FPL Energy Point Beach, LLC, 6610 Nuclear Road, Two Rivers, WI 54241

FPL Energy
Point Beach Nuclear Plant

September 19, 2008

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

Point Beach Nuclear Plant, Units 1 and 2
Dockets 50-266 and 50-301
Renewed License Nos. DPR-24 and DPR-27

Supplement to License Amendment Request Number 247
Spent Fuel Pool Storage Criticality Control

References: (1) FPL Energy Point Beach, LLC Letter to NRC, "Point Beach, Units 1 & 2, License Amendment Request No. 247, Transmittal of Changes to Technical Specifications re: Spent Fuel Pool Storage Criticality Control," dated July 24, 2008 (ML082240685)

(2) NRC Letter to FPL Energy Point Beach, LLC, "Acceptance Review for License Amendment Request Number 247 Spent Fuel Pool Criticality Control-Supplemental Information Required (TAC Nos. MD9321 and MD9322)," dated September 10, 2008.

In accordance with the provisions of 10 CFR 50.90, "Application for amendment of license, construction permit, or early site permit," FPL Energy Point Beach, LLC is submitting a supplement to the request for an amendment to the Point Beach Nuclear Plant (PBNP) Technical Specifications (TS) described in Reference (1).

The purpose of the supplement to the application is to provide additional quantitative information to support the fidelity of key methodology aspects described in Reference (2). The enclosure to this letter provides the detailed supplemental information.

This supplement does not alter the no significant hazards consideration determination or the environmental considerations previously provided in Reference (1).

This submittal contains no new commitments or revision to existing commitments. The list of new and revised commitments provided in Reference (1) is not changed by this supplement.

In accordance with 10 CFR 50.91, a copy of this amendment application supplement is being provided to the designated Wisconsin Official.

I declare under penalty of perjury that the foregoing is true and correct.
Executed on September 19, 2008.

Very truly yours,

FPL Energy Point Beach, LLC

Larry Meyer
Site Vice President

Enclosure

cc: Regional Administrator, USNRC, Region III
Resident Inspector, USNRC, Point Beach Nuclear Plant
Project Manager, USNRC, Point Beach Nuclear Plant
Public Service Commission of Wisconsin

ENCLOSURE

FPL ENERGY POINT BEACH, LLC
POINT BEACH NUCLEAR PLANT, UNITS 1 & 2

SUPPLEMENT TO LICENSE AMENDMENT REQUEST NUMBER 247

SPENT FUEL POOL STORAGE CRITICALITY CONTROL

SUPPLEMENTAL INFORMATION TO THE POINT BEACH UNITS 1 AND 2 SPENT FUEL POOL CRITICALITY ANALYSIS

12 pages follow

Question 1

Burnup uncertainty – Licensee proposes a method that deviates from staff guidance (Reference 1) but does not quantitatively justify the deviation. The proposed method was rejected by the staff for the BVPS submittal. Provide the quantitative justification for the deviation.

Response:

A calculation was performed for each configuration to determine the reactivity with all depleted fuel assemblies replaced with fresh 5.0 w/o assemblies. The burnup uncertainty was then recalculated consistent with a proposed method from Reference 1 - as 5% of the reactivity difference between this fresh k_{eff} and the target k_{eff} identified in WCAP-16541-P, Revision 2. If this "new" burnup uncertainty replaces the burnup uncertainty reported in Tables 3-4 through 3-6 of WCAP-16541-P, Revision 2, a new target k_{eff} may be determined[1].

The resulting changes in the sums of biases and uncertainties are presented in the table below. The increase is, in all cases, less than the 0.00500 Δk_{eff} of administrative margin allocated in WCAP-16541-P, Revision 2. Note that this does not revise WCAP-16541, Revision 2, but demonstrates that sufficient margin exists in the analysis as submitted to account for this "new" methodology.

Impact of "New" Burnup Uncertainty on Sum of Biases and Uncertainties

Storage Configuration	"New" BU Uncertainty	"New" Sum of Biases and Uncertainties	WCAP-16541-P, Revision 2, Sum of Biases and Uncertainties	**Change in Target k_{eff} (Δk_{eff})**
All-Cell	0.01006	0.02944	0.02813	**0.00131**
1-out-of-4 with 5.0 w/o Fresh with no IFBA	0.00981	0.02406	0.02104	**0.00302**
1-out-of-4 with 4.0 w/o Fresh with IFBA	0.00929	0.02530	0.02327	**0.00203**

[1] Iteration is performed in determining a new target k_{eff} until the difference in the burnup uncertainty is less than 0.00001 Δk_{eff}.

Question 2

Soluble Boron credit – Licensee does not quantitatively justify the use of "parallel" vs. "serial" application of boron worths, as was done for BVPS through RAIs. Provide the justification for the use of "parallel" vs. "serial" application of boron worths.

Response:

The soluble boron credit is calculated as shown in the equation given below, using three terms accounting for a 5% Δk_{eff} reduction, assembly reactivity uncertainties, and postulated accident mitigation. Each of these reactivity terms is converted into a soluble boron concentration using the data presented in Table 3-21 of WCAP-16541-P, Revision 2. The three concentrations are then summed to provide the recommended minimum boron concentration. This boron concentration is then adjusted to account for the effect of ^{10}B depletion, although this is not addressed in this response. The differential boron worth, as presented in the analysis, decreases as boron concentration increases. This physical behavior calls into question the "parallel" credit used in WCAP-16541-P, Revision 2, versus a "serial" approach where the three reactivity terms are summed and then converted to a recommended boron concentration.

$$SBC_{Total} = SBC_{95/95} + SBC_{RE} + SBC_{PA}$$

Where:

SBC_{Total} is the total soluble boron concentration requirement (ppm)
$SBC_{95/95}$ is the soluble boron requirement for 95/95 k_{eff} less than or equal to 0.95 (ppm)
SBC_{RE} is the soluble boron required to account for burnup and reactivity uncertainties (ppm)
SBC_{PA} is the soluble boron required to offset accident conditions (ppm)

WCAP-16541-P, Revision 2, reports 648 ppm as the soluble boron concentration required to maintain k_{eff} less than or equal to 0.95 including all biases and uncertainties and assuming the most limiting single accident scenario assuming 19.9 a/o ^{10}B. An analogous concentration can be determined using "serial" application of the boron worth equation. In this case, the Δk_{eff} values presented in WCAP-16541-P, Revision 2, are used for each term in the equation provided above. The Δk_{eff} values are 0.05, 0.02487, and 0.04795, respectively, for a total of 0.12282 Δk_{eff} units. This total reactivity is then converted to a soluble boron concentration using the equation provided in Table 3-21 of WCAP-16541-P, Revision 2. The "serial" application of the boron worth equation would therefore yield a minimum boron concentration of 818 ppm. Direct simulations were performed using the worst case postulated accident scenario reported in WCAP-16541-P, Revision 2, for each storage configuration using these two soluble boron concentrations to demonstrate that the method used in the analysis is sufficiently conservative to provide margin to the regulatory requirements.

The results are presented below, and indicate that more than 2.8% Δk_{eff} margin exists to the maximum k_{eff} limit in the borated condition for the accident condition assuming the 648 ppm determined using the "parallel" boron worths. The limiting accident scenario in terms of postulated accident reactivity increase, borated accident k_{eff}, and minimum margin to the k_{eff} limit is the "1-out-of-4 with 5.0 w/o Fresh with no IFBA" storage configuration. The maximum k_{eff} limits in the borated condition for each configuration are presented in the response to Question 5. This explicit comparison of the calculated k_{eff} to the maximum borated k_{eff} limit is a more precise method than was used in the BVPS RAI responses. The "serial" method is a more conservative method for the determination of the minimum required soluble boron concentration, but sufficient conservatism exists in the "parallel" method to meet regulatory requirements.

This identified margin is the result of the conservatisms included in the soluble boron concentration equation shown above and the method used to determine the soluble boron worth. The reactivity uncertainty of the fuel assembly is accounted for in the burnup uncertainty included in the determination of the burnup limits. The soluble boron worth is also conservatively determined in the full pool model loaded with depleted fuel which is less sensitive to the addition of soluble boron. These two conservatisms, which are implicit in the methodology used in the analysis presented in WCAP-16541-P, Revision 2, provide sufficient conservatism in the determination of the required boron concentration.

Accident Scenario Calculations with Different Soluble Boron Concentrations

Storage Configuration	Soluble Boron Concentration (ppm)	k_{eff}	σ	Δk_{eff} Margin to k_{eff} Limit
All-Cell	0	0.99256	0.00029	
	648	0.85897	0.00027	0.05614
	818	0.83310	0.00026	0.08201
1-out-of-4 5.0 w/o Fresh with no IFBA	0	1.01787	0.00029	
	648	0.89236	0.00026	0.02868
	818	0.86710	0.00024	0.05394
1-out-of-4 4.0 w/o Fresh with IFBA	0	1.00757	0.00032	
	648	0.89025	0.00029	0.02882
	818	0.86389	0.00025	0.05518

Question 3

SFP Temperature bias – Licensee does not provide the details of the SFP temperature bias calculations, as was done for BVPS through RAIs. Provide the details of the SFP temperature bias calculations.

Response:

The spent fuel pool temperature bias was determined by performing explicit calculations in the infinite array models for each storage configuration. For initial enrichments of 3.0, 4.0, and 5.0 w/o ^{235}U, calculations were performed above and below the appropriate minimum allowable burnup requirement. At each condition the reactivity is determined using the ENDF/B-V 238-group library at 68 °F and 180 °F. The 68 °F case assumes a water density of 1.0 g/cm^3 which actually occurs at 40 °F, thus conservatively covering the range of densities that could occur in the spent fuel pool. The 238-group library is used because it retains greater fidelity cross section data and is applicable over a wider range of applications than the 44-group library. No benchmark bias need be determined for this library as only changes in reactivity are determined. The reactivity increase caused by the temperature increase, including the Monte Carlo standard deviation uncertainties from each case, is determined as shown in the equation shown below.

$$\Delta k_{eff} = \left(k_{eff}^{180F} + \sigma^{180F}\right) - \left(k_{eff}^{68F} - \sigma^{68F}\right)$$

Where:

- Δk_{eff} is the temperature bias calculated for the particular condition
- k_{eff}^{180F} is the calculated k_{eff} value at 180 °F for the particular condition
- σ^{180F} is the calculated Monte Carlo uncertainty at 180 °F for the particular condition
- k_{eff}^{68F} is the calculated k_{eff} value at 68 °F for the particular condition
- σ^{68F} is the calculated Monte Carlo uncertainty at 68 °F for the particular condition

The largest bias from the six cases is selected as the temperature bias for the entire configuration at all conditions. This is a minor, but more conservative, deviation from the method used in the BVPS RAI responses. The BVPS RAI response considered the final bias at each initial enrichment through interpolation to the exact minimum allowable burnup requirement. The method presented here is more conservative as it results in a higher calculated bias.

The calculated k_{eff} values, associated Monte Carlo standard deviations, and calculated spent fuel pool temperature biases are presented in the table below for all six cases for all three configurations. The largest bias for each of the three configurations is highlighted. These resulting values are presented in WCAP-16541-P, Revision 2 in Tables 3-4, 3-5, and 3-6 for the "All-Cell", "1-out-of-4 5.0 w/o Fresh with No IFBA," and "1-out-of-4 4.0 w/o Fresh with IFBA" storage configurations, respectively.

Results of Temperature Bias Calculations

Storage Configuration	Initial Enrichment (w/o ^{235}U)	Burnup (MWd/MTU)	Temperature (°F)	k_{eff}	σ	Δk_{eff}
All-Cell	3.0	5000	68	0.99336	0.00035	0.00952
			180	1.00217	0.00036	
		15000	68	0.90891	0.00032	0.00815
			180	0.91639	0.00035	
	4.0	15000	68	0.97967	0.00035	0.01019
			180	0.98918	0.00033	
		25000	68	0.91706	0.00035	0.00856
			180	0.92490	0.00037	
	5.0	25000	68	0.97074	0.00036	0.01036
			180	0.98034	0.00040	
		35000	68	0.94735	0.00037	0.00943
			180	0.95605	0.00036	
1-out-of-4 5.0 w/o Fresh with no IFBA	3.0	25000	68	0.97224	0.00044	0.00795
			180	0.97933	0.00042	
		35000	68	0.95139	0.00049	0.00519
			180	0.95561	0.00048	
	4.0	35000	68	0.97665	0.00045	0.00696
			180	0.98269	0.00047	
		45000	68	0.95530	0.00045	0.00597
			180	0.96038	0.00044	
	5.0	45000	68	0.99326	0.00043	0.00783
			180	1.00028	0.00038	
		55000	68	0.97231	0.00045	0.00810
			180	0.97956	0.00040	
1-out-of-4 4.0 w/o Fresh with IFBA	3.0	15000	68	0.98185	0.00041	0.00803
			180	0.98911	0.00036	
		25000	68	0.94755	0.00043	0.00680
			180	0.95352	0.00040	
	4.0	25000	68	0.98239	0.00037	0.00841
			180	0.99004	0.00039	
		35000	68	0.95129	0.00044	0.00733
			180	0.95776	0.00042	
	5.0	35000	68	0.99714	0.00044	0.00837
			180	1.00470	0.00037	
		45000	68	0.97037	0.00043	0.00852
			180	0.97803	0.00043	

Question 4

Moderator Temperature Profile – Licensee does not quantitatively show the effect of the limiting temperature profile assumption for depletion calculations, as was done for BVPS through the RAIs. In addition to providing the moderator temperature profile for depletion calculations, the submittal should consider the effects of the assumed values for the other depletion parameters identified in NUREG-6665 (e.g., fuel temperature, soluble boron, specific power and operating history, fixed burnable poisons, integral burnable poisons). These effects should also be addressed for the uniform axial burnup profile where applicable.

Response:

The limiting temperature profile for the Point Beach Extended Power Uprate (EPU) is considered in the analysis presented in WCAP-16541-P, Revision 2. No quantitative effect is presented, as was done for BVPS, because the bounding plant capability data were used for the temperature profile. This temperature profile is assumed to be linear from the analyzed inlet temperature to the analyzed outlet temperature. The profile, as shown in Table 3-2 of WCAP-16541-P, Revision 2, is provided below.

Axial Temperature Profile for Use with Distributed Burnup Profile

Zone Number	Midpoint Height (in)	Temperature (°F)
8	142.46	614.5
7	137.85	612.2
6	133.24	609.9
5	128.63	607.6
4	72.00	579.1
3	15.38	550.6
2	9.23	547.5
1	3.08	544.4

The uniform burnup case represents core average parameters, and as such the moderator temperature used is the core average moderator temperature. The analysis presented in WCAP-16541, Revision 2, uses a core average moderator temperature of 581.0 °F, which is the highest core T_{avg} that will be licensed as part of the EPU.

Both the uniform and distributed burnup profiles are used in the analysis presented in WCAP-16541-P, Revision 2. The burnup profile with higher reactivity in the spent fuel pool environment is used for the purposes of determining minimum burnup requirements. The effect of blanketed burnup profiles has also been considered as described in WCAP-16541-P, Revision 2.

The fuel temperatures used in the depletion calculations are determined within the lattice code performing the depletion, which is PHOENIX-P for WCAP-16541-P, Revision 2. The FIGHT-H module is used in PHOENIX-P to calculate fuel and cladding temperatures based on the fuel rod power calculated and the moderator temperature input to the depletion calculation. Since the moderator temperature is maximized, the fuel temperatures are also conservatively maximized.

These temperature calculations are performed within each zone of the distributed burnup model and the uniform burnup model.

The soluble boron concentration used in the depletion calculations is a constant value which is a conservatively increased cycle average boron concentration. A review of recent cycles has confirmed that the boron concentration used is conservative relative to operating experience. The same conservative concentration is used in the distributed and uniform burnup models.

The effects of specific power and operating history are identified as being small in NUREG-6665. High burnup fuel may experience a decrease or increase in discharged reactivity as a function of specific power. Extended part power operations may increase reactivity slightly. The specific power that is used is based on the EPU power and loading. The use of added margin in another depletion parameter is recommended by NUREG-6665. The use of higher operating temperatures present during EPU operation provides significant conservatism for pre-uprate fuel relative to the increased specific power. The conservatism noted above in the soluble boron concentration is sufficient to account for potential operating history.

Two different types of fixed poisons have been used in Point Beach Nuclear Plant operations: glass burnable absorbers and hafnium flux suppression assemblies. Each of these fixed poisons will be considered separately in the following discussion.

The use of glass burnable absorbers at the Point Beach Nuclear Plant has been discontinued. The core operating temperatures and soluble boron concentrations in these past cycles were lower. The core outlet temperature was approximately 15 °F lower than that used in the analysis presented in WCAP-16541-P, Revision 2. The average soluble concentration was more than 200 ppm lower than that used in the analysis. These two effects provide approximately 0.5% Δk_{eff} and 0.6% Δk_{eff}, respectively, based on sensitivities provided in NUREG-6665. The increased reactivity caused by the presence of 20 BPRs is approximately 0.6% Δk_{eff}. This is a conservative estimate because only 16 guide tubes are available in the 14 x 14 fuel lattice. Either the temperature or boron concentration effects alone would be sufficient to provide the necessary margin relative to explicit consideration of glass burnable absorbers. The arguments are applicable to both the distributed and uniform burnup profiles.

Some assemblies in the Point Beach Nuclear Plant spent fuel pool were operated in locations with hafnium flux suppression assemblies in the lower or central six feet of the assembly height to reduce vessel fluence. These peripheral fuel assemblies have experienced depletion for two or three cycles and have low power in the peripheral location. These facts reduce the depletion experienced with the flux suppression assemblies inserted, thus reducing spectral hardening concerns. The flux suppression inserts being in the lower or central six feet of the assembly causes significant positive shifts in the power distribution in these assemblies. This positive shift reduces the end effect which controls reactivity for these high burnup assemblies. The reduction in the end effect negates any reactivity increase caused by spectral hardening in the heavily depleted lower portion of the fuel assembly. The above arguments are not applicable to the uniform burnup profile as the fuel assemblies which host flux suppression assemblies are depleted beyond the burnup at which it is applicable.

Explicit calculations were performed to demonstrate the conservatism of neglecting the impact of IFBA in the analysis presented in WCAP-16541-P, Revision 2. These calculations were performed only for the "All-Cell" storage configuration to maximize the reactivity effect. The other storage configurations contain a fresh assembly which will lower the impact of the spectral hardening in the depleted fuel assemblies. Calculations were performed to a burnup of 55,000 MWd/MTU, however, to consider the effects of higher burnup in these other storage configurations. For the sake of computation efficiency, these calculations were performed using the PARAGON lattice depletion code and SCALE version 5.1. No benchmarking data is presented because these calculations are used only to determine the relative reactivity of fuel assemblies depleted under different conditions.

Depletion calculations were performed considering 120 IFBA pins with a 1.5X IFBA loading. This configuration and loading combination are the most heavily shimmed assembly design used at the Point Beach Nuclear Plant in the past, thereby maximizing the spectral hardening effect. Only the distributed burnup profile was considered because the uniform burnup case is limiting only at low burnups. At these burnups the integrated impact of the spectral hardening effect is less and a considerable fraction of the ^{10}B remains from the IFBA. Depletion calculations were also performed with no IFBA to match the base case presented in WCAP-16541-P, Revision 2, because different computer codes were used.

The results of these calculations are presented in the table below. The depletion results with no IFBA are presented as well as two cases which considered the presence of IFBA during the depletion. One case neglects the residual IFBA in the spent fuel pool calculations and the second case considers this residual ^{10}B. The results demonstrate that including the residual ^{10}B provides sufficient reactivity margin to account for the spectral hardening caused by the presence of IFBA during the depletion.

Results of Calculations with IFBA Present During Depletion

Burnup	No IFBA Depletion		Residual ^{10}B Neglected			Residual ^{10}B Modeled		
(GWd/MTU)	k_{eff}	σ	k_{eff}	σ	Δk_{eff}[1]	k_{eff}	σ	Δk_{eff}[1]
5	1.11775	0.00017	1.11798	0.00018	-0.00023	1.02665	0.00018	0.09110
15	1.04799	0.00016	1.04992	0.00016	-0.00193	1.02813	0.00016	0.01986
25	0.98839	0.00017	0.99101	0.00016	-0.00262	0.98302	0.00016	0.00537
35	0.94045	0.00016	0.94255	0.00017	-0.00210	0.93698	0.00016	0.00347
45	0.89848	0.00016	0.90098	0.00017	-0.00250	0.89671	0.00016	0.00177
55	0.86037	0.00017	0.86279	0.00019	-0.00242	0.86014	0.00015	0.00023

1) $\Delta k_{eff} = k_{eff}(\text{No IFBA}) - k_{eff}(\text{IFBA})$

Question 5

Biases and Uncertainties with Boron – Licensee does not quantitatively show the effect of boron presence on biases and uncertainties. Provide the quantitative effect of boron presence on biases and uncertainties.

Response:

The bias and uncertainty calculations presented in Tables 3-4 through 3-6 were repeated, in this case with 648 ppm of soluble boron present in the pool water. The boron concentration selected is that recommended as the minimum concentration in WCAP-16541-P, Revision 2. The results are presented in the tables below for the "All-Cell", "1-out-of-4 5.0 w/o Fresh with no IFBA," and "1-out-of-4 4.0 w/o Fresh with IFBA" storage configurations, respectively. The models and methods used for evaluating the biases and uncertainties are the same as those described in WCAP-16541-P, as supplemented in the responses to Questions 1 and 3 specifically for the burnup uncertainty and temperature bias. The burnup uncertainty calculated and presented in response to Question 1 is used here. All cases shown in the response to Question 3 were performed again in the borated condition. The reported Δk_{eff} values reported include the Monte Carlo one sigma uncertainties as shown in the equation below.

$$\Delta k_{eff} = \left(k_{eff}^{pert} + \sigma^{pert}\right) - \left(k_{eff}^{base} - \sigma^{base}\right)$$

Where:

Δk_{eff} is the temperature bias calculated for the particular case

k_{eff}^{pert} is the calculated k_{eff} value for the perturbed case

σ^{pert} is the calculated Monte Carlo uncertainty for the perturbed case

k_{eff}^{base} is the calculated k_{eff} value for the base case

σ^{base} is the calculated Monte Carlo uncertainty for the base case

The results show only minor impacts to the overall sum of biases and uncertainties. The sum of biases and uncertainties for both the unborated case, taken from the response to Question 1, and the borated case are provided in a table below. The target k_{eff} can be determined as shown in the equation below. The target k_{eff} values are 0.91511, 0.92104, 0.91907, for the "All-Cell", "1-out-of-4 5.0 w/o Fresh with no IFBA," and "1-out-of-4 4.0 w/o Fresh with IFBA" storage configurations, respectively. The target k_{eff} was calculated for the fresh maximum storable enrichment for each configuration assuming 648 ppm soluble boron. These results are presented in the table below and demonstrate that margin exists to the limits listed above.

$$\text{Target } k_{eff} = 0.945 - \Sigma\text{BNU}$$

Where: Target k_{eff} is the maximum KENO calculated k_{eff} which will meet regulatory requirements considering applicable biases and uncertainties

0.945 is the 0.95 regulatory limit on k_{eff} conservatively reduced by 0.5% Δk_{eff} of administrative margin. This restores the full administrative margin, some of which is used in the response to Question 1 to account for the "new" burnup uncertainty.

ΣBNU is the sum of biases and uncertainties for the borated condition, as presented in the tables below

The use of this borated target k_{eff} in the response to Question 2 provides an explicit demonstration that the calculated k_{eff} in the postulated accident scenario meets the regulatory limit of 0.95 with sufficient margin, accounting for applicable biases and uncertainties calculated in the borated condition.

Biases and Uncertainties for the "All-Cell" Storage Configuration

Case Description	keff	σ	Δk_{eff}
Nominal Case	0.81626	0.00029	
Increase in Fuel Enrichment	0.82330	0.00032	0.00765
Decrease in Clad Outer Diameter and Thickness	0.81708	0.00031	0.00142
Decrease in Cell Pitch	0.81753	0.00032	0.00188
Decrease in Rack Thickness	0.81665	0.00031	0.00099
Off-Center Assembly Positioning	0.82119	0.00032	0.00554
Burnup Uncertainty			0.01006
Methodology Uncertainty[2]			0.00639
Statistical Sum of Uncertainties			0.01542
Methodology Bias			0.00310
Pool Temperature Bias			0.01137
Sum of Uncertainties and Biases			0.02989
Target k_{eff}			**0.91511**

Biases and Uncertainties for the "1-out-of-4 5.0 w/o Fresh with no IFBA" Storage Configuration

Case Description	keff	σ	Δk_{eff}
Nominal Case	0.84426	0.00038	
Increase in Fuel Enrichment	0.84822	0.00043	0.00477
Decrease in Clad Outer Diameter and Thickness	0.84512	0.00042	0.00166
Decrease in Cell Pitch	0.84638	0.00046	0.00296
Decrease in Rack Thickness	0.84483	0.00040	0.00135
Increase in Pellet Diameter	0.84557	0.00038	0.00207
Off-Center Assembly Positioning	0.84518	0.00038	0.00168
Burnup Uncertainty			0.00981
Methodology Uncertainty[3]			0.00642
Statistical Sum of Uncertainties			0.01344
Methodology Bias			0.00310
Pool Temperature Bias			0.00742
Sum of Uncertainties and Biases			0.02396
Target k_{eff}			**0.92104**

[2] The maximum KENO uncertainty considered in WCAP-16541-P, Revision 2, remains bounding.
[3] The maximum KENO uncertainty considered in WCAP-16541-P, Revision 2, remains bounding.

Biases and Uncertainties for the "1-out-of-4 4.0 w/o Fresh with IFBA" Storage Configuration

Case Description	keff	σ	Δk_{eff}
Nominal Case	0.83023	0.00037	
Increase in Fuel Enrichment	0.83393	0.00036	0.00443
Decrease in Clad Outer Diameter and Thickness	0.83043	0.00040	0.00097
Decrease in Cell Pitch	0.83117	0.00039	0.00170
Decrease in Rack Thickness[4]	0.82993	0.00038	0.00045
Increase in Pellet Diameter	0.82997	0.00039	0.00050
Off-Center Assembly Positioning	0.83111	0.00039	0.00164
Burnup Uncertainty			0.00929
Methodology Uncertainty[5]			0.00644
Statistical Sum of Uncertainties			0.01242
Methodology Bias			0.00310
Pool Temperature Bias			0.01041
Sum of Uncertainties and Biases			0.02593
Target k_{eff}			**0.91907**

Calculated Sum of Biases and Uncertainties in Unborated and Borated Conditions

Configuration	Unborated (Δk_{eff})	Borated (Δk_{eff})	Change (Δk_{eff})
All-Cell	0.02944	0.02989	0.00045
1-out-of-4 5.0 w/o Fresh with no IFBA	0.02406	0.02396	-0.00010
1-out-of-4 4.0 w/o Fresh with IFBA	0.02530	0.02593	0.00063

Calculated k_{eff} Values for Maximum Storable Fresh Enrichment

Configuration	k_{eff}	k_{eff} limit
All-Cell	0.81626	0.91511
1-out-of-4 5.0 w/o Fresh with no IFBA	0.84426	0.92104
1-out-of-4 4.0 w/o Fresh with IFBA	0.83023	0.91907

[4] The increase in rack thickness case was considered as well, but was less reactive than the decreased rack thickness case.
[5] The maximum KENO uncertainty considered in WCAP-16541-P, Revision 2, remains bounding.

References:

1. Laurence Kopp (USNRC), "Guidance on the Regulatory Requirements for Criticality Analysis of Fuel Storage at Light-Water Reactor Power Plants," August 19, 1998.