APPENDIX A

BFN SEVERE ACCIDENT MITIGATION ALTERNATIVES ANALYSIS

Contents

Page

Tables

Figures

I. Methodology

The methodology selected for this analysis involves identifying those Severe Accident Mitigation Alternatives (SAMA) candidates that have the most potential for reducing core damage frequency and person-rem risk. The phased approach consists of:

- Extending the Browns Ferry Nuclear Plant (BFN) probabilistic safety analysis (PSA) results to a Level 3 analysis by determining offsite dose and economic baseline risk values.
- Determining the maximum averted risk that is possible based on the BFN baseline risk.
- Identifying potential SAMA candidates based on BFN PSA results, the USNRC, and industry documents.
- Screening out potential SAMA candidates that are not applicable to the BFN design or are of low benefit in boiling water reactors.
- Screening out SAMA candidates whose estimated cost exceeds the maximum possible averted risk.
- Performing a more detailed cost estimate and Level 3 dose and economic risk evaluation of remaining candidates to see if any have a benefit in risk aversion that exceeds the expected cost.

II. Level 3 PSA Analysis

The MACCS2 code was used to perform the Level 3 consequence analysis for the BFN. Plant-specific release data includes the time-nuclide distribution of releases, release frequencies, and release locations. The behavior of the population during a release (evacuation/sheltering parameters) was based on the generic MACCS2 model. This data was used in combination with site-specific meteorology and population data to simulate the impact risks (exposure and economic) to the surrounding (within 50 miles) population from the release accident sequences at the BFN.

A. Population

The population surrounding the plant site was estimated for the year 2036 (2016 plus 20 years). The distribution was given in terms of population at distances to 1, 2, 3, 4, 5, 10, 20, 30, 40, and 50 miles from the plant and in the direction of each of the 16 compass points (i.e., N, ENE, NE......WNW). The total population for the 160 sectors (10 distances × 16 directions) in the region was based on 1990 data provided by the census. 1990 census data coupled with the 1999 data was used to generate growth estimates for each sector (reference 16). The estimated 2036 population distribution is given in Tables 2-1 and 2-2.

B. Meteorological Data Sampling Method

The atmospheric dispersion of radioactive material from a postulated accident depends on the meteorological conditions that exist from the start of the accident through a period of tens to hundreds of hours following the accident. Since the weather that could occur coincident with the accident is diverse, representative meteorological data sequences are selected as input to the dispersion model to reflect the dependence of the transport and dispersion process on the site weather. The selection process is done by means of sampling techniques from a full year of hourly weather data taken from the BFN on-site meteorological tower. For this analysis, the technique referred to as weather bin sampling in the MACCS2 V1.12 code was used for the 1980 year of data.

This sampling method ensures a complete coverage of diurnal, seasonal, and 4-day cycles without the statistical noise of methods that utilize random sampling and includes the important "rain tails" (deposition due to delayed rain).

The meteorological data assessment is done by sorting the weather sequence into categories that provide a realistic representation of the year's weather without overlooking weather conditions that are instrumental in producing major consequences. A set of 40 weather categories has been selected for the MACCS2 V1.12 model to reflect these requirements. Up to eight meteorological scenarios are selected for each category, limited by the number of meteorological scenarios available for that category.

Table 2-1. Estimated Population Distribution Within a 10-Mile Radius of BFN, Year 2036

Sector	0-1 mile	1-2 miles	2-3 miles	3-4 miles	4-5 miles	5-10 miles	10 miles total
N	11	17	37	52	102	1,020	1,239
NNE	7	17	37	91	345	2,978	3,475
NE	7	21	48	69	154	7,495	7,795
ENE	11	38	70	102	155	1,767	2,143
E	11	37	76	97	125	1,482	1,829
ESE	11	43	70	97	124	1,277	1,622
SE	11	37	61	67	63	5,562	5,801
SSE	6	9	10	22	25	5,525	5,597
S	4	4	10	17	44	3,282	3,361
SSW	3	4	10	18	53	2,397	2,485
SW	0	9	10	16	21	870	926
WSW	0	9	10	16	18	1,273	1,325
W	8	9	11	12	18	481	538
WNW	9	8	16	12	18	232	295
NW	15	17	22	37	54	520	665
NNW	11	26	37	51	62	363	550
TOTAL	126	306	534	776	1,378	36,524	39,644

Reference 16.

Table 2-2. Estimated Population Distribution Within a 50-Mile Radius of BFN, Year 2036

Sector	0-10 mile	10-20 miles	20-30 miles	30-40 miles	40-50 miles	50 miles total
N	1,239	3,543	5,325	21,013	7,792	38,912
NNE	3,475	7,795	6,534	6,185	9,020	33,008
NE	7,795	28,233	15,109	10,894	19,322	81,353
ENE	2,143	23,025	41,202	46,508	10,103	122,980
E	1,829	20,050	170,095	133,790	14,420	340,184
ESE	1,622	2,087	19,667	26,737	22,399	72,512
SE	5,801	46,030	13,251	10,374	29,381	104,837
SSE	5,597	40,304	16,417	40,518	40,387	143,224
S	3,361	12,410	2,468	5,799	8,834	32,871
SSW	2,485	9,477	1,454	3,193	7,339	23,948
SW	926	6,460	3,412	7,706	17,392	35,896
WSW	1,325	4,601	4,779	18,797	5,843	35,345
W	538	2,688	14,560	33,061	2,593	53,440
WNW	295	4,147	17,654	62,498	6,831	91,425
NW	665	4,996	7,886	8,560	8,597	30,704
NNW	550	2,905	4,085	21,542	18,260	47,341
TOTAL	39,644	218,750	343,898	457,176	228,512	1,287,980

Given a postulated large accident, large numbers of early fatalities and injuries are normally associated with relatively low probability weather events such as rainfall or wind speed slowdowns within 50 miles of the plant site or with stable weather and moderate wind speeds at the start of the release. In MACCS2 V1.12, these weather data types have been selected to be among the 40 categories utilized in the assessment process.

With this information, weather sequences can be sampled to reflect the weather data for the full year. This ensures representation of each type of weather sequence, those important to realistic representation of the weather data set, and those important to the occurrence of the most serious accident consequences due to rainout in high population areas.

C. Atmospheric Transport and Dispersion

The dispersion model implemented in MACCS2 V1.12 is described in detail in NUREG/CR-4691, Volume 2. It is a Gaussian, time-dependent, plume segment model that has been in use for consequence assessments since the Reactor Safety Study (RSS) in 1975. The plume is assumed to be transported in a straight line downwind in accordance with the measured wind direction.

For each start hour selected by the meteorological sampling technique, the MAACS2 V1.12 dispersion model uses the subsequent meteorological conditions to predict the dispersion and transport of the released plume of radioactive material. The sequence of hourly recordings is used to account for changing meteorological conditions.

In MACCS2 V1.12, the effects of release duration, mixing layer depth, building wake, plume rise due to sensible heat buoyancy, and dry and wet removal processes are included. The ground concentration is calculated from the air concentration and the deposition rate.

D. Nuclide Release

The current design basis core inventory is provided in Table 2-3 (References 1 and 9). Each of the major hypothetical accidents identified in the IPE study was assigned to one of several release categories based on the primary system and containment responses to the accident conditions calculated by the Modular Accident Analysis Program (MAAP). Each release category has associated release fractions of the initial core radionuclide inventory, which are used as input data to the consequence analysis model. In addition to the release magnitude, the parameters that characterize the various releases due to hypothetical accident sequences are time of release, duration of release, warning time for evacuation, height of release, and energy content of the released radioactive plume.

The time of start of release was taken from MAAP runs and refers to the time interval between the start of the hypothetical accident and the release of radioactive material from the containment building to the atmosphere. This parameter is used to calculate the decay of radioactivity as well as timing used in computing dose accumulated by evacuees in relation to plume location and deposited material. The duration of release is the total time during which radioactive material is emitted into the atmosphere; it is used to account for continuous releases by adjusting for horizontal dispersion due to changes in wind direction.

Table 2-3. BFN Core Inventory*

Nuclide	Core Inventory (Curies)	Nuclide	Core Inventory (Curies)	Nuclide	Core Inventory (Curies)
Kr-83m	1.127E7	Rb-88	6.413E7	Sn-130**	3.343E7
Kr-85m	2.351E7	Rb-89	8.204E7	Sb-127	1.044E7
Kr-85	1.359E6	Rb-90m**	1.881E7	Sb-129	3.073E7
Kr-87	4.481E7	Rb-90**	7.933E7	Sb-130m**	4.431E7
Kr-88	6.303E7	Rb-91**	9.946E7	Sb-130	9.976E6
Kr-89**	7.653E7	Se-84**	1.866E7	Sb-133**	5.356E7
Kr-90**	7.554E7	Sr-89	8.475E7	Te-125m	3.902E5
Xe-131m	1.050E6	Sr-90	1.085E7	Te-127m	1.389E6
Xe-133m	5.956E6	Sr-91	1.069E8	Te-127	1.036E7
Xe-133	1.847E8	Sr-92	1.166E8	Te-129m	4.502E6
Xe-135m	3.761E7	Sr-93**	1.331E8	Te-129	3.024E7
Xe-135	6.610E7	Sr-94**	1.260E8	Te-131m	1.367E7
Xe-137**	1.655E8	Y-90	1.122E7	Te-131	8.327E7
Xe-138	1.552E8	Y-91m	6.206E7	Te-132	1.333E8
Xe-139**	1.210E8	Y-91	1.100E8	Te-133m	6.830E7
Xe-140**	7.878E7	Y-92	1.171E8	Te-133	1.116E8
		Y-93	1.366E8	Te-134	1.549E8
I-130	3.735E6	Y-94	1.383E8	Ba-137m	1.424E7
I-131	9.378E7	Y-95	1.494E8	Ba-139	1.686E8
I-132	1.355E8	Y-96**	1.422E8	Ba-140	1.629E8
I-133	1.898E8	Zr-95	1.542E8	Ba-141	1.529E8
I-134	2.081E8	Zr-97	1.554E8	Ba-142	1.445E8
I-135	1.778E8	Nb-95	1.549E8	La-140	1.713E8
I-136m**	4.945E7	Nb-97m	1.474E8	La-141	1.536E8
		Nb-97	1.568E8	La-142	1.480E8
Br-83	1.124E7	Mo-99	1.767E8	La-143	1.407E8
Br-84m**	7.088E5	Tc-99m	1.547E8	Ce-141	1.546E8
Br-84	1.934E7	Tc-99	1.901E3	Ce-143	1.417E8
Br-85**	2.319E7	Tc-101	1.597E8	Ce-144	1.278E8
Br-87**	3.776E7	Ru-103	1.484E8	Ce-145**	9.671E7
Cs-134	2.508E7	Ru-105	1.040E8	Pr-143	1.375E8
Cs-135	8.679E1	Ru-106	6.096E7	Pr-144	1.285E8
Cs-136	7.868E6	Ru-107**	6.022E7	Pr-145	9.675E7
Cs-137	1.503E7	Rh-103m	1.337E8		
Cs-138	1.723E8	Rh-105m**	2.911E7		
Cs-139**	1.632E8	Rh-105	9.791E7		
Cs-140**	1.470E8	Rh-106	6.519E7		
Cs-141**	1.090E8	Rh-107	6.052E7		

*Reference 1, except where noted.

**Short lived isotopes not in MACCS2 database.

*** Reference 9.

The warning time for evacuation was estimated based on review of the accident sequences. This time is the interval between awareness of impending core melt and the release of radioactive material from the containment building. Finally, the height of release and the energy content of the released plume affect the manner in which the plume would be dispersed in the atmosphere.

The expected effect upon the core nuclide inventory of the EPU project will be to increase the quantity of most isotopes, and change the relative isotopic mix. This effect cannot be accurately projected by linear extrapolation of the design basis core inventory, but will be defined by new data generated by the ORIGIN computer code. This SAMA will be revised, as necessary, once the EPU core inventory data becomes available.

E. Evacuation and Other Protective Measures

Evacuation and other protective measures (i.e., sheltering and relocation) are taken to avoid or reduce immediate exposure to the passing radioactive plume and ground contamination. Evacuation is potentially the most effective method of avoiding radiation exposure and can provide essentially total protection if completed prior to arrival of the plume.

The evacuation model does not account for actual road networks, road capacity limitations, or lateral travel possibilities (evacuation is assumed to be in a straight-line radially away from the plant).

F. Results

The results of the Level 3 consequence analysis provide projected offsite radiation doses and offsite economic costs (in 2016 dollars for 3% and 7% discount rates) as a function of accident conditions (Reference 9). This information forms part of the input data to the economic model described in Section 3.0 of this analysis.

III. Determination of Present Value

This section explains how TVA calculated the monetized value of the status quo (i.e., accident consequences without SAMA implementation). TVA also used this analysis to establish the maximum benefit that a SAMA could achieve if it eliminated all BFN risk. The following costs are included in the analysis:

1. Offsite exposure cost
2. Offsite economic cost
3. Onsite exposure cost
4. Onsite cleanup cost
5. Replacement power cost

The cost will be determined independently for both Unit 2 and Unit 3. Two real discount rates will be used in the calculations. A 7% discount rate will be used to reflect a "base case" discount rate and 3% will be used to provide analysis sensitivity to the discount rate, in accordance with reference 10.

The sum of these costs will be used to screen out SAMAs that are not economically feasible; if the estimated cost of implementing a SAMA exceeds the maximum benefit, then it will be discarded from further analysis. Exceeding this threshold would mean that a SAMA would not have a positive net value even if it could eliminate all severe accident costs.

For the purposes of this analysis, the "present" is considered to be the year 2016. All constant dollar values from Reference 10 have been recalculated to the Year 2016 using a 3% inflation rate. Specifics are noted in the text to this section.

A. Offsite Exposure Cost

The baseline annual offsite exposure risk was converted to dollars using the USNRC conversion factor of $2,000 per person-rem (Reference 10, Section 5.7.1.2), and discounting to present value using the USNRC standard formula (Reference 10, Section 5.7.1.3):

$$W_{pha} = C \times Z_{pha}$$

Where:

W_{pha} = monetary value of public health risk after discounting

C = $[1-\exp(-rt_f)]/r$

t_f = years remaining until end of facility life = 20 years

r = real discount rate (as fraction) = either 0.03 or 0.07/year

Z_{pha} = monetary value of public health (accident) risk per year before discounting ($/year)

The calculated value for C using 20 years with a 3% discount rate is 15.04 and with a 7% discount rate is 10.76. Therefore, calculating the discounted monetary equivalent of accident risk involves multiplying the dose (person-rem per year) by monetary value of unit dose (1 person/rem) and by the C value (Reference 10 Section 5.7.12). Since the "present" for this analysis is the Year 2016, the future value of $2,000 at a 3% inflation rate was calculated to be $3,087, which was used in this calculation. The calculated offsite exposure cost is for each of the units is presented in Table 3-1.

Table 3-1. Calculated Offsite Exposure Cost for Units 2 and 3.

Real Discount Rate	Unit 2		Unit 3	
	3%	7%	3%	7%
C	15.04	10.76	15.04	10.76
Z_{pha}	$7,040	$7,040	$14,669	$14,669
W_{pha}	$105,885	$75,775	$220,623	$157,886

B. Offsite Economic Cost

The Level 3 analysis showed an annual offsite economic risk for the two units and discount rates is presented in Table 3-2. Calculated values for offsite economic costs caused by severe accidents must be discounted to present value as well. This is performed in the same manner as for public health risks and uses the same C value. The resulting values are also presented in Table 3-2.

Table 3-2. Calculated Offsite Economic Cost for Units 2 and 3

Real Discount Rate	**Unit 2**		**Unit 3**	
	3%	**7%**	**3%**	**7%**
C	15.04	10.76	15.04	10.76
Sum of Annual Economic Risk	$5,560	$5,560	$11,700	$11,700
Offsite Economic Costs	$83,609	$59,834	$176,138	126,051

C. Onsite Exposure Cost

TVA evaluated occupational health using the USNRC methodology in Reference 10, Section 5.7.3, which involves separately evaluating "immediate" and long-term doses.

Immediate Dose - For the case where the plant is in operation, the equation that the USNRC recommends using (Reference 10, Sections 5.7.3 and 5.7.3.3) are:

Equation 1: $W_{IO} = R\{(FD_{IO})_S - (FD_{IO})_A\} \{[1 - \exp(-rt_f)]/r\}$

Where:

W_{IO} = monetary value of accident risk avoided due to immediate doses, after discounting

R = monetary equivalent of unit dose ($/person-rem)

F = accident frequency (events/yr)

D_{IO} = immediate occupational dose (person-rem/event)

S = subscript denoting status quo (current conditions)

A = subscript denoting after implementation of proposed action

r = real discount rate

t_f = years remaining until end of facility life.

The values used in the BFN analysis are:

R = \$3,097/person-rem (\$2,000 inflation at 3% to 2016 values)

r = 0.03 and 0.07

D_{IO} = 3,300 person-rem/accident (best estimate)

t_f = 20 years (license extension period)

F = 1.05E-6 for Unit 2 and 1.90E-6 for Unit 3 (total core damage frequency)

For the basis discount rate, assuming $(FD_{IO})_A$ is zero, the best estimate of the immediate dose cost is:

$$W_{IO} = R\,(FD_{IO})_S\,\{[1 - \exp(-rt_f)]/r\}$$

The results of the immediate dose cost calculations are presented in Table 3-3.

Table 3-3. Immediate Dose Cost for Units 2 and 3

Real Discount Rate	Unit 2		Unit 3	
	3%	7%	3%	7%
Core Damage Frequency (per year)	1.05E-6	1.05E-6	1.90E-6	1.90E-6
Immediate Dose Cost	\$161	\$115	\$292	\$209

Long-Term Dose - For the case where the plant is in operation, the USNRC equation (Reference 10, Sections 5.7.3 and 5.7.3.3) is:

Equation 2: $W_{LTO} = R\{(FD_{LTO})_S - (FD_{LTO})_A\}\,\{[1 - \exp(-rt_f)]/r\}\{[1 - \exp(-rm)]/rm\}$

Where:

W_{LTO} = monetary value of accident risk avoided long-term doses, after discounting, \$

m = years over which long-term doses accrue

The values used in the BFN analysis are:

R = \$3,097/person-rem (\$2,000 inflated at 3% to 2016 values)

r = 0.03 AND 0.07

D_{LTO} = 20,000 person-rem/accident (best estimate)

m = "as long as 10 years"

t_f = 20 years (license extension period)

F = 1.05E-6 for Unit 2 and 1.90E-6 for Unit 3 (total core damage frequency)

For the basis discount rate, assuming $(FD_{LTO})_A$ is zero, the best estimate of the long-term dose is:

$$W_{LTO} = R\,(FD_{LTO})_S\,\{[1 - \exp(-rt_f)]/r\}\,\{[1 - \exp(-rm)]/rm\}$$

The results of the long-term dose cost calculations are presented in Table 3-4.

Table 3-4. Long-Term Dose Cost for Units 2 and 3

Real Discount Rate	Unit 2		Unit 3	
	3%	7%	3%	7%
Core Damage Frequency (per year)	1.05E-6	1.05E-6	1.90E-6	1.90E-6
Long-term Dose Cost	\$845	\$503	\$1,527	\$910

Total Occupational Exposure - Combining Equations 1 and 2 above and using the above numerical values, the total accident related on-site (occupational) exposure avoided (W_O) is presented in Table 3-5.

$$W_O = W_{IO} + W_{LTO}$$

Table 3-5. Total Occupational Exposure Cost for Units 2 and 3

Real Discount Rate	Unit 2		Unit 3	
	3%	7%	3%	7%
Immediate Dose Cost	$161	$115	$292	$209
Long-term Dose Cost	$845	$503	$1,527	$910
Total Occupational Exposure Cost	$1,006	$619*	$1,819	$1,118*

*Rounding effect.

D. Onsite Cleanup and Decontamination Cost

The net present value that the USNRC provides for cleanup and decontamination for a single event is $1.1 billion, discounted over a 10-year cleanup period (Reference 10, Section 5.7.6.1). The USNRC uses the following equation in integrating the net present value over the average number of remaining service years:

$$U_{CD} = [PV_{CD}/r][1\text{-}\exp(-rt_f)]$$

Where:

PV_{CD} = Net present value of a single event

r = real discount rate

t_f = years remaining until end of facility life.

The values used in the BFN analysis are:

PV_{CD} = $1.715E+9 ($1.1E+9 inflated at 3% to 2016 values)

r = 0.03 and 0.07

t_f = 20

The resulting net present value of cleanup integrated over the license renewal term must multiplied by the total core damage frequency to determine the expected value of cleanup and decontamination costs. The resulting monetary equivalent is presented in Table 3-6.

Table 3-6. Expected Value of Cleanup and Decontamination Costs for Units 2 and 3

Real Discount Rate	Unit 2		Unit 3	
	3%	7%	3%	7%
Net Present Value of Cleanup and Decontamination Costs	2.58+10	1.84E+10	2.58E+10	1.84E+10
Core Damage Frequency (per year)	1.05E-6	1.05E-6	1.90E-6	1.90E-6
Expected Value of Cleanup and Decontamination Costs	$27,057	$19,363	$48,904	$34,998

E. Replacement Power Cost

Long-term replacement power costs was determined following the USNRC methodology in Reference 10 Section 5.7.6.2. The net present value of replacement power for a single event, PV_{RP}, was determined using the following equation:

$$PV_{RP} = [\$1.2E + 08/r] * [1 - \exp(-rt_f)]^2$$

Where:

PV_{RP} = net present value of replacement power for a single event, ($). For the 3% discount rate PV_{RP} = 2.18E+9 (1.55E+10 –inflated at 3% to 2016 values, Reference 10, Section 5.6.7.2). The net present value of $1.20E+8 for the 7% discount rate was also recalculated to the Year 2016 using a 3% inflation rate.

r = 0.03 and 0.07

t_f = 20 years (license renewal period)

To attain a summation of the single-event costs over the entire license renewal period, the following equation is used:

$$U_{RP} = [PV_{RP} /_r] * [1 - \exp(-rt_f)]^2$$

Where:

U_{RP} = net present value of replacement power over life of facility ($-year). For the 3% discount rate, U_{RP} has been linearly interpolated to $1.55E+10 (Reference 10, Section 5.6.7.2). This has been inflated at 3% to 2016 and the value $2.41 used for this calculation. The net present value for the 7% discount rate was also recalculated to the Year 2016 using a 3% inflation rate.

After applying a correction factor to account for BFN's size relative to the "generic" reactor described in NUREG/BR-0184 (i.e., 1155 MWe/910 MWe), the replacement power costs are presented in Table 3-7.

Table 3-7. Expected Value of Cleanup and Decontamination Costs for Units 2 and 3

Real Discount Rate	Unit 2		Unit 3	
	3%	7%	3%	7%
Net Present Value of Replacement Power over the Life of the Facility	2.41E+10	1.23E+10	2.41E+10	1.23E+10
Correction Factor for size	1.27	1.27	1.27	1.27
Replacement Power Cost	3.07E+10	1.56E+10	3.07E+10	1.56E+10
Core Damage Frequency (F)	1.05E-6	1.05E-6	1.90E-6	1.90E-6
Replacement power costs per accident damage frequency	$32,176	$16,379	$58,152	$29,604

F. Baseline Screening

The sum of the baseline costs is presented in Table 3-8.

Table 3-8. Total Costs for Units 2 and 3

Real Discount Rate	Unit 2		Unit 3	
	3%	7%	3%	7%
Monetary Value of Public Health Risk After Discounting	$105,885	$76,775	$220,623	$157,886
Offsite Economic Costs	$83,609	$59,834	$176,138	$126,051
Total Accident on-site exposure avoided	$1,006	$619	$1,819	$1,118
Expected Value of Cleanup and Decontamination Costs	$27,057	$19,363	$48,904	$34,998
Replacement Power Costs	$32,176	$16,379	$58,155	$29,604
Total	$249,733	$171,970	$505,639*	$349,657*

*The most conservative value in Table 3-8 is $505,639. This value was rounded up to $510,000 to use in screening out SAMAs that are not economically feasible; if the estimated cost of implementing a SAMA exceeded $10,000, it was discarded from further analysis. Exceeding this threshold would mean that a SAMA would not have a positive net value even if it could eliminate all severe accident costs.

IV. SAMA Candidates and Screening Process

An initial list of SAMA candidates was developed from lists of Severe Accident Mitigation Alternatives for Hatch Nuclear Plant (Reference 8) and, most importantly, from the plant specific risk profile as provided by the BFN PSA (References 2 and 3) and the BFN IPEEE (References 4 through 7). This initial list was then screened to remove those that met the following criteria:

- does not apply to the BFN or to BWRs in general,
- already in place at BFN, or
- Rough order of magnitude (ROM) costs exceed the screening cost savings.

This screening process will leave unique SAMA candidates that are applicable to BFN and are of potential value in averting the risk of severe accidents. A preliminary cost estimate will be prepared for each of these candidates based on previous design/procedural modifications of similar scope to focus on those that had the possibility of having a positive benefit and to eliminate those whose costs were clearly beyond the possibility of any corresponding benefit.

A more detailed estimate will be prepared for those items that appear to be cost effective.

The initial list of candidates is provided in Tables 4-1 and 4-2.

Table 4-1. Disposition of Generic SAMAs Investigated

SAMA ID Number	SAMA Title	Description of Potential Enhancement	Screening Criterion*	Reference Paragraph Number
1	Cap downstream piping of normally closed component cooling water drain and vent valves.	SAMA to reduce the frequency of a loss of component cooling event, a large portion of which was derived from catastrophic failure of one of the many single isolation valves.	N/A	N/A
2	Enhance loss of component cooling procedure to facilitate stopping reactor coolant pumps.	SAMA to reduce the potential for RCP seal damage due to pump bearing failure.	B	N/A
3	Enhance loss of component cooling procedure to present desirability of cooling down RCS prior to seal LOCA.	SAMA would reduce the potential for RCP seal failure.	B	N/A
4	Additional training on the loss of component cooling.	SAMA would potentially improve the success rate of operator actions after a loss of component cooling (to prevent RCP seal damage).	B	N/A
5	Provide hardware connections to allow another essential raw cooling water system to cool charging pump seals.	SAMA would reduce effect of loss of component cooling by providing a means to maintain the centrifugal charging pump seal injection after a loss of component cooling.	B	N/A
5A	Procedure changes to allow cross connection of motor cooling for RHRSW pumps.	SAMA would allow continued operation of both RHRSW pumps on a failure of one train of PSW.	N/A	N/A
6	On loss of essential raw cooling water, proceduralize shedding component cooling water loads to extend component cooling heatup.	SAMA would increase time before the loss of component cooling (and reactor coolant pump seal failure) in the loss of essential raw cooling water sequences.	B	N/A
7	Increase CRD pump lube oil capacity.	SAMA would lengthen the time before control rod drive (CRD) pump failure due to lube oil		Phase II SAMA 01
8	Eliminate the RCP thermal barrier dependence on component cooling such that loss of component cooling does not result directly in core damage.	SAMA would prevent the loss of recirculation pump seal integrity after a loss of component cooling. Watts Bar Nuclear Plant IPE said that they could do this with essential raw cooling water connection to charging pump seals.	B	N/A
9	Add redundant DC Control Power for SW Pumps.	SAMA would increase reliability of SW and decrease core damage frequency due to a loss of SW. Relevant, potential concern at BFN is loss of DC-D		SAMA 57
10	Create an independent RCP seal injection system, with a dedicated diesel.	SAMA would add redundancy to RCP seal cooling alternatives, reducing CDF from loss of component cooling or service water or from a station blackout event.	B	N/A
11	Use existing hydro test pump for RCP seal injection.	SAMA would provide an independent seal injection source, without the cost of a new system.	B	N/A

Table 4-1. Disposition of Generic SAMAs Investigated (Continued)

SAMA ID Number	SAMA Title	Description of Potential Enhancement	Screening Criterion*	Reference Paragraph Number
12	Replace ECCS pump motor with passively cooled motors.	SAMA would eliminate ECCS dependency on EECW.		Phase II SAMA 02
13	Install improved RCS pumps seals.	RCP seal O-ring constructed of improved materials would reduce probability of RCP seal LOCA	B	N/A
14	Install additional component cooling water pump.	SAMA would reduce probability of loss of component cooling leading to RCP seal LOCA.	B	N/A
15	Prevent centrifugal charging pump flow diversion from the relief valves.	If relieve valve opening causes a flow diversion large enough to prevent RCP seal injection, then the modification would reduce the frequency of the loss of RCP seal cooling.	B	N/A
16	Change procedures to isolate RCP seal letdown flow on loss of component cooling, and guidance on loss of injection during seal LOCA.	SAMA would reduce CDF from loss of seal cooling.	B	N/A
17	Implement procedures to stagger CRD pump use after a loss of service water.	SAMA would allow injection with CRD to be extended after a loss of service water.		Phase II SAMA 03
18	Use fire protection system pumps as a backup seal injection and high pressure make-up.	SAMA would reduce the frequency of the RCP seal LOCA and the SBO CDF.	B	N/A
19	Procedural guidance for use of cross-tied component cooling or service water pumps.	SAMA would reduce the frequency of the loss of component cooling water and service water.	-	Phase II SAMA 04
20	Procedure enhancements and operator training in support system failure sequences, with emphasis on anticipating problems and coping.	SAMA would potentially improve the success rate of operator actions subsequent to support system failures.	-	Phase II SAMA 05
21	Improved ability to cool the residual heat removal heat exchangers	SAMA would reduce the probability of a loss of decay heat removal by implementing procedure and hardware modifications to allow manual alignment of the fire protection system or by installing a component cooling water crosstie.	-	Phase II SAMA 06
22	Provide reliable power to Control Building fans	SAMA would increase availability of control room ventilation on a loss of power.	N/A	Control Bay HVAC was not a critical function represented in the BFN models
23	Provide a redundant train of ventilation.	SAMA would increase the availability of components dependent on room cooling.	-	Phase II SAMA 07
24	Procedures for actions on loss of HVAC.	SAMA would provide for improved electrical equipment reliability upon a loss of Control Building HVAC)	C	N/A

Table 4-1. Disposition of Generic SAMAs Investigated (Continued)

SAMA ID Number	SAMA Title	Description of Potential Enhancement	Screening Criterion*	Reference Paragraph Number
25	Add a diesel building switchgear room high temperature alarm.	SAMA would improve diagnosis of a loss of switchgear room HVAC. Option 1: Install high temp alarm Option 2: Redundant louver and thermostat	-	Phase II SAMA 08
26	Create ability to switch fan power supply to direct current (DC) in an SBO event.	SAMA would allow continued operation in an SBO event. This SAMA was created for reactor core isolation cooling system room at Fitzpatrick Nuclear Power Plant.	N/A	N/A
27	Delay containment spray actuation after large LOCA.	SAMA would lengthen time of RWST availability.	N/A	N/A
28	Install containment spray pump header automatic throttle valves.	SAMA would extend the time over which water remains in the RWT, when full CS flow is not needed	N/A	N/A
29	Install an independent method of suppression pool cooling.	SAMA would decrease the probability of loss of containment heat removal.	D	SAMA 124
30	Develop an enhanced drywell spray system.	SAMA would provide a redundant source of water to the containment to control containment pressure, when used in conjunction with containment heat removal.	D	SAMA 46
31	Provide dedicated existing drywell spray system.	SAMA would provide a source of water to the containment to control containment pressure, when used in conjunction with containment heat removal. This would use an existing spray loop instead of developing a new spray system.	C	N/A
32	Install an unfiltered hardened containment vent.	SAMA would provide an alternate decay heat removal method for non-ATWS events, with the released fission products not being scrubbed.	C	N/A
33	Install a filtered containment vent to remove decay heat.	SAMA would provide an alternate decay heat removal method for non-ATWS events, with the released fission products being scrubbed. Option 1: Gravel Bed Filter Option 2: Multiple Venturi Scrubber		
34	Install a containment vent large enough to remove ATWS decay heat.	Assuming that injection is available, this SAMA would provide alternate decay heat removal in an ATWS event.	-	Phase II SAMA 09
35	Create/enhance hydrogen recombiners with independent power supply.	SAMA would reduce hydrogen detonation at lower cost, Use either a new, independent power supply, a nonsafety-grade portable generator, existing station batteries, or existing AC/DC independent power supplies.	N/A	N/A

Table 4-1. Disposition of Generic SAMAs Investigated (Continued)

SAMA ID Number	SAMA Title	Description of Potential Enhancement	Screening Criterion*	Reference Paragraph Number
35A	Install hydrogen recombiners.	SAMA would provide a means to reduce the chance of hydrogen detonation.	N/A	N/A
36	Create a passive design hydrogen ignition system.	SAMA would reduce hydrogen denotation system without requiring electric power.	N/A	N/A
37	Create a large concrete crucible with heat removal potential under the basemat to contain molten core debris.	SAMA would ensure that molten core debris escaping form the vessel would be contained within the crucible. The water cooling mechanism would cool the molten core, preventing a melt-through of the basemat.	E	Cost well in excess of $10M per unit,
38	Create a water-cooled rubble bed on the pedestal.	SAMA would contain molten core debris dropping on to the pedestal and would allow the debris to be cooled.	E	Cost well in excess of $10M per unit,
39	Provide modification for flooding the drywell head.	SAMA would help mitigate accidents that result in the leakage through the drywell head seal.	N/A	Containment failure dominated by WW failure or DE shell failure other than head region (BFN IPE NUREG-1150)
40	Enhance fire protection system and/or standby gas treatment system hardware and procedures.	SAMA would improve fission product scrubbing in severe accidents.	C	N/A
41	Create a reactor cavity flooding system.	SAMA would enhance debris coolability, reduce core concrete interaction, and provide fission product scrubbing.	C	N/A
42	Create other options for reactor cavity flooding.	SAMA would enhance debris coolability, reduce core concrete interaction, and provide fission product scrubbing.	D	SAMA 41
43	Enhance air return fans (ice condenser plants).	SAMA would provide an independent power supply for the air return fans, reducing containment failure in SBO sequences.	N/A	N/A

Table 4-1. Disposition of Generic SAMAs Investigated (Continued)

SAMA ID Number	SAMA Title	Description of Potential Enhancement	Screening Criterion*	Reference Paragraph Number
44	Create a core melt source reduction system.	SAMA would provide cooling and containment of molten core debris. Refractory material would be placed underneath the reactor vessel such that a molten core falling on the material would melt and combine with the material. Subsequent spreading and heat removal from the vitrified compound would be facilitated, and concrete attack would not occur.	E	Cost well in excess of $10M per unit,
45	Provide a containment inerting capability.	SAMA would prevent combustion of hydrogen and carbon monoxide gases.	C	N/A
46	Use the fire protection system as a back-up source for the containment spray system.	SAMA would provide redundant containment spray function without the cost of installing a new system.	-	Phase II SAMA 10
47	Install a secondary containment filter vent.	SAMA would filter fission products released from primary containment.	C	N/A
48	Install a passive containment spray system.	SAMA would provide redundant containment spray method without high cost.	-	Phase II SAMA 11
49	Strengthen primary/secondary containment.	SAMA would reduce the probability of containment overpressurization to failure.	E	Cost well in excess of $10M per unit
50	Increase the depth of the concrete basemat or use an alternative concrete material to ensure melt-through does not occur.	SAMA would prevent basemat melt-through.	N/A	N/A
51	Provide a reactor vessel exterior cooling system.	SAMA would provide the potential to cool a molten core before it causes vessel failure, if the lower head could be submerged in water.	E	Cost well in excess of $10M per unit
52	Construct a building to be connected to primary/secondary containment that is maintained at a vacuum.	SAMA would provide a method to depressurize containment and reduce fission product release.	E	Cost well in excess of $10M per site.
53	Not Used	None	N/A	N/A
54	Proceduralize alignment of spare diesel to shutdown board after Loss of Offsite Power and failure of the diesel normally supplying it.	SAMA would reduce the SBO frequency.	N/A	N/A
55	Not Used	None	N/A	N/A
56	Provide an additional diesel generator.	SAMA would increase the reliability and availability of onsite emergency AC power sources.	F	N/A
57	Provide additional DC battery capacity	SAMA would ensure longer batter capability during an SBO, reducing the frequency of long-term SBO sequences.	-	Phase II SAMA 12

Table 4-1. Disposition of Generic SAMAs Investigated (Continued)

SAMA ID Number	SAMA Title	Description of Potential Enhancement	Screening Criterion*	Reference Paragraph Number
58	Use fuel cells instead of lead-acid batteries.	SAMA would extend DC power availability in an SBO.	-	Phase II SAMA 12
59	Procedure to crosstie high pressure core spray diesel.	SAMA would improve core injection availability by providing a more reliable power supply for the high pressure core spray pumps.	N/A	N/A
60	Improve 4.16 kV bus crosstie ability.	SAMA would improve AC power reliability.	D	SAMA 132
61	Incorporate an alternate battery charging capability.	SAMA would improve DC power reliability by either cross-tying the AC buses, or installing a portable diesel-driven batter charger.	-	Phase II SAMA 13
62	Increase/improve DC bus load shedding.	SAMA would extend battery life in an SBO event.	-	Phase II SAMA 12
63	Replace existing batteries with more reliable ones.	SAMA would improve DC power reliability and thus increase available SBO recovery time.	-	Phase II SAMA 13
63A	Mod for DC Bus A reliability Loss of DC Bus A causes a loss of main condenser, prevents transfer from the main transformer to offsite power, and defeats one half of the low vessel pressure permissive for LPCI/CS injection valves.	SAMA would increase the reliability of AC power and injection capability.	N/A	Loss of DC bus does not cause plant trip
64	Create AC power crosstie capability with other unit.	SAMA would improve AC power reliability.	C	N/A
65	Create a crosstie for diesel fuel oil.	SAMA would increase diesel fuel oil supply and thus diesel generator, reliability.	C	N/A
66	Develop procedures to repair or replace failed 4 kV breakers.	SAMA would offer a recovery path from a failure of the breakers that perform transfer of 4.16kV non-emergency busses from unit station service transformers, leading to loss of emergency AC power.	-	Phase II SAMA 14
67	Emphasize steps in recovery of offsite power after an SBO.	SAMA would reduce human error probability during offsite power recovery.	C	N/A
68	Develop a severe weather conditions procedure.	For plants that do not already have one, this SAMA would reduce the CDF for external weather-related events.	C	N/A
69	Develop procedures for replenishing diesel fuel oil.	SAMA would allow for long-term diesel operation.	C	BFN UFSAR 8.5.3.4
70	Install gas turbine generator.	SAMA would improve onsite AC power reliability by providing a redundant and diverse emergency power system.	E	Cost greater than $10M for site
71	Not Used	None	N/A	N/A
72	Create a back-up source for diesel cooling. (Not from existing system)	This SAMA would provide a redundant and diverse source of cooling for the diesel generators which would contribute to enhanced diesel reliability.	E	Cost greater than $10M for site

Table 4-1. Disposition of Generic SAMAs Investigated (Continued)

SAMA ID Number	SAMA Title	Description of Potential Enhancement	Screening Criterion*	Reference Paragraph Number
73	Use Fire Protection System as a back-up source for diesel cooling.	This SAMA would provide a redundant and diverse source of cooling for the diesel generators which would contribute to enhanced diesel reliability.	-	Phase II SAMA 15
74	Provide a connection to an alternate source of offsite power.	SAMA would reduce the probability of a loss of offsite power event.	F	N/A
75	Bury offsite power lines.	SAMA could improve offsite power reliability, particularly during severe weather.	E	Cost greater than $10M for site
76	Replace anchor bolts on diesel generator oil cooler. Millstone Nuclear Power Station found a high seismic SBO risk due to failure of the diesel oil cooler anchor bolts.	For plants with a similar problem, this would reduce seismic risk. Note that these were Fairbanks Morse DGs.	D	SAMA 138
77	Change Undervoltage (UV), Auxiliary Feedwater Actuation Signal (AFAS) Block and High Pressurizer Pressure Actuation Signals to 3-out-of-4, instead of 2-out-of-4 logic.	SAMA would reduce risk of 2/4 inverter failure.	N/A	N/A
78	Provide DC power to the 120/240 V vital AC system from the Class 1E station service battery system instead of its own battery.	SAMA would increase the reliability of the 120 VAC Bus.	N/A	N/A
79	Install a redundant spray system to depressurize the primary system during a steam generator tube rupture (SGTR).	SAMA would enhance depressurization during a SGTR.	N/A	N/A
80	Improve SGTR coping abilities.	SAMA would improve instrumentation to detect SGTR, or additional system to scrub fission product releases.	N/A	N/A
81	Add other SGTR coping abilities.	SAMA would decrease the consequences of an SGTR.	N/A	N/A
82	Increase secondary side pressure capacity such that an SGTR would not cause the relief valves to lift.	SAMA would eliminate direct release pathway for SGTR sequences.	N/A	N/A
83	Replace steam generators (SG) with a new design.	SAMA would lower the frequency of an SGTR.	N/A	N/A
84	Revise emergency operating procedures to direct that a faulted SG be isolated.	SAMA would reduce the consequences of an SGTR.	N/A	N/A
85	Direct SG flooding after a SGTR, prior to core damage.	SAMA would provide for improved scrubbing of SGTR releases.	N/A	N/A
86	Implement a maintenance practice that inspects 100% of the tubes in an SG.	SAMA would reduce the potential for an SGTR.	N/A	N/A
87	Locate RHR inside of containment.	SAMA would prevent ISLOCA out the RHR pathway.	E	Cost greater than $10M per unit
88	Not Used.	None	N/A	N/A

Table 4-1. Disposition of Generic SAMAs Investigated (Continued)

SAMA ID Number	SAMA Title	Description of Potential Enhancement	Screening Criterion*	Reference Paragraph Number
89	Install additional instrumentation for ISLOCAs.	Pressure of leak monitoring instruments installed between the first two pressure isolation valves on low-pressure inject lines, RHR suction lines, and HPSI lines would decrease ISLOCA frequency.	-	Phase II SAMA 16
90	Increase frequency for valve leak testing.	SAMA could reduce ISLOCA frequency.	-	Phase II SAMA 16
91	Improve operator training on ISLOCA coping.	SAMA would decrease ISLOCA effects.	-	Phase II SAMA 16
92	Install relief valves in the CC System.	SAMA would relieve pressure buildup from an RCP thermal barrier tube rupture, preventing an ISLOCA.	N/A	N/A
93	Provide leak testing of valves in ISLOCA paths. At Kewaunee Nuclear Power Plant, four MOVs isolating RHR from the RCS were not leak tested.	This SAMA would help reduce ISLOCA frequency.	-	Phase II SAMA 16
94	Revise EOPs to improve ISLOCA identification. Salem Nuclear Power Plant had a scenario where an RHR ISLOCA could direct initial leakage back to the pressurizer relief tank, giving indication that the LOCA was inside containment.	Procedure enhancements would ensure LOCA outside containment could be identified as such.	N/A	N/A
95	Ensure all ISLOCA releases are scrubbed.	This SAMA would scrub all ISLOCA releases. One example is to plug drains in the break area so that the break point would cover with water.	-	Phase II SAMA 16
96	Add redundant and diverse limit switches to each containment isolation valve.	Enhanced isolation valve position indication could reduce the frequency of containment isolation failure and ISLOCAs.	-	See Phase II SAMA 16
97	Modify swing direction of doors separating turbine building basement from areas containing safeguards equipment.	SAMA would prevent flood propagation, for a plant where internal flooding from turbine building to safeguards areas is a concern.	N/A	Doors open into turbine building. No flooding scenarios propagating from turbine building to safeguards area (BFN IPE)
98	Improve inspection of rubber expansion joints on main condenser.	SAMA would reduce the frequency of internal flooding, for a plant where internal flooding due to a failure of circulating water system expansion joints is a concern.	-	Phase II SAMA 17
99	Implement internal flood prevention and mitigation enhancements.	This SAMA would reduce the consequences of internal flooding.	D	SAMA 128

Table 4-1. Disposition of Generic SAMAs Investigated (Continued)

SAMA ID Number	SAMA Title	Description of Potential Enhancement	Screening Criterion*	Reference Paragraph Number
100	Implement internal flooding improvements such as those implemented at Fort Calhoun.	This SAMA would reduce flooding risk by preventing or mitigating: a rupture in the RCP seal cooler of the component cooling system an ISLOCA in a shutdown cooling line, an AFW flood involving the need to remove a watertight door.	N/A	N/A
101	Install a digital feedwater upgrade.	This SAMA would reduce the chance of a loss of main feedwater following a plant trip.	C	N/A
102	Perform surveillances on manual valves used for back-up AFW pump suction.	This SAMA would improve success probability for providing alternative water supply to the AFW pumps.	N/A	N/A
103	Install manual isolation valves around AFW turbine-driven steam admission valves.	This SAMA would reduce the dual turbine-driven AFW pump maintenance unavailability.	N/A	N/A
104	Install accumulators for turbine-driven AFW pump flow control valves (CVs).	This SAMA would provide control air accumulators for the turbine-driven AFW flow CVs, the motor-driven AFW pressure CVs and SG PORVs. This would eliminate the need for LOCA manual action to align nitrogen bottles for control air during a LOOP.	N/A	N/A
105	Proceduralize intermittent operation of HPCI.	SAMA would allow for extended duration of HPCI availability.	C	If RCIC is available, HPCI used in test mode to control pressure and avoid cycling.
106	Increase the reliability of safety relief valves. (Adding signals to add electrical signal to open automatically).	SAMA reduces the probability of a certain type of medium break LOCA. Hatch evaluates medium LOCA initiated by an MSIV closure transient with a failure of SRVs to open. Reducing the likelihood of the failure for SRVs to open subsequently reduces the occurrence of this medium LOCA.	C	N/A
107	Install motor-driven feedwater pump.	This would increase the availability of injection subsequent to MSIV closure.	E	Cost greater than $10M per unit
108	Procedure to instruct operators to trip unneeded RHR/CS pumps on loss of room ventilation.	SAMA increases availability of required RHR/CS pumps. Reduction in room heat load allows continued operation of required RHR/CS pumps, when room cooling is lost.	-	Phase II SAMA 18

Table 4-1. Disposition of Generic SAMAs Investigated (Continued)

SAMA ID Number	SAMA Title	Description of Potential Enhancement	Screening Criterion*	Reference Paragraph Number
109	Increase available NPSH for injection pumps.	SAMA increases the probability that these pumps will be available to inject coolant into the vessel by increasing the available NPSH for the injection pumps.	C	NPSH concerns are not a concern in the dominant BFN sequences. RHR has been demonstrated to operate satisfactorily at less than "minimum" NPSH. Torus water temperature leading to loss of lube oil cooling rather than NPSH, are a limiting concern for HPCI and RCIC
110	Increase the SRV reseat reliability.	SAMA addresses the risk associated with dilution of boron caused by the failure of the SRVs to reseat after SLC injection.	-	Phase II SAMA 19
111	Reduce DC dependency between high pressure injection system and ADS.	SAMA would ensure vessel depressurization and high pressure injection upon a DC failure.	-	Phase II SAMA 20
112	Modify RWCU for use as a decay heat removal system and proceduralize use.	SAMA would provide an additional source of decay heat removal.	C	N/A
113	Use of CRD for alternate boron injection.	SAMA provides an additional system to address ATWS with SLC failure or unavailability.	-	Phase II SAMA 21
114	Increase seismic ruggedness of plant components.	SAMA would increase the availability of necessary plant equipment during and after seismic events.	D	SAMA 138
115	Allow cross connection of uninterruptable compressed air supply to opposite unit.	SAMA would increase the ability to depressurize containment using the hardened vent.	N/A	N/A

*N/A indicates that the proposed SAMA is not applicable to BFN or the BWR-4/Mark I design.

A indicates that the proposed SAMA is related to mitigation of an Intersystem LOCA (ISLOCA). Per IN-92-36, and its supplement, ISLOCA contributes little risk for boiling water reactors, because of the lower primary pressures. Because of the low risk contribution due to ISLOCA, this SAMA has not been developed further.

B indicates that the proposed SAMA is related to RCP seal leakage. A review of NUREG-1560 indicates that although RCP seal leakage is important for PWRs, recirculation pump leakage does not significantly contribute to CDF in BWRs.

C indicates that the proposed SAMA has already been installed at the BFN.

D indicates that similar item is addressed under other proposed SAMAs.

E indicates that SAMA did not pass initial cost and was therefore not examined in detail.

F Primary cause of loss of existing, redundant hardware is common cause event, which another string of hardware would not alleviate.

Table 4-2. Disposition of Plant Specific SAMAs Investigated

SAMA ID Number	SAMA Title	Description of Potential Enhancement	Screening Criterion*	Reference Paragraph Number
116	borate torus water	borate torus water to mitigate ATWS upon water injection from the torus.	-	Phase II SAMA 22
117	automate torus cooling	automate torus cooling on high torus temperature to avoid lack of torus cooling due to operator error	-	Phase II SAMA 23
117a	provide torus positive pressure relief valves	provide torus positive pressure relief valves to prevent containment overpressure failure	-	Phase II SAMA 24
117b	reduce DW head bolt pretension	reduce DW head bolt pretension to allow DW to "burp" thereby preventing catastrophic containment overpressure failure	-	Phase II SAMA 24
118	Eliminate operator action to inhibit ADS for ATWS	Mitigate failure to inhibit ADS due to operator error during ATWS conditions.	D	SAMA 116
119	Eliminate fine water level control for ATWS	Mitigate failure to control water level at TAF due to operator error for ATWS conditions.	D	SAMA 116
120	Provide redundancy for SLC	ATWS, Provide redundancy to mitigate failure of SLC due to hardware failure during ATWS conditions.	D	SAMA 116
121	automate SLC initiation	automate SLC initiation to mitigate failure of SLC due to operator error during ATWS conditions	-	Phase II SAMA 25
122	RPV replacement	replace the RPV to reduce probability of Excessive LOCA	E	Cost greater than $10M per unit
122a	RPV inspection	increase the RPV inspection frequency to reduce probability of Excessive LOCA	-	Phase II SAMA 26
123	remove DW high pressure signal from ADS logic	remove DW high pressure signal from ADS logic to mitigate loss of all HP injection coupled with failure to depressurize due to operator error	C	N/A
124	provide independent torus cooling system	mitigate failure of torus cooling due to hardware failure	-	Phase II SAMA 27
125	Eliminate operator action to initiate torus cooling	Mitigate loss of all HP injection due to hardware failure coupled with failure of torus cooling due to operator error	D	SAMA 117
126	Eliminate operator action to depressurize reactor in event of HP injection failure.	Mitigate loss of all HP injection due to operator error coupled with failure to depressurize due to operator error	D	SAMA 123
127	Provide core cooling system outside interfacing system LOCA zone of influence	Mitigate effects of interfacing system LOCA	D	SAMA 133
128	Provide core cooling system outside flood zone of influence	Mitigate effects of internal Flooding	D	SAMA 133
129	Not used			
130	Not used			
131	Not used			
132	Improve 4kV crosstie capability	Provide 4kV shutdown bus crosstie capability from Unit 1/2 to Unit 3.	-	Phase II SAMA 28
133	provide HP diesel-driven pump.	provide capability to inject river water at HP via diesel-driven pump to mitigate Station Blackout	-	Phase II SAMA 29

Table 4-2. Disposition of Plant Specific SAMAs Investigated (Continued)

SAMA ID Number	SAMA Title	Description of Potential Enhancement	Screening Criterion*	Reference Paragraph Number
134	Provide additional LP core cooling system	Mitigate SORV coupled with failure of LP injection due to hardware failure	D	SAMA 133
135	Not used			
136	Not used			
137	Reduce fire risk	Mitigate Fire effects	e	N/A
138	Reduce earthquake risk	Mitigate Earthquake effects	a, b, c	N/A
139	Reduce HFO risk	Mitigate effects of High winds, Floods, Transportation, and Other (HFO) External Events.	d	N/A

*N/A indicates that the proposed SAMA is not applicable to BFN or the BWR-4/Mark I design.

A indicates that the proposed SAMA is related to mitigation of an Intersystem LOCA (ISLOCA). Per IN-92-36, and its supplement, ISLOCA contributes little risk for boiling water reactors, because of the lower primary pressures. Because of the low risk contribution due to ISLOCA, this SAMA has not been developed further.

B indicates that the proposed SAMA is related to RCP seal leakage. A review of NUREG-1560 indicates that although RCP seal leakage is important for PWRs, recirculation pump leakage does not significantly contribute to CDF in BWRs.

C indicates that the proposed SAMA has already been installed at the BFN.

D indicates that similar item is addressed under other proposed SAMAs.

E indicates that SAMA did not pass initial cost and was therefore not examined in detail.

F Primary cause of loss of existing, redundant hardware is common cause event, which another string of hardware would not alleviate.

a) "The outliers identified [in accordance with the Seismic Qualification Utility Group Generic Implementation Procedure criteria] for BFN Unit 3 were resolved during the Cycle 7 refueling outage that completed on March 13, 1997." "TVA considers the commitments regarding USI A-46 and the seismic portion of IPEEE to be complete for BFN Unit 3." Letter from TVA to the USNRC. R08 970411 803.

b) "...TVA has completed the resolution of outliers for BFN Unit 2 identified in accordance with the Seismic Qualification Utility Group (SQUG) Generic Implementation Procedure (GIP) criteria." "The outliers identified for BFN Unit 2 were resolved ... during the Cycle 9 refueling outage that completed on October 19. 1997." "TVA considers the commitments regarding USI A-46 and the seismic portion of IPEEE to be complete for BFN Unit 2." Letter from TVA to the USNRC. R08 971118 922.

c) "The staff's review of the licensee's action regarding outliers indicates that identified outliers have been resolved by analysis or corrective actions." "The staff has also concluded that its findings regarding the USI A-46 program do not warrant any further regulatory action under the provisions of 10 CFR 50.54(f)." Letter from the USNRC to TVA dated 3/21/2000 and attached USI A-46 SER.

d) "These events were screened out in a manner consistent with the guidance given in NUREG-1407...." Letter from the USNRC to TVA dated 6/22/2000, and attached IPEEE SER.

e) "No plant modifications were found to be necessary as a result of the fire IPEEE for BFN Units 2 and 3." Letter from the USNRC to TVA dated 6/22/2000, and attached IPEEE SER.

V. SAMA Analysis Results for BFN

A. Summary of Phase II SAMA Analysis

A summary of Phase II SAMAs is shown in Table 5-1.

SAMA implementation costs were first estimated in 2001 dollars. These values were then inflated (at 3%/year) to arrive at Year 2016 estimated costs. This step is necessary to make the costs directly comparable to estimated costs averted.

Table 5-1. Summary of Phase II SAMA Analysis (Continued)

Phase II SAMA ID No.	Phase I SAMA ID No.	SAMA Title	Result of Potential Enhancement	Estimated Cost (2001)	Estimated Cost (2016)	Phase II Disposition
14	66	Develop procedures to repair or replace failed 4 kV breakers.	SAMA would offer a recovery path from a failure of the breakers that perform transfer of 4.16kV non-emergency busses from unit station service transformers, leading to loss of emergency AC power.	$50k/unit	$78k/unit	See 5.15
15	73	Use Fire Protection System as a back-up source for diesel cooling.	This SAMA would provide a redundant and diverse source of cooling for the diesel generators which would contribute to enhanced diesel reliability.	Greater than $1M/plant	Greater than $1.5M/plant	See 5.16

Table 5-1. Summary of Phase II SAMA Analysis (Continued)

Phase II SAMA ID No.	Phase I SAMA ID No.	SAMA Title	Result of Potential Enhancement	Estimated Cost (2001)	Estimated Cost (2016)	Phase II Disposition
12	57	Provide additional DC battery capacity.	SAMA would ensure longer batter capability during an SBO, reducing the frequency of long-term SBO sequences.	$1M/plant	$1.5M/plant	See 5.13.
	58	Use fuel cells instead of lead-acid batteries.	SAMA would extend DC power availability in an SBO.	Greater than $6M/plant	Greater than $9.3M/plant	
	62	Increase/improve DC bus load shedding.	SAMA would extend battery life in an SBO event.	$50k/plant	$78k/plant	
	9	Add redundant DC Control Power for SW pumps	SAMA would increase reliability of SW and decrease core damage frequency due to a loss of SW. Relevant potential concern at BFN is loss of DC-D	$1M/plant	$1.5M/plant	
13	61	Incorporate an alternate battery charging capability.	SAMA would improve DC power reliability by either cross-tying the AC buses, or installing a portable diesel-driven batter charger.	$100k/unit	155k/unit	See 5.14
	63	Replace existing batteries with more reliable ones.	SAMA would improve DC power reliability and thus increase available SBO recovery time.	Greater than $6M/plant	Greater than $9.3M/plant	

Table 5-1. Summary of Phase II SAMA Analysis

Phase II SAMA ID No.	Phase I SAMA ID No.	SAMA Title	Result of Potential Enhancement	Estimated Cost (2001)	Estimated Cost (2016)	Phase II Disposition
1	7	Increase CRD pump lube oil capacity.	SAMA would lengthen the time before control rod drive (CRD) pump failure due to lube oil	N/A	N/A	No significant risk decrease. See 5.2
2	12	Replace ECCS pump motor with air-cooled motors.	SAMA would eliminate ECCS dependency on ERCW.	Estimated cost greater than $6M per unit	Greater than $9.3M per unit	See 5.3
3	17	Implement procedures to stagger CRD pump use after a loss of service water.	SAMA would allow injection with CRD to be extended after a loss of service water.	$50k/unit	$78k/unit	No significant risk decrease. See 5.4
4	19	Procedural guidance for use of cross-tied component cooling or service water pumps.	SAMA would reduce the frequency of the loss of component cooling water and service water.	$50k/unit	$78k/unit	See 5.5
5	20	Procedure enhancements and operator training in support system failure sequences, with emphasis on anticipating problems and coping.	SAMA would potentially improve the success rate of operator actions subsequent to support system failures.	$50k/unit	$78k/unit	See 5.6
6	21	Improved ability to cool the residual heat removal heat exchangers	SAMA would reduce the probability of a loss of decay heat removal by implementing procedure and hardware modifications to allow manual alignment of the fire protection system or by installing a component cooling water crosstie.	Greater than $100k/unit	Greater than $155k/unit	See 5.7
7	23	Provide a redundant train of ventilation.	SAMA would increase the availability of components dependent on room cooling.	Greater than $6M/unit.	Greater than $9.3M per unit	See 5.8

Table 5-1. Summary of Phase II SAMA Analysis (Continued)

Phase II SAMA ID No.	Phase I SAMA ID No.	SAMA Title	Result of Potential Enhancement	Estimated Cost (2001)	Estimated Cost (2016)	Phase II Disposition
8	25	Add a diesel building switchgear room high temperature alarm.	SAMA would improve diagnosis of a loss of switchgear room HVAC. Option 1: Install high temp alarm Option 2: Redundant louver and thermostat	option 1: $400k per building option 2: $6M per building	Option 1: $623 per building. Option 2: $9.3M per building.	See 5.9
9	34	Install a containment vent large enough to remove ATWS decay heat.	Assuming that injection is available, this SAMA would provide alternate decay heat removal in an ATWS event.	$2M/unit	$3.1M/unit	See 5.10
10	46	Use the fire protection system as a back-up source for the containment spray system.	SAMA would provide redundant containment spray function without the cost of installing a new system.	$500k/unit	$779k/unit	See 5.11
11	48	Install a passive containment spray system.	SAMA would provide redundant containment spray method without high cost.	Greater than $6M/unit	Greater than $9.3M/unit	See 5.12

Table 5-1. Summary of Phase II SAMA Analysis (Continued)

Phase II SAMA ID No.	Phase I SAMA ID No.	SAMA Title	Result of Potential Enhancement	Estimated Cost (2001)	Estimated Cost (2016)	Phase II Disposition
16	89	Install additional instrumentation for ISLOCAs.	Pressure of leak monitoring instruments installed between the first two pressure isolation valves on low-pressure inject lines, RHR suction lines, and HPSI lines would decrease ISLOCA frequency.	$400k/unit	$623k/unit	See 5.17
	90	Increase frequency for valve leak testing.	SAMA could reduce ISLOCA frequency.	$100k/unit	$155k/unit	
	91	Improve operator training on ISLOCA coping.	SAMA would decrease ISLOCA effects.	$50k/unit	$78k/unit	
	93	Provide leak testing of valves in ISLOCA paths. At Kewaunee Nuclear Power Plant, four MOVs isolating RHR from the RCS were not leak tested.	This SAMA would help reduce ISLOCA frequency.	Greater than $100k/unit	Greater than $155k/unit	
	95	Ensure all ISLOCA releases are scrubbed.	This SAMA would scrub all ISLOCA releases. One example is to plug drains in the break area so that the break point would cover with water.	Greater than $1M/plant	Greater than $1.5M/plant	
	96	Add redundant and diverse limit switches to each containment isolation valve.	Enhanced isolation valve position indication could reduce the frequency of containment isolation failure and ISLOCAs.	$400k/unit	$623k/unit	

Table 5-1. Summary of Phase II SAMA Analysis (Continued)

Phase II SAMA ID No.	Phase I SAMA ID No.	SAMA Title	Result of Potential Enhancement	Estimated Cost (2001)	Estimated Cost (2016)	Phase II Disposition
17	98	Improve inspection of rubber expansion joints on main condenser.	SAMA would reduce the frequency of internal flooding, for a plant where internal flooding due to a failure of circulating water system expansion joints is a concern.	$100k/unit	$155k/unit	See 5.18
18	108	Procedure to instruct operators to trip unneeded RHR/CS pumps on loss of room ventilation.	SAMA increases availability of required RHR/CS pumps. Reduction in room heat load allows continued operation of required RHR/CS pumps, when room cooling is lost.	$50k/unit	$78k/unit	See 5.19
19	110	Increase the SRV reseat reliability.	SAMA addresses the risk associated with dilution of boron caused by the failure of the SRVs to reseat after SLC injection.	$700k/unit	$1.09M/unit	See 5.20
20	111	Reduce DC dependency between high pressure injection system and ADS.	SAMA would ensure vessel depressurization and high pressure injection upon a DC failure.	$500k/unit	$779k/unit	See 5.21
21	113	Use of CRD for alternate boron injection.	SAMA provides an additional system to address ATWS with SLC failure or unavailability.	$2M/unit	$3.1M/unit	See 5.22
22	116	Borate torus water	Borate torus water to mitigate ATWS upon water injection from the torus.	Greater than $6M/unit	Greater than $9.3M/unit	See 5.23
23	117	Automate torus cooling	Automate torus cooling on high torus temperature to avoid lack of torus cooling due to operator error	$400k/unit	$623k/unit	See 5.24

Table 5-1. Summary of Phase II SAMA Analysis (Continued)

Phase II SAMA ID No.	Phase I SAMA ID No.	SAMA Title	Result of Potential Enhancement	Estimated Cost (2001)	Estimated Cost (2016)	Phase II Disposition
24	117a	Provide torus positive pressure relief valves	Provide torus positive pressure relief valves to prevent containment overpressure failure	$700k/unit	$1.09M/unit	See 5.25
	117b	Reduce DW head bolt pretension	Reduce DW head bolt pretension to allow DW to "burp" thereby preventing catastrophic containment overpressure failure	$50k/unit	$78k/unit	
26	122a	RPV inspection	Increase the RPV inspection frequency to reduce probability of Excessive LOCA	$100k/unit	$155k/unit	See 5.27
25	121	Automate SLC initiation	Automate SLC initiation to mitigate failure of SLC due to operator error during ATWS conditions	$400k	$623k	See 5.26
27	124	Provide independent torus cooling system	Mitigate failure of torus cooling due to hardware failure	Greater than $6M/unit	Greater than $9.3M/unit	See 5.28
28	132	Improve 4kV crosstie capability	Provide 4kV shutdown bus crosstie capability from Unit 1/2 to Unit 3.	$5M/plant	$7.8M/plant	See 5.29
29	133	Provide HP diesel-driven pump.	Provide capability to inject river water at HP via diesel-driven pump to mitigate Station Blackout	Greater than $6M/plant	Greater than $9.3M/plant	See 5.30

B. Phase II SAMA Number 01: Increase CRD Lube Oil Capacity

This SAMA has the potential to increase the time before CRD pump failure due to failure of lube oil. The original SAMA addressed a PWR concern relating to charging pumps. The closest equivalent in BWRs are the CRD pumps.

The risk significance of the CRD pumps in the BFN models is modest. The risk reduction worth impact of the CRD system is approximately 6% and 3% for Unit 2 and Unit 3, respectively. In addition the contribution of lube oil failure to CRD system unavailability (BFN IPE) is approximately 0.2% of the total system unavailability.

It is therefore concluded that there is no significant risk reduction potential associated with this SAMA.

C. Phase II SAMA Number 02: Eliminate ECCS Dependency on EECW

This SAMA would replace ECCS pump motor with passively cooled motors. This would reduce the functional dependency of the RHR and Core Spray pumps on EECW.

This SAMA is related to Phase II SAMAs 7 and 18. The same bounding risk evaluation has been used for SAMAs 2 and 18.

To bound the potential impact of this SAMA, the dependency on all RHR and Core Spray pumps on EECW has been eliminated. In addition, the RHR and Core Spray top event models were reviewed. It was determined that failure of the pump coolers contributed approximately 20% to the split fractions representing the RHR pumps and the Core Spray system. All split fractions associated with the RHR pumps and Core Spray system were reduced by 20%. This has the effect of increasing the calculated availability of these pumps.

These changes necessitated changes to be made in the split fraction assignment rules in the low pressure transient event tree (LPGTET), as well as the large and medium LOCA event trees (LLOCA and MLOCA, respectively). In addition, the split fraction adjustments were made directly to the master frequency file (which is the reference table for the split fractions used in the scenario quantification).

These changes reflect the following bounding assumption: Replacing the pump motors with air cooled motors completely removes any dependency on EECW.

PSA Model Results

The results from this case indicates about a 19% reduction in Unit 2 CDF (CDF_{new}=8.543E-7). The new end state frequencies are presented in Table 5-2. For Unit 3 there is a 11% reduction in CDF (CDF_{new}=1.6788E-6) and the new end state frequencies are presented in Table 5-3.

Table 5-2. Unit 2 SAMA Number 02 Results

MAAP Case	Baseline Case	SAMA 02 Case
PIHDEP	3.65E-07	2.09E-07
PIHDEPV	2.52E-07	2.07E-07
PIHDLV	7.75E-10	4.14E-10
ENMKCTT	7.39E-08	7.08E-08
OIA	6.90E-08	8.61E-08
OIALF	2.93E-08	2.15E-08
MIALF	1.36E-07	1.37E-07
PJHNSP	6.14E-08	6.14E-08
PLF	4.07E-09	3.80E-09
PID	2.88E-08	2.84E-08
NIH	2.95E-08	2.96E-08
Person-rem	2.27	1.78
Unit 2 Total Cost (3%)	$249,733	$196,766
Unit 2 Total Cost (7%)	$171,970	$135,321
SAMA 02 Saving (3%)	$52,967	
SAMA 02 Saving (7%)	$36,649	

Table 5-3. Unit 3 SAMA Number 02 Results

MAAP Case	Baseline Case	SAMA 02 Case
PIHDEP	8.59E-07	6.38E-07
PIHDEPV	4.20E-07	3.71E-07
PIHDLV	7.75E-10	0.00E+00
ENMKCTT	1.52E-07	1.42E-07
OIA	1.60E-07	2.27E-07
OIALF	1.11E-08	8.43E-09
MIALF	1.32E-07	1.33E-07
PJHNSP	1.28E-07	1.28E-07
PLF	2.11E-08	1.94E-08
PID	9.67E-09	9.37E-09
NIH	3.75E-09	3.76E-09
Person-rem	4.74	4.15
Unit 3 Total Cost (3%)	$505,638	$443,629
Unit 3 Total Cost (7%)	$349,656	$306,685
SAMA 02 Saving (3%)	$62,010	
SAMA 02 Saving (7%)	$42,971	

D. Phase II SAMA Number 03: Implement Procedures to Stagger CRD Pump Use After Loss of Service Water

This SAMA originally was originally associated with the PWR concern of loss of high pressure injection following loss of service water. The CRD system at BFN can act as a source of high pressure injection and is dependent on RCW. RCW provides oil bearing cooling and thrust bearing cooling. Staggering CRD pump operation would have little benefit on loss of service water

E. Phase II SAMA Number 04: Enhance Ability to Crosstie Service Water

Several systems at BFN provide the generic 'service water' systems support function. These systems include RCW, EECW, RHRSW, and RBCCW.

The base case models reflect the potential to realign swing RHRSW pumps to support EECW.

To bound the potential benefit of further enhancing the ability to cross tie service water systems (via hardware and procedural changes), the following assumptions were made:

1. If sufficient EECW flow occurs and the RHRSW swing pumps are available, the actions necessary to align the swing pumps for EECW service are assumed to occur with a probability of 1.
2. RBCCW is assumed to be successful if RCW is available. In other words, it is assumed that RCW is cross-tied to RBCCW.
3. The frequency of the initiator Loss of RBCCW is assumed to be zero.

To reflect these changes, top OEE, alignment of the swing RHRSW to support EECW, is assumed to be successful if the swing pumps are available. Also top RBC representing the availability of the RBCCW system is assumed to be available if RCW is available.

PSA Model Results

The results from this case indicates about a 0.9% reduction in Unit 2 CDF (CDF_{new}=1.0400E-6). The new end state frequencies are presented in Table 5-4. Unit 3 there is a 1.5% reduction in CDF (CDF_{new}=1.8675E-6) and the new end state frequencies are presented in Table 5-5.

Table 5-4. Unit 2 SAMA Number 04 Results

MAAP Case	Baseline Case	SAMA 04 Case
PIHDEP	3.65E-07	3.63E-07
PIHDEPV	2.52E-07	2.49E-07
PIHDLV	7.75E-10	7.75E-10
ENMKCTT	7.39E-08	7.33E-08
OIA	6.90E-08	6.90E-08
OIALF	2.93E-08	2.93E-08
MIALF	1.36E-07	1.33E-07
PJHNSP	6.14E-08	6.13E-08
PLF	4.07E-09	3.87E-09
PID	2.88E-08	2.88E-08
NIH	2.95E-08	2.79E-08
Person-rem	2.27	2.26
Unit 2 Total Cost (3%)	$249,733	$248,015
Unit 2 Total Cost (7%)	$171,970	$170,804
SAMA 04 Saving (3%)	$1,718	
SAMA 04 Saving (7%)	$1,166	

Table 5-5. Unit 3 SAMA Number 04 Results

MAAP Case	Baseline Case	SAMA 04 Case
PIHDEP	8.59E-07	8.43E-07
PIHDEPV	4.20E-07	4.17E-07
PIHDLV	7.75E-10	0.00E+00
ENMKCTT	1.52E-07	1.50E-07
OIA	1.60E-07	1.60E-07
OIALF	1.11E-08	1.11E-08
MIALF	1.32E-07	1.26E-07
PJHNSP	1.28E-07	1.27E-07
PLF	2.11E-08	2.00E-08
PID	9.67E-09	9.67E-09
NIH	3.75E-09	3.50E-09
Person-rem	4.74	4.67
Unit 3 Total Cost (3%)	$505,638	$498,634
Unit 3 Total Cost (7%)	$349,656	$344,836
SAMA 04 Saving (3%)	$7,005	
SAMA 04 Saving (7%)	$4,821	

F. Phase II SAMA Number 05: Enhanced Recovery of Failed Support Systems

The base case models explicitly consider the recovery of key support systems. Specific recovery actions considered in one or both base case models are:

1. Alignment of RHRSW swing pumps to support EECW operation (top OEE).
2. Restoration of power at a diesel auxiliary board (top ODSB).
3. Restoration of power to support diesel room cooling (top ODSBU3).
4. Restoration of power at a 480V Reactor MOV board (top RMOV).
5. Alignment of spare battery charger (top CPREC).
6. Recovery of power at a 4-kV shutdown board (top SDREC).
7. Alignment of power to a unit board from 161-kV gives loss of the 500-kV supply (top OUB).
8. Other electric power recovery actions (top OX).

To estimate a bound for the potential impact of improved procedures, each of the split fractions associated with the above top events were assumed to improve (i.e., be more reliable) by a factor of 3.

The models were then quantified with all of the above operator recovery actions simultaneously improved.

PSA Model Results

The results from this case indicates about a 0.2% reduction in Unit 2 CDF (CDF_{new}=1.0473E-6). The new end state frequencies are presented in Table 5-6. For Unit 3 there is a 0.1% reduction in CDF (CDF_{new}=1.8954E-6) and the new end state frequencies are presented in Table 5-7.

Table 5-6. Unit 2 SAMA Number 05 Results

MAAP Case	Baseline Case	SAMA 05 Case
PIHDEP	3.65E-07	3.63E-07
PIHDEPV	2.52E-07	2.51E-07
PIHDLV	7.75E-10	7.77E-10
ENMKCTT	7.39E-08	7.39E-08
OIA	6.90E-08	6.88E-08
OIALF	2.93E-08	2.93E-08
MIALF	1.36E-07	1.36E-07
PJHNSP	6.14E-08	6.14E-08
PLF	4.07E-09	4.08E-09
PID	2.88E-08	2.85E-08
NIH	2.95E-08	2.95E-08
Person-rem	2.27	2.27
Unit 2 Total Cost (3%)	$249,733	$249,080
Unit 2 Total Cost (7%)	$171,970	$171,518
SAMA 05 Saving (3%)	$654	
SAMA 05 Saving (7%)	$452	

Table 5-7. Unit 3 SAMA Number 05 Results

MAAP Case	Baseline Case	SAMA 05 Case
PIHDEP	8.59E-07	8.59E-07
PIHDEPV	4.20E-07	4.20E-07
PIHDLV	7.75E-10	0.00E+00
ENMKCTT	1.52E-07	1.52E-07
OIA	1.60E-07	1.60E-07
OIALF	1.11E-08	1.11E-08
MIALF	1.32E-07	1.32E-07
PJHNSP	1.28E-07	1.28E-07
PLF	2.11E-08	2.11E-08
PID	9.67E-09	8.69E-09
NIH	3.75E-09	3.36E-09
Person-rem	4.74	4.74
Unit 3 Total Cost (3%)	$505,638	$505,436
Unit 3 Total Cost (7%)	$349,656	$349,525
SAMA 05 Saving (3%)	$202	
SAMA 05 Saving (7%)	$132	

G. Phase II SAMA Number 06: Fire Water as Backup for RHR Heat Exchange Cooling

To estimate the potential impact of providing a connection from the fire water system to the RHR heat exchangers, the following assumptions were made:

1. The fire water system was assumed to be capable of providing adequate cooling water flow to all Unit 2 and 3 RHR heat exchangers

2. The fire water system was assumed to have a 100% availability.

3. Any required operator actions associated with aligning the fire water system to provide flow to the RHR heat exchanger was assumed to be successfully completed in a timely manner.

To implement this bounding model, split fractions representing guaranteed success associated with the four RHRSW pumps were used. (In other words, the failure fraction for top events SW2A, SW2C, SW2B, and SW2D were set to zero.)

PSA Model Results

The results from this case indicates about a 2.6% reduction in Unit 2 CDF (CDF_{new}=1.0230E-6). The new end state frequencies are presented in Table 5-8. For Unit 3 there is a 0.9% reduction in CDF (CDF_{new}=1.7201E-6) and the new end state frequencies are presented in Table 5-9.

Table 5-8. Unit 2 SAMA Number 06 Results

MAAP Case	Baseline Case	SAMA 6 Case
PIHDEP	3.65E-07	3.39E-07
PIHDEPV	2.52E-07	2.39E-07
PIHDLV	7.75E-10	8.01E-10
ENMKCTT	7.39E-08	7.53E-08
OIA	6.90E-08	7.81E-08
OIALF	2.93E-08	2.97E-08
MIALF	1.36E-07	1.38E-07
PJHNSP	6.14E-08	6.10E-08
PLF	4.07E-09	3.24E-09
PID	2.88E-08	2.93E-08
NIH	2.95E-08	2.99E-08
Person-rem	2.27	2.26
Unit 2 Total Cost (3%)	$249,733	$242,109
Unit 2 Total Cost (7%)	$171,970	$166,686
SAMA 06 Saving (3%)	$7,625	
SAMA 06 Saving (7%)	$5,284	

Table 5-9. Unit 3 SAMA Number 06 Results

MAAP Case	Baseline Case	SAMA 6 Case
PIHDEP	8.59E-07	7.52E-07
PIHDEPV	4.20E-07	3.46E-07
PIHDLV	7.75E-10	0.00E+00
ENMKCTT	1.52E-07	1.53E-07
OIA	1.60E-07	1.63E-07
OIALF	1.11E-08	1.13E-08
MIALF	1.32E-07	1.34E-07
PJHNSP	1.28E-07	1.26E-07
PLF	2.11E-08	2.03E-08
PID	9.67E-09	9.99E-09
NIH	3.75E-09	3.84E-09
Person-rem	4.74	4.29
Unit 3 Total Cost (3%)	$505,638	$457,726
Unit 3 Total Cost (7%)	$349,656	$316,508
SAMA 06 Saving (3%)	$47,913	
SAMA 06 Saving (7%)	$33,149	

H. Phase II SAMA Number 07: Provide a Redundant Train of Ventilation

A limited number of systems are dependent on room or area cooling at BFN. The RHR and Core Spray pumps, as modeled, require fan coolers. In addition, room cooling is required for operation of the diesel generators.

A review of the systems analyses for the RHR and Core Spray systems (BFN IPE) reveals that the contribution (including common cause) to RHR or Core Spray pump unavailability due to fan cooler failure is less than 20%.

To bound the potential impact of a redundant ventilation for the RHR and Core Spray pumps, the split fractions representing these pumps (i.e., RPA, RPB, RPC, RPD and CS) were reduced by 20%.

In addition, the top event representing recovery of diesel generator room cooling was set to guaranteed success.

This bounding modeling approach assumes that the redundant ventilation has an availability of 1.0 (i.e., an unavailability of 0.0) and is independent of any support system such as electric power.

PSA Model Results

The results from this case indicates about a 19% reduction in Unit 2 CDF (CDF_{new}=8.5407E-7). The new end state frequencies are presented in Table 5-10. For

Unit 3 there is a 11% reduction in CDF (CDF_{new}=1.6788E-6) and the new end state frequencies are presented in Table 5-11.

Table 5-10. Unit 2 SAMA Number 07 Results

MAAP Case	Baseline Case	SAMA 07 Case
PIHDEP	3.65E-07	2.08E-07
PIHDEPV	2.52E-07	2.07E-07
PIHDLV	7.75E-10	4.14E-10
ENMKCTT	7.39E-08	7.08E-08
OIA	6.90E-08	8.61E-08
OIALF	2.93E-08	2.15E-08
MIALF	1.36E-07	1.37E-07
PJHNSP	6.14E-08	6.14E-08
PLF	4.07E-09	3.80E-09
PID	2.88E-08	2.84E-08
NIH	2.95E-08	2.96E-08
Person-rem	2.27	1.78
Unit 2 Total Cost (3%)	$249,733	$196,621
Unit 2 Total Cost (7%)	$171,970	$135,262
SAMA 07 Saving (3%)	$53,052	
SAMA 07 Saving (7%)	$36,708	

Table 5-11. Unit 3 SAMA Number 07 Results

MAAP Case	Baseline Case	SAMA 07 Case
PIHDEP	8.59E-07	6.37E-07
PIHDEPV	4.20E-07	3.71E-07
PIHDLV	7.75E-10	0.00E+00
ENMKCTT	1.52E-07	1.42E-07
OIA	1.60E-07	2.27E-07
OIALF	1.11E-08	8.43E-09
MIALF	1.32E-07	1.33E-07
PJHNSP	1.28E-07	1.28E-07
PLF	2.11E-08	1.94E-08
PID	9.67E-09	9.38E-09
NIH	3.75E-09	3.76E-09
Person-rem	4.74	4.15
Unit 3 Total Cost (3%)	$505,638	$443,622
Unit 3 Total Cost (7%)	$349,656	$306,680
SAMA 07 Saving (3%)	$62,017	
SAMA 07 Saving (7%)	$42,976	

I. Phase II SAMA Number 08: Improve Diagnostics for Diesel Generator Room HVAC

The base case models include the consideration of recovery of a diesel aux board (top ODSB, Unit 2 and Unit 3 models) and recovery of power associated with diesel C room cooling (top ODSBU3, Unit 3).

To bound the potential impact of improved diagnostics for loss of cooling to diesel generator rooms, top events relating to diesel support recovery (ODSB and ODSBU3) were set to guaranteed success.

PSA Model Results

The results from this case indicates about a 0.02% reduction in Unit 2 CDF (CDF_{new}=1.0495E-6). The new end state frequencies are presented in Table 5-12. For Unit 3 there is no reduction in CDF (CDF_{new}=1.8966E-6) and the new end state frequencies are presented in Table 5-13.

Table 5-12. Unit 2 SAMA Number 08 Results

MAAP Case	Baseline Case	SAMA 08 Case
PIHDEP	3.65E-07	3.65E-07
PIHDEPV	2.52E-07	2.52E-07
PIHDLV	7.75E-10	7.75E-10
ENMKCTT	7.39E-08	7.39E-08
OIA	6.90E-08	6.90E-08
OIALF	2.93E-08	2.93E-08
MIALF	1.36E-07	1.36E-07
PJHNSP	6.14E-08	6.14E-08
PLF	4.07E-09	4.07E-09
PID	2.88E-08	2.88E-08
NIH	2.95E-08	2.95E-08
Person-rem	2.27	2.27
Unit 2 Total Cost (3%)	$249,733	$249,646
Unit 2 Total Cost (7%)	$171,970	$171,909
SAMA 08 Saving (3%)	$87	
SAMA 08 Saving (7%)	$61	

Table 5-13. Unit 3 SAMA Number 08 Results

MAAP Case	Baseline Case	SAMA 08 Case
PIHDEP	8.59E-07	8.59E-07
PIHDEPV	4.20E-07	4.20E-07
PIHDLV	7.75E-10	0.00E+00
ENMKCTT	1.52E-07	1.52E-07
OIA	1.60E-07	1.60E-07
OIALF	1.11E-08	1.11E-08
MIALF	1.32E-07	1.32E-07
PJHNSP	1.28E-07	1.28E-07
PLF	2.11E-08	2.11E-08
PID	9.67E-09	9.67E-09
NIH	3.75E-09	3.75E-09
Person-rem	4.74	4.74
Unit 3 Total Cost (3%)	$505,638	$505,485
Unit 3 Total Cost (7%)	$349,656	$349,552
SAMA 08 Saving (3%)	$153	
SAMA 08 Saving (7%)	$105	

J. Phase II SAMA Number 09: Install a Containment Vent Large Enough to Remove ATWS Decay Heat

This SAMA would provide redundancy in the ability to remove decay heat and be of sufficient size to successfully handle ATWS decay heat levels.

To estimate the potential effects of this SAMA, the event tree structure (event tree TRANCDBIN) was reviewed along with the logic rules that determine whether a sequence is assigned to core damage or "success." The relevant logic macro (AHEAT) was modified to reflect the vent (top event VNT) as a potential success path.

PSA Model Results

The results from this case indicates about a 0.9% reduction in Unit 2 CDF (CDF_{new}=1.0400E-6). The new end state frequencies are presented in Table 5-14. For Unit 3 there is a 4% reduction in CDF (CDF_{new}=1.818E-6) and the new end state frequencies are presented in Table 5-15.

Table 5-14. Unit 2 SAMA Number 09 Results

MAAP Case	Baseline Case	SAMA 09 Case
PIHDEP	3.65E-07	3.65E-07
PIHDEPV	2.52E-07	2.52E-07
PIHDLV	7.75E-10	7.75E-10
ENMKCTT	7.39E-08	6.41E-08
OIA	6.90E-08	6.90E-08
OIALF	2.93E-08	2.93E-08
MIALF	1.36E-07	1.36E-07
PJHNSP	6.14E-08	6.14E-08
PLF	4.07E-09	4.07E-09
PID	2.88E-08	2.88E-08
NIH	2.95E-08	2.95E-08
Person-rem	2.27	2.23
Unit 2 Total Cost (3%)	$249,733	$245,836
Unit 2 Total Cost (7%)	$171,970	$169,244
SAMA 09 Saving (3%)	$3,898	
SAMA 09Saving (7%)	$2,726	

Table 5-15. Unit 3 SAMA Number 09 Results

MAAP Case	Baseline Case	SAMA 09 Case
PIHDEP	8.59E-07	8.59E-07
PIHDEPV	4.20E-07	4.20E-07
PIHDLV	7.75E-10	0.00E+00
ENMKCTT	1.52E-07	7.30E-08
OIA	1.60E-07	1.60E-07
OIALF	1.11E-08	1.11E-08
MIALF	1.32E-07	1.32E-07
PJHNSP	1.28E-07	1.28E-07
PLF	2.11E-08	2.11E-08
PID	9.67E-09	9.67E-09
NIH	3.75E-09	3.75E-09
Person-rem	4.74	4.41
Unit 3 Total Cost (3%)	$505,638	$474,249
Unit 3 Total Cost (7%)	$349,656	$327,704
SAMA 09 Saving (3%)	$31,389	
SAMA 09 Saving (7%)	$21,953	

K. Phase II SAMA Number 10: Fire Protection System as Backup Source for Containment Spray

This SAMA considers the use of the Fire Protection water as a backup source for Containment Spray.

To bound the potential impact of this SAMA, the analysis performed for Phase II SAMA 11 (the installation of a passive containment spray system) was used.

L. Phase II SAMA Number 11: Installation of a Passive Containment Spray System

This SAMA would result in the installation of a system capable of providing containment spray and be independent of operator actions.

To bound the potential impact of this SAMA, the top event representing the containment spray function (top event DWS) was set to "success."

PSA Model Results

The results from this case indicates about a 0.3% increase in Unit 2 CDF (CDF_{new}=1.0535E-6). The new end state frequencies are presented in Table 5-16. For Unit 3 there is a 0.5% increase in CDF (CDF_{new}=1.9061E-6) and the new end state frequencies are presented in Table 5-17.

Table 5-16. Unit 2 SAMA Number 11 Results

MAAP Case	Baseline Case	SAMA 11 Case
PIHDEP	3.65E-07	3.66E-07
PIHDEPV	2.52E-07	2.51E-07
PIHDLV	7.75E-10	7.39E-10
ENMKCTT	7.39E-08	7.40E-08
OIA	6.90E-08	9.94E-08
OIALF	2.93E-08	3.04E-08
MIALF	1.36E-07	1.65E-07
PJHNSP	6.14E-08	6.15E-08
PLF	4.07E-09	4.09E-09
PID	2.88E-08	0.00E+00
NIH	2.95E-08	1.19E-09
Person-rem	2.27	Not meaningful
Unit 2 Total Cost (3%)	$249,733	Not meaningful
Unit 2 Total Cost (7%)	$171,970	Not meaningful
SAMA 11 Saving (3%)	Not meaningful	
SAMA 11 Saving (7%)	Not meaningful	

Table 5-17. Unit 3 SAMA Number 11 Results

MAAP Case	Baseline Case	SAMA 11 Case
PIHDEP	8.59E-07	8.63E-07
PIHDEPV	4.20E-07	4.21E-07
PIHDLV	7.75E-10	0.00E+00
ENMKCTT	1.52E-07	1.52E-07
OIA	1.60E-07	1.72E-07
OIALF	1.11E-08	1.14E-08
MIALF	1.32E-07	1.36E-07
PJHNSP	1.28E-07	1.29E-07
PLF	2.11E-08	2.14E-08
PID	9.67E-09	0.00E+00
NIH	3.75E-09	2.18E-10
Person-rem	4.74	Not meaningful
Unit 3 Total Cost (3%)	$505,638	Not meaningful
Unit 3 Total Cost (7%)	$349,656	Not meaningful
SAMA 11 Saving (3%)	Not meaningful	
SAMA 11 Saving (7%)	Not meaningful	

The core damage frequency for this SAMA should be equal to the base case evaluation. The cost of the different cases does not significantly differ from the baseline costs. The fact that the calculated core damage frequencies are slightly greater than the baseline case is attributed to model resolution limitations.

The primary impact of this SAMA is to shift plant damage state to more benign plant damage. From the data presented in Table 3-8, the maximum costs averted are bounded by $100k and $200k for Units 2 and 3, respectively.

M. Phase II SAMA Number 12: Provide Additional DC Battery Capacity

This SAMA would provide additional functional battery life and be especially beneficial during a Station Blackout event.

To bound the potential impact of this SAMA, the logic associated with determining whether a sequence involves core damage or is "success" was modified. This was done by adding additional statements in the split fraction logic in the TRANCDBIN event tree (specifically for the split fraction assignment logic associated with top event NCD). Any sequence involving successful scram, no stuck open relief valves and successful operation and control of either HPCI or RCIC was considered to be successfully mitigated.

This approach involved making the bounding assumption concerning the reliability of operation of HPCI and RCIC for 24 hours. For the purposes of providing a bounding assessment of this SAMA, representing the operation of HPCI/RCIC for 24 hours with the top event representing 6 hours of operation is conservative.

PSA Model Results

The results from this case indicates about a 45.1% reduction in Unit 2 CDF (CDF_{new}=5.7609E-7). The new end state frequencies are presented in Table 5-18. For Unit 3 there is a 51.1% reduction in CDF (CDF_{new}=9.2731E-7) and the new end state frequencies are presented in Table 5-19.

Table 5-18. Unit 2 SAMA Number 12 Results

MAAP Case	Baseline Case	SAMA 12 Case
PIHDEP	3.65E-07	2.24E-08
PIHDEPV	2.52E-07	1.68E-07
PIHDLV	7.75E-10	7.75E-10
ENMKCTT	7.39E-08	7.39E-08
OIA	6.90E-08	3.67E-08
OIALF	2.93E-08	2.93E-08
MIALF	1.36E-07	1.36E-07
PJHNSP	6.14E-08	5.92E-08
PLF	4.07E-09	4.07E-09
PID	2.88E-08	2.02E-08
NIH	2.95E-08	2.52E-08
Person-rem	2.27	1.08
Unit 2 Total Cost (3%)	$249,733	$120,999
Unit 2 Total Cost (7%)	$171,970	$82,888
SAMA 12 Saving (3%)	$128,734	
SAMA 12 Saving (7%)	$89,082	

Table 5-19. Unit 3 SAMA Number 12 Results

MAAP Case	Baseline Case	SAMA 12 Case
PIHDEP	8.59E-07	2.57E-07
PIHDEPV	4.20E-07	1.89E-07
PIHDLV	7.75E-10	0.00E+00
ENMKCTT	1.52E-07	1.52E-07
OIA	1.60E-07	4.81E-08
OIALF	1.11E-08	1.11E-08
MIALF	1.32E-07	1.32E-07
PJHNSP	1.28E-07	1.07E-07
PLF	2.11E-08	2.11E-08
PID	9.67E-09	6.54E-09
NIH	3.75E-09	3.57E-09
Person-rem	4.74	2.26
Unit 3 Total Cost (3%)	$505,638	$239,791
Unit 3 Total Cost (7%)	$349,656	$165,642
SAMA 12 Saving (3%)	$265,847	

SAMA 12 Saving (7%)	$184,014

N. Phase II SAMA Number 13: Improve DC Power Reliability

Two specific Phase I SAMAs focused on improving DC power reliability. SAMA 61 would incorporate additional/alternate battery charging capacity. SAMA 63 would replace station batteries with more reliable ones.

It should be noted that the PSA models already take credit for aligning the spare battery charger.

Reanalyzing the PSA models with "improved" failure probabilities assumed for the station batteries bound the potential impact of improving DC reliability. For the purposes of this analysis, it was assumed that it was possible to improve the unavailability of each of the three station batteries by a factor of 10. This is believed to be a conservative assumption.

PSA Model Results

The results from this case indicates about a 12.3% reduction in Unit 2 CDF (CDF_{new}=9.2058E-7). The new end state frequencies are presented in Table 5-20. For Unit 3 there is a 3.1% reduction in CDF (CDF_{new}=1.8372E-6) and the new end state frequencies are presented in Table 5-21.

Table 5-20. Unit 2 SAMA Number 13 Results

MAAP Case	Baseline Case	SAMA 13 Case
PIHDEP	3.65E-07	3.67E-07
PIHDEPV	2.52E-07	1.76E-07
PIHDLV	7.75E-10	4.83E-10
ENMKCTT	7.39E-08	7.43E-08
OIA	6.90E-08	6.62E-08
OIALF	2.93E-08	2.77E-08
MIALF	1.36E-07	1.35E-07
PJHNSP	6.14E-08	6.15E-08
PLF	4.07E-09	2.97E-09
PID	2.88E-08	5.32E-09
NIH	2.95E-08	4.14E-09
Person-rem	2.27	2.09
Unit 2 Total Cost (3%)	$249,733	$227,368
Unit 2 Total Cost (7%)	$171,970	$156,785
SAMA 13 Saving (3%)	$22,365	
SAMA 13 Saving (7%)	$15,175	

Table 5-21. Unit 3 SAMA Number 13 Results

MAAP Case	Baseline Case	SAMA 13 Case
PIHDEP	8.59E-07	8.61E-07
PIHDEPV	4.20E-07	3.74E-07
PIHDLV	7.75E-10	0.00E+00
ENMKCTT	1.52E-07	1.48E-07
OIA	1.60E-07	1.58E-07
OIALF	1.11E-08	8.83E-09
MIALF	1.32E-07	1.30E-07
PJHNSP	1.28E-07	1.28E-07
PLF	2.11E-08	2.11E-08
PID	9.67E-09	5.70E-09
NIH	3.75E-09	2.47E-09
Person-rem	4.74	4.62
Unit 3 Total Cost (3%)	$505,638	$492,402
Unit 3 Total Cost (7%)	$349,656	$340,571
SAMA 13 Saving (3%)	$13,237	
SAMA 13 Saving (7%)	$9,086	

O. Phase II SAMA Number 14: Develop Procedures to Repair or Replace failed 4-kV Breakers

The specific concern addressed by this SAMA centers on the potential for failure to transfer 4-kV non-emergency busses from the unit station service transformers could lead to the loss of emergency AC power.

To bound the potential impact of this SAMA, the models were reanalyzed with the transfer of power at the unit board level assumed to occur without fault.

PSA Model Results

The results from this case indicates about a 0.02 % increase in Unit 2 calculated CDF (CDF_{new}=1.0500E-6). The new end state frequencies are presented in Table 5-22. For Unit 3 there is a 0.03% increase in the calculated CDF (CDF_{new}=1.8971E-6) and the new end state frequencies are presented in Table 5-23. These changes are due to model resolution limitations. Any costs averted would be very small.

Table 5-22. Unit 2 SAMA Number 14 Results

MAAP Case	Baseline Case	SAMA 14 Case
PIHDEP	3.65E-07	3.65E-07
PIHDEPV	2.52E-07	2.52E-07
PIHDLV	7.75E-10	7.76E-10
ENMKCTT	7.39E-08	7.40E-08
OIA	6.90E-08	6.90E-08
OIALF	2.93E-08	2.93E-08
MIALF	1.36E-07	1.36E-07
PJHNSP	6.14E-08	6.14E-08
PLF	4.07E-09	4.08E-09
PID	2.88E-08	2.88E-08
NIH	2.95E-08	2.95E-08
Person-rem	2.27	2.27
Unit 2 Total Cost (3%)	$249,733	$249,789
Unit 2 Total Cost (7%)	$171,970	$172,308
SAMA 14 Saving (3%)	Not meaningful	
SAMA 14 Saving (7%)	Not meaningful	

Table 5-23. Unit 3 SAMA Number 14 Results

MAAP Case	Baseline Case	SAMA 14 Case
PIHDEP	8.59E-07	8.59E-07
PIHDEPV	4.20E-07	4.20E-07
PIHDLV	7.75E-10	0.00E+00
ENMKCTT	1.52E-07	1.52E-07
OIA	1.60E-07	1.60E-07
OIALF	1.11E-08	1.11E-08
MIALF	1.32E-07	1.32E-07
PJHNSP	1.28E-07	1.28E-07
PLF	2.11E-08	2.11E-08
PID	9.67E-09	9.67E-09
NIH	3.75E-09	3.75E-09
Person-rem	4.74	4.74
Unit 3 Total Cost (3%)	$505,638	$505,659
Unit 3 Total Cost (7%)	$349,656	$349,673
SAMA 14 Saving (3%)	Not meaningful	
SAMA 14 Saving (7%)	Not meaningful	

P. Phase II SAMA Number 15: Redundant and Diverse Source of Cooling to the Diesel Generators

This SAMA would provide a redundant and diverse source, such as the fire protection system, of cooling water for the diesel generators.

To bound the potential impact of this SAMA, the "logical loop" linking the operation of the diesel generators and their normal cooling water source (EECW) was broken. Three assumptions were made:

1. It was assumed that the fire protection system has sufficient capacity to service all eight diesel generators.

2. It was further assumed that the fire protection system is aligned for diesel cooling in a timely manner.

3. The fire protection system is assumed to be perfectly available (i.e., its unavailability is zero) and the operators align the system (or a passive alignment scheme has been implemented) without failure.

To accomplish this model change, top OEE in the high pressure transient event tree (HPGTET) was set to "success". This has the effect of making the generator status macros (e.g., "NOGA" for diesel A) dependent only on the hardware status of the diesel and its associated equipment. In the large LOCA and medium LOCA event trees (LLOCA and MLOCA, respectively), the definition of the generator status macros were modified directly.

PSA Model Results

The results from this case indicates about an 18.9% reduction in Unit 2 CDF (CDF_{new}=8.5118E-7). The new end state frequencies are presented in Table 5-24. For Unit 3 there is a14.2% reduction in CDF (CDF_{new}=1.6266E-6) and the new end state frequencies are presented in Table 5-25.

Table 5-24. Unit 2 SAMA Number 15 Results

MAAP Case	Baseline Case	SAMA 15 Case
PIHDEP	3.65E-07	2.06E-07
PIHDEPV	2.52E-07	2.15E-07
PIHDLV	7.75E-10	4.22E-10
ENMKCTT	7.39E-08	7.39E-08
OIA	6.90E-08	6.59E-08
OIALF	2.93E-08	2.93E-08
MIALF	1.36E-07	1.36E-07
PJHNSP	6.14E-08	6.14E-08
PLF	4.07E-09	4.07E-09
PID	2.88E-08	2.88E-08
NIH	2.95E-08	2.95E-08
Person-rem	2.27	1.76
Unit 2 Total Cost (3%)	$249,733	$194,492
Unit 2 Total Cost (7%)	$171,970	$133,714
SAMA 15 Saving (3%)	$55,242	
SAMA 15 Saving (7%)	$38,256	

Table 5-25. Unit 3 SAMA Number 15 Results

MAAP Case	Baseline Case	SAMA 15 Case
PIHDEP	8.59E-07	6.52E-07
PIHDEPV	4.20E-07	3.76E-07 -
PIHDLV	7.75E-10	0.00E+00
ENMKCTT	1.52E-07	1.52E-07
OIA	1.60E-07	1.41E-07
OIALF	1.11E-08	1.12E-08
MIALF	1.32E-07	1.32E-07
PJHNSP	1.28E-07	1.28E-07
PLF	2.11E-08	2.11E-08
PID	9.67E-09	9.72E-09
NIH	3.75E-09	3.72E-09
Person-rem	4.74	4.03
Unit 3 Total Cost (3%)	$505,638	$430,403
Unit 3 Total Cost (7%)	$349,656	$297,556
SAMA 15 Saving (3%)	$75,236	
SAMA 15 Saving (7%)	$52,100	

Q. Phase II SAMA Number 16: Interfacing System LOCA

This analysis bounds the impact of several potential SAMAs that address interfacing system LOCA scenarios.

To bound the potential impact of these SAMAs, the initiating event frequency for the interfacing system LOCA was set to zero.

PSA Model Results

The results from this case indicates about a 4.4% reduction in Unit 2 CDF (CDF_{new}= 1.0034E-6). The new end state frequencies are presented in Table 5-26. For Unit 3 there is a 2.4% reduction in CDF (CDF_{new}=1.8502E-6) and the new end state frequencies are presented in Table 5-27.

Table 5-26. Unit 2 SAMA Number 16 Results

MAAP Case	Baseline Case	SAMA 16 Case
PIHDEP	3.65E-07	3.65E-07
PIHDEPV	2.52E-07	2.52E-07
PIHDLV	7.75E-10	7.75E-10
ENMKCTT	7.39E-08	7.39E-08
OIA	6.90E-08	6.90E-08
OIALF	2.93E-08	2.93E-08
MIALF	1.36E-07	1.36E-07
PJHNSP	6.14E-08	1.50E-08
PLF	4.07E-09	4.07E-09
PID	2.88E-08	2.88E-08
NIH	2.95E-08	2.95E-08
Person-rem	2.27	2.12
Unit 2 Total Cost (3%)	$249,733	$234,517
Unit 2 Total Cost (7%)	$171,970	$161,379
SAMA 16 Saving (3%)	$15,217	
SAMA 16 Saving (7%)	$10,591	

Table 5-27. Unit 3 SAMA Number 16 Results

MAAP Case	Baseline Case	SAMA 16 Case
PIHDEP	8.59E-07	8.59E-07
PIHDEPV	4.20E-07	4.20E-07
PIHDLV	7.75E-10	7.75E-10
ENMKCTT	1.52E-07	1.52E-07
OIA	1.60E-07	1.60E-07
OIALF	1.11E-08	1.11E-08
MIALF	1.32E-07	1.32E-07
PJHNSP	1.28E-07	8.16E-08
PLF	2.11E-08	2.11E-08
PID	9.67E-09	9.67E-09
NIH	3.75E-09	3.75E-09
Person-rem	4.74	4.58
Unit 3 Total Cost (3%)	$505,638	$490,280
Unit 3 Total Cost (7%)	$349,656	$338,969
SAMA 16 Saving (3%)	$15,358	
SAMA 16 Saving (7%)	$10,688	

R. Phase II SAMA Number 17: Improve Inspection of Rubber Expansion Joints on Main Condenser

This SAMA has the potential to decrease the frequency of flooding events impacting the turbine building.

To estimate the potential impact of improved inspection of condenser expansion joints, the basis for the turbine building flood frequencies was reviewed. Plant-specific screening of the generic flood database in support of the BFN IPE determined that 11 events were applicable to BFN. These 11 events formed the basis for the estimate of the turbine building flooding frequency in the IPE. Two of the eleven events involved failure of expansion joints (of all types). This observation supports the assumption that eliminating expansion joint failure would result in an approximate 20% reduction in the turbine building flooding frequency.

To represent the potential impact of the implementation of this SAMA, the models were reanalyzed with the initiating event flooding frequencies reduced from the base case by 20%. The new flooding frequencies for small and large turbine building floods become 1.152×10^{-2} and 1.760×10^{-3} per year, respectively.

PSA Model Results

The results from this case indicates about a 0.7% reduction in Unit 2 CDF (CDF_{new}=1.0423E-6). The new end state frequencies are presented in Table 5-28. For Unit 3 there is a 0.6% reduction in CDF (CDF_{new}=1.8858E-6) and the new end state frequencies are presented in Table 5-29.

Table 5-28. Unit 2 SAMA Number 17 Results

MAAP Case	Baseline Case	SAMA 17 Case
PIHDEP	3.65E-07	3.64E-07
PIHDEPV	2.52E-07	2.50E-07
PIHDLV	7.75E-10	7.75E-10
ENMKCTT	7.39E-08	7.37E-08
OIA	6.90E-08	6.82E-08
OIALF	2.93E-08	2.93E-08
MIALF	1.36E-07	1.34E-07
PJHNSP	6.14E-08	6.14E-08
PLF	4.07E-09	3.99E-09
PID	2.88E-08	2.80E-08
NIH	2.95E-08	2.94E-08
Person-rem	2.27	2.26
Unit 2 Total Cost (3%)	$249,733	$248,375
Unit 2 Total Cost (7%)	$171,870	$171,046
SAMA 17 Saving (3%)	$1,358	
SAMA 17 Saving (7%)	$924	

Table 5-29. Unit 3 SAMA Number 17 Results

MAAP Case	Baseline Case	SAMA 17 Case
PIHDEP	8.59E-07	8.55E-07
PIHDEPV	4.20E-07	4.18E-07
PIHDLV	7.75E-10	0.00E+00
ENMKCTT	1.52E-07	1.51E-07
OIA	1.60E-07	1.59E-07
OIALF	1.11E-08	1.11E-08
MIALF	1.32E-07	1.30E-07
PJHNSP	1.28E-07	1.27E-07
PLF	2.11E-08	2.08E-08
PID	9.67E-09	9.42E-09
NIH	3.75E-09	3.73E-09
Person-rem	4.74	4.71
Unit 3 Total Cost (3%)	$505,638	$503,004
Unit 3 Total Cost (7%)	$349,656	$347,845
SAMA 17 Saving (3%)	$2,635	
SAMA 17 Saving (7%)	$1,811	

S. Phase II SAMA Number 18: Procedure to Trip Unneeded RHR/CS Pumps on Loss of Room Ventilation

This SAMA would increase the availability of RHR and/or Core Spray pumps by lessening the heat load on the room when area cooling is lost.

The assessment performed to determine the impact on core damage frequency is identical to that performed for Phase II SAMA 2. In this assessment, the contribution of RHR pump and Core Spray train unavailability due to fan cooling failure was determined to no more that 20% of total pump or train unavailability. The PSA models were reanalyzed with the RHR pump and Core Spray train split fractions reduced by 20%. This had the effect of assuming that these pumps no longer had a functional dependency on room cooling.

PSA Model Results

The results from this case indicates about a 19% reduction in Unit 2 CDF (CDF_{new}=8.5438E-7). The new end state frequencies are presented in Table 5-30. For Unit 3 there is an 11% reduction in CDF (CDF_{new}=1.6788E-6) and the new end state frequencies are presented in Table 5-31.

Table 5-30. Unit 2 SAMA Number 18 Results

MAAP Case	Baseline Case	SAMA 18 Case
PIHDEP	3.65E-07	2.09E-07
PIHDEPV	2.52E-07	2.07E-07
PIHDLV	7.75E-10	4.14E-10
ENMKCTT	7.39E-08	7.08E-08
OIA	6.90E-08	8.61E-08
OIALF	2.93E-08	2.15E-08
MIALF	1.36E-07	1.37E-07
PJHNSP	6.14E-08	6.14E-08
PLF	4.07E-09	3.80E-09
PID	2.88E-08	2.84E-08
NIH	2.95E-08	2.96E-08
Person-rem	2.27	1.78
Unit 2 Total Cost (3%)	$249,733	$196,766
Unit 2 Total Cost (7%)	$171,970	$135,321
SAMA 18 Saving (3%)	$52,967	
SAMA 18 Saving (7%)	$36,649	

Table 5-31. Unit 3 SAMA Number 18 Results

MAAP Case	Baseline Case	SAMA 18 Case
PIHDEP	8.59E-07	6.38E-07
PIHDEPV	4.20E-07	3.71E-07
PIHDLV	7.75E-10	0.00E+00
ENMKCTT	1.52E-07	1.42E-07
OIA	1.60E-07	2.27E-07
OIALF	1.11E-08	8.43E-09
MIALF	1.32E-07	1.33E-07
PJHNSP	1.28E-07	1.28E-07
PLF	2.11E-08	1.94E-08
PID	9.67E-09	9.37E-09
NIH	3.75E-09	3.76E-09
Person-rem	4.74	4.15
Unit 3 Total Cost (3%)	$505,638	$443,629
Unit 3 Total Cost (7%)	$349,656	$306,685
SAMA 18 Saving (3%)	$62,010	
SAMA 18 Saving (7%)	$42,971	

T. Phase II SAMA Number 19: Increase the SRV Reseat Reliability

This SAMA would reduce the likelihood that an SRV would fail to reseat following a successful lift.

To bound the potential impact of this SAMA, the PSA models were reanalyzed with the assumption that any valves that lift would successfully reseat. The baseline PSA models associated with initiating events involving the inadvertent lifting of relief valves were not altered in the assessment of this SAMA.

PSA Model Results

The results from this case indicates about a 6% reduction in Unit 2 CDF (CDF_{new}=9.8871E-7). The new end state frequencies are presented in Table 5-32. For Unit 3 there is a 4% reduction in CDF (CDF_{new}=1.8249E-6) and the new end state frequencies are presented in Table 5-33.

Table 5-32. Unit 2 SAMA Number 19 Results

MAAP Case	Baseline Case	SAMA 19 Case
PIHDEP	3.65E-07	3.69E-07
PIHDEPV	2.52E-07	2.08E-07
PIHDLV	7.75E-10	7.75E-10
ENMKCTT	7.39E-08	6.98E-08
OIA	6.90E-08	5.16E-08
OIALF	2.93E-08	2.93E-08
MIALF	1.36E-07	1.38E-07
PJHNSP	6.14E-08	6.12E-08
PLF	4.07E-09	4.12E-09
PID	2.88E-08	2.74E-08
NIH	2.95E-08	2.98E-08
Person-rem	2.27	2.13
Unit 2 Total Cost (3%)	$249,733	$233,905
Unit 2 Total Cost (7%)	$171,970	$161,036
SAMA 19 Saving (3%)	$15,828	
SAMA 19 Saving (7%)	$10,934	

Table 5-33. Unit 3 SAMA Number 19 Results

MAAP Case	Baseline Case	SAMA 19 Case
PIHDEP	8.59E-07	8.69E-07
PIHDEPV	4.20E-07	3.59E-07
PIHDLV	7.75E-10	0.00E+00
ENMKCTT	1.52E-07	1.46E-07
OIA	1.60E-07	1.45E-07
OIALF	1.11E-08	1.11E-08
MIALF	1.32E-07	1.34E-07
PJHNSP	1.28E-07	1.27E-07
PLF	2.11E-08	2.14E-08
PID	9.67E-09	9.54E-09
NIH	3.75E-09	3.79E-09
Person-rem	4.74	4.57
Unit 3 Total Cost (3%)	$505,638	$487,208
Unit 3 Total Cost (7%)	$349,656	$336,926
SAMA 19 Saving (3%)	$18,430	
SAMA 19 Saving (7%)	$12,730	

U. Phase II SAMA Number 20: Reduce the Dependency between the High Pressure Injection System and ADS

This SAMA would reduce the likelihood that failure of the DC power system would significantly impact redundant means of mitigating transients and small LOCAs.

To bound the potential impact of this SAMA, the PSA models were reanalyzed with the DC dependency on HPCI completely removed.

PSA Model Results

The results from this case indicates about a 1% reduction in Unit 2 CDF (CDF_{new}=1.0390E-6). The new end state frequencies are presented in Table 5-34. For Unit 3 there is a 1.5% reduction in CDF (CDF_{new}=1.8675E-6) and the new end state frequencies are presented in Table 5-35.

Table 5-34. Unit 2 SAMA Number 20 Results

MAAP Case	Baseline Case	SAMA 20 Case
PIHDEP	3.65E-07	3.70E-07
PIHDEPV	2.52E-07	2.48E-07
PIHDLV	7.75E-10	7.75E-10
ENMKCTT	7.39E-08	7.39E-08
OIA	6.90E-08	6.90E-08
OIALF	2.93E-08	2.93E-08
MIALF	1.36E-07	1.36E-07
PJHNSP	6.14E-08	6.14E-08
PLF	4.07E-09	1.42E-09
PID	2.88E-08	2.13E-08
NIH	2.95E-08	2.88E-08
Person-rem	2.27	2.28
Unit 2 Total Cost (3%)	$249,733	$249,422
Unit 2 Total Cost (7%)	$171,970	$171,812
SAMA 20 Saving (3%)	$312	
SAMA 20 Saving (7%)	$158	

Table 5-35. Unit 3 SAMA Number 20 Results

MAAP Case	Baseline Case	SAMA 20 Case
PIHDEP	8.59E-07	8.66E-07
PIHDEPV	4.20E-07	3.84E-07
PIHDLV	7.75E-10	0.00E+00
ENMKCTT	1.52E-07	1.52E-07
OIA	1.60E-07	1.60E-07
OIALF	1.11E-08	1.11E-08
MIALF	1.32E-07	1.32E-07
PJHNSP	1.28E-07	1.28E-07
PLF	2.11E-08	1.93E-08
PID	9.67E-09	2.46E-09
NIH	3.75E-09	2.96E-09
Person-rem	4.74	4.67
Unit 3 Total Cost (3%)	$505,638	$498,123
Unit 3 Total Cost (7%)	$349,656	$344,532
SAMA 20 Saving (3%)	$7,515	
SAMA 20 Saving (7%)	$5,124	

The small increase in the calculated dose for Unit 2 is believed to be due to model resolution limitations.

V. Phase II SAMA Number 21: Use of CRD for Alternate Boron Injection

The intent of this SAMA is to provide a second means of injecting a boron solution into the vessel in the event of an ATWS and failure of the SLC System.

The potential benefit of this SAMA was bounded by crediting operation of the CRD hydraulic system as a redundant backup to the SLC system. This was accomplished by modifying the split fraction logic rules that select the value used for top event NCD in the event tree TRANCDBIN. The top event NCD determines whether a sequence involves core damage or is successfully mitigated.

Three assumptions were made:

1. It was assumed that success of top event OSLC (the operator actions associated with initiating the SLC system) was necessary for success of the CRD system in delivering the boron solution to the reactor. Actions by the operator are assumed to be necessary to initiate boron injection via the CRD system. This assumption completely couples those actions with the actions associated with initiating the SLC system. The implication of this assumption is that the CRD system would provide redundancy for hardware failures of the SLC system.

2. It was assumed that any additional operator actions associated with initiating the CRD are represented by top event OSLC.

3. It was also assumed that any additional failure modes of the CRD system over those analyzed in the base case PSA were not significant contributors to CRD system unavailability in its postulated function of delivering boron solution to the reactor.

PSA Model Results

The results from this case indicates about a 1.54% reduction in Unit 2 CDF (CDF_{new}=1.0336E-6). The new end state frequencies are presented in Table 5-36. For Unit 3 there is a 1.5% reduction in CDF (CDF_{new}=1.8811E-6) and the new end state frequencies are presented in Table 5-37.

Table 5-36. Unit 2 SAMA Number 21 Results

MAAP Case	Baseline Case	SAMA 21 Case
PIHDEP	3.65E-07	3.65E-07
PIHDEPV	2.52E-07	2.52E-07
PIHDLV	7.75E-10	7.75E-10
ENMKCTT	7.39E-08	5.77E-08
OIA	6.90E-08	6.90E-08
OIALF	2.93E-08	2.93E-08
MIALF	1.36E-07	1.36E-07
PJHNSP	6.14E-08	6.14E-08
PLF	4.07E-09	4.07E-09
PID	2.88E-08	2.88E-08
NIH	2.95E-08	2.95E-08
Person-rem	2.27	2.21
Unit 2 Total Cost (3%)	$249,733	$243,292
Unit 2 Total Cost (7%)	$171,970	$167,465
SAMA 21 Saving (3%)	$6,441	
SAMA 21 Saving (7%)	$4,505	

Table 5-37. Unit 3 SAMA Number 21 Results

MAAP Case	Baseline Case	SAMA 21 Case
PIHDEP	8.59E-07	8.59E-07
PIHDEPV	4.20E-07	4.20E-07
PIHDLV	7.75E-10	0.00E+00
ENMKCTT	1.52E-07	1.36E-07
OIA	1.60E-07	1.60E-07
OIALF	1.11E-08	1.11E-08
MIALF	1.32E-07	1.32E-07
PJHNSP	1.28E-07	1.28E-07
PLF	2.11E-08	2.11E-08
PID	9.67E-09	9.67E-09
NIH	3.75E-09	3.75E-09
Person-rem	4.74	4.67
Unit 3 Total Cost (3%)	$505,638	$499,343
Unit 3 Total Cost (7%)	$349,656	$345,256
SAMA 21 Saving (3%)	$6,295	
SAMA 21 Saving (7%)	$4,401	

W. Phase II SAMA Number 22: Borate Torus Water

The intent of this SAMA is to provide additional reactivity control by replacing the water in the torus with borated water.

No specialized model was created to provide a bounding assessment of the potential impact of this SAMA. The base case PSA models map all ATWS core damage sequences to a single endstate: ENMKCTT. To bound the potential impact of this SAMA, the frequency of this endstate was set to zero. This has the same effect as assuming that all ATWS scenarios are successfully mitigated.

This analysis does not consider any detrimental effects on plant availability and associated costs that would result with the introduction of borated water into the vessel not in response to an ATWS.

PSA Model Results

The results from this case indicates about a 0.7% reduction in Unit 2 CDF (CDF_{new}=9.759E-7). The new end state frequencies are presented in Table 5-38. For Unit 3 there is a 8% reduction in CDF (CDF_{new}=1.7449E-6) and the new end state frequencies are presented in Table 5-39.

Table 5-38. Unit 2 SAMA Number 22 Results

MAAP Case	Baseline Case	SAMA 22 Case
PIHDEP	3.65E-07	3.65E-07
PIHDEPV	2.52E-07	2.52E-07
PIHDLV	7.75E-10	7.75E-10
ENMKCTT	0.00E-00	0.00E+00
OIA	6.90E-08	6.90E-08
OIALF	2.93E-08	2.93E-08
MIALF	1.36E-07	1.36E-07
PJHNSP	6.14E-08	6.14E-08
PLF	4.07E-09	4.07E-09
PID	2.88E-08	2.88E-08
NIH	2.95E-08	2.95E-08
Person-rem	2.27	1.96
Unit 2 Total Cost (3%)	$249,733	$220,352
Unit 2 Total Cost (7%)	$171,970	$151,419
SAMA 22 Saving (3%)	$29,381	
SAMA 22 Saving (7%)	$20,551	

Table 5-39. Unit 3 SAMA Number 22 Results

MAAP Case	Baseline Case	SAMA 22 Case
PIHDEP	8.59E-07	8.59E-07
PIHDEPV	4.20E-07	4.20E-07
PIHDLV	7.75E-10	7.75E-10
ENMKCTT	0.00E+00	0.00E+00
OIA	1.60E-07	1.60E-07
OIALF	1.11E-08	1.11E-08
MIALF	1.32E-07	1.32E-07
PJHNSP	1.28E-07	1.28E-07
PLF	2.11E-08	2.11E-08
PID	9.67E-09	9.67E-09
NIH	3.75E-09	3.75E-09
Person-rem	4.74	4.10
Unit 3 Total Cost (3%)	$505,638	$445,371
Unit 3 Total Cost (7%)	$349,656	$307,502
SAMA 22 Saving (3%)	$60,268	
SAMA 22 Saving (7%)	$42,155	

X. Phase II SAMA Number 23: Automate Torus Cooling

The purpose of this SAMA is to eliminate the possibility of failing to initiate torus cooling because of operator error.

To represent the potential impact of this SAMA, the operator action associated with the initiation of torus cooling was set to "guaranteed success."

This change was implemented in the low pressure transient event tree (LPGTET), the large LOCA event tree (LLOCA) and the medium LOCA event tree (MLOCA) by setting the value (failure probability) of top event OSP (operator initiates torus cooling) to 0.

The model adopted assumes that the contribution to failure of any necessary sensors, monitors or other actuation devices does not significantly contribute to the likelihood of actuation failure.

PSA Model Results

The results from this case indicates about a 6% reduction in Unit 2 CDF (CDF_{new}=9.8217E-7). The new end state frequencies are presented in Table 5-40. For Unit 3 there is a 9% reduction in CDF (CDF_{new}=1.7264E-6) and the new end state frequencies are presented in Table 5-41.

Table 5-40. Unit 2 SAMA Number 23 Results

MAAP Case	Baseline Case	SAMA 23 Case
PIHDEP	3.65E-07	3.51E-07
PIHDEPV	2.52E-07	1.99E-07
PIHDLV	7.75E-10	7.70E-10
ENMKCTT	7.39E-08	7.42E-08
OIA	6.90E-08	6.90E-08
OIALF	2.93E-08	2.93E-08
MIALF	1.36E-07	1.36E-07
PJHNSP	6.14E-08	6.14E-08
PLF	4.07E-09	2.76E-09
PID	2.88E-08	2.88E-08
NIH	2.95E-08	2.94E-08
Person-rem	2.27	2.12
Unit 2 Total Cost (3%)	$249,733	$232,927
Unit 2 Total Cost (7%)	$171,970	$160,377
SAMA 23 Saving (3%)	$16,807	
SAMA 23 Saving (7%)	$11,593	

Table 5-41. Unit 3 SAMA Number 23 Results

MAAP Case	Baseline Case	SAMA 23 Case
PIHDEP	8.59E-07	7.86E-07
PIHDEPV	4.20E-07	3.33E-07
PIHDLV	7.75E-10	0.00E+00
ENMKCTT	1.52E-07	1.48E-07
OIA	1.60E-07	1.60E-07
OIALF	1.11E-08	1.11E-08
MIALF	1.32E-07	1.32E-07
PJHNSP	1.28E-07	1.28E-07
PLF	2.11E-08	1.54E-08
PID	9.67E-09	9.67E-09
NIH	3.75E-09	3.68E-09
Person-rem	4.74	4.33
Unit 3 Total Cost (3%)	$505,638	$461,218
Unit 3 Total Cost (7%)	$349,656	$318,866
SAMA 23 Saving (3%)	$44,421	
SAMA 23 Saving (7%)	$30,690	

Y. Phase II SAMA Number 24: Containment Overpressure Protection

This Phase II SAMA represents the potential impact of two specific Phase I SAMAs: 117a (Provide Torus Positive Pressure Relief Valves); and, 117b (Reduce Drywell Head Bolt Pretension).

As analyzed, this SAMA does not alter the calculated core damage frequency, but instead changes the core damage endstate for selected sequences. The current models only consider a limited number of plant damage endstates. The only "containment failed late" endstate is "PLF." All sequences mapped to PLF were instead mapped to endstate "PIHDEP," implying low vessel pressure, no water on the drywell floor, no water to the debris and no suppression pool cooling.

It is possible that this SAMA could reduce the core damage frequency of the units. One typical BWR core damage scenario involves loss of offsite power and long term operation of HPCI and/or RCIC to maintain vessel level. In this scenario, all the decay heat is being deposited in the suppression pool, the ultimate source of water for HPCI and RCIC. If the excess heat is not removed from the suppression pool (and assuming that the high temperature water does not cause failure of the systems used for vessel level control), then ultimately the containment will fail by overpressure. At this point, the suppression pool water may be below saturation pressure. Loss of vessel injection is then possible, and core damage is likely to occur. If the containment overpressure failure can be avoided, then more time would be available to recover power or other support systems. An evaluation of the results of the two base case models concludes that the suppression pool cooling failure occurs in 4% and 28% (by frequency) of the Unit 2 and Unit 3 core damage scenarios, respectively.

On the other hand, faulty operation of containment pressure relief valves or premature lifting of the drywell head could lead to loss of NPSH and a potential increase in the core damage frequency.

PSA Model Results

As analyzed, results from this case indicates negotiable (less than 0.15%) change in the calculated Unit 2 CDF. The new end state frequencies are presented in Table 5-42. For Unit 3 there is also a negotiable (less than 1.1%) change in the calculated CDF and the new end state frequencies are presented in Table 5-43.

Table 5-42. Unit 2 SAMA Number 24 Results

MAAP Case	Baseline Case	SAMA 24 Case
PIHDEP	3.65E-07	5.16E-07
PIHDEPV	2.52E-07	1.05E-07
PIHDLV	7.75E-10	7.75E-10
ENMKCTT	7.39E-08	7.39E-08
OIA	6.90E-08	6.90E-08
OIALF	2.93E-08	2.93E-08
MIALF	1.36E-07	1.36E-07
PJHNSP	6.14E-08	6.14E-08
PLF	4.07E-09	1.42E-09
PID	2.88E-08	2.88E-08
NIH	2.95E-08	2.95E-08
Person-rem	2.27	2.36
Unit 2 Total Cost (3%)	$249,733	$256,932
Unit 2 Total Cost (7%)	$171,970	$177,112
SAMA 24 Saving (3%)	Not meaningful	
SAMA 24 Saving (7%)	Not meaningful	

Table 5-43. Unit 3 SAMA Number 24 Results

MAAP Case	Baseline Case	SAMA 24 Case
PIHDEP	8.59E-07	1.19E-06
PIHDEPV	4.20E-07	1.14E-07
PIHDLV	7.75E-10	0.00E+00
ENMKCTT	1.52E-07	1.52E-07
OIA	1.60E-07	1.60E-07
OIALF	1.11E-08	1.11E-08
MIALF	1.32E-07	1.32E-07
PJHNSP	1.28E-07	1.28E-07
PLF	2.11E-08	1.93E-08
PID	9.67E-09	9.67E-09
NIH	3.75E-09	3.75E-09
Person-rem	4.74	4.94
Unit 3 Total Cost (3%)	$505,638	$524,348
Unit 3 Total Cost (7%)	$349,656	$362,927
SAMA 24 Saving (3%)	Not meaningful	
SAMA 24 Saving (7%)	Not meaningful	

The negative saving values implied here are likely due to limitations in the Level 2 interface and represent limits in the resolution of the model for this issue. If all suppression pool cooling failure scenarios were eliminated by this SAMA, then the costs would be reduced by approximately 4% and 28% for Unit 2 and Unit 3, respectively. This bounding approach would suggest that the savings would be bounded by $9,989 and $141,600 for Units 2 and 3, respectively.

Z. Phase II SAMA Number 25: Automate SLC Initiation

This SAMA would eliminate the failure of the SLC system to inject boron solution to the vessel due to operator error.

To represent the potential impact of this SAMA, the operator action associated with the initiation of the SLC system was set to "guaranteed success."

This change was implemented in the high pressure transient event tree (HPGTET) by setting the value (failure probability) of top event OSLC (operator initiates SLC injection) to 0.

The model adopted assumes that the contribution to failure of any necessary sensors, monitors or other actuation devices does not significantly contribute to the likelihood of actuation failure.

PSA Model Results

The results from this case indicates about a negotiable (less than 2.5%) change in Unit 2 CDF (CDF_{new}=1.0258E-6). The new end state frequencies are presented in Table 5-44. For Unit 3 there is also a negotiable (less than 1.5%) change in CDF (CDF_{new}=1.8746E-6) and the new end state frequencies are presented in Table 5-45.

Table 5-44. Unit 2 SAMA Number 25 Results

MAAP Case	Baseline Case	SAMA 25 Case
PIHDEP	3.65E-07	3.65E-07
PIHDEPV	2.52E-07	2.52E-07
PIHDLV	7.75E-10	7.75E-10
ENMKCTT	7.39E-08	5.00E-08
OIA	6.90E-08	6.90E-08
OIALF	2.93E-08	2.93E-08
MIALF	1.36E-07	1.36E-07
PJHNSP	6.14E-08	6.14E-08
PLF	4.07E-09	4.07E-09
PID	2.88E-08	2.88E-08
NIH	2.95E-08	2.95E-08
Person-rem	2.27	2.17
Unit 2 Total Cost (3%)	$249,733	$240,203
Unit 2 Total Cost (7%)	$171,970	$165,304
SAMA 25 Saving (3%)	$9,531	
SAMA 25 Saving (7%)	$6,666	

Table 5-45. Unit 3 SAMA Number 25 Results

MAAP Case	Baseline Case	SAMA 25 Case
PIHDEP	8.59E-07	8.59E-07
PIHDEPV	4.20E-07	4.20E-07
PIHDLV	7.75E-10	0.00E+00
ENMKCTT	1.52E-07	1.30E-07
OIA	1.60E-07	1.60E-07
OIALF	1.11E-08	1.11E-08
MIALF	1.32E-07	1.32E-07
PJHNSP	1.28E-07	1.28E-07
PLF	2.11E-08	2.11E-08
PID	9.67E-09	9.67E-09
NIH	3.75E-09	3.75E-09
Person-rem	4.74	4.64
Unit 3 Total Cost (3%)	$505,638	$496,764
Unit 3 Total Cost (7%)	$349,656	$343,452
SAMA 25 Saving (3%)	$8,874	
SAMA 25 Saving (7%)	$6,205	

AA. Phase II SAMA Number 26: Decrease Frequency of Excessive LOCA

This Phase II SAMA addressed Phase I SAMA 122a (Increase the Inspection Frequency of the Reactor Vessel).

To bound the potential impact of this SAMA, the models were reanalyzed with the initiating event frequency of "Excessive LOCA" set to 0.

PSA Model Results

The results from this case indicates about a 0.9% reduction in Unit 2 CDF (CDF_{new}=1.0404E-6). The new end state frequencies are presented in Table 5-46. For Unit 3 there is a 0.5% reduction in CDF (CDF_{new}=1.8873E-6) and the new end state frequencies are presented in Table 5-47.

Table 5-46. Unit 2 SAMA Number 26 Results

MAAP Case	Baseline Case	SAMA 26 Case
PIHDEP	3.65E-07	3.65E-07
PIHDEPV	2.52E-07	2.52E-07
PIHDLV	7.75E-10	7.75E-10
ENMKCTT	7.39E-08	7.39E-08
OIA	6.90E-08	5.96E-08
OIALF	2.93E-08	2.93E-08
MIALF	1.36E-07	1.36E-07
PJHNSP	6.14E-08	6.14E-08
PLF	4.07E-09	4.07E-09
PID	2.88E-08	2.88E-08
NIH	2.95E-08	2.95E-08
Person-rem	2.27	2.25
Unit 2 Total Cost (3%)	$249,733	$247,240
Unit 2 Total Cost (7%)	$171,970	$170,246
SAMA 26 Saving (3%)	$2,493	
SAMA 26 Saving (7%)	$1,724	

Table 5-47. Unit 3 SAMA Number 26 Results

MAAP Case	Baseline Case	SAMA 26 Case
PIHDEP	8.59E-07	8.59E-07
PIHDEPV	4.20E-07	4.20E-07
PIHDLV	7.75E-10	0.00E+00
ENMKCTT	1.52E-07	1.52E-07
OIA	1.60E-07	1.51E-07
OIALF	1.11E-08	1.11E-08
MIALF	1.32E-07	1.32E-07
PJHNSP	1.28E-07	1.28E-07
PLF	2.11E-08	2.11E-08
PID	9.67E-09	9.67E-09
NIH	3.75E-09	3.75E-09
Person-rem	4.74	4.71
Unit 3 Total Cost (3%)	$505,638	$503,005
Unit 3 Total Cost (7%)	$349,656	$347,837
SAMA 26 Saving (3%)	$2,634	
SAMA 26 Saving (7%)	$1,819	

BB. Phase II SAMA Number 27: Provide an Independent Torus Cooling System

This SAMA would mitigate the failure of torus cooling due to hardware failures.

The base case models already include consideration of the possibility of recovery of torus cooling, if failure was due to hardware unavailability. To bound the potential impact of this SAMA, the top event in the low pressure transient event tree (LPGTET), the large LOCA event tree (LLOCA) and the medium LOCA event tree (MLOCA) which represents recovery of suppression pool cooling (top SPR) was set to 'guaranteed success".

The results of the reanalysis with SPR set to guaranteed success are shown below in Tables 5-48 and 5-49.

PSA Model Results

Table 5-48. Unit 2 SAMA Number 27 Results

MAAP Case	Baseline Case	SAMA 27 Case
PIHDEP	3.65E-07	3.45E-07
PIHDEPV	2.52E-07	2.31E-07
PIHDLV	7.75E-10	7.36E-10
ENMKCTT	7.39E-08	7.39E-08
OIA	6.90E-08	1.85E-07
OIALF	2.93E-08	2.93E-08
MIALF	1.36E-07	1.36E-07
PJHNSP	6.14E-08	6.14E-08
PLF	4.07E-09	3.26E-09
PID	2.88E-08	3.05E-08
NIH	2.95E-08	2.95E-08
Person-rem	2.27	Not meaningful
Unit 2 Total Cost (3%)	$249,733	Not meaningful
Unit 2 Total Cost (7%)	$171,970	Not meaningful
SAMA 27 Saving (3%)	Not meaningful	
SAMA 27 Saving (7%)	Not meaningful	

Table 5-49. Unit 3 SAMA Number 27 Results

MAAP Case	Baseline Case	SAMA 27 Case
PIHDEP	8.59E-07	6.32E-07
PIHDEPV	4.20E-07	2.96E-07
PIHDLV	7.75E-10	0.00E+00
ENMKCTT	1.52E-07	1.36E-07
OIA	1.60E-07	5.85E-07
OIALF	1.11E-08	1.11E-08
MIALF	1.32E-07	1.32E-07
PJHNSP	1.28E-07	1.28E-07
PLF	2.11E-08	1.97E-08
PID	9.67E-09	1.14E-08
NIH	3.75E-09	3.67E-09
Person-rem	4.74	Not meaningful
Unit 3 Total Cost (3%)	$505,638	Not meaningful
Unit 3 Total Cost (7%)	$349,656	Not meaningful
SAMA 27 Saving (3%)	Not meaningful	
SAMA 27 Saving (7%)	Not meaningful	

Note that the calculated the total core damage frequencies for the SAMA 27 case are larger than the corresponding values of the base case. This is due to limitations of the base case model. Any costs averted would be less than $250k and $506k for Units 2 and 3, respectively.

CC. Phase II SAMA Number 28: Improve 4-kV Crosstie Capability

This SAMA seeks to improve the ability to crosstie emergency boards from Units 1 and 2 to Unit 3. This would be accomplished using the shutdown busses. Likewise, the ability to crosstie Unit 3 boards to support Unit 2 was considered. It is noted that the base case model already includes limited support of Unit 2 emergency busses from Unit 3.

To bound the potential impact of this SAMA, individual split fraction rules and macro-logic associated with AC power support of RHR, Core Spray, and long term operation of HPCI and RCIC were modified. It was assumed that any Unit 3 diesel could feed any Unit 1 or 2 4-kV shutdown board, and that any Units 1 or 2 diesel could feed any Unit 3 4-kV shutdown board. It was further assumed that any necessary operator actions to accomplish required breaker manipulations would be done without fail and that breaker and bus failures would not significantly contribute to failure.

PSA Model Results

The results from this case indicates about a 4.2% reduction in Unit 2 CDF (CDF_{new}=1.0053E-6). The new end state frequencies are presented in Table 5-50. For

Unit 3 there is a 29% reduction in CDF (CDF_{new}=1.3417E-6) and the new end state frequencies are presented in Table 5-51.

Table 5-50. Unit 2 SAMA Number 28 Results

MAAP Case	Baseline Case	SAMA 28 Case
PIHDEP	3.65E-07	3.09E-07
PIHDEPV	2.52E-07	2.33E-07
PIHDLV	7.75E-10	7.75E-10
ENMKCTT	7.39E-08	7.39E-08
OIA	6.90E-08	9.95E-08
OIALF	2.93E-08	2.93E-08
MIALF	1.36E-07	1.36E-07
PJHNSP	6.14E-08	6.14E-08
PLF	4.07E-09	4.82E-09
PID	2.88E-08	2.83E-08
NIH	2.95E-08	2.95E-08
Person-rem	2.27	2.15
Unit 2 Total Cost (3%)	$249,733	$237,149
Unit 2 Total Cost (7%)	$171,970	$163,251
SAMA 28 Saving (3%)	$12,584	
SAMA 28 Saving (7%)	$8,719	

Table 5-51. Unit 3 SAMA Number 28 Results

MAAP Case	Baseline Case	SAMA 28 Case
PIHDEP	8.59E-07	5.35E-07
PIHDEPV	4.20E-07	2.55E-07
PIHDLV	7.75E-10	0.00E+00
ENMKCTT	1.52E-07	1.51E-07
OIA	1.60E-07	9.80E-08
OIALF	1.11E-08	1.11E-08
MIALF	1.32E-07	1.32E-07
PJHNSP	1.28E-07	1.28E-07
PLF	2.11E-08	1.92E-08
PID	9.67E-09	8.43E-09
NIH	3.75E-09	3.67E-09
Person-rem	4.74	3.35
Unit 3 Total Cost (3%)	$505,638	$355,428
Unit 3 Total Cost (7%)	$349,656	$245,733
SAMA 28 Saving (3%)	$150,210	
SAMA 28 Saving (7%)	$103,924	

DD. Phase II SAMA Number 29: Provide High Pressure Diesel-Driven Pump

This SAMA would provide an additional means of mitigating a station blackout event by allowing river water to be injected into the vessel.

To bound the potential impact of this SAMA, a variant of the model developed to consider SAMA 12 was used. To estimate the effect of an independent diesel driven high pressure injection source, two changes were made to the base case models. First a new logic rule was added to the TRANCDBIN event tree for top event NCD. Top event NCD determines whether a sequence is assigned to a core damage state or represents successful mitigation of the event. This new "success" rule states that if RPS is successful and if HPCI and operator control are successful, then core damage is averted. Next, the split fractions, including the one representing "guaranteed failure" of short term HPCI operation were modified. It was estimated that the unavailability of a diesel driven injection system, including start, 24-hour operation and maintenance would be on the order of 0.1. Therefore the HPCI split fractions were reduced by one order of magnitude.

PSA Model Results

The results from this case indicates about a 74% reduction in Unit 2 CDF (CDF_{new}=2.7173E-7). The new end state frequencies are presented in Table 5-52. For Unit 3 there is a 82% reduction in CDF (CDF_{new}=3.4154E-7) and the new end state frequencies are presented in Table 5-53.

Table 5-52. Unit 2 SAMA Number 29 Results

MAAP Case	Baseline Case	SAMA 29 Case
PIHDEP	3.65E-07	0.00E+00
PIHDEPV	2.52E-07	5.69E-08
PIHDLV	7.75E-10	7.71E-10
ENMKCTT	7.39E-08	7.41E-08
OIA	6.90E-08	1.24E-08
OIALF	2.93E-08	2.82E-08
MIALF	1.36E-07	1.41E-08
PJHNSP	6.14E-08	6.09E-08
PLF	4.07E-09	1.75E-10
PID	2.88E-08	2.67E-09
NIH	2.95E-08	2.15E-08
Person-rem	2.27	0.69
Unit 2 Total Cost (3%)	$249,733	$71,496
Unit 2 Total Cost (7%)	$171,970	$49,418
SAMA 29 Saving (3%)	$178,238	
SAMA 29 Saving (7%)	$122,552	

Table 5-53. Unit 3 SAMA Number 29 Results

MAAP Case	Baseline Case	SAMA 29 Case
PIHDEP	8.59E-07	0.00E+00
PIHDEPV	4.20E-07	5.13E-08
PIHDLV	7.75E-10	0.00E+00
ENMKCTT	1.52E-07	1.56E-07
OIA	1.60E-07	1.83E-08
OIALF	1.11E-08	1.11E-08
MIALF	1.32E-07	1.38E-08
PJHNSP	1.28E-07	8.74E-08
PLF	2.11E-08	1.35E-09
PID	9.67E-09	7.40E-10
NIH	3.75E-09	1.79E-09
Person-rem	4.74	1.11
Unit 3 Total Cost (3%)	$505,638	$109,861
Unit 3 Total Cost (7%)	$349,656	$76,425
SAMA 29 Saving (3%)	$395,778	
SAMA 29 Saving (7%)	$273,232	

EE. Verification of the Model

Two RISKMAN® models were received from BFN for use in the SAMA analysis. Model U2011701 represents the base case for the operation of Unit 2 while model U3011701 represents the base case for the operation of Unit 3.

Because multiple computers were used to perform the required analyses, it was first necessary to verify that these computers would reproduce the results of the base cases. For each computer used in the SAMA analysis, models U2011701 and U3011701 were reanalyzed and the results compared to the original base case results. In all cases, the base case results were reproduced exactly.

FF. Reassignment of Core Damage Scenario End States

Models U2011701 and U3011701 characterized core damage scenarios as either 'LERF' or 'NLERF'. These characterizations are referred to as "end states". LERF scenarios are those core damage sequences that result in a "large early release" of radioactive material. The sum of the frequencies of these scenarios is the "large early release frequency." In a similar manner, core damage scenarios that do not involve a "large early release" were assigned to the 'NLERF' (no 'LERF') end state.

The LERF and NLERF end states do not sufficiently differentiate the core damage sequences to enable linkage to the conditional offsite consequence analyses. The offsite consequence analyses, and supporting MAAP analyses, utilized the end state definitions developed in the BFN Unit 2 IPE. It was therefore necessary to reassign the core damage scenarios used in the base case models to the set of end states consistent with the Level 2 (MAAP) and Level 3 (CRAC2) analyses.

The base case models with the IPE endstate binning were named U2PDSB and U3PDSB corresponding to Unit 2 and Unit 3, respectively.

Since only the assignments of end states were changed, the total calculated core damage frequency for either unit did not change.

GG. Investigation of the Impact of "Truncation Frequency" Chosen

Since the models are so large and take a significant amount of time to run, an analysis was performed to verify that the "truncation frequency" used in the U2011701 and U3011701 models would yield reasonable results. To accomplish this, several computer runs were completed. These runs included a baseline run for each unit with additional computer runs for both units with the resolved sequence frequencies truncated at 1E-13, 1E-14, and 1E-15. For Unit 2 an additional run was completed with the frequency truncated at 1E-16. The results of these runs are presented in Figures 5-1 and 5-2.

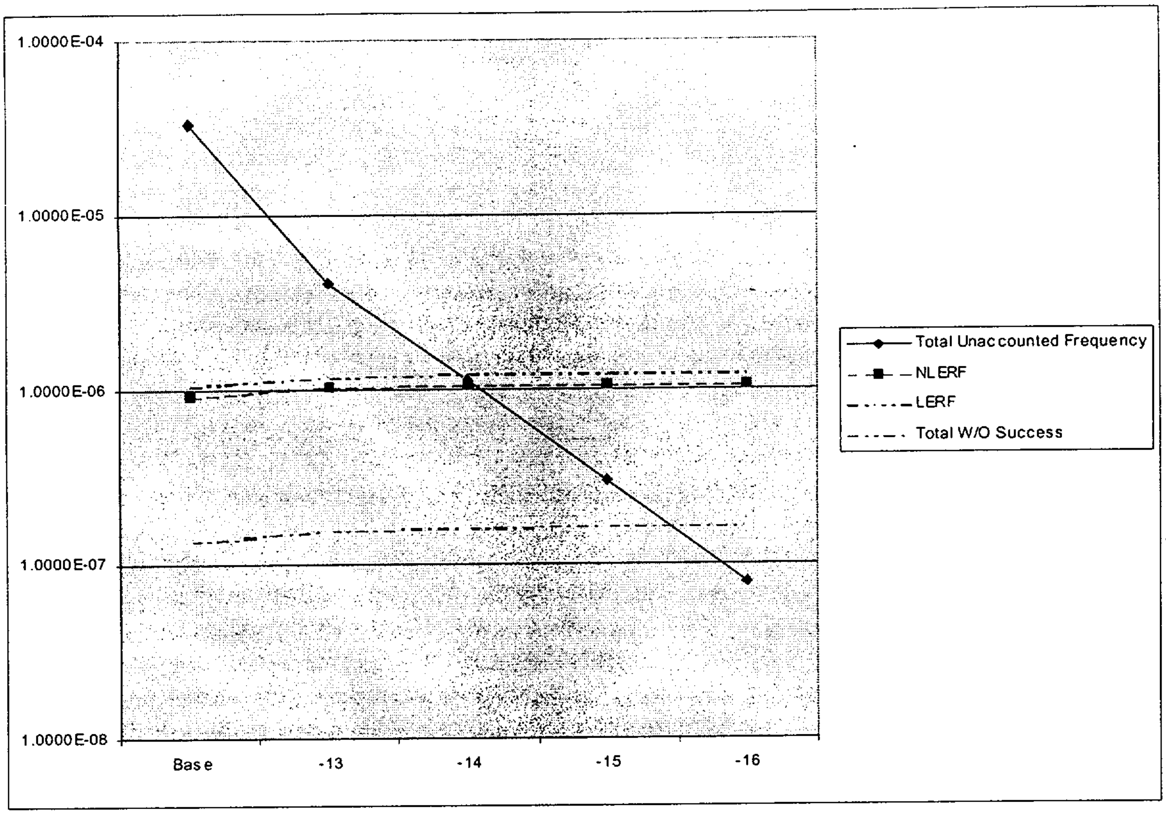


Figure 5-1. Results of the Truncation Frequency Verification for Unit 2

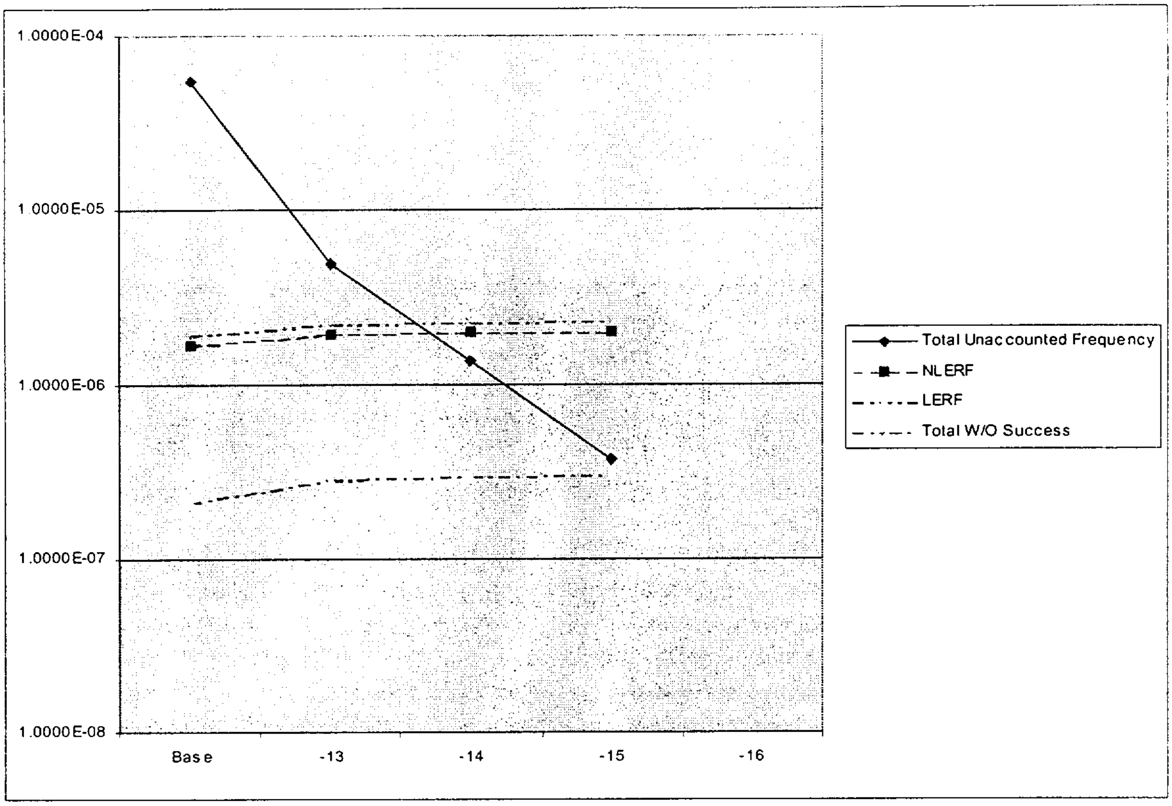


Figure 5-2. Results of the Truncation Frequency Verification for Unit 3

As can be seen in Figures 5-1 and 5-2, there is very little change between the values for LERF and NLERF above 1E-13. Based on these results the SAMA computer runs were truncated at 1E-13.

HH. Consideration of Dual Unit Events

As discussed in the BFN Multi Unit PRA, selected initiator, have the potential to result in core damage in both Unit 2 and Unit 3. SBO is an example of a class of scenarios with this potential. The cost of such scenario, in the unlikely event that they were to occur, would likely be equal to or less than the cost associated with two independent core damage events. It is therefore concluded that considering post accident costs on a per unit basis is appropriate and perhaps conservative.

Implementation costs, on the other hand, are result approximately considered on a per plant basis for specific SAMAs. One example would be replacement of the station batteries. The cost/benefits comparison for these specific SAMAs are made on a plant basis.

II. Uncertainty

An important consideration in any PSA involves the evaluation of uncertainty and its potential impact on the information provided to support management decisions. The uncertainty in the total core damage frequency was calculated for both base case models. The results are shown in Table 5-54.

Table 5-54. Table x Core Damage Uncertainty

	Unit 2	Unit 3
Mean value	1.0498E-6	1.9866E-6
5th percentile	2.4458E-7	3.1794E-7
50th percentile	7.2170E-7	1.1919E-6
95th percentile	2.8152E-6	5.6597E-6

Note that the ratio of the 95th percentile to the mean is 2.7 and 2.8 for Units 2 and 3, respectively. The values in Table X reflect the uncertainty in the data distributions used in the analysis. Each of the Phase II SAMA evaluations were reviewed to determine if a factor of 3 would alter the decision to screen any of them

One SAMA (SAMA 108: Procedure to Trip Unneeded RHR/CS Pumps on Loss of Ventilation) would survive the screening process under this decision criterion.

A second source of uncertainty is "modeling uncertainty." Typically this is included in PSAs in the form of uncertainty in success criteria or phenomenological issues. In the BFN models, however, conservative success criteria were used when analyses to support more realistic criteria were not available. Also, phenomenological phenomena considerations were limited to the Level 2 analyses. However, the linked event tree approach does allow for the determination of the modeling uncertainty introduced in the quantification process. Because of the method of quantification, the total frequency of truncated sequences are tracked in the linked event tree analysis approach when frequency truncation is used. The analyses investigating the potential impact of the selected frequency truncation values offers evidence that the potential impact of this source of uncertainty is on the order of 20%. None of the screened Phase II SAMAs were within 20% of acceptance using the base case truncation parameters.

JJ. Relationship of SAMA PSA Models to BFN IPE and Multiunit PSA Models

(This section to be added by TVA)

VI. SAMA Analysis Results

A. SAMA Analysis Results for BFNP

A summary comparison of estimate costs and costs averted is shown in Table 6-1 for the Phase II SAMAs.

B. SAMA Analysis Results from Previous Submittals

A review of previously approved and submitted SAMA analyses was performed to determine the potential scope of changes that would reasonably be expected to be applicable to this analysis. The following paragraphs are quoted from the conclusion of each referenced SAMA analysis.

Calvert Cliffs (approved) – "BGE identified and committed to pursue one enhancement in accordance with the CCNPP modification process. This involves the installation of a watertight door between the service water pump room and the adjacent fan room to reduce the likelihood of core damage from internal flooding events. BGE also committed to further evaluate the adequacy of CCNPP procedures regarding response to internal floods following resolution of the hardware flooding enhancement. BGE concluded that no additional mitigation alternatives are cost-beneficial and warrant implementation at CCNPP."

Oconee (approved) – "Because the environmental impacts of potential severe accidents are of small significance and because additional measures to reduce such impacts would not be justified from a public risk perspective, Duke concludes that no additional severe accident mitigation alternative measures beyond those already implemented during the current term license would be warranted for Oconee."

Hatch (in review by the USNRC) – "None of the SAMAs analyzed would be being[sic] justified on a cost-benefit basis."

Arkansas Nuclear One Unit 1 (approved by the USNRC) – "As a result of this reassessment, the "marginally" cost-beneficial SAMA 129 became more cost-beneficial. All other SAMA candidates retained negative net values. SAMA 129 involves improvements in training and awareness associated with operator actions required to swapover from the injection phase to low-pressure recirculation during a large LOCA. This SAMA does not relate to adequately managing the effects of aging during the period of extended operation and based on further information provided by Entergy, appears to be adequately addressed within the current operations training cycle. Therefore, no further action is necessary as part of license renewal pursuant to 10 CFR Part 54.

G:\DWSnodgrass\BFN\Third Draft\Appendix A SAMA 3rd Draft.doc
/oc

Table 6-1. Evaluation of Phase II SAMAs

Phase II SAMA ID No.	Phase I SAMA ID No.	SAMA Title	Estimated Cost (2001)	Estimated Cost (2016)	Maximum Cost Avoidance (Unit 2 / Unit 3)	Cost Effective?
1	7	Increase CRD pump lube oil capacity.	N/A	N/A	N/A	N
2	12	Replace ECCS pump motor with air-cooled motors.	Estimated cost greater than $6M per unit	Greater than $9.3M per unit	$53k/$62k	N
3	17	Implement procedures to stagger CRD pump use after a loss of service water.	$50k/unit	$78k/unit	N/A	N
4	19	Procedural guidance for use of cross-tied component cooling or service water pumps.	$50k/unit	$78k/unit	$1.7k/$7k	N
5	20	Procedure enhancements and operator training in support system failure sequences, with emphasis on anticipating problems and coping.	$50k/unit	$78k/unit	Less than $1k/Less than $1k	N
6	21	Improved ability to cool the residual heat removal heat exchangers	Greater than $100k/unit	Greater than $155k/unit	$7.2k/$47.9k	N
7	23	Provide a redundant train of ventilation.	Greater than $6M/unit.	Greater than $9.3M per unit	$53k/$62k	N
8	25	Add a diesel building switchgear room high temperature alarm.	option 1: $400k per building option 2: $6M per building	Option 1: $623 per building Option 2: $9.3M per building	Less than $100/ Less than $200	N
9	34	Install a containment vent large enough to remove ATWS decay heat.	$2M/unit	$3.1M/unit	$3.9k/$31.4k	N
10	46	Use the fire protection system as a back-up source for the containment spray system.	$500k/unit	$779k/unit	Less than $100k/ Less than $200k *	N
11	48	Install a passive containment spray system.	Greater than $6M/unit	Greater than $9.3M/unit	Less than $100k/ Less than $200k *	N

G:\DWSnodgrass\BFN\Third Draft\Appendix A SAMA 3rd Draft.doc

/oc

Table 6-1. Evaluation of Phase II SAMAs (Continued)

Phase II SAMA ID No.	Phase I SAMA ID No.	SAMA Title	Estimated Cost (2001)	Estimated Cost (2016)	Maximum Cost Avoidance (Unit 2 / Unit 3)	Cost Effective?
12	57	Provide additional DC battery capacity.	$1M/plant	$1.5M/plant	$129k/$266k	N
	58	Use fuel cells instead of lead-acid batteries.	Greater than $6M/plant	Greater than $9.3M/plant		N
	62	Increase/improve DC bus load shedding.	$50k/plant	$78k/plant		Y
	9	Add redundant DC Control Power for SW pumps	$1M/plant	$1.5M/plant		N
13	61	Incorporate an alternate battery charging capability.	$100k/unit	155k/unit	$22.3k/$13.2k	N
	63	Replace existing batteries with more reliable ones.	Greater than $6M/plant	Greater than $9.3M/plant		N
14	66	Develop procedures to repair or replace failed 4 kV breakers.	$50k/unit	$78k/unit	Very small*	N
15	73	Use Fire Protection System as a back-up source for diesel cooling.	Greater than $1M/plant	Greater than $1.5M/plant	$55.2k/$75.2k	N

Table 6-1. Evaluation of Phase II SAMAs (Continued)

Phase II SAMA ID No.	Phase I SAMA ID No.	SAMA Title	Estimated Cost (2001)	Estimated Cost (2016)	Maximum Cost Avoidance (Unit 2 / Unit 3)	Cost Effective?
16	89	Install additional instrumentation for ISLOCAs.	$400k/unit	$623k/unit	$15.2k/$15.4k	N
	90	Increase frequency for valve leak testing.	$100k/unit	$155k/unit		N
	91	Improve operator training on ISLOCA coping.	$50k/unit	$78k/unit		N
	93	Provide leak testing of valves in ISLOCA paths. At Kewaunee Nuclear Power Plant, four MOVs isolating RHR from the RCS were not leak tested.	Greater than $!00k/unit	Greater than $155k/unit		N
	95	Ensure all ISLOCA releases are scrubbed.	Greater than $1M/plant	Greater than $1.5M/plant		N
	96	Add redundant and diverse limit switches to each containment isolation valve.	$400k/unit	$623k/unit		N
17	98	Improve inspection of rubber expansion joints on main condenser.	$100k/unit	$155k/unit	$1.4k/$2.6k	N
18	108	Procedure to instruct operators to trip unneeded RHR/CS pumps on loss of room ventilation.	$50k/unit	$78k/unit	$53k/$62k	N
19	110	Increase the SRV reseat reliability.	$700k/unit	$1.09M/unit	$15.8k/$18.4k	N

Table 6-1. Evaluation of Phase II SAMAs (Continued)

Phase II SAMA ID No.	Phase I SAMA ID No.	SAMA Title	Estimated Cost (2001)	Estimated Cost (2016)	Maximum Cost Avoidance (Unit 2 / Unit 3)	Cost Effective?
20	111	Reduce DC dependency between high pressure injection system and ADS.	$500k/unit	$779k/unit	Less than $500/$7.5k	N
21	113	Use of CRD for alternate boron injection.	$2M/unit	$3.1M/unit	$6.4k/$6.3k	N
22	116	borate torus water	Greater than $6M/unit	Greater than $9.3M/unit	$29.4k/$60.3k	N
23	117	automate torus cooling	$400k/unit	$623k/unit	$16.8k/$44.4k	N
24	117a	provide torus positive pressure relief valves	$700k/unit	$1.09M/unit	$10k/$141.6k	N
	117b	reduce DW head bolt pretension	$50k/unit	$78k/unit		Y
25	121	automate SLC initiation	$400k	$623k	$9.5k/8.9k	N
26	122a	RPV inspection	$100k/unit	$155k/unit	$2.5k/$2.6k	N
27	124	provide independent torus cooling system	Greater than $6M/unit	Greater than $9.3M/unit	Less than $250k/Less than $506k*	N
28	132	Improve 4kV crosstie capability	$5M/plant	$7.8M/plant	$12.6k/150.2k	N
29	133	provide HP diesel-driven pump.	Greater than $6M/plant	Greater than $9.3M/plant	$178k/$396k	N

* Model limitations preclude direct estimate of cost avoidance. Conservative characterizations used for comparison.

VII. Conclusions

Based on the SAMA's approved to date, or that are in review, it is not anticipated that Browns Ferry will identify any hardware modifications that will be justified through the SAMA analysis.

The current SAMA analysis suggests that the following SAMAs be retained for additional consideration:

- SAMA 62: Improve DC Bus Load Shedding
- SAMA 117b (for Unit 3): Reduce DW Head Bolt Pretension

In addition, SAMA 108 (Procedure to Trip Unneeded RMR/CS Pumps on Loss of Ventilation) surround the uncertainty screening decision rule.

Both the estimated costs and the bounding PSA analyses associated with these SAMAs warrant additional scrutiny.

VIII. References

1. TVA calculation ND-Q0999-980016, R3, RIMS R14 000207 104

2. Browns Ferry Nuclear Plant Probabilistic Safety Assessment, Unit 2 Summary Report, R0.

3. Browns Ferry Nuclear Plant Probabilistic Safety Assessment, Unit 3 Summary Report, R0.

4. Letter from TVA to the USNRC, Browns Ferry Nuclear Plant (BFN) – Generic letter (GL) 88-20, Supplement 4, Individual Plant Examination of External Events (IPEEE) for Sever Accident Vulnerabilities – Partial Submittal of Report. RIMS R08 950724 976.

5. Letter from TVA to the USNRC, Browns Ferry Nuclear Plant (BFN) – Units 1, 2, and 3 – Final Response to Request for Additional Information Regarding Browns Ferry Nuclear Plant Individual Plant Examination for External Events (IPEEE) (TAC Nos. M83595, M83596, M83597). RIMS R08 990129 770.

6. Letter from the USNRC to TVA, Browns Ferry Units 1, 2, and 3, Individual Plant Examination of External Events (IPEEE) and Related Generic Safety Issues. Issuance of Staff Evaluation (TAC Nos. M83595, M83596, M83597). 6/22/2000.

7. Letter from the USNRC to TVA, Browns Ferry, Units 1, 2, and 3 RE: Completion of Licensing Action for Generic Letter 87-02 (TAC Nos. M83595, M83596, M83597). 3/21/2000.

8. Edwin I. Hatch Nuclear Plant, Application for License Renewal, Environmental Report, Appendix D, Attachment F. February 2000.

9. TVA calculation CN-BFN-MEB-MDN0-999-2001-0011, R0

10. Regulatory Analysis Technical Evaluation Handbook, NUREG/BR-0184.

11. Preparation of Supplemental Environmental Reports for Applications to Renew Nuclear Power Plant Operating Licenses, Regulatory Guide 4.2, Supplement 1.

12. Environmental Standard Review Plan – Operating License Renewal, NUREG-1555, Supplement 1.

13. Treatment of Averted Onsite Costs in Regulatory Analysis, SECY-99-169.

14. Final Rulemaking on "Environmental Review for Renewal of Nuclear Power Plant Operating Licenses," 10CFR Part 51, SECY-96-035.

15. Supplemental Environmental Impact Statement for License Renewal of Arkansas Nuclear One Unit One, NUREG-1437, Supplement 1.

16. TVA calculation MDN0-999-2001-0016, Revision 0

APPENDIX B

SUPPORTING TECHNICAL DATA
(to be completed for Final)

APPENDIX C

AGENCY CORRESPONDENCE

United States Department of the Interior

FISH AND WILDLIFE SERVICE
P. O. Drawer 1190
Daphne, Alabama 36526

IN REPLY REFER TO:

March 12, 2001

Mr. Bruce L. Yeager
Environmental Policy and Planning
Tennessee Valley Authority
400 West Summit Hill Drive
Mail Stop WT 8C-K
Knoxville, TN 37902

Dear Mr. Yeager:

This letter is in response to the Notice of Intent, dated February 15, 2001, to prepare a Supplemental Environmental Impact Statement (SEIS) for the Browns Ferry Nuclear Plant Operations License Renewal, Limestone County, Alabama (ER 01/126).

The U.S. Fish and Wildlife Service, Daphne, Alabama Field Office has concerns with the thermal plume that will be created if the maximum operating power level is increased for the facility. Thermal plume could impact aquatic organisms, particularly the rough pigtoe (*Pleurobema plenum*), an endangered mussel found in the vicinity of the discharge. The Service requests that surveys for threatened and endangered mussels be conducted and thermal plume models be produced pursuant to the preparation of the SEIS, and provided to this office for review.

The Service appreciates the early coordination on this project and we look forward to working with you during the preparation of the SEIS. If you have questions or comments, please direct them to Mr. Bruce Porter, at 334-441-5181, ext 37 or via email bruce_porter@fws.gov.

Sincerely,

Larry E. Goldman
Field Supervisor

cc: USFWS, Region IV Ecological Services
ATTN: Mr. Bruce Bell

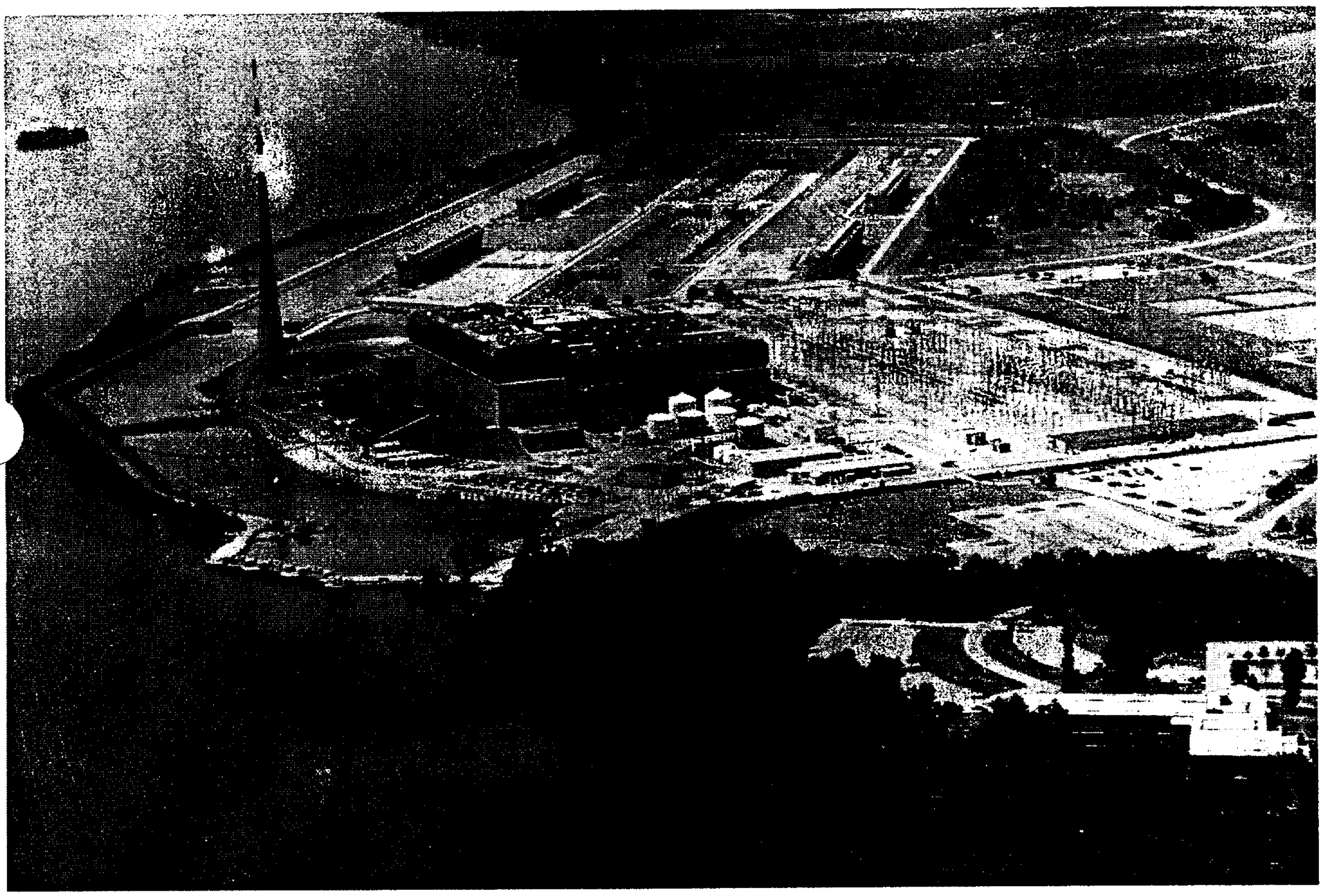
APPENDIX D

SCOPING MEETING REPORT

DRAFT SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT

Browns Ferry Nuclear Plant
Operating License Renewal
Athens, Alabama

Scoping Report



TENNESSEE VALLEY AUTHORITY
March 2001

TVA

Introduction

TVA proposes to submit an application to the Nuclear Regulatory Commission (NRC) requesting renewal of the operating licenses for Units 2 and 3 of the Browns Ferry Nuclear Plant (BFN), located in Limestone County, Alabama. In additional to requesting continued operation of Units 2 and 3 for an additional 20 years, consideration is being given to relicensing and recovery of Unit 1 which has been non-operational for 15 years; addition of a spent fuel storage facility; and a few new office buildings. This Supplemental EIS (SEIS) is being prepared to provide the public and TVA decision-makers an assessment of the environmental impacts of relicensing as well as the additional proposals.

In *Energy Vision 2020*, TVA's load forecast indicates that future electricity needs in the TVA Power Service Area will exceed TVA's current generating capacity by the year 2020. The proposal to renew the operating license for BFN and to restart Unit 1 are consistent with TVA's plans to continue to make maximum use of existing power production facilities at the BFN site into the foreseeable future in order to meet projected annual growth rate of two to three percent over the next 20 years.

An important activity in EIS preparation is the description of what topics the environmental review will cover, known as the **scope**. The EIS scope is based on the nature of the proposed action and the issues to be evaluated. During the scoping process, the general public, potentially affected parties, TVA experts, and other government agencies are asked to help identify the issues to be evaluated and to help define the alternative actions to be considered in the EIS. This report describes the scoping process used by TVA to determine the issues to be evaluated and the scope of the EIS based on public input.

The Scoping Process

TVA invited comments from the public to help determine the scope of this EIS by publishing a Notice of Intent (NOI) in the *Federal Register* (65 FR 47817) on February 15, 2001. The NOI provided background information on the reason for the EIS, a discussion of the alternatives being considered, and a description of the scoping process. A copy of the NOI is provided in Appendix E of the SEIS.

A public meeting was held on March 6, 2001 in Decatur, Alabama on the campus of Calhoun Community College. The public was notified about the meeting by paid newspaper announcements in the March 4, 2001 Sunday edition of the *Decatur Daily, The Athens News-Courier, The Huntsville Times,* and *the Florence Times Daily* and the March 6, 2001 edition of the *The Athens News-Courier.* A news release about the project and upcoming meeting was provided to the local media on March 4 and 6, 2001. Articles about the project and the public scoping meeting were carried in Sunday editions of *The Athens News-Courier* on February 25, 2001 and *The Decatur Daily* on March 4, 2001. *The Florence Times Daily* carried a similar article on March 5, 2001. In addition to the paid announcement and press release, on February 22, 2001 TVA mailed a letter of invitation to the public meeting to 99 U. S. and State Representatives, area Mayors, County Commissioners, Judges, and other local officials.

The paid announcements included a map illustrating the location of Browns Ferry Nuclear Plant as well as the location of the public meeting. The announcements and the press release both stated that the meeting was being held to obtain public input on TVA's proposed plan to apply for renewal of the operating licenses for Units 1,2, and 3 at BFN. They further stated that written comments on the project would be received through March 23, 2001. Copies of the paid announcements and news releases are in Appendix E.

Approximately 60 members of the public along with 15 College officials attended the public meeting on March 6, including representatives from the following newspapers: *The Huntsville times, The Birmingham News, The Knoxville News-Sentinel, The Athens News-Courier, The Decatur Daily*, and *The Florence Times Daily*. Representatives from WVNN/WZYP radio and WVNN-TV, both from Athens, Alabama, were also present.

The meeting was facilitated by Dr. Dena Stephanon of Calhoun State College. It began with began with a brief presentation by Karl Singer, Senior Vice President of Nuclear Operations. Mr. Singer explained the environmental review process, the purpose of scoping and the proposed BFN License Renewal Project. Following the presentation, the attendees were divided into four small groups facilitated by Calhoun State College and TVA staff. In the small groups, participants were invited to list **issues and concerns** (Question 1) they might have concerning the potential environmental impacts that might result from the proposed actions and alternatives to the proposed action (Question 2) that should be addressed in the SEIS.

Comments received during the public meeting were noted and later reviewed to help identify environmental issues that should be addressed in the SEIS as well as those minor issues which do not warrant detailed evaluation. In addition to the providing verbal input at a public meeting, the public and other government agencies were invited to provide written comments at the meeting, by mail, or by e-mail. One e-mail and two letters were received and are included in this scoping report.

Major Themes in Public Comments

Several recurring themes representing diverse points of view were present in the oral and written comments concerning this EIS project. Many commenters shared the following concerns or opinions regarding nuclear power and the relicensing of BFN:

- **Nuclear Waste** - People were concerned about how much high and low level waste would be generated, and how and where it would be stored. The cost of storage was also mentioned. One commenter, however, stated that the storage issue is a political scare.

- **Emergency Management/Safety** - People were concerned that there be adequate plans for evacuation to ensure the safety of those who live near the plant. The need to ensure worker safety and concerns about the age of Unit 1 as it relates to prospects for safe operation were also mentioned.

- **Water Quality** - Concerns were expressed about thermal impacts on water as well as run off from construction.

- **Cost of Restarting Unit 1** - People were concerned about the impact of completing Unit 1 on TVA's debt load.

- **Relationship to Plans for Bellefonte Nuclear Plant** - Several people questioned how plans for BFN would impact plans for nearby, incomplete Bellefonte Nuclear Plant and vice versa.

- **Alternatives to Relicensing and or Restarting Unit 1** - Of the many alternative power sources mentioned, the primary alternatives to additional nuclear power cited were coal, natural gas, energy conservation, and "green" energy sources. Fact-based clarification of TVA's future power needs was sought.

- **Proponents of Increased Nuclear Power** - Many participants favored nuclear power as the source of choice for the future, citing reduction of air pollution, sunk costs, safety, and environmental preference as reasons. Power shortages in California were cited as an example of the result of poor or weak power planning.

Table 1 includes a paraphrased list of all issues raised during public scoping for the Browns Ferry Nuclear Plant Relicensing project, by topic. A copy of the flip chart notes and letters received are part of the public record of this project.

Table 1 Topical List of Issues Raised During Public Scoping for Browns Ferry Nuclear Plant Relicensing Project

Topic	Sub Issues
1. Nuclear Waste/spent fuel	• dangers of transporting nuclear waste • cost of storing both low level and high level waste • disposition/management of spent fuel • amount of additional waste to be generated by Unit 1 • amount of low and high level waste to be generated (2)* • location of low and high level waste storage (3) • plans for on-site waste storage • safety precautions for on-site storage of high level waste • plans for further waste reduction • will TVA rent waste storage space on the Goshutes Indian Reservation • advocates national funding for technology to study hazard waste clean up and effects of nuclear energy use • nuclear waste storage is a political scare—not as big a problem as public perceives
2. Emergency management/Safety	• use of iodine capsules in case of disaster • proximity of nearest resident to plant • possibility of train tracks crossing the emergency route • adequacy of evacuation routes for traffic • range of evacuation plan • adequacy of safety monitoring (supervisors should live within 5-10 mile radius) • process for reporting safety problems for Unit 1 start-up • concerns about NRC becoming lax with aging reactors pushed beyond design limitations • implications of increasing dependence on aging, less reliable reactors • status of cracked shroud and implications for restart • amount of curies released into air/water • exposure of workers to ionizing radiation • responsibility for exposed workers

Topic	Sub Issues
3. Water Quality	• increased heat load; temperature • potential impact of thermal plume on aquatic organisms (e.g. rough tiptoe musel) • construction runoff • more water screening at construction/demolition landfill • extent of use of cooling towers • meeting meet new EPA requirements on water intake and thermal discharge
4. Environment	• need more personnel and resources allocated to the environment (2) • what will be the net environmental impact of start-up
5. Environmental justice	• potential impact on low-income or minority population to plant
6. public notification	• process for informing public about meeting • when will Unit 1 go on-line
7. nuclear power, general	• public needs more education to clear misconception; improve understanding of nuclear technology (how clean and safe it is) • public needs more education about BFNP safety record • Decatur needs a visitor area to show the public a nuclear plant • encourage and educate young people about nuclear power operations/ environmental tracking
8. Costs of Unit 1 restart	• use cost/benefit analysis to choose best option • How was $1B cost estimated (look at minimum costs to possible costs)? • Cost analysis of limited lifespan, considering plant is 15 years old • impact on TVA debt of bringing Unit 1 online—already $25 billion (2) • cost comparison of starting Unit 1 Bellefonte vs. Unit 1 BFNP
9. Other Unit 1 startup issues	• how will TVA compensate for parts taken from Unit 1 • how does restart fit with plans for river management and hydro generation • potential impact of TVA loosing integrated river management system • effects of deregulation of BFNP Unit 1 startup • potential length of service for units under the re-licensing extension (TVA could ask NRC to extend licenses to account for years each unit was off line) • impact of Calpine, a proposed private merchant plant proposed for nearby location.

Topic	Sub Issues
10. Alternate uses of Unit 1	• gas-powered plant (cost, impact of pipeline, environmental impact of plant)2) • look at cost/efficiency/ impact of coal plant • explore cost/competitiveness of natural gas • explore cost/competitiveness of using other sources • close Unit 1; build new nuclear plant elsewhere • consider the socioeconomic impacts of decommissioning BFNP
11. Other considerations for meeting new power needs	• consider TVA's debt level • increase conservation; don't waste energy • is TVA expecting more use of its coal fired plants • control end-user demand (3) • energy efficiency initiatives (2) • population growth projections (anticipated growth/decline in demand) • need a balanced national energy policy—mix of sources • power supply planning is important and as are alternative power sources • deregulation will probably not benefit the public • improve efficiency of transmission to minimize power loss • improve building codes to require energy conservation • discuss TVA 's power mix in next 40 years • explore the long term implications of TVA's forecast of becoming more dependant on natural gas • alternative power source being considered if BFNP is decommissioned • decommission BFNP Units 1&2; use restart money for clean development of clean energy technologies like fuel cells, distributed generation • purchase power off-system • evaluate the possible sale of assets and service area to other utilities • explore relationship of increasing TVA nuclear power and reducing air pollution from fossil fuel • consider building new nuclear power plants (2) • nuclear power is most desirable long-term energy source (energy crisis is due to restrictions on fossil fueled energy sources have driven up price of natural gas) work aggressively to increase nuclear production (TVA and U.S.)(3)
12. Relationship to Bellefonte	• does Bellefonte require a separate EIS • has there been any decision about whether or not to bring Bellefonte online • licensing status of Bellefonte/ relationship to Browns Ferry Nuclear Plant (2)

* Numbers in parentheses following comments indicate the number of times that or a similar comment was noted

APPENDIX E

ANNOUNCEMENTS, NOTICES, AND NEWS RELEASES

[Federal Register: February 15, 2001 (Volume 66, Number 32)]
[Notices]
[Page 10557-10558]
From the Federal Register Online via GPO Access [wais.access.gpo.gov]
[DOCID:fr15fe01-95]

===

TENNESSEE VALLEY AUTHORITY

Supplemental Environmental Impact Statement: Browns Ferry Nuclear Plant Operating License Renewal

AGENCY: Tennessee Valley Authority.

ACTION: Notice of intent.

SUMMARY: This notice is provided in accordance with the Council on Environmental Quality's regulations (40 CFR parts 1500-1508) and TVA's procedures for implementing the National Environmental Policy Act. The Tennessee Valley Authority (TVA) will prepare a supplemental environmental impact statement (SEIS) to address the environmental impacts associated with obtaining license extensions for the Browns Ferry Nuclear Plant (BFN) located in Limestone County, Alabama. Renewal of the operating licenses will allow the plant to continue to operate for an additional 20 years beyond the expiration dates of the current operating licenses. The regulations of the Nuclear Regulatory Commission (NRC) in 10 CFR part 54 set forth the applicable license extension requirements. This SEIS will also consider the impacts of the possible restart of Unit 1, which has been in a non-operational status since 1985, with an extended operating license. At this early stage, TVA contemplates that the action alternatives in the EIS could include a combination of license renewal and restart of Unit 1. The no-action alternative considered is a decision by TVA to not seek renewal of the operating licenses for the BFN units. Public comment is invited concerning both the scope of alternatives and environmental issues that should be addressed as part of the SEIS.

DATES: Comments on the scope of the SEIS must be postmarked or e-mailed no later than March 23, 2001 to ensure consideration.

ADDRESSES: Written comments or e-mails on the scope of issues to be addressed in the SEIS should be sent to Bruce L. Yeager, Senior Specialist, National Environmental Policy Act, Environmental Policy and Planning, Tennessee Valley Authority, 400 West Summit Hill Drive, Mail Stop WT 8C-K, Knoxville, Tennessee 37902 (e-mail: blyeager@tva.gov).

FOR FURTHER INFORMATION CONTACT: Charles L. Wilson, Nuclear Licensing Staff, Tennessee Valley Authority, 1101 Market Street, Mail Stop BR 4X-C, Chattanooga, Tennessee, 37402 (e-mail: clwilson@tva.gov), Roy V. Carter, Tennessee Valley Authority, Mail Stop CEB 4C-M, Muscle Shoals, Alabama, 35662 (e-mail: rvcarter@tva.gov) or Bruce Yeager, Tennessee Valley Authority, 400 West Summit Hill Drive, Mail Stop WT 8C-K, Knoxville, Tennessee 37902 (e-mail: blyeager@tva.gov).

SUPPLEMENTARY INFORMATION:

Background

The proposal to renew the operating licenses for the Browns Ferry Nuclear Plant (BFN) was part of a system-wide evaluation of future power needs. A range of options to meet those needs was evaluated in TVA's Integrated Resource Plan and Environmental Impact Statement, Energy Vision 2020, released on December 21, 1995.

The Final Environmental Statement for BFN was published in 1972. BFN was TVA's first nuclear power plant. The facility is located on an 840-acre tract adjacent to Wheeler Reservoir in Limestone County, Alabama, 10 miles southwest of Athens, Alabama. BFN has three General Electric boiling water reactors and associated turbine-generators that can produce more than 3,000 megawatts (MW) of power. Unit 1 began commercial operation in August 1974, Unit 2 in 1975 and Unit 3 in 1977. An extended shutdown of all units at Browns Ferry began in 1985 to review the TVA nuclear power program. Unit 2 returned to service in May 1991 and Unit 3 in November 1995. Unit 1 has been idled since 1985, and changes would be necessary prior to restarting the unit. The current operating characteristics of Units 2 and 3 are considered representative of future operations at Browns Ferry because of the changes in personnel, procedures, and equipment that occurred during and following the extended regulatory outage which began in 1985. For example, since return to service from the regulatory outage, Units 2 and 3 have performed well with consistently higher levels of availability and generating capacity than before the outage.

Proposed Action

TVA proposes to submit an application to the Nuclear Regulatory Commission (NRC) requesting renewal of BFN operating licenses. Renewal of the current operating licenses would permit operation for an additional twenty years past the current (original) 40-year operating license terms which expire in 2014 and 2016 for Units 2 and 3, respectively. The Unit 1 operating license expires in 2013. License renewal of the operating BFN facilities does not involve new major construction or modifications beyond normal maintenance and minor refurbishment.

The SEIS will also examine the impacts associated with the possible recovery and restart of Unit 1, which has been in a non-operational status for 15 years. Among the impacts to be examined in this SEIS are those resulting from thermal (heat) discharges to Wheeler Reservoir associated with three-unit operation. The cooling capaicity necessary to mitigate thermal impacts under the various alternatives would also be examined in the SEIS. Other aspects of the actions under consideration include the impacts associated with a spent fuel storage facility and a few new office buildings.

Independent of the matters considered in the SEIS, TVA is considering a project which would uprate the maximum operating power level of Units 2 and 3 to 120 percent of their originally licensed power levels. If this project is approved, the various alternatives in the SEIS will be modified as appropriate to reflect the higher operating levels. If Unit 1 is returned to service, it is currently contemplated that it would also be operated at 120 percent of its originally licensed power level. Additional information about the uprate project is available from the contacts listed above.

Range of Alternatives

As required by Council on Environmental Quality (CEQ) regulations

(40 CFR 1502.14), TVA will evaluate a reasonable range of alternatives in this SEIS. Action alternatives TVA is currently considering include license extensions for Units 2 and 3 to continue power operation for an additional 20 years, and the possible return to service of Unit 1 with a 20-year license extension. TVA will also consider a ``no action'' alternative which would be a decision by the TVA Board of Directors to not

[[Page 10558]]

pursue license renewal. Under the no action alternative the plant would cease to produce power and TVA would choose one of the decommissioning options. Under this alternative, the power no longer being produced by Browns Ferry may or may not be generated or obtained by other means.

Preliminary Identification of Environmental Issues

This SEIS will discuss the need to continue to operate the plant and will describe the existing environmental, cultural, recreational, and socioeconomic resources. The SEIS will consider the potential environmental impacts resulting from refurbishment, operation and maintenance of the existing facilities, as well as any additional impacts from returning Unit 1 to service. TVA's evaluation of environmental impacts to resources will include, but not necessarily be limited to, the potential impacts on air quality, surface and ground water quality and resources, vegetation, wildlife, aquatic ecology, endangered and threatened species, floodplains, wetlands and wetland wildlife, aesthetics and visual resources, land use, cultural and historic resources, light, noise, socioeconomics, transport

TVA

NEWS RELEASE

DRAFT

TVA To Seek Public Input on Analyzing Environmental Impacts of Browns Ferry License Extensions

DECATUR, Ala. – TVA will hold a public meeting Tuesday, March 6, near Decatur, Ala., to seek comments on analyzing the potential environmental impacts of extending the operating licenses for Browns Ferry Nuclear Plant.

Renewal of the licenses will permit TVA to continue operating Browns Ferry units 2 and 3 for an additional 20 years past the 40-year operating license terms, which expire in 2014 and 2016, respectively. TVA must apply to the Nuclear Regulatory Commission to extend the licenses.

TVA is planning to prepare a supplemental environmental impact statement on the license extensions and will also consider the impacts of the possible restart of Unit 1 – shut down since 1985 – with an extended operating license. However, no decision has been made to restart Unit 1.

The meeting will be held at the Aerospace Technology Building Auditorium on the campus of Calhoun State Community College on Highway 31 North. Registration for the meeting will be from 6 to 6:30 p.m.

Visual displays and written information will be available during the registration period. TVA staff will explain the environmental process and the proposed license renewal project, followed by group discussions to record issues and concerns that should be considered in the supplemental environmental review.

--MORE

Following the meeting, TVA will review the comments, assess the impact on the proposed alternatives, and identify significant environmental issues to be addressed. Following analysis of the environmental impacts of each alternative, TVA will prepare a draft supplemental environmental impact statement for public review and comment. TVA expects to release a final environmental statement by next January.

Written comments or e-mails on the scope of issues to be addressed in the supplemental environmental impact statement can be sent to Bruce L. Yeager, Senior Specialist, National Environmental Policy Act, Environmental Policy and Planning, Tennessee Valley Authority, 400 West Summit Hill Drive, Knoxville, Tennessee 37902 (e-mail: blyeager@tva.gov). Comments must be postmarked or e-mailed no later than March 23 to ensure consideration.

The proposal to renew Browns Ferry operating licenses was part of a system-wide evaluation of future power needs. A range of options to meet those needs was evaluated in TVA's Integrated Resource Plan and Environmental Impact Statement, Energy Vision 2020, completed in 1995.

Browns Ferry is located on Wheeler Lake, 10 miles southwest of Athens, Ala. The plant consists of two General Electric boiling water reactors that can produce enough electricity to provide power to about 500,000 homes.

# # #

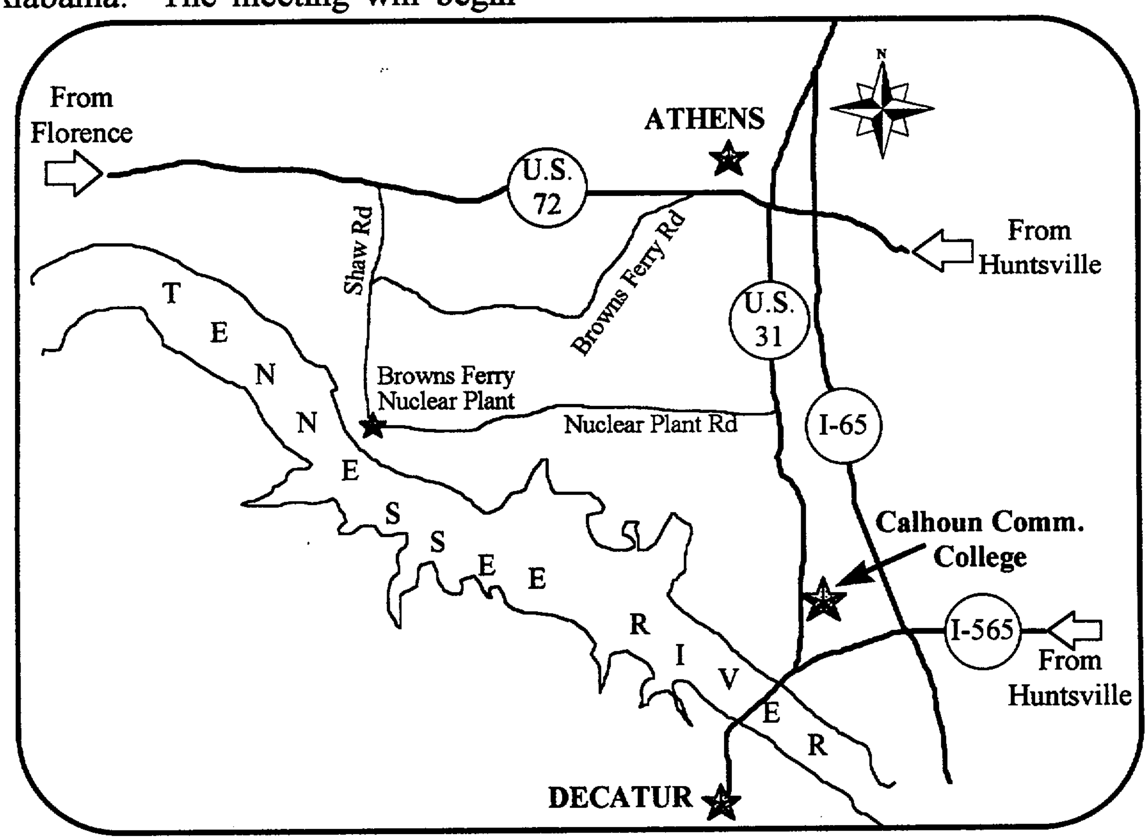
Media Contact: Phillip Harris, Browns Ferry Nuclear, (256) 729-7698
Media Relations, Knoxville, (865) 632-6000
TVA Home page: www.tva.com

(Mailed/faxed February xx, 2001)

Media:newsrel:BFN License

NOTICE
of TVA's Public Scoping Meeting to Discuss Plans for Environmental Analysis of Proposed Renewal of Browns Ferry Nuclear Plant Operating Licenses

TVA will hold a public scoping meeting March 6, 2001, at Calhoun Community College, to obtain public comments on analyzing the potential environmental impacts of extending the operating licenses for Browns Ferry Nuclear Plant. The input would be used to determine the scope of an environmental review planned for the project. Registration for the meeting will begin at 6:00 p.m. CST, in the Aerospace Technology Building of Calhoun Community College, Highway 31 North, Decatur, Alabama. The meeting will begin at 6:30 p.m. The Draft Environmental Impact Statement (DEIS) for the project will be available for review about August 2001. Written comments on the project may be submitted through March 23, 2001, to Bruce L. Yeager, TVA, 400 West Summit Hill Drive, Mail Stop WT 8C-K, Knoxville, Tennessee 37902-1499, or by e-mail to blyeager@tva.gov. Further information may be obtained by contacting Mr. Yeager at (865) 632-8051 or Charles L. Wilson at (423) 751-6153.



PAPER: KNOXVILLE NEWS SENTINEL

CITY: KNOXVILLE, TN

DATE: 3-7-01 PAGE: A6

TVA gets citizens' input on extending life of Browns Ferry

By Bryan Mitchell
News-Sentinel staff writer

DECATUR, Ala. – The public had its first opportunity to voice its opinion about the future of a Tennessee Valley Authority nuclear power plant here Tuesday night.

"We've enjoyed it," said Steve Crunk, who attended the meeting with a friend. "If you had a problem they let you come right out and say it."

Approximately 80 people converged on the Calhoun State Community College campus for a two-part meeting about a proposal to extend the life of the Browns Ferry Nuclear Power Plant.

The plant, which houses three nuclear units, is roughly 10 miles from the campus on an 84-acre tract.

Only two of the three units are currently producing power, and the operating licenses for each will expire in 2014 and 2016, respectively.

The meeting was designed to measure public opinion about applying for a 20-year extension license for each unit.

The licenses are granted by the Nuclear Regulatory Commission and may take up to six years to receive approval, officials said.

First, Karl Singer, senior vice president of nuclear operations for TVA, addressed the crowd about why the meeting was held.

Singer was primarily interested in gauging the environmental impact of the extension and also ascertaining what alternatives citizens could offer.

"We want to listen to your thoughts and ideas," Singer said to the crowd, which filled about half of the Aerospace Technology Building's auditorium.

After Singer spoke for roughly 20 minutes, the crowd broke off into 10 different focus groups, in which individuals' interests could be addressed.

Before the different groups separated, an impromptu survey was held in which the crowd demonstrated overwhelming support for the extension, with only four people raising their hands in opposition.

"It seems like a short-term fix," said Jackie Tipper, one of the four who opposed the extension.

Tipper, who lives just up the Tennessee River from the Browns Ferry plant, said she is happy with the job TVA does, but pleaded for an alternative.

"TVA does good stuff, but it seems like we ought to do better for our children," Tipper said.

Others disagreed, citing the economic importance of cheap nuclear power to the area.

"So far we have enjoyed the availability," Crunk said. "(TVA) needs to use all the resources it has."

At the end of the meeting, all of the questions, concerns and ideas were compiled and will help to create a report which is required by the National Environmental Protection Act.

Singer will then present a rough draft of that report to another group of citizens around the end of this summer.

After the second public conference, Singer will create a final draft which he will present before the TVA Board of Directors in Knoxville.

PAPER: FLORENCE TIMES DAILY

CITY: FLORENCE, AL

DATE: 3-6-01 PAGE: B3

TVA looks to preparing for rise in power demand in coming years

By Jason Strait
THE ASSOCIATED PRESS

CHATTANOOGA, Tenn. – The Tennessee Valley Authority is considering reviving a dormant nuclear reactor and retooling an unfinished one to meet a looming demand for more power.

TVA has proposed restarting the Unit 1 reactor at Browns Ferry Nuclear Power Plant near Athens, Ala., to satisfy an electricity demand that is expected to increase by 3 percent next year. The reactor was shut down in 1985 amid public fears about radioactive waste and safety.

"We're closely looking at the feasibility and the payback of bringing Unit 1 online at Browns Ferry. That is one of a number of options that we're considering," TVA board member Glenn McCullough said Monday.

Board members Monday also discussed converting the incomplete Bellefonte plant, near Scottsboro, Ala., into a new source of power for TVA's seven-state region.

Construction on the $4.6 billion Bellefonte nuclear plant was stalled in 1988 when TVA announced decreased demand for power was forcing it to delay completion by five years.

In 1994, the agency's directors decided they couldn't afford to finish the project without a financing partner.

Since then, TVA has been spending $8 million annually to maintain the reactors.

McCullough said the plant may yet have a future in the TVA power system, though it likely will not be as grand as TVA officials originally planned.

"Bellefonte's future most likely will not be nuclear. We are looking at a number of options that could make the Bellefonte site productive," he said.

He declined to specify what those options were, however the utility in the past had considered converting the facility to a gas- or coal-powered plant.

Both options would be costly and could affect TVA's goal of reducing its debt by $2 billion to $8 billion – to $18 billion to $24 billion – depending on natural gas prices and other variables by 2007.

It could cost up to $1 billion to restart the Browns Ferry reactor, the country's oldest and TVA's first.

That option has met with resistance from energy conservation activists, including the Southern Alliance for Clean Energy.

A public hearing on the potential environmental effects of restarting the Browns Ferry reactor is set for Wednesday.

TVA is expected to release a final environmental statement at the end of the year.

PAPER: FLORENCE TIMES DAILY
CITY: FLORENCE, AL
DATE: 3-5-01 PAGE: A1

TVA wants others' opinions

Public utility plans to extend life of nuclear plant

Dennis Sherer
STAFF WRITER

The Tennessee Valley Authority wants to hear north Alabama residents' opinions on its plan to extend the life of Browns Ferry Nuclear Power Plant.

The operating license from the Nuclear Regulatory Commission for reactor Units 2 and 3 at Browns Ferry are scheduled to expire in 2014 and 2016, respectively.

TVA wants the Nuclear Regulatory Commission to extend the licenses by 20 years.

TVA will conduct a meeting Tuesday at Calhoun Community College on U.S. 31 in Decatur to solicit comments on the plan. Registration for the meeting is 6-6:30 p.m.

The issue is causing much debate.

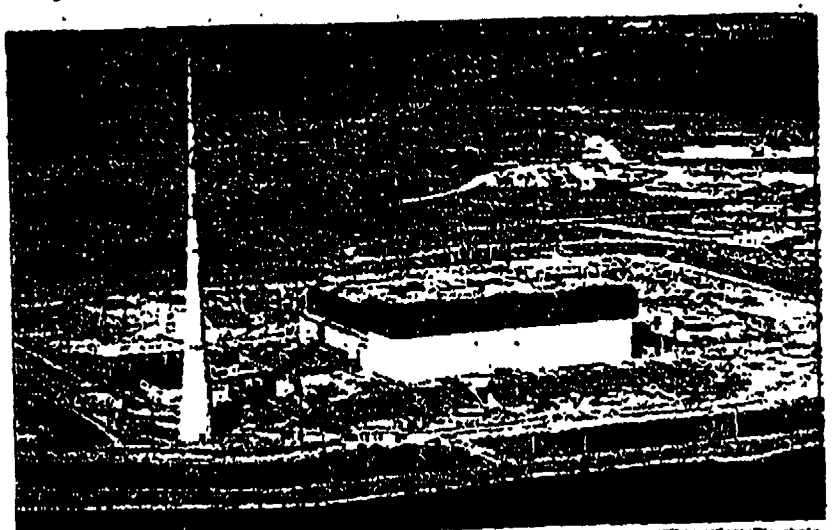
TVA officials contend nuclear power plants can be operated longer than originally thought.

"Initially, everybody thought that 40 years of plant life was a reasonable period," said John Scalice, TVA's chief nuclear officer. "But as we have gotten more experience in this industry and demonstrated better maintenance and operations, we recognize these plants can operate safely much longer than originally envisioned."

Opponents, such as Steven Smith, the executive director of the Knoxville, Tenn.- based Southern Alliance for Clean Energy, question the plan.

"Clearly, these reactors were designed for 40-year lives. They were not designed for a 60-year life cycle," Smith said.

A supplemental environmental impact statement TVA is preparing to try to extend the life of



MATT McKEAN/File photo

Browns Ferry Nuclear Power Plant is the subject of a Tuesday meeting.

Browns Ferry Units 2 and 3 also will include the impact of a restart of reactor Unit 1, which has been idle since 1985.

No decision has been made on the possible reactivation of Unit 1.

U.S. Sen. Jeff Sessions, R-Ala., and U.S. Rep. Bud Cramer, D-Ala., have urged TVA to restart Unit 1 to help ensure it can meet the future power needs of its customers.

In addition to increasing TVA's capacity to produce electricity, Sessions and Cramer said restarting Unit 1 would produce up to 2,000 construction jobs and about 300 permanent jobs.

Sessions and Cramer contend the new jobs would boost the economy of communities around the nuclear plant, including the Shoals.

But instead of being beneficial, Smith claims the restart could hurt the economy of the TVA region. He said the estimated $1 billion it would take to prepare Unit 1 for use could lead to higher utility bills for TVA customers.

Instead of restarting the idle nuclear reactor, Smith wants TVA to promote energy conservation. He said homes in the TVA region have the highest electrical power consumption rate in the nation.

TVA officials contend they do promote energy conservation and are looking for new ways to help customers reduce their electricity usage. Much of the research into ways to conserve electricity is conducted at TVA's Public Power Institute in Muscle Shoals.

Comments from Tuesday's meeting will be used to prepare the report on the Browns Ferry reactors. The report is expected to be released early next year.

PAPER: DECATUR DAILY
CITY: DECATUR, AL
DATE: 3-4-01 PAGE: B3

Hearing planned on Browns Ferry impact

By Winford Turner
DAILY Senior Writer

The Tennessee Valley Authority will hold a public meeting Tuesday to seek comments on the potential environmental impacts of extending the operating licenses for Browns Ferry Nuclear Plant.

Renewal of the licenses will allow TVA to continue operating Browns Ferry Units 2 and 3 for an additional 20 years past the 40-year operating license terms, which expire in 2014 and 2016, respectively.

The meeting will be at Calhoun Community College's Aerospace Technology Building. Registration will be from 6 until 6:30 p.m.

The Nuclear Regulatory Commission requires environmental impact hearings before licenses are renewed for nuclear plants. Browns Ferry employs about 950 employees.

U.S. Sen. Jeff Sessions, R-Mobile, said TVA will receive an extension to operate the two Browns Ferry units. He said there is no doubt in his mind that the plant is safe.

Sessions praised workers at Browns Ferry for going 547 consecutive days without a shutdown on Unit 3.

"That is a perfect record," Sessions said. "Add this to the 450 days in a row that Unit 2 went without shutting down over the past two years, and you've got an excellent record."

Sessions predicts that Browns Ferry's role will increase as demand for electrical power becomes greater.

"I think we are about to go through a period where the number of critics to nuclear power will decline," Sessions said during a visit to the plant Feb. 19.

"I think nuclear power is the way to go in producing electrical power in the future," Sessions said. "It is cheaper and cleaner to make."

Sessions, U.S. Sen. Richard Shelby, R-Tuscaloosa, and 5th U.S. Rep. Bud Cramer, D-Huntsville, have called on TVA to restart Unit 1 at Browns Ferry.

TVA officials said they would consider the request later this year.

APPENDIX F

INDIVIDUALS AND AGENCIES PROVIDING COMMENTS
(to be completed for Final)

APPENDIX G

RESPONSES TO PUBLIC COMMENTS
(to be completed for Final)

GLOSSARY

A-weighted decibel (dBA) - A unit of weighted sound pressure level, measured by the use of a metering characteristic and the "A" weighting specified by American National Standard Institute S1.4-1971(R176). (See decibel).

Absorbed dose - The energy deposited per unit mass by ionizing radiation. The unit of absorbed dose is the rad.

Accident - One or more unplanned events involving materials that have the potential to endanger the health and safety of workers and the public. An accident can involve a combined release of energy and hazardous materials (radiological or chemical) that might cause prompt or latent adverse health effects.

Accident sequence - With regard to nuclear facilities, an initiating event followed by system failures or operator errors, which can result in significant core damage, confinement system failure, and/or radionuclide releases.

Actinide - Any of a series of chemically similar, mostly synthetic, radioactive elements with atomic numbers ranging from actinium at 89 through lawrencium at 103.

Activation products - Nuclei, usually radioactive, formed by the bombardment and absorption of material with neutrons, protons, or other nuclear particles.

Acute exposure - The exposure incurred during and shortly after a radiological release. Generally, the period of acute exposure ends when long-term interdiction is established, as necessary. The period of acute exposure is generally assumed to end 1 week after the inception of a radiological accident.

Alpha particle - A positively charged particle consisting of two protons and two neutrons that is emitted from the nucleus of certain nuclides during radioactive decay. It is the least penetrating of the three common types of radiation (alpha, beta, and gamma).

Alpha activity - The emission of alpha particles by radioactive materials.

Alpha particle - A positively charged particle, consisting of two protons and two neutrons, that is emitted during radioactive decay from the nucleus of certain nuclides. It is the least penetrating of the three common types of radiation (alpha, beta, and gamma).

Alpha radiation - The least penetrating of the four common types of radiation (alpha, beta, gamma, and neutron). It consists of a positively charged particle with two protons and two neutrons that is emitted from the nucleus of certain nuclides during decay.

Alpha wastes - Wastes containing radioactive isotopes that decay by producing alpha particles.

Ambient air - The surrounding atmosphere as it exists around people, plants, and structures. Air quality standards are used to provide a measure of the health-related and visual characteristics of the air.

Archaeological sites (resources) - Any location where humans have altered the terrain or discarded artifacts during either prehistoric or historic times.

Artifact - An object produced or shaped by human workmanship of archaeological or historical interest.

As Low as Reasonably Achievable (ALARA) - A concept applied to ensure the quantity of radioactivity released to the environment and the radiation exposure of onsite workers in routine operations, including "anticipated operational occurrences," is maintained as low as reasonably achievable. It takes into account the state of technology, economics of improvements in relation to benefits to public health and safety, and other societal and economic considerations in relation to the use of nuclear energy in the public interest.

Atomic Energy Act of 1954, as amended - The statute that established U.S. requirements with respect to nuclear energy and nuclear materials. This Act, as amended, provides the statutory framework for government control of the possession, use, and production of atomic energy, special nuclear material, and other radioactive material, whether owned by the government or others.

Average daily traffic (ADT) - The number of vehicles that pass a defined point on a defined roadway over a 24-hour period.

AXAIRQ - A computer model that analyzes doses from airborne radionuclide releases.

Background radiation - Ionizing radiation present in the environment from cosmic rays and natural sources in the Earth; background radiation varies considerably with location.

Badged worker - A worker who has the potential to be exposed to radiation and is equipped with a dosimeter to measure his/her dose.

Barrier - Any material or structure that prevents or substantially delays movement of radionuclides toward the accessible environment.

Baseline - A quantitative expression of conditions, costs, schedule, or technical progress to serve as a base or standard for measurement during the performance of an effort; the established plan against which the status of resources and progress of a project can be measured. For this environmental impact statement, the environmental baseline is the site environmental conditions as they exist or have been estimated to exist in the absence of the proposed action.

Baseload - The minimum amount of electric power or natural gas delivered or required over a given period of time at a steady rate. The minimum continuous load or demand in a power system over a given period of time usually not temperature sensitive.

Baseload capacity - The generating equipment normally operated to serve loads on an around-the-clock basis.

Benthic - Plants and animals dwelling at the bottom of oceans, lakes, rivers, and other surface waters.

Best Management Practices (BMP) - A practice or combination or practices that is determined by a state (or other planning agency) after problem assessment, examination of alternative practices, and appropriate public participation to be the most effective, practicable means of preventing or reducing the amount of pollution generated by nonpoint sources to a level compatible with air or water quality goals.

Beta particle - A charged particle emitted from the nucleus of an atom during radioactive decay. A negatively charged beta particle is identical to an electron; a positively charged beta particle is called a "positron."

Beta radiation - Consists of an elementary particle emitted from a nucleus during radioactive decay; it is negatively charged, is identical to an electron, and is easily stopped by a thin sheet of metal.

Biodiversity - The diversity of life in all its forms and all its levels of organization. Also termed "biological diversity."

Block groups - U.S. Bureau of the Census term describing a cluster of blocks generally selected to include 250 to 550 housing units.

Blowdown - A maintenance procedure to remove sediment in power plant components.

Boiling water reactor - A type of nuclear reactor that uses fission heat to generate steam in the reactor core or vessel to drive turbines and generate electricity.

Boron-10 - An isotope of the element boron that has a high-capture cross-section for neutrons. It is used in reactor absorber rods for reactor control.

Bounding accident - An accident whose calculated consequences encompass all other possible accident consequences for that facility. For example, a bounding accident for the release of hazardous material from a storage tank would postulate the release of the entire tank contents. The consequences from this accident would be greater than the consequences of all other tank release accidents.

Burnable absorber - A material, such as boron or lithium, that captures neutrons and transmutes or changes to another isotope.

Burnable poison rod - A nuclear reactor rod used to capture or absorb neutrons created in the core by the fission reactions during the early core life.

Burnup - The total energy released through fission by a given amount of nuclear fuel; generally measured in megawatt-days.

Cancer - The name given to a group of diseases characterized by uncontrolled cellular growth with cells having invasive characteristics such that the disease can transfer from one organ to another.

Canister - A stainless-steel container in which nuclear material is sealed.

Capable geology - Describes a geological fault that has moved at or near the ground surface within the past 35,000 years.

Capacity factor - A power production performance measure that compares the amount of power actually produced per year to the maximum power output possible. This measure is typically expressed as a fraction or percentage of the megawatt hours (MWh) produced relative to the possible MWh that would have been produced had the unit or system operated every hour of the year.

Carcinogenic - Capable of inducing cancer.

Cesium - A silver-white alkali metal. A radioactive isotope of cesium, cesium-137, is a common fission product.

Chain reaction - A reaction that initiates its own repetition. In a fission chain reaction, a fissionable nucleus absorbs a neutron and fissions spontaneously, releasing additional neutrons. These, in turn, can be absorbed by other fissionable nuclei, releasing still more neutrons. A fission chain reaction is self-sustaining when the number of neutrons is constant or increases over a period of time.

Chemical oxygen demand - A measure of the quantity of chemically oxidizable components present in water.

Chronic exposure - Low-level radiation exposure incurred over a long time period due to residual contamination.

Cladding - The metal tube that forms the outer jacket of a nuclear fuel rod or burnable absorber rod. It prevents the release of radioactive material into the coolant. Stainless steel and zirconium alloys *are* common cladding materials.

Capacity factor - The ratio of the annual average power production of a power plant to its rated capacity.

Cold standby - Maintenance of a protected reactor condition in which the fuel is removed, the moderator is stored in tanks, and equipment and system lay-up is performed to prevent deterioration, such that future refueling and restart are possible.

Collective committed effective dose equivalent - The committed effective dose equivalent of radiation for a population.

Committed effective dose equivalent - The sum of the committed dose equivalents to various tissues in the body multiplied by their appropriate tissue weighting factor. Equivalent in effect to a uniform external dose of the same value.

Consumptive water use - The difference in the volume of water withdrawn from a body of water and the amount released back into the body of water.

Container - With regard to radioactive wastes, the metal envelope in the waste package that provides the primary containment function of the waste package and is designed to meet the containment requirements of lOCFR6O.

Containment design-basis - For a nuclear reactor, those bounding conditions for the design of the containment, including temperature, pressure, and leakage rate. Because the containment is provided as an additional barrier to mitigate the consequences of accidents involving the release of radioactive materials, the containment design-basis may include an additional specified margin above those conditions expected to result from the plant design-basis accidents to ensure that the containment design can mitigate unlikely or unforeseen events.

Control rod - A rod containing material such as boron that is used to control the power of a nuclear reactor. By absorbing excess neutrons, a control rod prevents the neutrons from causing further fissions; i.e., increasing power.

Cooling water - Water pumped into a nuclear reactor or accelerator to cool components and prevent damage from the intense heat generated when the reactor or accelerator is operating.

Credible accident - An accident that has a probability of occurrence greater than or equal to one in a million years.

Criticality - A reactor state in which a self-sustaining nuclear chain reaction is achieved.

Crop - A process that cuts off or otherwise removes the hardware on the fuel assemblies, leaving primarily the active fuel for subsequent processes.

Cultural resources - Archaeological sites, historical sites, architectural features, traditional use areas, and Native American sacred sites.

Cumulative impacts - In an environmental impact statement, the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions, regardless of what agency (Federal or nonfederal), private industry, or individual(s) undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time (40 CFR 1508.7).

Curie (Ci) - A unit of radioactivity equal to 37 billion disintegrations per second; also a quantity of any nuclide or mixture of nuclides having I Curie radioactivity.

Daughter - A nuclide formed by the radioactive decay of another nuclide, which is the "parent."

Day-night average sound level - The 24-hour A-weighted equivalent sound level expressed in decibels, with a 10-decibel penalty added to sound levels between 10:00 p.m. and 7:00 a.m. to account for increased annoyance due to noise during nighttime hours.

Decay heat (radioactivity) - The heat produced by the decay of certain radionuclides.

Decay (radioactive) - The decrease in the amount of any radioactive material with the passage of time due to the spontaneous transformation of an unstable nuclide into a different nuclide or into a different energy state of the same nuclide; the emission of nuclear radiation (alpha, beta, or gamma radiation) is part of the process.

Decibel (dB) - A logarithmic unit of sound measurement which describes the magnitude of a particular quantity of sound pressure power with respect to a standard reference value. in general, a sound doubles in loudness for every increase of 10 decibels.

Decibel, A-weighted (dBA) - A unit of frequency weighted sound pressure level, measured by the use of a metering characteristic and the "A" weighting specified by the American National Standards institution ANSI Si .4-1983 (RI 594), that accounts for the frequency response of the human ear.

Decommissioning - The removal from service of facilities such as processing plants, waste tanks, and burial grounds, and the reduction or stabilization of radioactive contamination. Decommissioning includes decontamination, dismantling, and return of the area to original condition without restrictions or partial decontamination, isolation of remaining residues, and continuation of surveillance and restrictions.

Decontamination - The actions taken to reduce or remove substances that pose a substantial present or potential hazard to human health or the environment, such as radioactive or chemical contamination from facilities, equipment, or soils by washing, heating, chemical or electrochemical action, mechanical cleaning, or other techniques.

Decoupler - That part of an accelerator between the high-energy neutron source and the moderating blanket that contains feedstock material that will absorb low-energy neutrons and help protect the neutron source.

Demographic - Related to the statistical study of human populations, including size, density, distribution, and such vital statistics as age, gender, and ethnicity.

Depleted uranium - A mixture of uranium isotopes where uranium-235 represents less than 0.7 percent of the uranium by mass.

Derived Concentration Guide (DCG) - The concentration of a radionuclide in air or water that, under conditions of continuous exposure for one year by one exposure mode (i.e., ingestion of water, submersion in air, or inhalation), would result in an effective dose equivalent of 100 mrem (0.1 rem = 1 mSv [milliSievert]).

Design-basis accident - For nuclear facilities, information that identifies the specific functions to be performed by a structure, system, or component and the specific values (or ranges of values) chosen for controlling parameters for reference bounds for design. These values may be: (1) restraints derived from generally accepted state-of-the-art practices for achieving functional goals; (2) requirements derived from analysis (based on calculation andlor experiments) of the effects of a postulated accident for which a structure, system, or component must meet its functional goals; or (3) requirements derived from Federal safety objectives, principles, goals, or requirements.

Design-basis events - Postulated disturbances in process variables that can potentially lead to design-basis accidents.

Deuterium - A nonradioactive isotope of the element hydrogen with one neutron and one proton in the atomic nucleus.

Distribution (electrical) - The system of lines, transformers, and switches that connect between the transmission network and customer load. The transport of electricity to ultimate use points such as homes and businesses. The portion of an electric system that is dedicated to delivering electric energy to an end user at relatively low voltages.

Dose - The energy imparted to matter by ionizing radiation. The unit of absorbed dose is the rad.

Dose commitment - The dose an organ or tissue would receive during a specified period of time (e.g., *50* to 100 years) *as* a result of intake (by ingestion or inhalation) of one or more radionuclides from a defined release, frequently over a year's time.

Dose conversion factor - Factor used to calculate the dose received from exposure to radiation.

Dose equivalent - The product of absorbed dose in rad (or Gray) and a quality factor, which quantifies the effect of this type of radiation in fissue. Dose equivalent is expressed in units of rem or Sievert, where 1 rem equals 0.01 Sievert.

Dose rate - The radiation dose delivered per unit time (e.g., rem per year).

Dosimeter - A small device (instrument) carried by a radiation worker that measures cumulative radiation dose (e.g., film badge or ionization chamber).

Drift - Effluent mist or spray carried into the atmosphere from cooling towers.

Drinking water standards - The level of constituents or characteristics in a drinking water supply specified in regulations under the Safe Drinking Water Act as the maximum permissible.

Effective dose equivalent - The sum of the products of the dose equivalent received by specified tissues of the body and a tissue-specific weighting factor. This sum is a risk-equivalent value and can be used to estimate the health effects risk to the exposed individual. The tissue-specific weighting factor represents the fraction of the total health risk resulting from uniform whole-body irradiation that would be contributed by that particular tissue. The effective dose equivalent includes the committed effective dose equivalent from internal deposition of radionuclides, and the effective dose equivalent due to penetrating radiation from sources external to the body. Effective dose equivalent is expressed in units of rem or Sievert.

Effluent - A gas or fluid discharged into the environment.

Effluent monitoring - The collection and analysis of samples or measurements of liquid and gaseous effluents to characterize and quantify contaminants, assess radiation exposure to members of the public, and demonstrate compliance with applicable standards; occurs at the point of discharge, such as an air stack or drainage pipe.

Electromagnetic fields - Two types of energy fields which are emitted from any device that generates, transmits, or uses electricity.

Electron - An elementary particle with a mass of 9.107 x 10^{-28} gram (or 1/1837 of a proton) and a negative charge. Electrons surround the positively charged nucleus and determine the chemical properties of the atom.

Element - One of the 109 known chemical substances that cannot be divided into simpler substances by chemical means. All isotopes of an element have the same atomic number (number of protons) but have different numbers of neutrons.

Emergency Response Planning Guideline (ERPG) Values - These values, which are specific for each chemical, are established for three general severity levels: exposure to concentrations greater than ERPG-1 values for a period of time greater than 1 hour results in an unacceptable likelihood that a person would experience mild transient adverse health effects, or perception of a clearly objectionable odor; exposure to concentrations greater than ERPG-2 values for a period of time greater than 1 hour results in an unacceptable likelihood that a person would experience or develop irreversible or other serious health effects, or symptoms that could impair one's ability to take protective action; exposure to concentrations greater than ERPG-3 values for a period of time greater than 1 hour results in an unacceptable likelihood that a person would experience or develop life-threatening health effects.

Emission standards - Legally enforceable limits on the quantities and/or kinds of air contaminants that may be emitted into the atmosphere.

Endangered species - Any species which is in danger of extinction throughout all or significant portions of its range. The Endangered Species Act of 1973, as amended, establishes procedures for placing species on the Federal lists of endangered or threatened species.

Endangered Species Act of 1973 - The Act requires Federal agencies, with the consultation and assistance of the Secretaries of the Interior and Commerce, to ensure that their actions likely will not jeopardize the continued existence of any endangered or threatened species or adversely affect the habitat of such species.

Engineered safety features - For a nuclear facility, features that prevent, limit, or mitigate the release of radioactive material from its primary containment.

Enriched uranium - Uranium in which the abundance of the isotope uranium-235 is increased above the normal (naturally occurring) level of 0.711 weight percent.

Enrichment - A process in which the fraction of the uranium-235 isotopes has been artificially increased above the natural abundance level of 0.72 percent.

Entrainment - The involuntary capture and inclusion of organisms in Streams of flowing water; a term often applied to the cooling water systems of power plants/reactors. The organisms involved may include phyto-and zooplankton, fish eggs and larvae (ichthyoplankton), shellfish larvae, and other forms of aquatic life.

Environment - The sum of all external conditions and influences affecting the life, development, and ultimately the survival of an organism.

Environment, safety, and health program - In the context of the U.S. Department of Energy (DOE), encompasses those DOE requirements, activities, and functions in the conduct of all DOE and DOE-controlled operations that are concerned with: impacts to the biosphere; compliance with environmental laws, regulations, and standards controlling air, water, and soil pollution; limiting the risks to the well-being of both the operating personnel and the general public; and protecting property against accidental loss or damage. Typical activities and functions related to this program include, but are not limited to, environmental protection, occupational safety, fire protection, industrial hygiene, health physics, occupational medicine, process and facilities safety, nuclear safety, emergency preparedness, quality assurance, and radioactive and hazardous waste management.

Environmental justice - The fair treatment of people of all races, cultures, incomes, and educational levels with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. Fair treatment implies that no population of people should be forced to shoulder a disproportionate share of the negative environmental impacts of pollution or environmental hazards due to a lack of political or economic influence.

Epidemiology - The science concerned with the study of events that determine and influence the frequency and distribution of disease, injury, and other health-related events and their causes in a defined human population.

Equivalent sound (pressure) level - The equivalent steady sound level that, if continuous during a specified time period, would contain the same total energy as the actual time varying sound. For example, L_{eq}(1-h) and L_{eq} (24-h) are the 1-hour and 24-hour equivalent sound levels, respectively.

Exposure limit - The level of exposure to a hazardous chemical (set by law or a standard) at which or below which adverse human health effects are not expected to occur:

(1) Reference dose is the chronic exposure dose (milligrams or kilograms per day) for a given hazardous chemical at which or below which adverse human noncancer health effects are not expected to occur.

(2) Reference concentration is the chronic exposure concentration (milligrams per cubic meter) for a given hazardous chemical at which or below which adverse human non cancer health effects are not expected to occur.

Exposure to radiation - The incidence of radiation on living or inanimate material by accident or intent. Background exposure is the exposure to natural background ionizing radiation. Occupational exposure is the exposure to ionizing radiation that occurs at a person's workplace. Population exposure is the exposure to a number of persons who inhabit an area.

Exposure pathway - The course a chemical or physical agent takes from the source to the exposed organism. The pathway describes a unique mechanism by which an individual or population is exposed to chemicals or physical agents at or originating from the site. Each exposure pathway includes a source or release from a source, an exposure point, and an exposure route. If the exposure point differs from the source, a transport/exposure medium (e.g., air) is included.

Fertile - Describing radionuclides that can be converted into fissile material (e.g., thorium-232 and uranium-238 can be converted through neutron capture to uranium-233 and plutonium-239, respectively).

Fissile materials - Although sometimes used as a synonym for fissionable material, this term has acquired a more restricted meaning, namely, any material fissionable by thermal (slow) neutrons. The three primary fissile materials are uranium-233, uranium-235, and plutonium-239.

Fission (fissioning) - The splitting of a nucleus into at least two other nuclei and the release of a relatively large amount of energy. Two or three neutrons are usually released during this type of transformation.

Fission chain reaction - Nuclear reaction in which atomic nuclei in reactor fuel respond to collisions with neutrons by splitting into two or three major fragments and additional neutrons accompanied by the emission of gamma radiation.

Fission fragments - The parts into which atomic nuclei in reactor fuel split during a fission chain reaction.

Fission products - Nuclei formed by the fission of heavy elements (primary fission products); also, the nuclei formed by the decay of the primary fission products, many of which are radioactive.

Fissionable material - Material that could undergo fission by fast neutrons.

Floodplain - The lowlands adjoining inland and coastal waters and relatively flat areas.

Fluvial - Deposits produced by the action of a stream/river.

Flux - Rate of flow through a unit area; in reactor operation, the apparent flow of neutrons in a defined energy range (see neutron flux).

Fuel assembly - A cluster of fuel rods (or plates). Also called a fuel element. Approximately 200 fuel assemblies make up a reactor core.

Fuel rod - Nuclear reactor component that includes the fissile material.

Fugitive emissions - Emissions to the atmosphere from pumps, valves, flanges, seals, and other process points not vented through a stack. Also includes emissions from area sources such as ponds, lagoons, landfills, piles of stored material, and exposed soil.

Gamma rays - High-energy, short-wavelength, electromagnetic radiation accompanying fission and either emitted from the nucleus of an atom or emitted by some radionuclide or fission product. Gamma rays are very penetrating and can be stopped only by dense materials (such as lead) or a thick layer of shielding materials.

Global warming - The theory that increasing concentrations of certain gases such as carbon dioxide, methane, and chlorofluorocarbons in the Earth's atmosphere are effectively reducing radiative cooling, thus elevating the Earth's ambient temperatures.

Greater-than-Class-C waste - Radioactive waste that contains long-lived radionuclides and requires special disposal considerations.

Grid - A transmission and distribution system for electric power.

Groundshine - The radiation dose received from an area on the ground where radioactivity has been deposited by a radioactive plume or cloud.

Habitat - The environment occupied by individuals of a particular species, population, or community.

Half-life - The time in which half the atoms of a radioactive isotope decay to another nuclear form. Half-lives vary from millionths of a second to billions of years.

Hazardous material - A material, including a hazardous substance, as defined by 49 CFR 171.8, which poses a risk to health, safety, and property when transported or handled.

Hazardous substance - Any substance that when released to the environment in an uncontrolled fashion could be harmful to the biota or human health and when released in an unpermitted fashion becomes subject to the reporting and possible response provisions of the Clean Water Act and the Comprehensive Environmental Response, Compensation, and Liability Act.

Hazardous/toxic air pollutants - Air pollutants known or suspected to cause serious health problems such *as* cancer, poisoning, or sickness, and may have immunological, neurological, reproductive, developmental, or respiratory effects.

Hazardous/toxic waste - Any solid waste (can also be semisolid or liquid, or contain gaseous material) having the characteristics of ignitability, corrosivity, toxicity, or reactivity, defined by the Resource Conservation and Recovery Act and identified or listed in 40 CPR 261 or by the Toxic Substances Control Act.

Heat exchanger - A device that transfers heat from one fluid (liquid or gas) to another.

High Efficiency Particulate Air Filter (HEPA) - A filter used to remove very small particulates from dry gaseous effluent streams.

High-level waste - The highly radioactive waste material that results from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid waste derived from the liquid. High-level waste contains a combination of transuranic waste and fission products in concentrations requiring permanent isolation.

High(ly) enriched uranium - Uranium that is equal to or greater than 20 percent uranium-235 weight. Many of the fuels discussed in this EIS are based primarily on highly enriched uranium.

High-level radioactive waste - Highly radioactive material from the reprocessing of spent nuclear fuel that contains a combination of transuranic waste and fission products in concentration that require permanent isolation. It includes both liquid waste produced by reprocessing and solid waste derived from that liquid.

Historic resources - Archaeological sites, architectural structures, and objects produced after the advent of written history dating to the time of the first Euro-American contact in an area.

Icthyoplankton - The early life stages of fish (eggs and larvae) that spend part of their life cycle as free-floating plankton.

Impingement - The process by which aquatic organisms too large to pass through the screens of a water intake structure become caught on the screens and are unable to escape.

Induced economic effects - The spending of households resulting from direct and indirect economic effects. Increases in output from a new economic activity lead to an increase in household spending throughout the economy as firms increase their labor inputs.

Interium storage - Safe and secure storage for spent nuclear fuel and radioactive wastes until the materials are dispositioned (treatment and/or disposal).

Internal initiators - Events that normally originate in and around the facility but are always a result of facility operations (equipment or structural failures, human errors, internal flooding). In accident scenarios, initiators start the events that culminate in a release of hazardous or radioactive materials.

Ion - An atom that has too many or too few electrons, causing it to be electrically charged; an electron that is not associated (in orbit) with a nucleus.

Ion exchange - A unit physiochemical process that removes anions and cations, including radionuclides, from liquid streams (usually water) for the purpose of purification or decontamination.

Ion-exchange medium - A substance (see resin) that preferentially removes certain ions from a solution.

Ionizing radiation - Alpha particles, beta particles, gamma rays, neutrons, high-speed electrons, high-speed protons, and other particles or electromagnetic radiation that can displace electrons from atoms or molecules, thereby producing ions.

Irradiation - Exposure to radiation.

Isotope - An atom of a chemical element with a specific atomic number and atomic mass. Isotopes of the same element have the same number of protons, but different numbers of neutrons and different atomic masses. Isotopes are identified by the name of the element and the total number of protons and neutrons in the nucleus. For example, plutonium-239 is a plutonium atom with 239 protons and neutrons.

Isotope dilution - Mixing a less-enriched radioisotope with a highly enriched radioisotope to yield an isotope with lower nuclear enrichment.

Joule - A metric unit of energy, work, or heat, equivalent to 1 watt-second, 0.737 foot-pound, or 0.239 calories.

Latent cancer fatalities - Fatalities associated with acute and chronic environmental exposures to chemical or radiation that occur within 30 years of exposure.

Laydown - Area of construction site used to sort and store construction materials.

Licensee amendment - Changes to an existing reactor's operating license that are approved by the U.S. Nuclear Regulatory Commission.

Light water - The common form of water (a molecule with two hydrogen atoms and one oxygen atom, H_20) in which the hydrogen atom consists completely of the normal hydrogen isotope (one proton).

Light water reactor - A nuclear reactor in which circulating light water is used to cool the reactor core and to moderate (reduce the energy of) the neutrons created in the core by the fission reactions.

Loss-of-coolant accident - An accident that results from the loss of reactor coolant because of a break in the reactor coolant system.

Low-enriched uranium (LEU) - Uranium with uranium-235 enriched above the natural concentration (0.72 percent) but below 20 percent; highly enriched uranium (HEU) is enriched 20 percent or higher.

Low-level waste - Waste that contains radioactivity, but is not classified as high-level waste, transuranic waste, spent nuclear fuel, or by-product material as defined by Section lie (2) of the Atomic Energy Act of 1954, as amended. Test specimens of fissionable material irradiated for research and development only, and not for the production of power or plutonium, may be classified as low-level waste, provided the concentration of transuranic waste is less than 100 nanocuries per gram. Some low-level waste is considered classified because of the nature of the generating process and/or constituents, because the waste would tell too much about the process.

Makeup water - Replacement for water lost through drift, blowdown, or evaporation (as in a cooling tower).

MAXIGASP - A computer program used to calculate doses of airborne releases of radioactivity to the maximally exposed member of the public.

Maximum Contaminant Levels (MCLs) - The maximum permissible level of a contaminant in water delivered to any user of a public drinking water system. Maximum contaminant levels are enforceable standards under the Safe Drinking Water Act.

Maximally exposed off site individual - A hypothetical person who could potentially receive the maximum dose of radiation or hazardous chemicals.

Megawatt (MW) - A unit of power equal to 1 million watts. "Megawatt-thermal" is commonly used to define heat produced, while "megawatt-electric" defines electricity produced.

Millirem - One thousandth of a rem. (See rem)

Minority communities - A population classified by the Bureau of the Census as Black, Hispanic, Asian and Pacific Islander, American Indian, Eskimo, Aleut, and other nonwhite persons, the composition of which is at least equal to or greater than the state minority average of a defined area of jurisdiction.

Mixed waste - Waste that contains both "nonradloactive hazardous waste" and "radioactive waste" as defined in this glossary.

National Ambient Air Quality Standards (NAAQS) - Uniform, national air quality standards established by the Environmental Protection Agency under the authority of the Clean Air Act that restrict ambient levels of criteria pollutants to protect public health (primary standards) or public welfare (secondary standards), including plant and animal life, visibility, and materials. Standards have been set for ozone, carbon monoxide, particulates, sulfur dioxide, nitrogen dioxide, and lead.

National Emission Standards for Hazardous Air Pollutants - A set of national emission standards for listed hazardous pollutants emitted from specific classes or categories of new and existing sources.

National Historic Preservation Act - This Act provides that property resources with significant national historic value be placed on the national Register of Historic Places. It does not require any permits, but, pursuant to Federal code, if a proposed action might impact an historic property resource, it mandates consultation with the proper agencies.

National Pollutant Discharge Elimination System (NPDES) - Federal permitting system required for water pollution effluents under the Clean Water Act, as amended.

National Register of Historic Places - A list maintained by the Secretary of the Interior of districts, sites, buildings, structures, and objects of prehistoric or historic local, state, or national significance under Section 2(b) of the Historic Sites Act of 1935(16 U.S.C. 462) and Section 101(a) (1) (A) of the National Historic Preservation Act of 1966, as amended.

Natural phenomena initiators - Natural occurrences that are independent of facility operations and events at nearby facilities or operations (earthquakes, high winds, floods, lightning, snow). Although these initiators are independent of external facilities, they can affect such facilities and compound the progression of the accident.

National radiation or natural radioactivity - Background radiation. Radiation arising from cosmic and terrestrial naturally-occurring radionuclide sources.

Neutron - An uncharged elementary particle with a mass slightly greater than that of the proton, found in the nucleus of every atom heavier than hydrogen-1. A free neutron is unstable and decays with a half-life of about 13 minutes into an electron and a proton; used in the fission process.

Neutron flux - The product of neutron number density and velocity (energy), giving an apparent number of neutrons flowing through a unit area per unit time.

Neutron poison - A chemical solution (e.g., a boron or component sheet or a burnable absorber rod) inserted into a nuclear reactor or spent fuel pool to absorb neutrons and end criticality. Any material with a strong affinity for absorbing neutrons without generating new neutrons that can be used to control the nuclear chain reaction.

Nuclear grade - Material of a quality adequate for use in a nuclear application.

Nuclear material - Composite term applied to: (1) special nuclear material; (2) source material such as uranium, thorium, or ores containing uranium or thorium; and (3) by-product material, which is any radioactive material that is made radioactive by exposure to a radiation incident or to the process of producing or using special nuclear material.

Nuclear radiation - Particles (alpha, beta, neutrons) or photons (gamma) emitted from the nucleus of unstable radioactive atoms as a result of radioactive decay.

Nuclear reaction - A reaction in which an atomic nucleus is transformed into another isotope of that respective nuclide, or into another element altogether; it is always accompanied by the liberation of either particles or energy.

Nuclear reactor - A device that sustains a controlled nuclear fission chain reaction that releases energy in the form of heat.

Nuclear Regulatory Commission (NRC) - The Federal agency that regulates the civilian nuclear power industry in the United States.

Nuclide - A species of atom characterized by the constitution of its nucleus and, hence, by the number of protons, the number of neutrons, and the energy content.

Occupational Safety and Health Administration - Oversees and regulates workplace health and safety, created by the Occupational Safety and Health Act of 1970.

Off-normal event - An unexplained event that exceeds the range of normal operating parameters, but that usually does not have a significant impact (inside or beyond the SRS boundary).

Outfall - The discharge point of a drain, sewer, or pipe as it empties into a body of water.

Peaking capacity - The capacity of facilities or equipment normally used to supply incremental gas or electricity under extreme demand conditions. Peaking capacity is generally available for a limited number of days at a maximum rate.

Peak load - The maximum load consumed or produced by a unit or group of units in a stated period of time.

Pellets - One configuration of the reactive material in a target rod.

Permeator - A device that selectively allows the passage of hydrogen atoms and prevents the passage of other elements. Used to separate hydrogen and tritium from helium.

Person-rem - The unit of collective radiation dose to a given population; the sum of the individual doses received by a population segment.

Plume - A flowing, often somewhat conical, trail of emissions from a continuous point source.

Plume immersion - With regard to radiation, the situation in which an individual is enveloped by a cloud of radiation gaseous effluent and receives an external radiation dose.

Plutonium (Pu) - A heavy, radioactive, metallic element with the atomic number 94. It is produced artificially in a reactor by bombardment of uranium with neutrons and is used in the production of nuclear weapons.

Poison - A material that has an affinity for absorbing neutrons. Poisons are added to nuclear materials with a potential critically concern to lessen the likelihood of an uncontrolled nuclear reaction.

Pressurized water reactor - A light water reactor in which heat is transferred from the core to an exchanger by water kept under pressure in the primary system. Steam is generated in a secondary circuit. Many reactors producing electric power are pressurized water reactors.

Primary system - With regard to nuclear reactors, the system that circulates a coolant (e.g., water) through the reactor core to remove the heat of reaction.

Prime farmland - Land that has the best combination of physical and chemical characteristics for producing food, feed, fiber, forage, oil-seed, and other agricultural crops with minimum inputs of fuel, fertilizer, pesticides, and labor without intolerable soil erosion, as determined by the Secretary of Agriculture (Farmland Protection Act of 1981, 7 CPR 7, paragraph *658)*.

Probabilistic risk assessment - A comprehensive, logical, and structured methodology to identify and quantitatively evaluate significant accident sequences and their consequences.

Probable maximum flood - The hypothetical flood (peak discharge, volume, and hydrograph shape) that is considered to be the most severe reasonably possible, based on comprehensive hydrometeorological application of Probable Maximum Precipitation, and other hydrologic factors favorable for maximum flood runoff, such as sequential storms and snowmelt. (Reference: FSAR)

Probable Maximum Precipitation - The theoretically greatest depth of precipitation for a given duration that is physically possible over a particular drainage area at a certain time of year. (Reference: American Meteorological Society, 1959)

Processing (of spent nuclear fuel) - Applying a chemical or physical process designed to alter the characteristics of the spent fuel matrix.

Proton - An elementary nuclear particle with a positive charge equal in magnitude to the negative charge of the electron; it is a constituent of all atomic nuclei, and the atomic number of an element indicates the number of protons in the nucleus of each atom of that element.

Pyrophoric - The tendency to spontaneously ignite in air. Some uranium and thorium metal fuels may be pyrophoric.

Quality factor - The principal modifying factor that is employed to derive dose equivalent from absorbed dose.

Radiation - The emitted particles or photons from the nuclei of radioactive atoms. Some elements are naturally radioactive; others are induced to become radioactive by bombardment in a reactor. Naturally occurring radiation is indistinguishable from induced radiation.

Radiation Absorbed Dose (rad) - The basic unit of absorbed dose equal to the absorption of 0.01 Joule per kilogram of absorbing material.

Radiation shielding - Radiation-absorbing material that is interposed between a source of radiation and organisms that would be harmed by the radiation (e.g., people).

Radioactive waste - Materials from nuclear operations that are radioactive or are contaminated with radioactive materials, and for which use, reuse, or recovery are impractical.

Radioactivity - The spontaneous decay or disintegration of unstable atomic nuclei, accompanied by the emission of radiation.

Radioisotopes - Radioactive nuclides of the same element (same number of protons in their nuclei) that differ in the number of neutrons.

Radiological - Related to radiology, the science that deals with the use of ionizing radiation to diagnose and treat disease.

Radiolysis - Decomposition of a material by ionizing radiation.

Radionuclide - A radioactive element characterized according to its atomic mass and atomic number which can be man-made or naturally occurring.

Radon - Gaseous, radioactive element with the atomic number 86 resulting from the radioactive decay or radium. Radon occurs naturally in the environment, and can collect in unventilated enclosed areas, such as basements. Large concentrations of radon can cause lung cancer in humans.

RADTRAN - A computer code that combines user-determined meteorological, demographic, transportation, packaging, and material factors with health physics data to calculate the expected radiological consequences and accident risk of transporting radioactive material.

Reactor - A device or apparatus in which a chain reactor of fissionable material is initiated and controlled; a nuclear reactor.

Reactor accident - See "design basis accident; severe accident."

Reactor coolant system - The system used to transfer energy from the reactor core either directly or indirectly to the heat rejection system.

Reactor core - In a heavy water reactor: the fuel assemblies including the fuel and target rods, control assemblies, blanket assemblies, safety rods, and coolant/moderator. In a light water reactor: the fuel assemblies including the fuel and target rods, control rods, and coolant/moderator. In a modular high-temperature gas-cooled reactor: the graphite elements including the fuel and target elements, control rods, and other reactor shutdown mechanisms, and the graphite reflectors.

Reactor facility - Unless it is modified by words such as containment, vessel, or core, the term reactor facility includes the housing, equipment, and associated areas devoted to the operation and maintenance of one or more reactor cones. Any apparatus that is designed or used to sustain nuclear chain reactions in a controlled manner, including critical and pulsed assemblies and research, tests, and power reactors, is defined as a reactor. All assemblies designed to perform subcritical experiments that could potentially reach criticality are also to be considered reactors.

Record of Decision (ROD) - A document prepared in accordance with the requirements of the Council on Environmental Quality and National Environmental Policy Act regulations 40 CFR 1505.2, that provides a concise public record of the decision on a proposed Federal action for which an environmental impact statement was prepared. A Record of Decision identifies the alternatives considered in reaching the decision, the environmentally preferable alternative(s), factors balanced in making the decision, whether all practicable means to avoid or minimize environmental harm have been adopted, and if not, why they were not.

Refueling outage - The period of time that a reactor is shut down for refueling operations. A refueling outage usually lasts four to eight weeks.

Repository - A place for the disposal of immobilized high-level waste and spent nuclear fuel in isolation from the environment.

Reprocessing (of spent nuclear fuel) - Processing of reactor-irradiated nuclear material (primarily spent nuclear fuel) to recover fissile and fertile material, in order to recycle such materials primarily for defense programs or generation of electricity. Historically, reprocessing has involved aqueous chemical separations of elements (typically uranium or plutonium) from undesired elements in the fuel.

Resin - An ion-exchange medium; organic polymer used for the preferential removal of certain ions from a solution.

Risk - In accident analysis, the probability-weighted consequence of an accident, defined as the accident frequently per year multiplied by the dose. The term "risk" also is used commonly in other applications to describe the probability of an event occurring.

Risk assessment (chemical or radiological) - The qualitative and quantitative evaluation performed in an effort to define the risk posed to human health and/or the environment by the presence or potential presence and/or use of specific chemical or radiological materials.

Roentgen - A unit of exposure to ionizing X or gamma radiation equal to or producing 1 electrostatic unit of charge per cubic centimeter of air. It is approximately equal to 1 rad.

Roentgen Equivalent Man (rem) - A measure of radiation dose (i.e., the average background radiation dose is 0.3 rem per year). The unit of biological dose equal to the product of the absorbed dose in rads; a quality factor, which accounts for the variation in biological effectiveness of different types of radiation; and other modifying factors.

Runoff - The portion of rainfall, melted snow, or irrigation water that flows across the ground surface and eventually enters streams.

Safety analysis report - A safety document that provides a complete description and safety analysis of a reactor design, normal and emergency operations, hypothetical accidents and their predicted consequences, and the means proposed to prevent such accidents or mitigate their consequences.

Safety evaluation report - A document prepared by the U.S. Nuclear Regulatory Commission that evaluates documentation (i.e., technical specifications, safety analysis reports, and special safety reviews and studies) submitted by a reactor licensee for its approval. This ensures that all of the safety aspects of part or all of the activities conducted at a reactor are formally and thoroughly analyzed, evaluated, and recorded.

Scoping - The solicitation of comments from interested persons, groups, and agencies at public meetings, public workshops, in writing, electronically, or via fax to assist in defining the proposed action, identifying alternatives, and developing preliminary issues to be addressed in an environmental impact statement.

Secondary system - The system that circulates a coolant (water) through a heat exchanger to remove heat from the primary system.

Seismicity - The tendency for earthquakes to occur.

Seismic zone - An area defined by the Uniform Building Code (1991), designating the amount of damage to be expected as the result of earthquakes. The United States is divided into six zones: (1) Zone 0: no damage; (2) Zone 1: minor damage, corresponds to intensities V and VI of the modified Mercalli intensity scale; (3) Zone 2A: moderate damage, corresponds to intensity VII of the modified Mercalli intensity scale (eastern U.S.); (4) Zone 2B: slightly more damage than 2A (western U.S.); (5) Zone 3: major damage, corresponds to intensity VII and higher of the modified Mercalli intensity scale; (6) Zone 4: areas within Zone 3 determined by proximity to certain major fault systems.

Severe accident - An accident with a frequency rate of less than 10^6 per year that would have more severe consequences than a design-basis accident, in terms of damage to the facility, off site consequences, or both. Also called "beyond design-basis reactor accidents" for this environmental impact statement.

Shielding - With regard to radiation, any material of obstruction (bulkheads, walls, or other construction) that absorbs radiation in order to protect personnel or equipment.

Short-lived activation products - An element formed from neutron interaction that has a relatively short half-life and which is not produced from the fission reaction (e.g., a cobalt isotope formed from impurities in the metal of the reactor piping).

Short-lived nuclides - Radioactive isotopes with half-lives no greater than about 30 years (e.g., cesium-137 and strontium-90).

Shutdown - For a U.S. Department of Energy (DOE) reactor, that condition in which the reactor has ceased operation and DOE has declared officially that it does not intend to operate it further (see DOE Order 5480.6, - Safely of Department of Energy-Owned Nuclear Reactors).

Source term - The estimated quantities of radionuclides or chemical pollutants released to the environment.

Special nuclear materials - As defined in Section 11 of the Atomic Energy Act of *1954,* special nuclear A material means: (1) plutonium, uranium enriched in the isotope 233 or in the isotope *235,* and any other material which the U.S. Nuclear Regulatory Commission determines to be special nuclear material; or (2) any material artificially enriched by any of the above. Tritium is NOT a special nuclear material.

Spent nuclear fuel - Fuel that has been withdrawn from a nuclear reactor following irradiation, the constituent elements of which have not be separated.

Stabilization - The action of making a nuclear material more chemically or physically stable by converting its physical or chemical form or placing it in a more stable environment.

Standby (cold standby) - Condition under which a facility is maintained in a protected condition to prevent deterioration such that it can be brought back into operation.

Strontium - Naturally occurring element with 38 protons in its nucleus. Some manmade isotopes of strontium are radioactive (e.g., strontium-89, strontium-90).

Technical specifications - With regard to U.S. Nuclear Regulatory Commission (NRC) regulations, part of A an NRC license authorizing the operation of a nuclear reactor facility. A technical specification establishes requirements for items such as safety limits, limiting safety system settings, limiting control settings limiting conditions for operation, surveillance requirements, design features, and administrative controls.

Thermophilic - Related to plants and animals that thrive in heated water.

Threatened species - Any species designated under the Endangered Species Act as likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

Threshold limit values - The recommended highest concentrations of contaminants to which workers may be exposed according to the American Conference of Governmental Industrial Hygienists.

Tier - To link to another in a hierarchical chain. An upper-tier document might be programmatic to the entire DOE complex of sites; a lower-tier document might be specific to one site or process.

Tritium - A radioactive isotope of the element hydrogen with two neutrons and one proton. Common symbols for the isotope are "H-3" and "T." Tritium has a half-life of 12.3 years.

Uranium - A heavy, silvery-white metallic element (atomic number 92) with several radioactive isotopes that is used as fuel in nuclear reactors.

Vault - A reinforced concrete structure for storing strategic nuclear materials used in national defense or other programmatic purposes or for disposing of radioactive or hazardous waste.

Wetlands - Land or areas exhibiting the following: hydric soil conditions, saturated or inundated soil during some portion of the year, and plant species tolerant of such conditions; also, areas that are inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas.

Whole-body dose - With regard to radiation, the dose resulting from the uniform exposure of all organs and tissues in a human body. (Also see effective dose equivalent.)

X/Q (Chi/Q) - The relative calculated air concentration due to a specific air release and atmospheric dispersion; units are (seconds per cubic meter). For example (Curies per cubic meter)/(Curies per second)= (seconds per cubic meter) or (grams per cubic meter)/(grams per second) = (seconds per cubic meter).

Index