R. R. Sgarro
Manager-Nuclear Regulatory Affairs

PPL Bell Bend, LLC
38 Bomboy Lane, Suite 2
Berwick, PA 18603
Tel. 570.802.8102 FAX 570.802.8119
rrsgarro@pplweb.com

ppl™

April 12, 2010

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

BELL BEND NUCLEAR POWER PLANT
PARTIAL RESPONSE TO RAI No. 90 AND
REQUEST FOR EXTENSION
BNP-2010-089 Docket No. 52-039

References: 1) M. Canova (NRC) to R. Sgarro (PPL Bell Bend, LLC), Bell Bend COLA – Request for Information No. 90 (RAI No. 90) – SEB1-2508, email dated March 11, 2010

2) BNP-2009-400, T. Harpster (PPL Bell Bend, LLC) to U.S. NRC Document Control Desk, "BBNPP Schedule Update," dated December 8, 2009

The purpose of this letter is to respond to portions of the request for additional information (RAI) identified in the referenced NRC correspondence to PPL Bell Bend, LLC (PPL) and to request an extension for the remainder of the questions. This RAI addresses Foundations as discussed in Chapter 3 of the Final Safety Analysis Report (FSAR) and submitted in Part 2 of the Bell Bend Nuclear Power Plant (BBNPP) Combined License Application (COLA).

The enclosure provides our response to questions 03.08.05-1, 2, 3, 6, 10, and 11.

The response to question 03.08.05-9 requires additional development. PPL will provide the response to question 03.08.05-9 by April 30, 2010.

As the staff is aware, PPL is revising the footprint of the proposed BBNPP within the existing project boundary. This re-location may change site-specific characteristics, such as Ground Motion Response Spectra (GMRS) and soil properties.

The following questions from RAI No. 90 are impacted by the re-location of the plant physical siting:

03.08.05-4
03.08.05-5
03.08.05-7
03.08 04-8

This re-location will result in supplemental COLA information being submitted to the NRC, and will include information necessary to address these questions regarding FSAR Section 3.8. PPL is currently in the process of updating the schedule information previously provided to the staff in Reference 2, and will update the staff upon completion.

D079
NRO

Should you have questions or need additional information, please contact the undersigned at 570.802.8102.

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

Executed on April 12, 2010

Respectfully,

Rocco R. Sgarro

RRS/kw

Enclosure: As stated

cc: (w/o Enclosures)

Mr. Samuel J. Collins
Regional Administrator
U.S. Nuclear Regulatory Commission
Region I
475 Allendale Road
King of Prussia, PA 19406-1415

Mr. Michael Canova
Project Manager
U.S. Nuclear Regulatory Commission
11545 Rockville Pike, Mail Stop T6-E55M
Rockville, MD 20852

Enclosure 1

Response to NRC Request for Additional Information No. 90,
Questions 03.08.05-1, 03.08.05-2, 03.08.05-3, 03.08.05-6, 03.08.05-10, 03.08.05-11
Bell Bend Nuclear Power Plant

RAI 90
Question 03.08.05-1:

For supplemental information item SUP 3.8 (7) in the Bell Bend Nuclear Power Plant (BBNPP) combined license (COL) Final Safety Analysis Report (FSAR), Subsection 3.8.5.3, "Loads and Load Combinations" (Standard Review Plan (SRP) Section 3.8.5), the applicant states (Page 3-188) that "Additional loads and load combinations include those defined in Section 3.8.4.3.1 and 3.8.4.3.2 and Table 3E.4-1 and Table 3E.4-2."

To what loads and loading combinations are the "additional loads and loading combinations" added?

Response:

The response to RAI 90, question 03.08.05-1 is similar to the response provided to NRC RAI 79, Question 03.08.04-12, in letter BNP-2010-085, dated March 19, 2010 (ML100830214). Subsection 3.8.4.3.2 of BBNPP COL FSAR, Revision 0 referred to Table 3E.4-1 and Table 3E.4-2 which are now Table 3E-1 and Table 3E-2 in BBNPP COL FSAR, Revision 2. Loads and load combinations are included in FSAR Section 3.8.4.3.1, Section 3.8.4.3.2, Table 3E-1 and Table 3E-2, with the exception of aircraft impact loads. Subsection 3.8.5.3 of the FSAR will be revised to clarify that loads and load combinations are defined in Section 3.8.4.3.1, Section 3.8.4.3.2, and Tables 3E-1 and 3E-2.

COLA Impact:

The BBNPP FSAR will be revised as shown:

3.8.5.3 Loading Combinations

{~~Additional l~~Loads and load combinations ~~include those~~ are defined in Section 3.8.4.3.1 and 3.8.4.3.2 and Table 3E-1 and Table 3E-2.}

RAI 90
Question 03.08.05-2:

For supplemental information item SUP 3.8 (8) in the BBNPP COL FSAR, Subsection 3.8.5.4.6,"[Essential Service Water Emergency Make-up System] ESWEMS Pumphouse Base Mat" (SRP Section 3.8.5), the applicant states in the first paragraph (Page 3-189) that "Although the dynamic response spectrum analysis for the ESWEMS Pumphouse envelops the (International Civil Engineering Consultants, Inc--System for the Analysis of Soil Structure Interaction) ICEC SASSI (V. 1.3) analysis results, the detail design of the base mat will be more refined and involve a three step analytical process:

1. Time history analysis by ICEC SASSI (V. 1.3) to determine in-structure seismic response spectra using a GT-STRUDL (Georgia Tech-Structural Design Language) finite element model of both base mat and the superstructure.

2. Static analysis via the GT-STRUDL (V. 29.1) finite element model for all applicable load cases and design load combinations, including static seismic loads of the SSE, hydrostatic and soil pressures.

3. Global design forces and moments are extracted from the GT-STRUDL (V. 29.1) static analysis for the design of the base mat in accordance with the provisions of ACI 349-01 ([American Concrete Institute] ACI, 2001a) (with supplemental guidance of Regulatory Guide 1.142 (NRC, 2001))."

The NRC Staff requests that the applicant provide the following information:

(1) (a) Where are the dynamic spectrum analysis for the ESWEM Pumphouse and the ICEC SASSI analysis presented?
(b) Does the input for the dynamic spectrum analysis include the effect of SSI (soil structure interaction)?
(c) What is the input motion used for the ICEC SASSI analysis?
(d) Describe the structural model used in ICEC SASSI analysis.

(2) Explain the meaning of the sentence in Step 1 more clearly, and include a discussion of the use of the two computer codes and two models and how they interrelate.

(3) (a) Provide a description for "static seismic loads of SSE" in Step "2".
(b) How were the "static seismic loads of SSE" in Step "2" computed and applied to the model?

(4) In the GT-STRUDL static analysis, what are the boundary conditions assumed for the model?

Response:

1. (a) The description of dynamic spectrum analysis and ICEC SASSI analysis for the ESWEMS Pumphouse are presented in Final Safety Analysis Report (FSAR) Sections 3.7.2.1.2 and 3.7.2.1.1, respectively.

(b) The Response Spectrum Method employed a 3-D FEM Model on fixed supports; as such, the effect of SSI is not included.

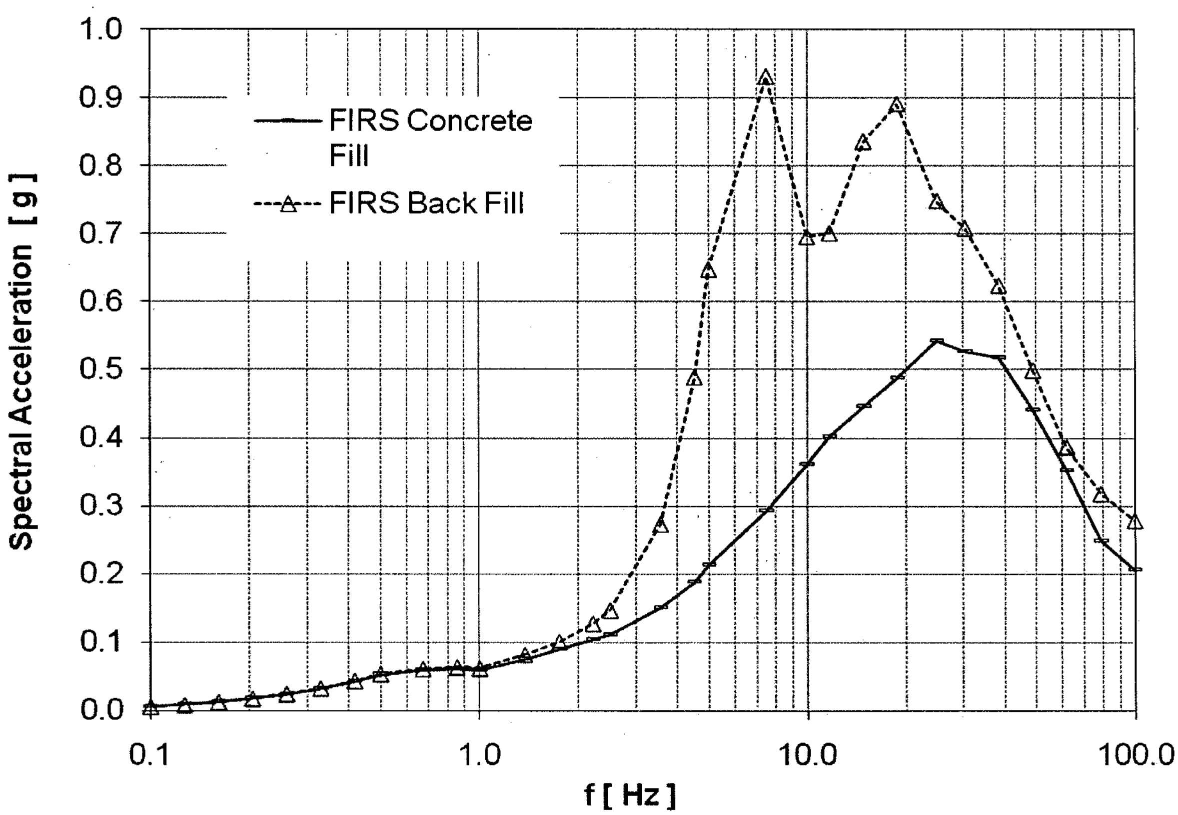
(c) As delineated in FSAR Section 3.7.2.1.1, the SASSI analysis used three ground motion time histories, as described in FSAR Section 3.7.1.1.2, to represent the design basis seismic ground motion in the three orthogonal directions. The times histories represent the control motions at the free field soil surface of the soil-structure system.

(d) The structural model used in ICEC SASSI analysis is described in FSAR Section 3.7.2.3.2.

2. The base mat of the ESWEMS Pumphouse was designed using a Response Spectrum Method. The input FIRS used in the design were for engineered back fill rather than concrete fill, which has a lower input motion as shown in Figure A, below:

FIGURE A

COMPARISON OF THE FIRS ALONG THE HORIZONTAL DIRECTION



For the design of the structural components, such as walls, floors, base mat, and shear keys of the ESWEMS Pumphouse, the axial, shear forces, and moments were derived from element reactions. They are tabulated in FSAR Tables 3.E-3 through 3.E-6. Given the inherent conservatism in the input FIRS and use of rigid supports without SSI effects, the detail design of the structure can be more refined using a three step analytical process as described in FSAR Section 3.8.5.4.6. Step 1 involved a Time History Analysis by ICEC SASSI (V. 1.3) to determine in-structure seismic response spectra (ISRS), using a GT-STRUDL finite element model. This step is essential to provide refined ISRS inputs for subsequent response spectrum analysis. In this case, its 3-D model has a built-in SSI effect, rather than ignoring it. Ignoring the SSI effect is overly conservative.

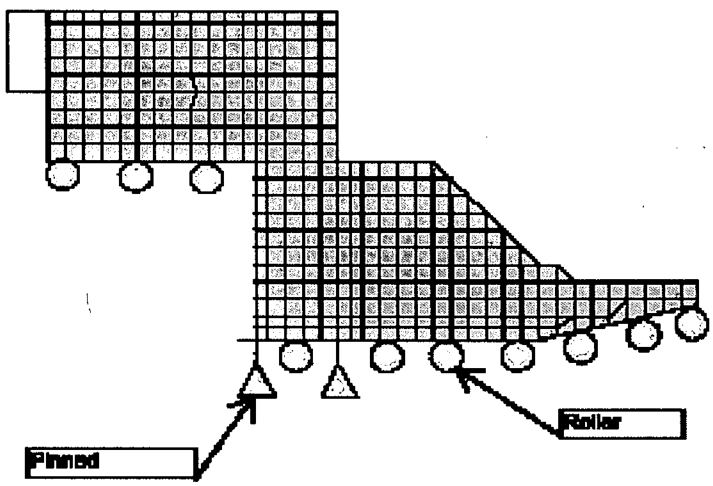
3 (a) Pseudo static loads are developed by GT-STRUDL using the response spectrum method to represent seismic SSE loadings on the FEM elements.

(b) The Response Spectrum method applies the inertia loads in all three directions of earthquake motions. Each direction is calculated separately and independently. Subsequently, the method combines similar forces and moments using the 100-40-40 percent rule or Square-Root-of-the-Sum-of-the-Squares (SRSS) procedure, as permitted in Regulatory Guide 1.92, Rev. 2. Load combinations are in accordance with ACI-349 requirements to provide the structural demands in the structure for all loading conditions.

(4) In the GT-STRUDL Pseudo static analysis, boundary conditions for supporting elements are demonstrated in the figure below and consistent with the description in FSAR 3.7.2.1.2, which stated in part:

> "The base mat founded on concrete back fill is modeled as roller supports. The building shear keys which are embedded in the Mahantango foundation are modeled as hinged supports. The supporting media below the apron base is modeled as roller supports."

Pinned (hinged) and roller supports were used to idealize the pumphouse founded on concrete backfill and/or on top of the Mahantango formation. The soil springs were not used given the rigidity of concrete backfill and/or Mahantango formation. Hence, rigid supports are considered appropriate.



COLA Impact:

The BBNPP FSAR will not be revised as a result of this response.

RAI 90
Question 03.08.05-3:

For COL information item COL 3.8 (13) in the BBNPP COL FSAR Subsection 3.8.5.5,"Structural Acceptance Criteria" (SRP Section 3.8.5) , in the last sentence (Page 3-190) the applicant states that "For the ESWEMS, the static and dynamic coefficient of friction between the concrete base mat, the concrete backfill and the underlying Mahantango formation is conservatively set at 0.6."

The NRC Staff requests that the applicant provide the following information:

(1) Provide the range of coefficient of friction between concrete and soils normally used for these analyses, or obtained by measurements for both static and dynamic coefficient of friction.
(2) Demonstrate the conservatism of the value used by the applicant of 0.6 for both the static and dynamic coefficient of friction

(3) As stated in BBNPP FSAR Subsection 3.8.5.6.1, the ESWEMS Pumphouse is approximately 1 ft submerged in water. If the effect of the water on the coefficient of friction has been considered and analyzed, provide this information. If not, provide justification for omitting this analysis.

Response:

(1)The ESWEMS Pumphouse, including the extended apron, is a reinforced concrete structure found on top of lean concrete backfill overlaid on the Mahantango formation. There is no subgrade of supporting soil. Hence, the coefficient of friction between concrete and soils is not used.

(2) The ESWEMS Pumphouse stability is evaluated for static and dynamic loading conditions. In both evaluations, a coefficient of friction of 0.6 is used for concrete cast at different times. The value is tabulated in ACI 349-01, Section 11.7.4.3 for "concrete placed against hardened concrete not intentionally roughened". It is also noted that 0.6 is the lowest coefficient of friction among the values listed in the code and is therefore the most conservative.

For dynamic loading conditions, the inertia force overcomes the friction force between two concrete surfaces. The concrete surfaces are considered sliding relative to each other. The building shear keys are interlocked inside bedrock. It is necessary that the keys are designed, using shear friction concept, with enough strength to transfer the SSE loads to the bedrock.

Shear keys are not considered in resisting driving forces from static loading conditions, such as wind/tornado winds, earth pressure, or hydro-static pressure. The analysis, using a static coefficient of friction of 0.6, results in enough friction resistance to prevent the building from sliding. The static coefficient of friction is normally a higher value than the dynamic coefficient of friction; therefore, using the same value is conservative. The ESWEMS Pumphouse is found stable without the shear keys and/or a higher value of the static coefficient.

(3) The final groundwater level in relation to the depth of ESWEMS foundation and basemat will not be known until the re-location of the footprint of the Bell Bend Nuclear Power Plant is complete and site-specific characteristics are determined. The final site-specific characteristics will be provided with the FSAR Section 3.8 supplement. However, a submerged ESWEMS basemat does not have a significant impact on the coefficient of friction for structural analysis.

The concrete basemat is cast directly on top of lean concrete backfill with no gap at the interface. Since the calculated Factor-Of-Safety against flotation is 3.0 (Ref. FSAR Table 3.8-1), the ESWEMS basemat will not float or become separated from the lean concrete backfill. Therefore, water cannot enter the interface to reduce the coefficient of friction.

COLA Impact:

The BBNPP FSAR will not be revised as a result of this response.

RAI 90
Question 03.08.05-6:

For COL information item COL 3.8 (13) in the BBNPP COL FSAR, Subsection 3.8.5.5.2,"Emergency Power Generating Buildings Foundation Base Mats," Page 3-190 (SRP Section 3.8.5), the last sentence of the paragraph states that "The allowable bearing capacity is specified in Section 2.5.4.10."

The equation for calculating the ultimate bearing capacity given in BBNPP FSAR Section 2.5.4.10, Eq. 2.5.4-13, has three terms. The second term of the equation considers the effect of water, but the third term does not.

(1) Is the effect of water considered in the first term? If so, explain this analysis. If not, provide justification for excluding this analysis
(2) Does the third term consider the effect of water? If so, explain this analysis. If not, provide justification for excluding this analysis.

Response:

The effect of water is considered in the bearing capacity equation. As identified in the BBNPP FSAR, from the U.S. Army Corps of Engineers, "Bearing Capacity of Soils," American Society of Civil Engineers (ASCE), 1993, the ultimate gross bearing capacity was calculated using the Terzaghi equation with the Vesic capacity factors:

$$q_{ult} = CN_cS_c + \gamma' D_f N_q S_q + \frac{1}{2}\gamma' BN_\gamma S_\gamma$$

Where,

C = cohesion
γ' = effective unit weight of soil
D_f = Depth to calculate the effective overburden pressure at the base of foundation
B = width of foundation
N_c, N_q and N_γ = Bearing capacity factor (Vesic)
S_c, S_q and S_γ = Shape factors (Vesic)

In this equation the influence of water is considered in the second and third terms of the equation.

The first term considers only cohesion (C) and it is not dependent on ground water elevation.

The third term of the bearing capacity equation is:

$$\frac{1}{2}\gamma' BN_\gamma S_\gamma$$

As stated in the U.S. Army Corps of Engineers, "Bearing Capacity of Soils," American Society of Civil Engineers (ASCE), 1993, this term calculates the influence in the bearing capacity of the soil weight and surcharge. In this term, the effect of water is considered in the calculation of the effective unit weight (γ').

The third term in BBNPP FSAR Equation 2.5.4-13 used γ instead of γ' for the effective unit weight of soil. BBNPP FSAR Equation 2.5.4-13 will be revised to include the proper symbol for the effective unit weight of soil.

Finally, BBNPP FSAR Table 2.5-58 presents the results the ultimate bearing capacity values. The bearing capacity calculated using the Terzaghi equation is compared with the concrete bearing capacity; the lower of these two values will be defined as ultimate bearing capacity and used to calculate the allowable bearing capacity.

COLA Impact

The BBNPP FSAR will be revised as shown:

Equation 2.5.4-13:

$$q_{ult} = \cancel{c}\underline{C}N_c\cancel{s}\underline{S}_c + \gamma' D_f N_q \cancel{s}\underline{S}_q + \frac{1}{2}\cancel{\gamma}\underline{\gamma'}BN_\gamma\cancel{s}\underline{S}_\gamma$$

$\cancel{c}\underline{C}$	→	Cohesion,
$\cancel{\gamma'}\ \underline{\gamma'}$	→	Effective unit weight of soil,
D_f	→	Depth to calculate effective overburden pressure at base of foundation,
B	→	Width of foundation,
N_c, N_q, N_γ	→	Bearing capacity factors (defined in Vesic, 1975),
$\cancel{s}\underline{S}_c$, $\cancel{s}\underline{S}_q$, $\cancel{s}\underline{S}_\gamma$	→	Shape factors (defined in Vesic, 1975).

RAI 90
Question 03.08.05-10:

For supplemental information item SUP 3.8 (9) in the BBNPP COL FSAR, Subsection 4.5.5.4, "ESWEMS Pumphouse Base Mat," Page 3-190, (SRP Section 3.8.5), the staff requests that the applicant provide an explanation for the data in Table 3.8-1 on Page 3-195, ESWEMS Pumphouse Base Mat & Pump Well Foundation, Summary Table On the Building Stability.

(1) In the top three rows, the data identified as "allowable" safety margin should be values determined to be the minimum safety margin required by a specific design code or standard. Please amplify the meaning of these table values.

(2) Please explain why there are several "N/A" for the allowable values, and provide justification for excluding this information from the table.

<u>Response:</u>

(1) Building stability includes, but is not limited to, the measure of the building Factor-Of-Safety (FS) against overturning, sliding, and flotation. The data identified as "allowable" is the FS determined to be the minimum requirement in accordance with NUREG-0800, Standard Review Plan (SRP), Section 3.8.5. The calculated (minimum) FS is the ratio between calculated resisting moment, force, and dead load with respect to the driving moment, force, and flotation from appropriate loading conditions. Safety margin is a measurement of risk with respect to minimum ACI 349-01 code requirements.

a) <u>Factor-Of-Safety against Overturning</u>:

A strong lateral force, mainly from wind and/or earthquakes, may cause significant building response, including displacement of the building center of gravity (C.G.). At first, the structure undergoes rocking motions pivoting about either edge of the base. As the amplitude of rocking motion intensifies, the C.G. would reach a position above either edge of the base. The building becomes unstable and may tip-over. In order to maintain the building stability, a minimum FS shall be met. The FS is the ratio between the resisting moment and the applied moment. The FS = 3.0 in FSAR Table 3.8-1 indicates that the resisting moment is a minimum of three times the applied moments. Given the allowable FS of 1.5, it results in a safety margin of (3.0 – 1.5) divided by 1.5, or 100%.

b) <u>Factor-Of-Safety against Sliding:</u>

A strong lateral force may also displace the building along the direction of the applied force. The driving/active forces consist of seismic and/or wind loadings, or active soil pressure, etc. Resisting forces from the structure block, passive soil pressure resistance, or the building skin frictional resistance shall prevent such displacement from taking place. The FS against sliding is the ratio between the resisting and the active forces.

c) <u>Factor-Of-Safety against Flotation:</u>

The FS against flotation is defined as: $FS = \frac{F_{DL}}{F_B}$

Where: F_{DL}=the downward force due to dead load; F_B =the upward force due to buoyancy

(2) The Factor-Of-Safety against flotation is a static load case (D +F'), as defined in NUREG-0800, Section 3.8.5. The dynamic load condition is not applicable. Therefore, "N/A", which denotes "Not Applicable", is used in FSAR Table 3.8-1 in the "Dynamic Load Condition" "Allowable" column for Factor-Of-Safety Against Flotation.

The "N/A" is applicable to allowable building global sways or lateral deflections on top of the roof under dynamic loading condition. The calculated maximum displacement of the building roof is 0.20 inches. The building is designed with concrete shear wall systems for applied lateral forces from safe-shutdown earthquake (SSE) loading conditions. By conservatively assuming the shear wall to be a free cantilevered wall 24 ft. high from the base, the displacement represents < 0.1% of its height and is insignificant. The NUREG 0800, Section 3.7.2, "Seismic System Analysis", SRP Acceptance Criteria have no set limit on lateral drift or displacement of the building structure, except for the consideration of maximum relative displacements between adjacent supports of Seismic Category I Structures, Systems, and Components (SSCs). When seismic interaction is not a concern, such as for the stand-alone ESWEMS Pumphouse, the limit of maximum building lateral global sway does not apply.

COLA IMPACT:

The BBNPP FSAR will be revised as follows:

Table 3.8-1 {ESWEMS Pumphouse & Pump Well Foundation Summary Table On the Building Stability}

Required Stability Item	Static Load Condition		Dynamic Load Condition	
	Calculated (Minimum)	~~Allowable~~ <u>Required (Minimum)</u>	Calculated	~~Allowable~~ <u>Required (Minimum)</u>

RAI 90
Question 03.08.05-11:

BBNPP COL, Table 3E.4-3 (SRP Section 3.8.5), states in the 4th row:"Average values for dynamic condition, including SSE loading."

(1) Please explain the meaning of "average values" in Table 3E.4-3,Table 3E.4-4, and Table 3E.4-5, of the BBNPP COL FSAR.

(2) The last sentence in the notes below the Table 3E.4-3 incorrectly states: "Refer to Figure 3E.4-2 for GT Strudl Finite Element Planar Reference System for Plate Forces and Moments." Please revise this subsection of the FSAR to include the correct reference, which should be to Figure 3E.4-3. (Note that Figure 3E.4-4 is correctly cited in Table 3E4.-4 and Table 3E.4-5.)

Response:

Revision 2 of the BBNPP COL FSAR changed the Revision 0 numbering of Table 3E.4-1, Table 3E.4-2, Table 3E.4-3, Table 3E.4-4, and Table 3E.4-5; to Table 3E-1, Table 3E-2, Table 3E-3, Table 3E-4, and Table 3E-5, respectively.

(1) The FEM 3-D model for the ESWEMS Pumphouse was established with element groups representing key structural components. However, the demand forces and moments obtained from the GT Strudl program are in terms of the maximum positive and negative values for individual elements only. These values are not a true indicator of the average force or moment in a group. Their peak values indicated areas of high local stress concentration, such as those located at corners or intersections between the wall and slab group. The use of an average demand for the design of a concrete structure along a reasonable section cut is reasonable. The assumption is certain areas are to be slightly under-designed while others are slightly over-designed; stress redistribution will occur and make the section adequately designed. In fact, the GT Strudl program has a command to Calculate Average in assisting the design. Although the average demands were listed in the tables, more conservative values of maximum demands were actually used in the design of the structural component group, such as shear key and the base mat.

(2) Figures 3E.4-2 and 3E.4-3 were also re-designated Figure 3E-2 and Figure 3E-3 in Revision 2 of the BBNPP FSAR. The last sentence in the Notes for Table 3E-3 will be revised to reflect Figure 3E-3 as the referenced figure.

COLA IMPACT:

The BBNPP FSAR will be revised as follows:

Table 3E-3 {ESWEMS Pumphouse Base Mat Resultant Membrane Forces and Moments}

Notes:
Refer to Figure ~~3E-2 For GTStrudl~~ 3E-3 for GT STRUDL Finite Element Planar Reference System for Plate Forces and Moments.