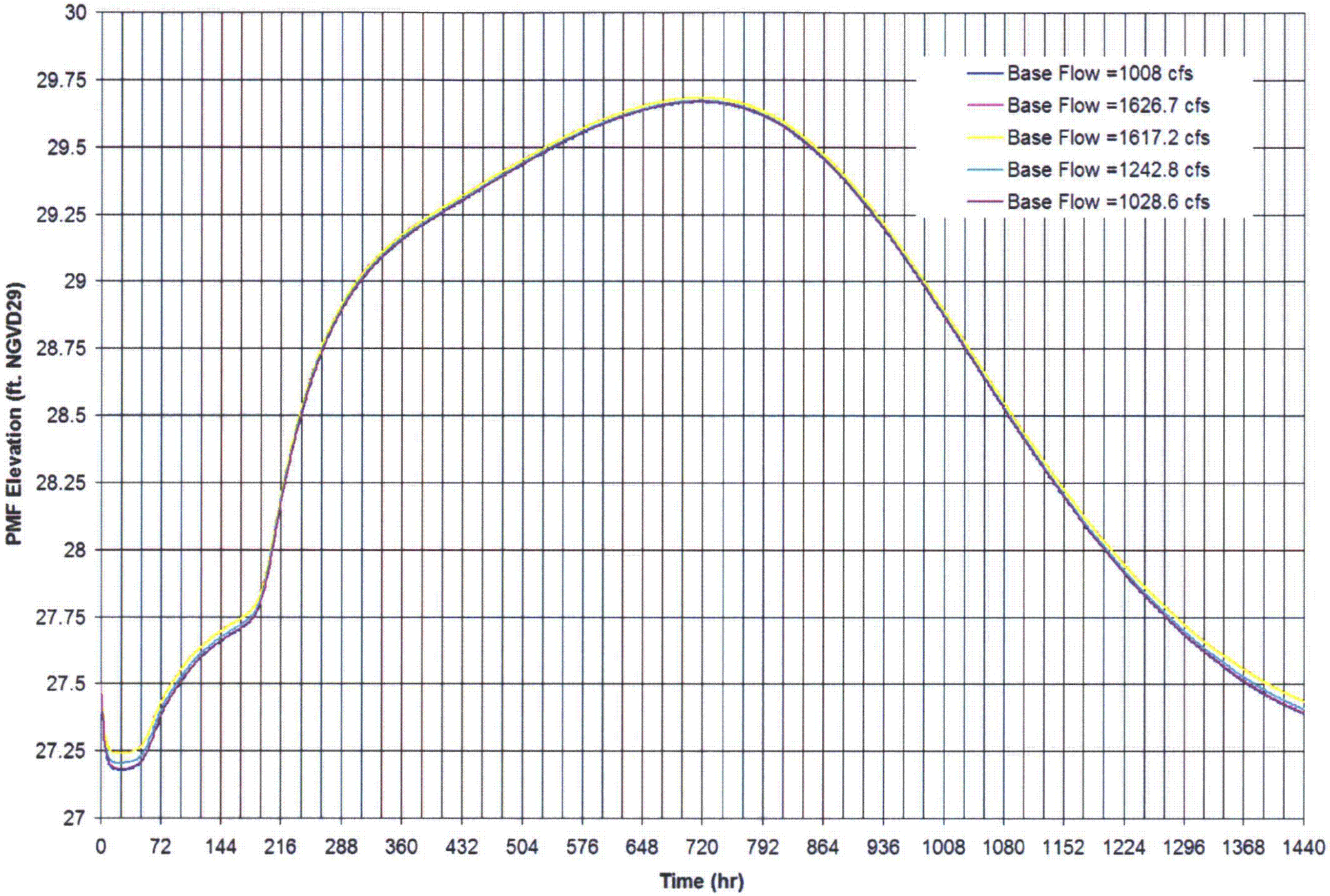
FIGURE 1



Progress Energy Florida

Levy Nuclear Plant
Units 1 and 2

Monthly Mean and Mean Annual Discharge at
USGS Station 02313000 on the
Withlacoochee River near Holder
FIGURE 2



Progress Energy Florida

Levy Nuclear Plant
Units 1 and 2

Results of the Sensitivity Analysis -
Impact of Base Flow on the PMF Elevation

FIGURE 3