NUCLEAR FUEL MANAGEMENT DEPARTMENT
NUCLEAR DESIGN INFORMATION TRANSMITTAL

☒ SAFETY RELATED ☐ NON-SAFETY RELATED ☐ REGULATORY RELATED	Originating Organization ☒ Nuclear Fuel Management ☐ Other (specify) _____	NDIT No. NFM9900022 Seq. No. 1 Page 1 of 15

Station Braidwood Unit 2 Cycle 8 Generic _____

To: Lonnie K. Kepley

Subject: Braidwood Unit 2 Cycle 8 Core Operating Limits Report in ITS Format and W(z) Function

R. Lee Preparer	Preparer's Signature	7/12/99 Date
J. Gurley Reviewer	Reviewer's Signature	7/12/99 Date
D. Redden NFM Supervisor	Supervisor's Signature	7/12/99 Date

Status of Information:

☒ Verified
☐ Unverified
☐ Engineering Judgement

Method and Schedule of Verification for Unverified NDITs: _____

Description of Information: Attached is the Braidwood Unit 2 Cycle 8 Core Operating Limits Report (COLR) in the ITS format and W(z) function.

Purpose of Information: **Sequence 1 of this NDIT supersedes NDIT NFM9900022, Seq. 0.** This COLR incorporates the ITS format and W(Z) function. Sequence 1 incorporates a revised K(Z) curve for assembly average burnup ≤ 4000 MWD/MTU due to the recent issue on the LOCBART code discrepancy affecting LBLOCA analysis. Braidwood Station is requested to perform an Independent Technical Review (ITR) of this document. Upon completion of the ITR, Braidwood Station is to transmit the COLR portion to the Nuclear Regulatory Commission. Please provide NFM (Rob Lee) with a copy of Braidwood Station's completed ITR and COLR submittal to the NRC.

Source of Information:
1) PND Calculation Number PC-01, "BR2C8 W(z) Curve Generation," File NDN 10.6, dated 3/8/99
2) PND Calculation Number SP-14, "BR2C8 SPIL - UET," File NDN 10.6, dated 1/21/99
3) Westinghouse letter CAE-99-058 / CCE-99-063, "K(z) Curve Ramifications to LOCBART Code Non-Conformance Fq Reductions," dated July 2, 1999
4) PSS Calculation Number PSSCN-99-008, "BR2C8 BEACON Model Development," Rev. 1, dated 7/8/99

Supplemental Distribution: J. Bauer (DG), E. Young/B. Manges (DG), Braidwood Central File, M. G. Needham (BW), H. S. Kim/J. Dunlap (DG), D. G. Central Files, P. Boyle (BW), D. R. Redden

CORE OPERATING LIMITS REPORT (COLR) for BRAIDWOOD UNIT 2 CYCLE 8

1.0 CORE OPERATING LIMITS REPORT

This Core Operating Limits Report (COLR) for Braidwood Station Unit 2 Cycle 8 has been prepared in accordance with the requirements of Technical Specification 5.6.5 (ITS).

The Technical Specifications affected by this report are listed below:

LCO 3.1.1 Shutdown Margin (SDM)

LCO 3.1.3 Moderator Temperature Coefficient

LCO 3.1.4 Rod Group Alignment Limits

LCO 3.1.5 Shutdown Bank Insertion Limits

LCO 3.1.6 Control Bank Insertion Limits

LCO 3.1.8 Physics Tests Exceptions – Mode 2

LCO 3.2.1 Heat Flux Hot Channel Factor ($F_Q(Z)$)

LCO 3.2.2 Nuclear Enthalpy Rise Hot Channel Factor ($F^N_{\Delta H}$)

LCO 3.2.3 Axial Flux Difference (AFD)

LCO 3.3.9 Boron Dilution Protection System (BDPS)

LCO 3.9.1 Boron Concentration

The portions of the Technical Requirements Manual affected by this report are listed below:

TRM TLCO 3.1.b Boration Flow Paths – Operating

TRM TLCO 3.1.d Charging Pumps – Operating

TRM TLCO 3.1.f Borated Water Sources - Operating

TRM TLCO 3.1.h Shutdown Margin (SDM) – MODE 1 and MODE 2 with keff ≥ 1.0

TRM TLCO 3.1.i Shutdown Margin (SDM) – MODE 5

TRM TLCO 3.1.j Shutdown and Control Rods

CORE OPERATING LIMITS REPORT (COLR) for BRAIDWOOD UNIT 2 CYCLE 8

2.0 OPERATING LIMITS

The cycle-specific parameter limits for the specifications listed in Section 1.0 are presented in the following subsections. These limits are applicable for the entire cycle unless otherwise identified. These limits have been developed using the NRC-approved methodologies specified in Technical Specification 5.6.5.

2.1 Shutdown Margin (SDM)

The SDM limit for MODES 1, 2, 3, and 4 is:

2.1.1 The SDM shall be greater than or equal to 1.3% $\Delta k/k$ (LCOs 3.1.1, 3.1.4, 3 1.5, 3.1.6, 3.1.8, 3.3.9, and 3.9.1; TRM TLCOs 3.1.b, 3.1.d, 3.1.f, 3.1.h, and 3.1.j)

The SDM limits for MODE 5 are:

2.1.2.1 SDM shall be greater than or equal to 1.0% $\Delta k/k$ (LCO 3.1.1).

2.1.2.2 SDM shall be greater than or equal to 1.3% $\Delta k/k$ (LCO 3.3.9; TRM TLCO 3.1.i and 3.1.j).

2.2 Moderator Temperature Coefficient (LCO 3.1.3)

The Moderator Temperature Coefficient (MTC) limits are:

2.2.1 The BOL/ARO/HZP-MTC shall be less positive than $+3.7 \times 10^{-5}$ $\Delta k/k/°F$.

2.2.2 The EOL/ARO/HFP-MTC shall be less negative than -4.1×10^{-4} $\Delta k/k/°F$.

2.2.3 The EOL/ARO/HFP-MTC Surveillance limit at 300 ppm shall be less negative than or equal to -3.2×10^{-4} $\Delta k/k/°F$.

where: BOL stands for Beginning of Cycle Life
ARO stands for All Rods Out
HZP stands for Hot Zero Thermal Power
EOL stands for End of Cycle Life
HFP stands for Hot Full Thermal Power

2.3 Shutdown Bank Insertion Limit (LCO 3.1.5)

2.3.1 All shutdown banks shall be withdrawn to at least 228 steps.

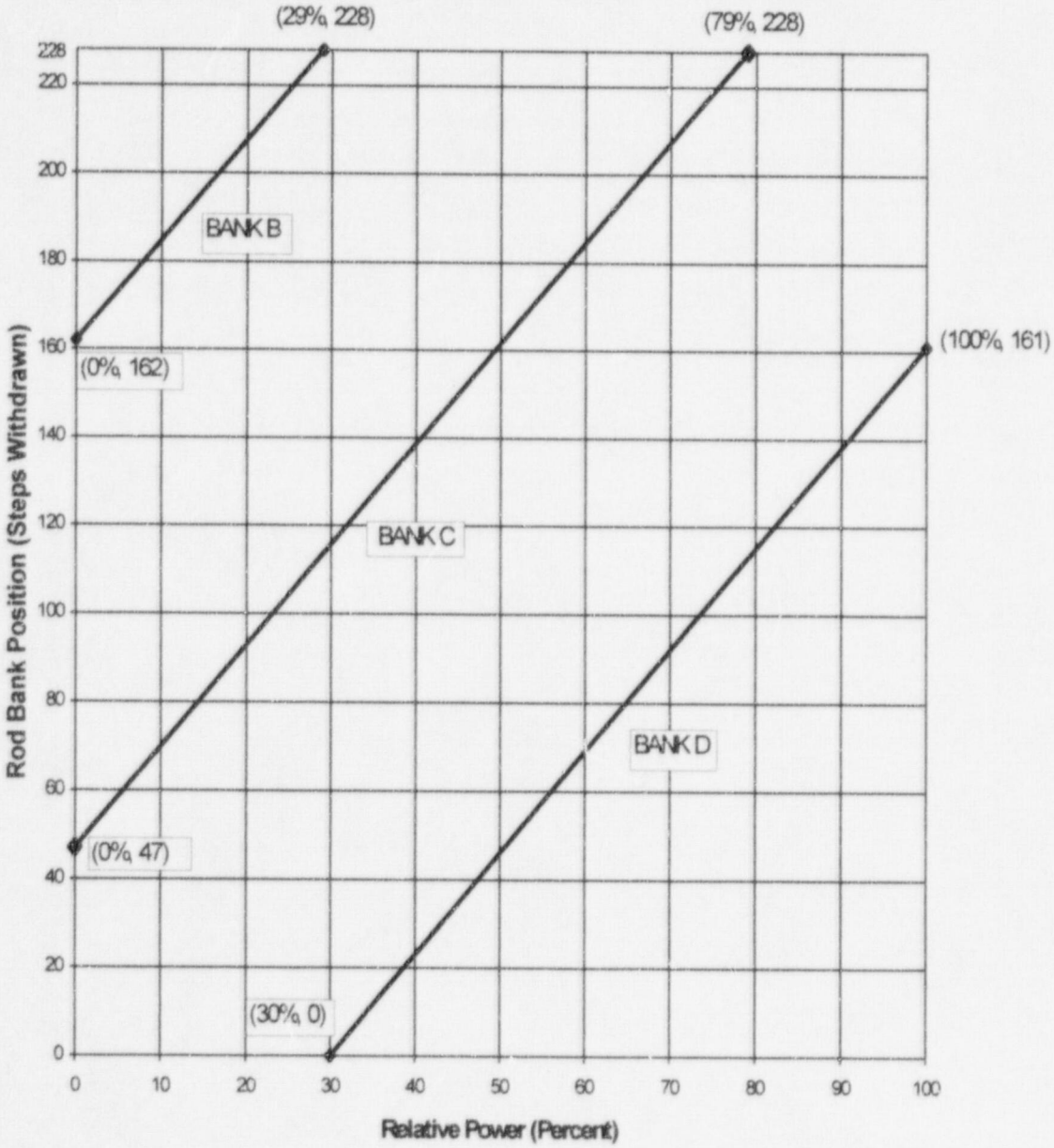
2.4 Control Bank Insertion Limits (LCO 3.1.6)

2.4.1 The control banks shall be limited in physical insertion as shown in Figure 2.4.1.

2.4.2 The control banks shall be operated in sequence by withdrawal of Bank A, Bank B, Bank C and Bank D. The control banks shall be sequenced in reverse order upon insertion.

2.4.3 The control banks shall be operated with a 113 step overlap.

Figure 2.4.1:
Control Bank Insertion Limits Versus Percent Rated Thermal Power



2.5 Heat Flux Hot Channel Factor ($F_Q(Z)$) (LCO 3.2.1)

2.5.1

$$Fq(Z) \leq \frac{Fq^{RTP}}{0.5} xK(Z) \text{ for } P \leq 0.5$$

$$Fq(Z) \leq \frac{Fq^{RTP}}{P} xK(Z) \text{ for } P > 0.5$$

where: P = the ratio of THERMAL POWER to RATED THERMAL POWER

$F_q^{RTP} = 2.60$

K(Z) for assembly average burnup > 4000 MWD/MTU is provided in Figure 2.5.1. K(Z) for assembly average burnup ≤ 4000 MWD/MTU is provided in Figure 2.5.1.a.

2.5.2 W(Z) is provided in Figures 2.5.2.a through 2.5.2.d.

The normal operation W(Z) values have been determined at burnups of 150, 4000, 10000, and 19600 MWD/MTU.

Table 2.5.2 shows the $F^C_Q(z)$ penalty factors that are greater than 2% per 31 Effective Full Power Days. These values shall be used to increase the $F^W_Q(z)$ as per Surveillance Requirement 3.2.1.2. A 2% penalty factor shall be used at all cycle burnups that are outside the range of Table 2.5.2.

Multiplication Factor = 1.02

Figure 2.5.1: K(Z) - Normalized Fq(Z) as a Function of Core Height (Assembly BU > 4000 MWD/MTU)

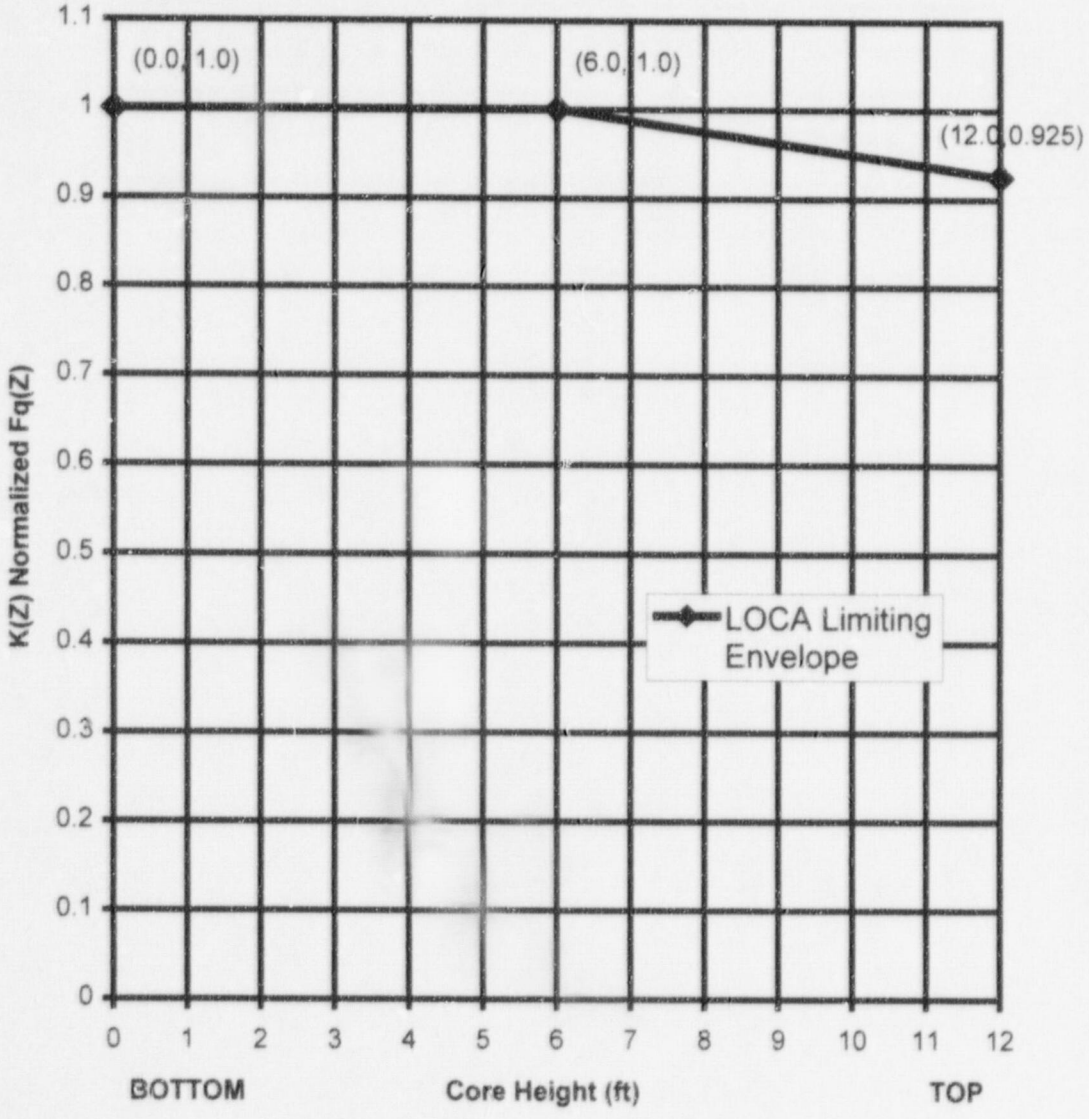
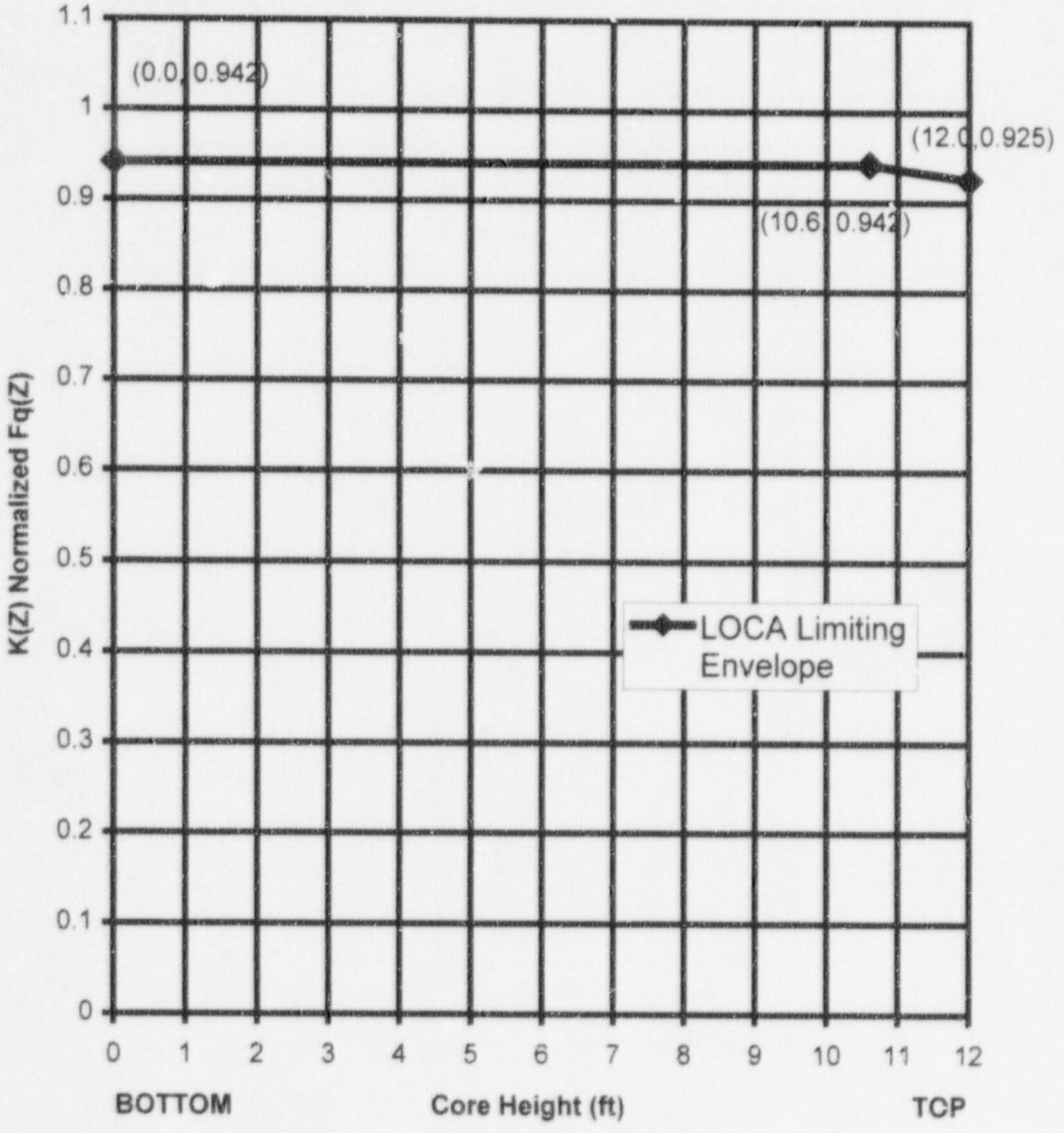


Figure 2.5.1.a: K(Z) - Normalized Fq(Z) as a Function of Core Height (Assembly BU ≤ 4000 MWD/MTU)



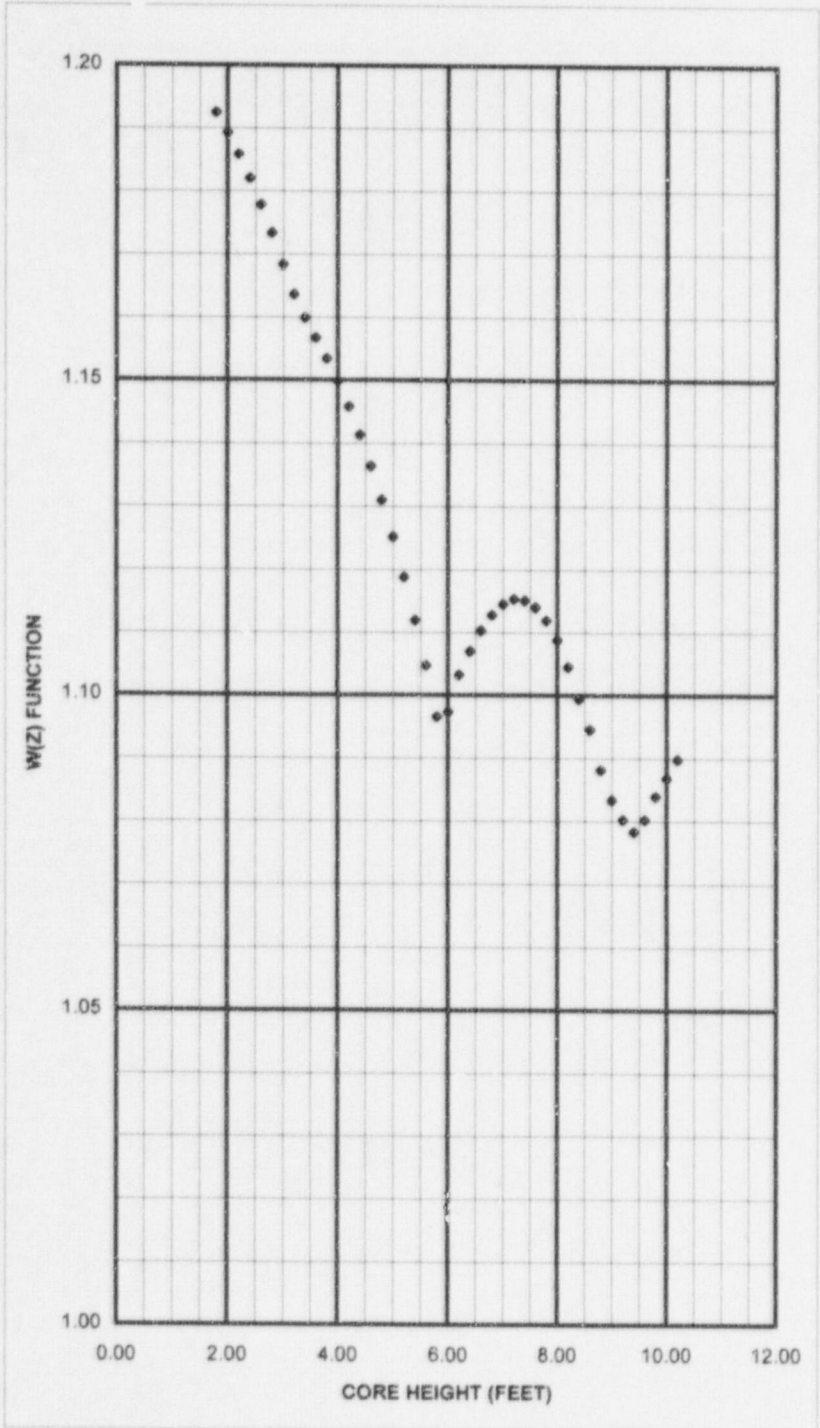
CORE OPERATING LIMITS REPORT (COLR) for BRAIDWOOD UNIT 2 CYCLE 8

Height Feet	MAX W(Z)
0.00	1.0000
0.20	1.0000
0.40	1.0000
0.60	1.0000
0.80	1.0000
1.00	1.0000
1.20	1.0000
1.40	1.0000
1.60	1.0000
1.80	1.1925
2.00	1.1892
2.20	1.1858
2.40	1.1820
2.60	1.1778
2.80	1.1733
3.00	1.1683
3.20	1.1636
3.40	1.1599
3.60	1.1567
3.80	1.1534
4.00	1.1498
4.20	1.1458
4.40	1.1413
4.60	1.1364
4.80	1.1310
5.00	1.1252
5.20	1.1188
5.40	1.1119
5.60	1.1047
5.80	1.0965
6.00	1.0973
6.20	1.1032
6.40	1.1070
6.60	1.1103
6.80	1.1128
7.00	1.1145
7.20	1.1153
7.40	1.1151
7.60	1.1140
7.80	1.1119
8.00	1.1088
8.20	1.1045
8.40	1.0994
8.60	1.0945
8.80	1.0881
9.00	1.0833
9.20	1.0802
9.40	1.0783
9.60	1.0802
9.80	1.0839
10.00	1.0868
10.20	1.0898
10.40	1.0000
10.60	1.0000
10.80	1.0000
11.00	1.0000
11.20	1.0000
11.40	1.0000
11.60	1.0000
11.80	1.0000
12.00	1.0000

Braidwood Unit 2 Cycle 8

Figure 2.5.2.a

Summary of W(Z) Function at 150 MWD/MTU
(Top and Bottom 15% Excluded per WCAP-10216)



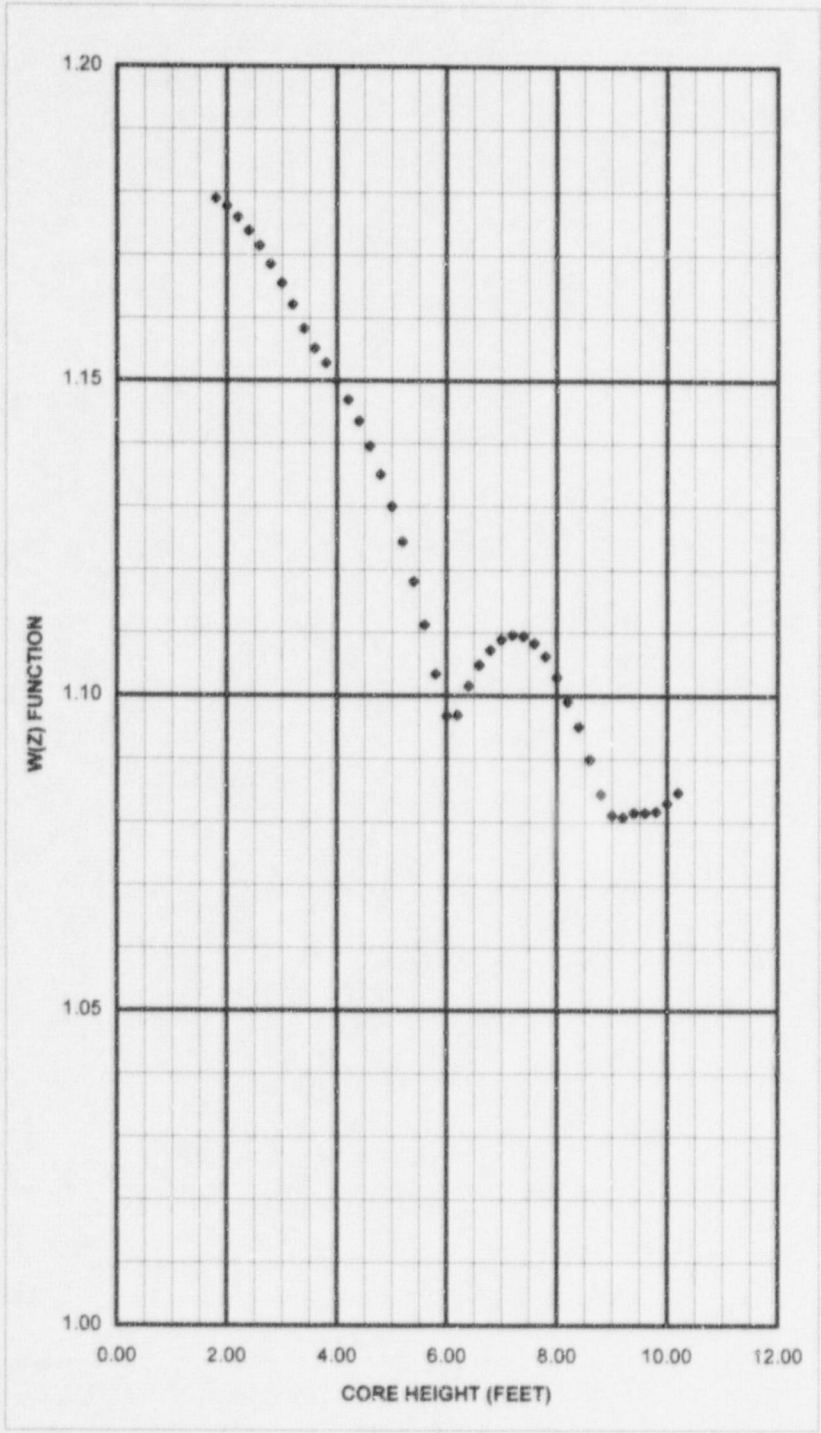
CORE OPERATING LIMITS REPORT (COLR) for BRAIDWOOD UNIT 2 CYCLE 8

Height Feet	MAX W(Z)
0.00	1.0000
0.20	1.0000
0.40	1.0000
0.60	1.0000
0.80	1.0000
1.00	1.0000
1.20	1.0000
1.40	1.0000
1.60	1.0000
1.80	1.1789
2.00	1.1777
2.20	1.1759
2.40	1.1738
2.60	1.1714
2.80	1.1685
3.00	1.1655
3.20	1.1621
3.40	1.1583
3.60	1.1551
3.80	1.1528
4.00	1.1500
4.20	1.1470
4.40	1.1436
4.60	1.1396
4.80	1.1351
5.00	1.1300
5.20	1.1244
5.40	1.1181
5.60	1.1112
5.80	1.1034
6.00	1.0968
6.20	1.0969
6.40	1.1015
6.60	1.1048
6.80	1.1072
7.00	1.1089
7.20	1.1096
7.40	1.1094
7.60	1.1083
7.80	1.1062
8.00	1.1029
8.20	1.0990
8.40	1.0951
8.60	1.0899
8.80	1.0844
9.00	1.0811
9.20	1.0808
9.40	1.0815
9.60	1.0815
9.80	1.0817
10.00	1.0830
10.20	1.0847
10.40	1.0000
10.60	1.0000
10.80	1.0000
11.00	1.0000
11.20	1.0000
11.40	1.0000
11.60	1.0000
11.80	1.0000
12.00	1.0000

Braidwood Unit 2 Cycle 8

Figure 2.5.2.b

Summary of W(Z) Function at 4000 MWD/MTU
(Top and Bottom 15% Excluded per WCAP-10216)



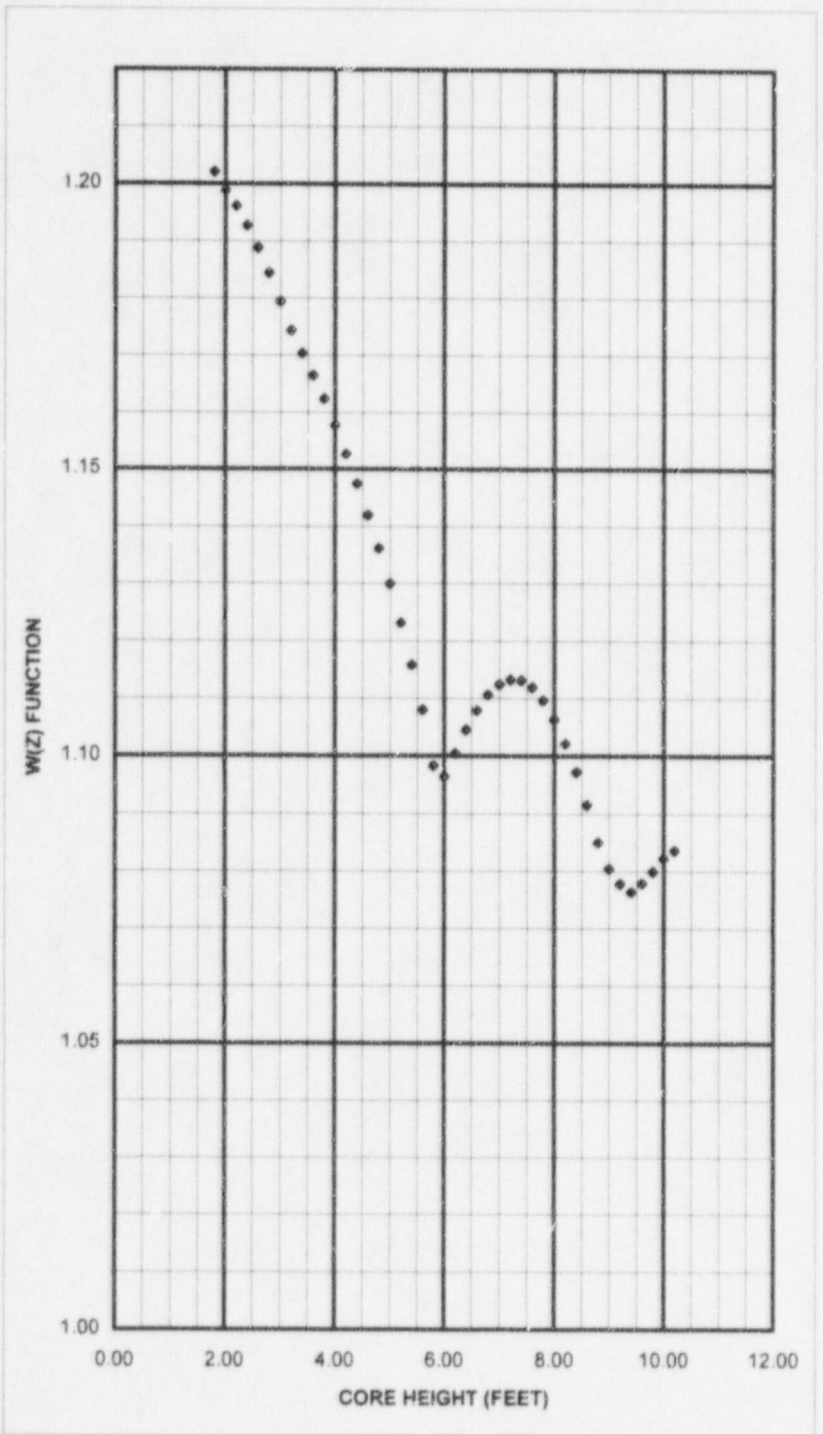
CORE OPERATING LIMITS REPORT (COLR) for BRAIDWOOD UNIT 2 CYCLE 8

Height Feet	MAX W(Z)
0.00	1.0000
0.20	1.0000
0.40	1.0000
0.60	1.0000
0.80	1.0000
1.00	1.0000
1.20	1.0000
1.40	1.0000
1.60	1.0000
1.80	1.2020
2.00	1.1988
2.20	1.1961
2.40	1.1927
2.60	1.1888
2.80	1.1844
3.00	1.1794
3.20	1.1743
3.40	1.1703
3.60	1.1665
3.80	1.1624
4.00	1.1577
4.20	1.1526
4.40	1.1474
4.60	1.1419
4.80	1.1361
5.00	1.1299
5.20	1.1231
5.40	1.1158
5.60	1.1080
5.80	1.0983
6.00	1.0964
6.20	1.1004
6.40	1.1045
6.60	1.1079
6.80	1.1106
7.00	1.1124
7.20	1.1132
7.40	1.1131
7.60	1.1119
7.80	1.1096
8.00	1.1063
8.20	1.1021
8.40	1.0972
8.60	1.0915
8.80	1.0850
9.00	1.0804
9.20	1.0778
9.40	1.0764
9.60	1.0779
9.80	1.0799
10.00	1.0822
10.20	1.0836
10.40	1.0000
10.60	1.0000
10.80	1.0000
11.00	1.0000
11.20	1.0000
11.40	1.0000
11.60	1.0000
11.80	1.0000
12.00	1.0000

Braidwood Unit 2 Cycle 8

Figure 2.5.2.c

Summary of W(Z) Function at 10000 MWD/MTU
(Top and Bottom 15% Excluded per WCAP-10216)



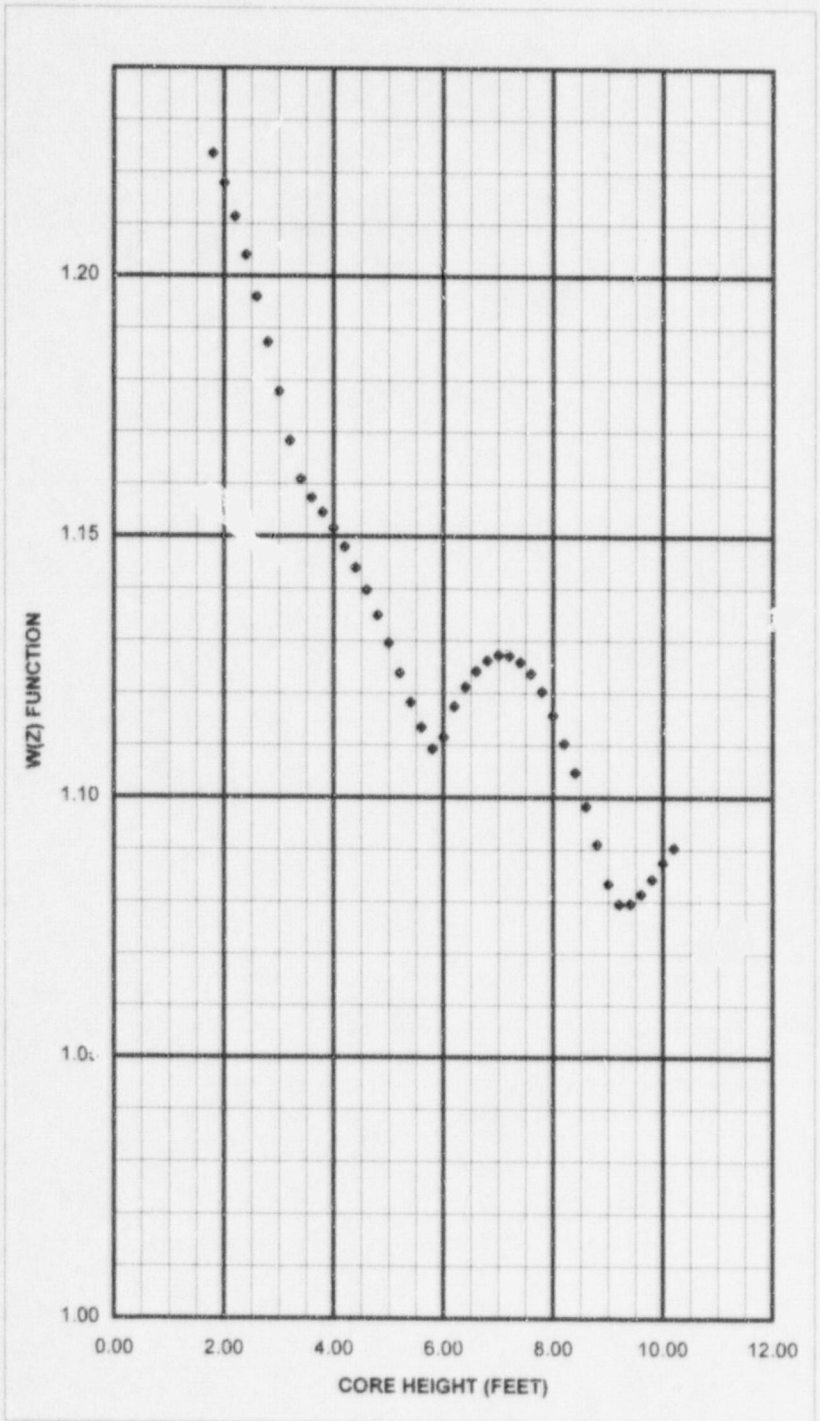
CORE OPERATING LIMITS REPORT (COLR) for BRAIDWOOD UNIT 2 CYCLE 8

Height Feet	MAX W(Z)
0.00	1.0000
0.20	1.0000
0.40	1.0000
0.60	1.0000
0.80	1.0000
1.00	1.0000
1.20	1.0000
1.40	1.0000
1.60	1.0000
1.80	1.2236
2.00	1.2179
2.20	1.2114
2.40	1.2040
2.60	1.1960
2.80	1.1873
3.00	1.1778
3.20	1.1683
3.40	1.1609
3.60	1.1574
3.80	1.1546
4.00	1.1515
4.20	1.1480
4.40	1.1440
4.60	1.1397
4.80	1.1349
5.00	1.1295
5.20	1.1238
5.40	1.1182
5.60	1.1134
5.80	1.1093
6.00	1.1115
6.20	1.1174
6.40	1.1212
6.60	1.1242
6.80	1.1262
7.00	1.1272
7.20	1.1271
7.40	1.1259
7.60	1.1237
7.80	1.1203
8.00	1.1157
8.20	1.1103
8.40	1.1048
8.60	1.0983
8.80	1.0910
9.00	1.0834
9.20	1.0795
9.40	1.0796
9.60	1.0814
9.80	1.0843
10.00	1.0875
10.20	1.0903
10.40	1.0000
10.60	1.0000
10.80	1.0000
11.00	1.0000
11.20	1.0000
11.40	1.0000
11.60	1.0000
11.80	1.0000
12.00	1.0000

Braidwood Unit 2 Cycle 8

Figure 2.5.2.d

Summary of W(Z) Function at 19600 MWD/MTU
(Top and Bottom 15% Excluded per WCAP-10216)



CORE OPERATING LIMITS REPORT (COLR) for BRAIDWOOD UNIT 2 CYCLE 8

Table 2.5.2

Fq Margin Decreases in Excess of 2% per 31 EFPD

Cycle Burnup (MWD/MTU)	Max % Decrease in Fq Margin
150	5.27
314	5.21
478	5.10
642	4.95
806	4.75
970	4.39
1134	3.94
1298	3.44
1462	2.98
1626	2.55
1790	2.18
1954	2.00
11301	2.00
11465	2.09
11629	2.39
11793	2.86
11957	2.89
12121	3.09
12285	3.26
12449	3.37
12613	3.36
12777	3.28
12941	3.14
13105	3.00
13269	2.83
13433	2.59
13597	2.31
13761	2.02
13925	2.00

Note: All cycle burnups outside the range of the table shall use a 2% decrease in Fq margin for compliance with the 3.2.1.2 Surveillance Requirements.

CORE OPERATING LIMITS REPORT (COLR) for BRAIDWOOD UNIT 2 CYCLE 8

2.6 Nuclear Enthalpy Rise Hot Channel Factor ($F^N_{\Delta H}$) (LCO 3.2.2)

2.6.1 $F^N_{\Delta H} \leq F^{RTP}_{\Delta H}[1.0 + PF_{\Delta H}(1.0 - P)]$

where: P = the ratio of THERMAL POWER to RATED THERMAL POWER
$F^{RTP}_{\Delta H} = 1.70$
$PF_{\Delta H} = 0.3$

2.7 Axial Flux Difference (AFD) (LCO 3.2.3)

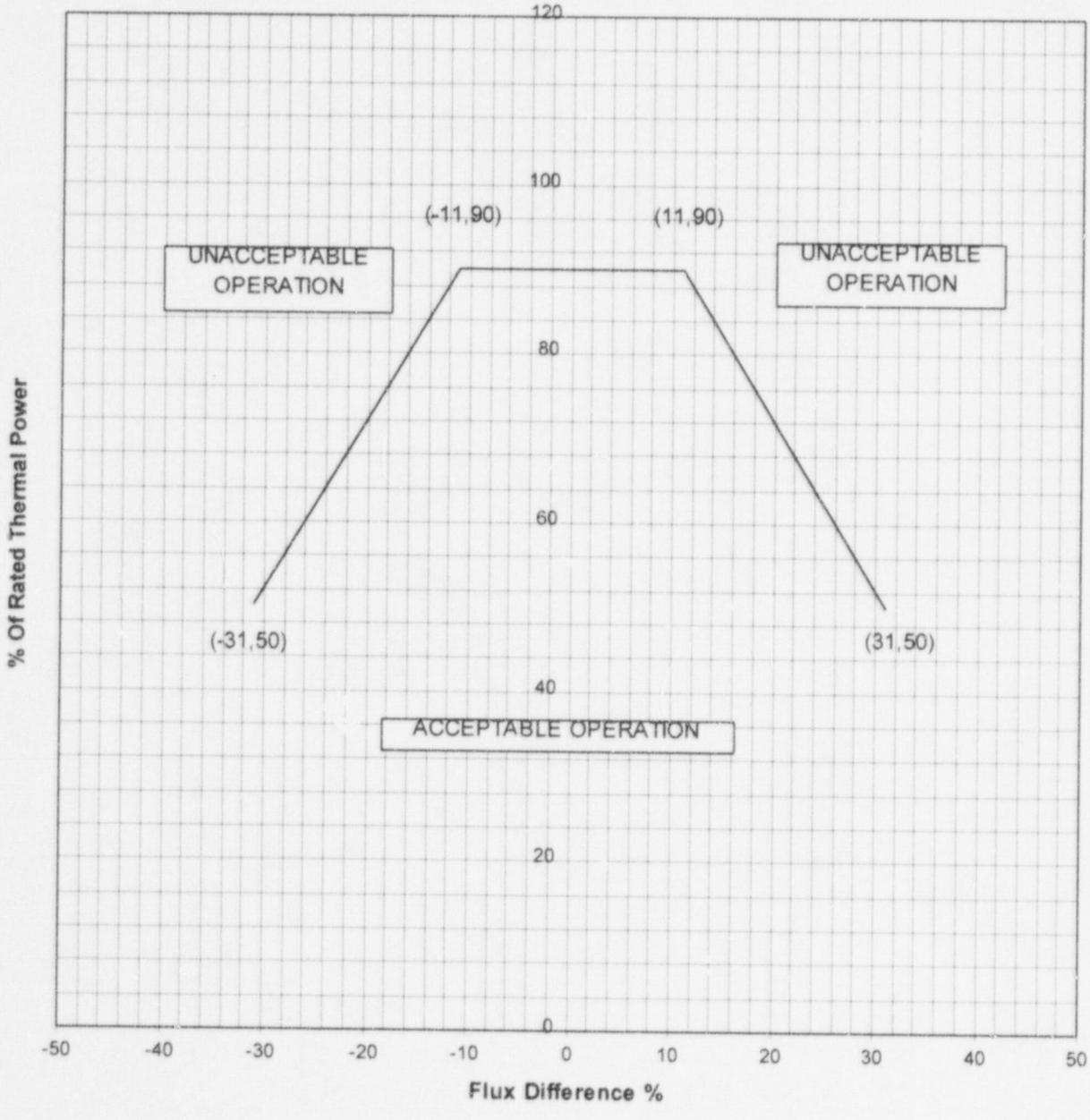
2.7.1 The AXIAL FLUX DIFFERENCE (AFD) target band is +3, -12% of the target flux difference.

2.7.2 The AFD Acceptable Operation Limits are provided in Figure 2.7.1.

2.8 Boron Concentration (LCO 3.9.1)

2.8.1 The refueling boron concentration shall be greater than or equal to 2000 ppm.

FIGURE 2.7.1: Axial Flux Difference Limits As A Function of Rated Thermal Power



Attachment 1 – NRC Correspondence Approval Form

Organizational review denotes explicit affirmation of the accuracy of the information provided in the document and explicit concurrence with the commitments made, if any, in the document.

Correspondence Number: BW990044

Location from which the Correspondence will be submitted: Braidwood Station

Subject: Revised Core Operating Limits Report for Braidwood Unit 2, Cycle 8

Prepared By: Don Cecchett Date: 7-20-99

Reference: N/A

Organization Review or Concurrence

	Due Date		Print Name/Signature	Date
[ ]	_____	Operations	_____	/
[ ]	_____	Maintenance	_____	/
[✓]	_____	Engineering	Rahandaran	/ 7/20/99
[ ]	_____	Radiation Protection	_____	/
[ ]	_____	Training	_____	/
[ ]	_____	Security	_____	/
[ ]	_____	Attorney	_____	/
[✓]	_____	Corporate Reg Services	Comments via Telecon OK	/ 7/30/99
[ ]	_____	Independent Technical Review	_____	/
[ ]	_____	PORC	_____	/
[ ]	_____	Other	RAS	/ 7-20-99
[ ]	_____		_____	/
[ ]	_____		_____	/

Final Review and Approval

[✓] Site Vice President _____ Date: 7-21-99

[ ] Station Manager: _____ Date: _____

RAM/S: _____ Date: 7-22-99

Comments: _____

cc: completed Attachment 1 to Corporate Regulatory Services