Progress Energy

Crystal River Nuclear Plant
Docket No. 50-302
Operating License No. DPR-72

Ref: 10 CFR 54

October 9, 2009
3F1009-03

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

Subject: Crystal River Unit 3 – Response to Request for Additional Information Regarding Severe Accident Mitigation Alternatives for Crystal River Unit 3 Nuclear Generating Plant License Renewal Application (TAC NO. ME0278)

References: (1) CR-3 to NRC letter, 3F1208-01, dated December 16, 2008, "Crystal River Unit 3 – Application for Renewal of Operating License"

(2) NRC to CR-3 letter, dated August 10, 2009, "Request for Additional Information Regarding Severe Accident Mitigation Alternatives for Crystal River Unit 3 Nuclear Generating Plant License Renewal Application (TAC NO. ME0278)"

Dear Sir:

On December 16, 2008, Florida Power Corporation (FPC), doing business as Progress Energy Florida, Inc. (PEF), requested renewal of the operating license for Crystal River Unit 3 (CR-3) to extend the term of its operating license an additional 20 years beyond the current expiration date (Reference 1). Subsequently, the Nuclear Regulatory Commission (NRC), by letter dated August 10, 2009, provided a request for additional information (RAI) concerning the CR-3 License Renewal Application (Reference 2). The Enclosure to this letter provides the response to Reference 2.

No new regulatory commitments are contained in this submittal.

If you have any questions regarding this submittal, please contact Mr. Mike Heath, Supervisor, License Renewal, at (910) 457-3487, e-mail at mike.heath@pgnmail.com.

Sincerely,

Jon A. Franke
Vice President
Crystal River Unit 3

JAF/dwh

Enclosure: Response to Request for Additional Information

xc: NRC CR-3 Project Manager
NRC License Renewal Project Manager
NRC Regional Administrator, Region II
Senior Resident Inspector

A001
A035
NRR

Progress Energy Florida, Inc.
Crystal River Nuclear Plant
15760 W. Power Line Street
Crystal River, FL 34428

STATE OF FLORIDA

COUNTY OF CITRUS

Jon A. Franke states that he is the Vice President, Crystal River Nuclear Plant for Florida Power Corporation, doing business as Progress Energy Florida, Inc.; that he is authorized on the part of said company to sign and file with the Nuclear Regulatory Commission the information attached hereto; and that all such statements made and matters set forth therein are true and correct to the best of his knowledge, information, and belief.

Jon A. Franke
Vice President
Crystal River Nuclear Plant

The foregoing document was acknowledged before me this 9th day of October, 2009, by Jon A. Franke.

Signature of Notary Public
State of Florida

CAROLYN E. PORTMANN
Notary Public - State of Florida
My Commission Expires Mar 1, 2010
Commission # DD 524380
Bonded By National Notary Assn.

(Print, type, or stamp Commissioned Name of Notary Public)

Personally Known ✓ -OR- Produced Identification ______

PROGRESS ENERGY FLORIDA, INC.

CRYSTAL RIVER UNIT 3

DOCKET NUMBER 50 - 302 / LICENSE NUMBER DPR - 72

ENCLOSURE

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

1. Provide the following information regarding the Level 1 Probabilistic Safety Assessment (PSA) used for the Severe Accident Mitigation Alternatives (SAMA) analysis:

   a. Section E.2.1 provides a detailed description of the PSA model changes made since the IPE Level 1 model.

      i. Provide the core damage frequency (CDF) and large early release frequency (LERF) for each version of the PSA Model of Record (MOR) to demonstrate how changes in the PSA model impacted the calculated CDF and LERF.

      ii. For each version of the PSA, identify the model changes listed in Section E.2.1 that most impacted the change in CDF and LERF.

   b. Section E.2.2.1 states that the MOR 2006 PSA model used for the SAMA analysis reflects Crystal River Nuclear Power Plant (CR-3) as designed and operated up to April 2006. Identify any changes to the plant (physical and procedural modifications) since April 2006, that could have a significant impact on the results of the PSA and/or the SAMA analyses. Provide a qualitative assessment of their impact on the PSA and on the results of the SAMA evaluation.

   c. Section E.2 states that an industry peer review was performed on the MOR 2000 PSA model and that all Level A, B, C, and D Facts and Observations (F&Os) have been addressed and closed. Section E.2.1.1.10 further states that the Level 2 PSA was not completed in time to support the industry Peer Review. In light of this, and the fact that the peer review of the PSA was performed several years prior to the development of the MOR 2006 PSA model used for the SAMA analysis, provide a description of the quality controls applied to the development of the MOR 2006, Level 1 and 2 PSA model. Identify and discuss any additional internal and external reviews. Describe any significant review comments, their resolution, and the potential impact of any unresolved comments on the results of the SAMA analysis.

   d. Figure E.2-1 provides the contribution to CDF by initiator as a percentage of the internal events CDF (4.99E-06/yr). Provide the actual numerical value for the CDF contribution for each initiator that sums to the total internal events CDF.

Response

1.a.i The changes to the CDF and LERF for the CR-3 PRA history are summarized in the table below:

	CDF	LERF	Ref
IPE	*1.4E-5*	*1.2E-6*[1]	*1*
MOR00	*3.4E-6*	*NC*	*2*
MOR01	*5.1E-6*	*NC*	*3*
MOR02	*6.83E-6*	*3.59E-7*	*4*
MOR03	*7.49E-6*	*3.42E-7*	*5*
MOR03a	*7.49E-6*	*3.72E-7*	*6*
MOR03b	*5.40E-6*	*3.98E-7*	*7*
MOR06	*4.99E-6*	*3.69E-7*	*8*

NC – Not Calculated
[1] *IPE LERF is a combination of Containment Fails early and Containment bypassed.*

References:

1. *Crystal River 3 Individual Plant Examination, March 1993*
2. *CR-3 PSA Model of Record, N01-0002, Rev. 0*
3. *CR-3 PSA Model of Record, N01-0002, Rev. 1*
4. *CR-3 PSA Model of Record, N01-0002, Rev. 2*
5. *PSA Model of Record, P02-0001, Rev. 0*
6. *PSA Model of Record, P02-0001, Rev. 1*
7. *PSA Model of Record, P02-0001, Rev. 2*
8. *PSA Model of Record, P02-0001, Rev. 3*

1.a.ii The major items that impacted the PRA model for each model revision are listed below:

MOR00
- *Added Backup ES Transformer (BEST) - ("A" and "B" safeguards trains powered from separate transformers)*
- *Feedwater Pump 7 (FWP-7) powered with diesel generator MTDG-1*
- *Appendix R chiller installed*
- *Installed Alternate AC diesel, which could power an Essential Bus*

MOR01
- *Updates to the timing for post initiator events and dependency.*
- *Revised the Steam Generator Tube Rupture (SGTR) binning per revised Event Tree.*

MOR02
- *Added IE_F6A based upon internal flooding analysis revision.*
- *Updated the Post HRA values and the dependency analysis.*
- *Revised the binning and updated the sequences for the level 2 analysis*

MOR03
- *New initiating event fault trees were added for Loss of Service Water (T10) and Loss of Make-up (T16).*
- *Updated mutually exclusive events*

MOR03a

- *Updated table 8 bin definitions. Bin 12 is now late, medium (from early, low)*

MOR03b

- *PORV block valve alignment*
- *Added HHUTHR1Y, (Operator fails to control HPI following spurious actuation)*
- *Added HHUTHR2Y, (Operator fails to control HPI before liquid relief)*

MOR06

- *The major model changes were the installation of an alternate diesel generator EGDG-1C, the removal of MTDG-1, and the ability to align unit buses from the auxiliary transformer.*

1.b *A working model was quantified July 2009 and has a CDF of 3.63E-06 and a LERF of 1.82E-07. There have been no plant changes that have a significant impact to the PRA model since MOR06. The major changes to the model from the issue of MOR06 to July 2009 have been to comply with Regulatory Guide (RG) 1.200 and to include the addition of potential multiple spurious operation (MSO) events. None of these changes are expected to have a significant impact on the results of the SAMA evaluation.*

1.c *Quality control of the PRA model is prescribed in an administrative procedure for updates to the PSA Model. The administrative procedure outlines the methodology to ensure the PRA model is maintained current with the changes to the plant. The PSA model update procedure covers model update administration, implementation, and tracking of the error and improvement opportunities.*

A full scope PRA self assessment (except flooding) of MOR06 was performed in 2007 to the requirements of the RG 1.200 standard. The required model changes from the facts and observations were incorporated in the working model in 2008. Also, a limited scope peer review was performed in 2009 covering a portion of the Technical Elements of the internal events, at-power PRA. The Technical Elements included in the focused review were Initiating Events Analysis (IE), Quantification (QU) (partial), and LERF Analysis (LE). The findings from these reviews should not have a significant impact on the results of the SAMA analysis.

1.d *The following table gives the contribution of the IE to the CDF.*

	Initiating Event	***1E-12***	***%E-12***
IE_A	*LARGE BREAK LOCA*	*1.74E-07*	*3.5%*
IE_F10	*RUPTURE OF CIRC WATER EXP JOINTS ON TURB BLD EL 95 (FIRE ZONE TB-95-400A)*	*7.87E-09*	*0.2%*
IE_F1B	*FIRE SERVICE PIPING RUPTURE IN FIRE ZONE AB-119-6E (SPRAY)*	*7.03E-10*	*0.0%*
IE_F3	*PIPE RUPTURE IN FIRE ZONE TB-119-400E*	*2.11E-10*	*0.0%*
IE_F4	*RUPTURE OF BWST PIPING IN DECAY HEAT PIT B (FIRE ZONE AB-75-4)*	*1.60E-10*	*0.0%*
IE_F5	*RUPTURE OF BWST PIPING IN DECAY HEAT PIT A (FIRE ZONE AB-75-5)*	*2.68E-11*	*0.0%*
IE_F6A	*PIPE RUPTURE ON ELEVATION 95 OF THE AUX BLDG (FIRE ZONE AB-95-X)*	*3.83E-07*	*7.7%*
IE_F9A	*PIPE RUPTURE ON ELEVATION 95 OF TURB BLDG (FIRE ZONE TB-95-400A)*	*1.34E-09*	*0.0%*
IE_F9B	*PIPE RUPTURE ON ELEVATION 95 OF TURB BLDG (FIRE ZONE TB-95-400A) –*	*4.61E-09*	*0.1%*

	Initiating Event	*1E-12*	*%E-12*
	(SPRAY)		
IE_M	*MEDIUM BREAK LOCA*	*1.09E-07*	*2.2%*
IE_R	*STEAM GENERATOR TUBE RUPTURE*	*3.53E-07*	*7.1%*
IE_S	*SMALL BREAK LOCA*	*1.52E-06*	*30.5%*
IE_T1	*REACTOR TRIP*	*2.73E-07*	*5.5%*
IE_T10	*LOSS OF NSCCC*	*1.07E-07*	*2.1%*
IE_T11	*LOSS OF INTAKE*	*3.14E-07*	*6.3%*
IE_T12	*LOSS OF 'A' DC POWER BUS*	*1.62E-08*	*0.3%*
IE_T13	*LOSS OF 'B' DC POWER BUS*	*5.17E-08*	*1.0%*
IE_T14	*LOSS OF "C" BATTERY BACKED BUS*	*7.74E-08*	*1.6%*
IE_T15	*LOSS OF STARTUP/BACKUP ES TRANSFORMER*	*1.29E-09*	*0.0%*
IE_T16	*LOSS OF MAKEUP*	*1.53E-07*	*3.1%*
IE_T2	*LOSS OF MAIN FEEDWATER*	*1.22E-07*	*2.4%*
IE_T3	*LOSS OF OFFSITE POWER*	*3.03E-07*	*6.1%*
IE_T4	*EXCESSIVE FEEDWATER*	*4.75E-08*	*1.0%*
IE_T5	*STEAM/FEEDLINE BREAK*	*2.72E-08*	*0.5%*
IE_T7	*SPURIOUS ES ACTUATION*	*6.34E-08*	*1.3%*
IE_T8	*LOSS OF 4160V ES BUS 3A*	*2.63E-07*	*5.3%*
IE_T9	*LOSS OF 4160V ES BUS 3B*	*6.42E-08*	*1.3%*
IE_V	*ISLOCA - DHR DROP LINE AND INJECTION LINES*	*5.14E-08*	*1.0%*
IE_Z	*REACTOR VESSEL RUPTURE*	*5.00E-07*	*10.0%*
Total		***4.99E-06***	

2. Provide the following information relative to the Level 2 analysis:

   a. Describe how the Level 2 model used for the SAMA analysis differs from the Individual Plant Examination (IPE) backend analysis.

   b. Table E.5-2, Level 2 Importance List Review for Risk Reduction Worth (RRW) Greater than 1.02, presents the basic events with an RRW greater than 1.02 for LERF sequences. Not counting flags, split fractions and initiating events only five basic events are presented. Explain why there are so few basic events with an RRW greater than 1.02 for LERF sequences. Specifically address why there are no loss of offsite power related events. Also, provide the Risk Reduction Worth values for each entry in Table E.5-2.

   c. Section E.2.1.3.10, states that certain sequences (i.e. MK, SK, RK ATWS) were deleted from the Level II PSA model due to low frequency. Provide the cutoff frequency used to delete these sequences. Also, define MK, SK, and RK ATWS.

   d. Provide a breakdown of the CDF and population dose by containment release mode (e.g., intact containment, containment isolation failure, containment bypass – Steam Generator Tube Rupture [SGTR], containment bypass – ISLOCA, IVR).

e. In the discussion of the Level 2 analysis (Sections E.2.2.2, E.2.2.3 and E.3.4), the process used to map Level 1 results into the Level 2 model and group the containment event tree (CET) end states into release categories is not clear.

   i. Provide a description of the process used to map the Level 1 results into the Level 2 analysis. Describe the plant damage states and how they were applied.

   ii. Provide a description of the process used to group the containment event tree (CET) end states into release categories. Provide a typical CET showing release categories assigned to each end state.

   iii. Identify and describe the number of Modular Accident Analysis Program (MAAP) calculations made to obtain the fission product release fractions for each release category. Provide an example of the weighting calculation for a representative CET sequence. Also, identify the version of MAAP used in the SAMA evaluation.

   iv. Section E.5.1.2 explains that "...even though Release Categories 3B and 4C were not contributors to LERF, they were large contributors to Level 3 offsite consequence" and that a review was performed to determine if further risk dominant basic events could be identified. Section E.5.1.2 goes on to explain that no new dominant risk contributors not already identified from Level 1 results were found. Whereas Table E.5-2 identifies the LERF sequences having RRW values greater than 1.02, no corresponding table or information is presented that shows how risk importance events contributing to Release Categories 3B or 4C were reviewed. Identify the risk contributors from the Level 1 review that are also dominant contributors to Release Categories 3B and 4C and clarify why these are the dominant risk contributors.

Response

2.a The general concepts used to develop the Level 2 in MOR06 is similar to that used in the IP; however, the analysis has been completely revised using a different set of analysis tools and methods consistent with other Progress Energy plant PRAs. The process of binning and assigning plant damage states is similar although the current method uses a single top fault tree solution whereas the IPE solved the Level 1 and Level 2 sequences separately and combined them with post processing tools. The IPE also used STCP and CONTAIN for T-H and containment analysis while MOR06 is based upon MAAP.

2.b Table E.5-2 was intended to identify only those events unique to both LERF and those Release Categories (RCs) responsible for a large contribution to the total offsite dose (i.e., RCs 3B and 4C). However, since it appears that there were only a few basic events identified that were unique to both LERF and these RCs, the following table was generated to identify all events in any cutset that was associated with a Plant Damage State (PDS) that has a possible contribution to these release categories. For example, even though an event may not be a specific contributor to LERF, but it belonged to a cutset that was identified with a PDS that had some non-zero split fraction assigned to LERF, or RCs 3B or 4C, it was listed in the below table to identify whether it was previously assessed as part of the Level 1 importance list review. In all cases, the *events listed below that could have a possible contribution to LERF or RCs 3B or 4C were all assessed as part of the Level 1 review in Table E.5-1.*

Loss of offsite power-related events were addressed as part of the Level 1 importance list review, e.g., SAMA 18 dealt with the provision of an additional EDG to mitigate common cause failure events. For the Crystal River Nuclear Power Plant (CR-3), the loss of offsite power events were not significant contributors to LERF and the other release categories responsible for relatively high contributions to offsite dose.

For CR-3, LERF is mainly dominated by SGTR and ISLOCA events. The number of events unique to LERF with RRW values greater than 1.02 is small due to the fact that ISLOCA is modeled as a point estimate, while SGTR sequences are dominated by operator action failures to cool down and depressurize the reactor coolant system, e.g., RHUPORVY - OPERATORS FAIL TO OPEN PORV FOR PRESSURE RELIEF. Also, support systems, such as HPI and AFW, have sufficient redundancy and a good "defense-in-depth" design such that these support systems are not significant contributors to LERF.

SAMA RAI 2.b Response				
Event Name	Probability	Red W	Description	Potential SAMAs
FLG_X	1.00E+00	1.75	TAG EVENT - LONG TERM COOLING (HPR/LPR/REFILL)	Already accounted for in the Level 1 importance list
IE_S	5.00E-04	1.45	SMALL BREAK LOCA	Already accounted for in the Level 1 importance list
FLG_HVAC	1.00E+00	1.37	HVAC REQUIRED DUE TO AVAILABILITY OF AC POWER	Already accounted for in the Level 1 importance list
FLG_QHUEFWMR	1.00E+00	1.33	OPERATORS FAIL TO MANUALLY OPEN CONTROL VALVE	Already accounted for in the Level 1 importance list
QSPLHVAC	5.00E-01	1.33	SPLIT FRACTION - VALVES FAIL CLOSED ON LOSS OF HVAC	Already accounted for in the Level 1 importance list
FLG_SW	1.00E+00	1.24	TAG EVENT - LOSS OF NORMAL SW	Already accounted for in the Level 1 importance list
JHUCHP2R	1.00E+00	1.14	OPERATORS FAIL TO USE DEDICATED CHILLED WATER SYSTEM	Already accounted for in the Level 1 importance list
IE_Z	5.00E-07	1.12	REACTOR VESSEL RUPTURE	Already accounted for in the Level 1 importance list
QPMFWP7M	2.03E-02	1.12	FWP-7 IN MAINTENANCE	Already accounted for in the Level 1 importance list
JHUCHP2Z	5.00E-02	1.11	JHUCHP2R	Already accounted for in the Level 1 importance list
QHUFW7EY	1.00E+00	1.10	OPERATORS FAIL TO START FWP-7 BEFORE PORV LIFTS	Already accounted for in the Level 1 importance list
RHUPORVY	5.00E-01	1.09	OPERATORS FAILS TO OPEN PORV FOR PRESSURE RELIEF	Already accounted for in the Level 1 importance list
IE_F6A	2.63E-03	1.08	PIPE RUPTURE ON ELEVATION 95 OF THE AUX BLDG (FIRE ZONE AB-95-X)	Already accounted for in the Level 1 importance list
IE_R	3.00E-03	1.07	STEAM GENERATOR TUBE RUPTURE	Already accounted for in the Level 1 importance list
QMMEFP3F	3.29E-02	1.07	EFP-3 PUMP TRAIN FAILS TO RUN	Already accounted for in the Level 1 importance list
IE_T3	7.27E-03	1.07	LOSS OF OFFSITE POWER	Already accounted for in the Level 1 importance list
HHUHPRCY	4.40E-04	1.07	OPERATORS FAIL TO SWITCH FROM HIGH PRESSURE INJECTION TO RECIRCULATION	Already accounted for in the Level 1 importance list
IE_T11	1.16E-04	1.07	LOSS OF INTAKE	Already accounted for in the Level 1 importance list
IE_T8	3.21E-03	1.06	LOSS OF 4160V ES BUS 3A	Already accounted for in the Level 1 importance list
HHUMPSBY	1.00E+00	1.06	OPERATOR FAILS TO START STANDBY MAKEUP PUMP	Already accounted for in the Level 1 importance list
RHUCOOLY	5.80E-04	1.06	OPERATORS FAIL COOLDOWN VIA OTSG	Already accounted for in the Level 1 importance list
QHUFWP7Y	5.60E-03	1.06	OPERATORS FAIL TO START FWP-7	Already accounted for in the Level 1 importance list
RMMRCVSC	2.50E-02	1.06	SAFETY RELIEF VALVE FAILS TO CLOSE (STEAM RELIEF)	Already accounted for in the Level 1 importance list
SPMRW3BM	8.60E-03	1.06	RWP-3B IN MAINTENANCE	Already accounted for in the Level 1 importance list
ZHUCOM2Z	2.80E-01	1.05	COND PROB OF RHUPORVY GIVEN RHUCOOLY	Already accounted for in the Level 1 importance list
IE_T1	1.10E+00	1.05	REACTOR TRIP	Already accounted for in the Level 1 importance list
APWNR01R	6.40E-01	1.04	BOTH EDGS FTS, BOTH EFPS FTS	Already accounted for in the Level 1 importance list
FLG_TBQR	1.00E+00	1.04	TAG EVENT - STUCK OPEN RELIEF AFTER B	Already accounted for in the Level 1 importance list
LPM001BM	1.03E-02	1.04	DHP-1B TRAIN IN MAINTENANCE	Already accounted for in the Level 1 importance list
HHUINJAY	5.00E-01	1.04	OPERATORS FAIL TO SWITCH MUV-23/24 TO BACKUP POWER	Already accounted for in the Level 1 importance list

SAMA RAI 2.b Response				
Event Name	**Probability**	**Red W**	**Description**	**Potential SAMAs**
QMMEFP2F	3.37E-02	1.04	EFP-2 FAILS TO CONTINUE TO RUN	Already accounted for in the Level 1 importance list
IE_A	5.00E-06	1.04	LARGE BREAK LOCA	Already accounted for in the Level 1 importance list
LPM001AM	1.03E-02	1.04	DHP-1A TRAIN IN MAINTENANCE	Already accounted for in the Level 1 importance list
SCCHDABF	2.39E-04	1.04	COMMON CAUSE FAILURE OF HXs DCHE-1A AND DCHE-1B PLUGGED	Already accounted for in the Level 1 importance list
LMMDHPBF	4.90E-03	1.04	FAILURE OF DHP-1B AND ITS VALVES	Already accounted for in the Level 1 importance list
SPLT_RA	5.00E-01	1.03	SGTR OCCURS ON OTSG-A <SPLIT FRACTION>	Already accounted for in the Level 1 importance list
SPLT_RB	5.00E-01	1.03	SGTR OCCURS ON OTGS-B <SPLIT FRACTION>	Already accounted for in the Level 1 importance list
LMMDV43F	4.65E-03	1.03	FAILURE OF TRAIN B RECIRC VALVE DHV-43	Already accounted for in the Level 1 importance list
LMMDV12F	4.65E-03	1.03	TRAIN B RECIRC VALVE DHV-12 FAILS	Already accounted for in the Level 1 importance list
QMMCST	6.46E-03	1.03	FAILURE OF CST WATER SUPPLY	Already accounted for in the Level 1 importance list
LMMDHPAF	4.90E-03	1.03	FAILURE OF DHP-1A AND ITS VALVES	Already accounted for in the Level 1 importance list
QHUEFW9Y	2.70E-03	1.03	OPERATORS FAIL TO RAISE OTSGs LEVEL	Already accounted for in the Level 1 importance list
H_SPLT_B	7.00E-01	1.03	FRACTION OF SLOCAS IN COLD LEG LOCATIONS REQUIRING SECONDARY COOLING	Already accounted for in the Level 1 importance list
IE_T16	1.00E+00	1.03	LOSS OF MAKEUP	Already accounted for in the Level 1 importance list
FLG_TQR	1.00E+00	1.03	TAG EVENT - STUCK OPEN RELIEF	Already accounted for in the Level 1 importance list
FHUF6A1Y	1.90E-03	1.03	OPERATOR FAILS TO ISOLATE FLOOD F6A (CASE 1)	Already accounted for in the Level 1 importance list
LMMDV42F	4.65E-03	1.03	FAILURE OF TRAIN A RECIRC VALVE DHV-42	Already accounted for in the Level 1 importance list
SPMRW3AM	8.60E-03	1.03	RWP-3A IN MAINTENANCE	Already accounted for in the Level 1 importance list
LMMDV11F	4.65E-03	1.03	TRAIN A RECIRC VALVE DHV-11 FAILS	Already accounted for in the Level 1 importance list
LHULPRCY	2.50E-02	1.03	OPERATORS FAIL TO GO TO LOW PRESSURE RECIRCULATION	Already accounted for in the Level 1 importance list
RCCDRODA	1.00E-06	1.03	MECH FAILURE OF ENOUGH CONTROL RODS TO DROP	Already accounted for in the Level 1 importance list
HHUMBACY	1.00E+00	1.03	OPERATORS FAIL TO SWITCH MUP-1B POWER SOURCE IN	Already accounted for in the Level 1 importance list
FLG_PHURMFWR	1.00E+00	1.03	OPERATORS FAIL TO RECOVER MFW	Already accounted for in the Level 1 importance list
ZHUCOM1Z	2.80E-01	1.03	COND PROB OF RHUPORVY GIVEN QHUEFW9Y	Already accounted for in the Level 1 importance list
FLG_BATFA	1.00E+00	1.03	FLAG EVENT - AC NOT RESTORED BEFORE DPBA-1A DEPLETES (APPROX. 4 HRS)	This is a flag identifying battery depletion sequences, not a basic event. However, a SAMA has been proposed to provide a portable battery charger to extend battery life (SAMA 2).
SMMDHCCB	2.73E-03	1.03	DHCCC TRAIN B FAULTS	Already accounted for in the Level 1 importance list
SMMRW3BF	2.69E-03	1.03	RWP-3B PUMP TRAIN FAILS TO OPERATE	Already accounted for in the Level 1 importance list
SPMDHCBM	4.00E-03	1.03	DHCCC TRAIN B IN MAINTENANCE	Already accounted for in the Level 1 importance list
ADGES3BM	3.37E-02	1.03	EGDG-1B IN MAINTENANCE	Already accounted for in the Level 1 importance list

SAMA RAI 2.b Response				
Event Name	**Probability**	**Red W**	**Description**	**Potential SAMAs**
HCCMV44N	1.43E-04	1.02	COMMON CAUSE FAILURE OF MUV-23, MUV-24, MUV-25, AND MUV-26 TO OPEN	Already accounted for in the Level 1 importance list
QHUEFT2Y	7.70E-04	1.02	OPERATORS FAIL TO CROSSTIE EFW SOURCES	Already accounted for in the Level 1 importance list
PMMICSBH	7.45E-02	1.02	OTSG B LEVEL CONTROL FAULTS	Already accounted for in the Level 1 importance list
IE_T10	1.00E+00	1.02	LOSS OF NSCCC	Already accounted for in the Level 1 importance list
PMMICSAH	7.45E-02	1.02	OTSG A LEVEL CONTROL FAULTS	Already accounted for in the Level 1 importance list
IE_M	4.00E-05	1.02	MEDIUM BREAK LOCA	Already accounted for in the Level 1 importance list
ADGEG1CF	7.68E-02	1.02	EGDG-1C FAILS TO RUN	Already accounted for in the Level 1 importance list
HHUINJBY	5.00E-01	1.02	OPERATORS FAIL TO SWITCH MUV-25/26 TO BACKUP POWER	Already accounted for in the Level 1 importance list
IE_T2	2.40E-01	1.02	LOSS OF MAIN FEEDWATER	Already accounted for in the Level 1 importance list
AHUEG1CY	5.00E-01	1.02	OPERATORS FAIL TO START AND ALIGN EGDG-1C	Already accounted for in the Level 1 importance list
MTC	2.50E-01	1.02	MTC GREATER THAN 95%	Already accounted for in the Level 1 importance list

2.c *The contribution from the MK, SK, and RK sequences in the MOR01 model was 7E-9 or less and was considered small enough to remove from the event tree. No specific cutoff frequency was listed in the calculation. Below is the description of the sequences.*

MK	*Medium LOCA followed by a failure to trip (event K).*
SK	*Small LOCA with failure of the reactor to trip.*
RK	*SGTR with failure of the reactor to trip.*

2.d *A breakdown of CDF and the population dose by release category was given for each SAMA in Section E.6, and each release category is described in detail in Table E.2-3. The CDF and population dose by containment release mode is given in Table E.3-7.*

2.e.i *Calculation P02-0011, Revision 2, provides the description of how the Level 1 results are mapped into the Level 2 analysis. The following paragraphs are taken from the calculation.*

The CSET and the assignment of core damage and plant damage state bins are accomplished using a CAFTA model and a rule-based recovery file. The CAFTA model is joined with the core damage model and containment system models to create a plant damage state model. The core damage model is described in another document. The model used to generate the PDSs is described herein.

The model is comprised of two parts. The first assigns the core damage event tree endstates to the appropriate core damage bin. The model solution combines the accident sequences developed in the core damage model with an appropriate flag event representing the core damage bin (e.g., FL_CDB1). This tags each sequence with its associated core damage bin.

The second part of the model develops the possible outcomes of the CSET (states A through S). The model is developed with the associated success logic inserted into the different states. This precludes core damage cut set replication in more than one plant damage state. The model includes state A (all working) to define a complete solution. Each CSET is assigned a flag event to provide a tag (FL_PDSA).

Combining the CSET solutions with the core damage bin solutions provides the plant damage state solution with two tags (CDB and CSET state). A mutually exclusive gate deletes the PDS states for the interfacing system LOCA case since it is only assigned to PDS S.

The rule-based recovery file is then applied which adds the associated plant damage state (FL_PDS1A) and deletes the individual events (FL_CDB1 and FL_PDSA). This defines the complete PDS definition. The rule-based recovery file then uses the "class" statement to assign the results to individual classes. This allows the results to be reported in terms of the plant damage state to support the level 2 analysis. The results are then available for review and use in support of the level 2 analysis. The fault trees, mutually exclusive events, and recovery rules are maintained as controlled files as part of the Model of record.

2.e.ii *Calculation P02-0012, Revision 2, provides the process used to group the containment event tree end states into release categories. The following paragraphs are taken from the calculation.*

The end states of the CET correspond to the outcome of possible severe accident sequences. Each end point defines a different containment state with an associated radionuclide release. Simplifications can be attained by grouping sequences with similar release characteristics into a release category that can be applied to the containment end states. A set of release categories is defined such that all accidents assigned to the same category are assumed to have the same set of release fractions.

The main characteristics of the containment end states considered when developing these release categories were:

- *Release Energy*
- *Containment Isolation Failure Size*
- *Timing of The Release*
- *Isotopic Composition*

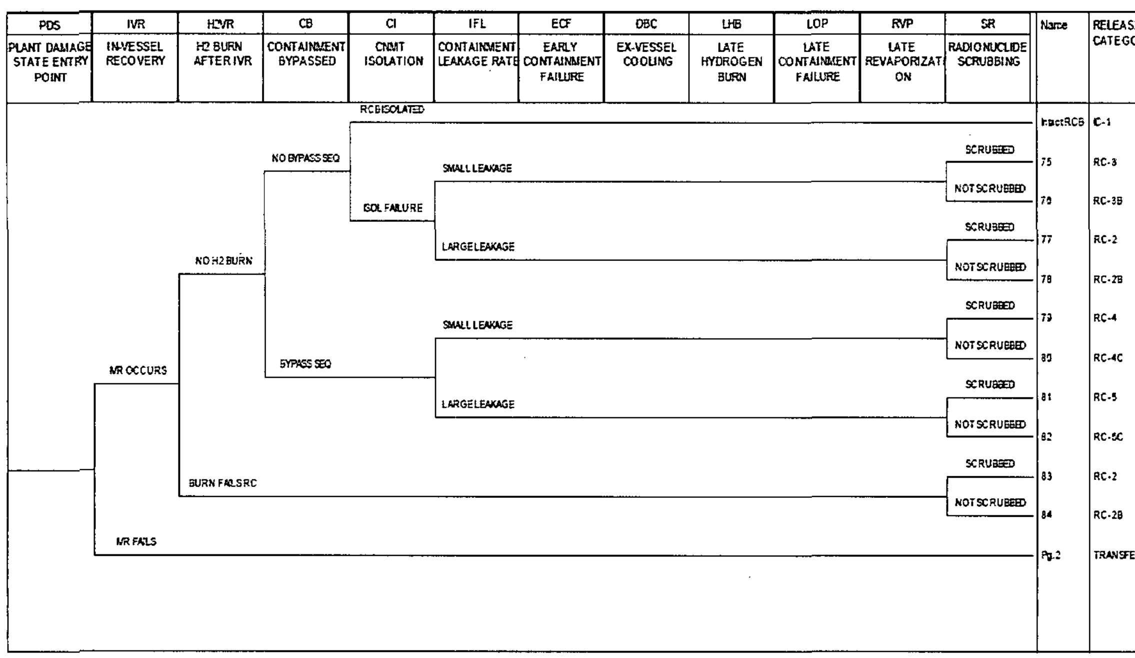

Figure 8. CR3 Containment Event Tree (page 1 of 4)

2.e.iii *The following table summarizes the mapping of the Level 1 sequences to the Level 2 release categories. Note that a single MAAP run was designated for each release category based on the representative case defined for the release category; no weighting of multiple MAAP cases was required.*

The version of MAAP used in the SAMA evaluation is MAAP4.0.6, with executable dated December 13, 2005, 2:53:06 PM.

SAMA RAI 2.e.iii Response
Representative MAAP Level 2 Case Descriptions

Case	Release Cat.	Sequ.	Representative Case Description	MAAP Case Description	MAAP ID
1	IC-1	SX_P	Small LOCA + SSHR success + injection success + no recirculation - oper fails to do recirc, cc and random failures of both DH trains (Successful isolation, sprays fail in injection and fans succeed)	SMALL LOCA, W/ HPI INJECTION W/O RECIRC, SSHR AVAILIBLE, NO CONT SPRAYS AND RBCU'S (FANS) AVAILABLE	IC1_CR3_406
2	RC-1	TQX_P	Transient + SSHR success + safety valve lifts and sticks open + high head injection success + failure to switch to recirc - opers fail to prevent PZ overfill, fail to recirc (Successful isolation, sprays fail in injection and fans succeed)	TRANSIENT AND SORV, W/ HPI INJECTION W/O RECIRC, SSHR AVAILABLE, NO CONT SPRAYS AND RBCU'S(FANS) OFF @ VESSEL FAILURE	RC1_CR3_406
3	RC-1A	SBP_P	Small LOCA + operators fail to raise SG level (=inadequate SSHR) + PORV fails to open - oper fails to control level, PORV (Successful isolation, sprays fail in injection and fans succeed)	SMALL LOCA AND PORV FAILS CLOSED, W/ HPI INJECTION, NO SSHR, NO CONT SPRAYS AND RBCU'S (FANS) OFF @ VESSEL FAILURE	RC1a_CR3_406
4	RC-1B	TBL1U_P	Transient + SSHR failure + injection failure - HVAC and AFW control probs (Successful isolation, sprays fail in injection and fans succeed)	TRANSIENT, W/O INJECTION, W/O SSHR, NO CONT SPRAYS AND RBCU'S(FANS) OFF @ VESSEL FAILURE, 4" DIAMETER CONTAINMENT FAILURE	RC1b_CR3_406
5	RC-1BA	TBL1U_P	Transient + SSHR failure + injection failure - HVAC and AFW control probs (Successful isolation, sprays fail in injection and fans succeed)	TRANSIENT, W/O INJECTION, W/O SSHR, NO CONT SPRAYS AND RBCU'S(FANS) OFF @ VESSEL FAILURE, 4" DIAMETER CONTAINMENT FAILURE	RC1b_CR3_406
6	RC-2	TBL1U_P	Transient + SSHR failure + injection failure - HVAC and AFW control probs (Successful isolation, sprays fail in injection and fans succeed)	TRANSIENT, W/O INJECTION, W/O SSHR, NO CONT SPRAYS AND RBCU'S(FANS) OFF @ VESSEL FAILURE, 1' DIAMETER CONTAINMENT FAILURE	RC2_CR3_406
7	RC-2B	TQX_P	Transient + SSHR success + safety valve lifts and sticks open + high head injection success + failure to switch to recirc - opers fail to prevent PZ overfill, fail to recirc (Successful isolation, sprays fail in injection and fans succeed)	TRANSIENT AND SORV, W/ HPI INJECTION W/O RECIRC, SSHR AVAILABLE, NO CONT SPRAYS AND RBCU'S(FANS) OFF @ VESSEL FAILUR, 4" DIAMETER CONTAINMENT FAILURE	RC2b_CR3_406
8	RC-3	TBL1U_P (Note 1)	Transient + SSHR failure + injection failure - HVAC and AFW control probs (Small isolation failure, sprays fail in injection and fans succeed)	TRANSIENT, W/O INJECTION, W/O SSHR, W/ CONT SPRAYS AND RBCU'S(FANS) OFF @ VESSEL FAILURE, 4" DIAMETER CONTAINMENT FAILURE	RC3_CR3_406
9	RC-3B	TBL1U_P	Transient + SSHR failure + injection failure - HVAC and AFW control probs (Small isolation failure, sprays fail in injection and fans succeed)	TRANSIENT, W/O INJECTION W/O SSHR, W/O CONT SPRAYS AND RBCU'S(FANS) OFF @ VESSEL FAILURE, 4" DIAMETER CONTAINMENT FAILURE	RC3b_CR3_406
10	RC-4C	RCP_P	SGTR + failure to cooldown/depressurize using secondary side + failure to depressurize using PORV - opers fail to cooldown, open PORV (Containment bypass)	SGTR WITH STUCK-OPEN S/G PORV, NO SSHR, NO CONT SPRAYS AND RBCU'S(FANS) ARE AVAILABLE	RC4c_CR3_406
11	RC-5C	ISLOC_P	LLOCA outside containment + injection failure - DHR drop line (Containment bypass)	ISLOCA, W/ FAILURE OF ALL INJECTION, NO CONT SPRAYS AND RBCU'S(FANS) ARE AVAILABLE	RC5c_CR3_406

Note 1: TBLX is the correct sequence that was meant to be referenced. Although this was a typographical error in the original SAMA report, the MAAP run for this Release Category was performed correctly. The TBLX sequence represents a transient with an extended loss of heat removal via the SGs. Feed-and-bleed cooling succeeds, but feedwater cannot be restored in the long term, and HPR fails. This scenario eventually leads to core damage.

2.e.iv See response to RAI 2.b.

Table E.3-7 lists the dose-risk (p-rem/yr) for each release category, which reveals that categories 3B and 4C accounted for 75% of the total dose-risk.

3. Provide the following information with regard to the treatment and inclusion of external events in the SAMA analysis:

   a. Provide fire CDF by fire zone/area and the total fire CDF for CR-3. If the fire CDF is different than that reported in the Individual Plant Examination for External Events (IPEEE), provide an explanation for the differences.

   b. For each of the dominant fire areas, explain what measures, if any, have already been taken (since the IPEEE) to reduce fire risk. Include in the response specific improvements to fire detection systems, enhancements to fire suppression capabilities, changes that would improve cable separation, and improvements to processes/procedures for monitoring and controlling the quantity of combustible materials in critical areas.

   c. The SAMA analysis assumes that risks posed by external and internal events is approximately equal (page E.5-7). Based on this assumption, the estimated benefit from reduction of internal event risk was doubled to account for a corresponding reduction in external event risk. However, Section 1.4 of the IPEEE identifies the calculated CDF from fires to be 4.2E-05 per year, a factor of 8.5 greater than the internal events CDF (4.95E-06 per year) used in the SAMA analysis. Furthermore, while a seismic CDF was not developed for the IPEEE, the U.S. Nuclear Regulatory Commission (NRC) staff estimates the seismic CDF for CR-3 to be about 1.2E-05 per year using the approximation method described in a paper by Robert P. Kennedy, "Overview of Methods for Seismic PRA and Margin Analysis Including Recent Innovations" and using updated 2008 seismic hazard curve data from the U.S. Geologic Survey (USGS). Based on this, provide justification for why a multiplier of 12 [(4.2E-05 + 1.2E-05) / 4.95E-06 + 1] shouldn't be used to account for the additional risk of all external events (seismic, fire, high winds, etc.) rather than the multiplier of two used in the SAMA analysis.

   d. Provide an assessment of the impact on the initial and final SAMA screenings if the internal events risk reduction estimate is increased by a factor of 12 (or a smaller factor for which sufficient basis can be provided). Provide a Phase II analysis for any Phase I SAMAs that were screened out in the Environmental Report (ER) but would not have been with the higher factor.

   e. Section E.5.1.6 of the ER notes that at the time of the 1997 IPEEE submittal, the plan was for CR-3's plant-specific response to unresolved safety issue (USI) A-46, "Seismic Qualification of Equipment in Operating Plants," to sufficiently address seismic risk. The USI A-46 safety evaluation report (SER) in 2000 identified three topics that required additional work to resolve: 1) one equipment seismic capacity outlier, 2) five outliers associated with differences between the caveats in generic implementation procedure (GIP)-2 and those in the plant-specific procedure (PSP), and 3) revision of abnormal procedure (AP)-961. The USI A-46 SER further states that each of these issues is being tracked in the CR-3 Corrective Action Program. ER Section E.5.1.6 is silent as to the status of these issues. Clarify the resolution status of each of these unresolved issues. If still unresolved, identify and evaluate seismic SAMAs to address each unresolved issue.

Response

3.a Table 1.4-1 was extracted from the CR-3 IPEEE report. This table represents the majority of the core damage risk due to fire for CR-3 and is associated with fires occurring in fire zones within the control complex. Table 1.4-1 lists the fire zones which have a core damage frequency due to fire of greater than $1x10^{-6}$ per year, along with the control room and cable spreading room.

Table 1.4-1
Fire Zone Core Damage Frequencies

Zone	Description	CDF
CC-108-106	BATTERY CHARGER ROOM 3A	1.49E-05
CC-108-108	4160V ES SWITCHGEAR BUS ROOM 3A	7.31E-06
CC-108-107	4160V ES SWITCHGEAR BUS ROOM 3B	6.79E-06
CC-124-117	480V ES SWITCHGEAR BUS ROOM 3A	3.79E-06
CC-108-105	BATTERY CHARGER ROOM 3B	2.72E-06
CC-108-102	HALLWAY AND REMOTE SHUTDOWN ROOM	2.66E-06
CC-124-111	CRD & COMMUNICATION EQUIP ROOM	1.58E-06
CC-108-109	INVERTER ROOM 3B	1.45E-06
CC-145-118B	CONTROL ROOM	5.7E-07
CC-134-118A	CABLE SPREADING ROOM	9.9E-08

The fire CDF beyond the IPEEE has not been performed.

3.b Since completion of the IPEEE review by the NRC staff, various plant modifications that may impact fire risk have been undertaken; however, no quantification of the fire risk impact has been performed. A specific fire PRA will be completed as part of the ongoing CR-3 transition to NFPA 805, "Performance Based Standard for Fire Protection for Light Water Reactor Electric Generating Plants", 2001 edition. Specific fire protection related modifications that have been performed include:

- *Installation of Emergency Lighting*
- *Improve separation of electrical cables,*
- *Improved administrative controls of transient combustibles,*
- *Modifications resulting from the ongoing NFPA Code review:*
    - *Fire Detector Upgrade (in progress),*
    - *Suppression system upgrades, e.g., improvement of sprinkler systems in the Fire Pump House and Control Complex 95 ft. elevation,*
    - *Upgraded programmatic controls for penetration seals.*

3.c CR-3 has not performed a seismic analysis and while the approximation method described in "Overview of Methods for Seismic PRA and Margin Analysis Including Recent Innovations" is a conservative method, it is beyond the scope of the SAMA analysis to develop a seismic PRA.

CR-3 is in the process of developing an updated fire PRA, but the model is incomplete and updated CDF information is not available. The level of effort required to provide quantitative justifications for reducing the fire CDFs documented in the IPEEE is also considered to be beyond the scope of the SAMA analysis.

As a result, no exceptions are taken to the proposed use of a multiplier of 12 to account for external events contributors at CR-3.

3.d As documented in the response to RAI 3.c, the resources required to provide a detailed, quantitative justification for an external events multiplier of less than 12 are not available. This response provides an assessment of the impact of using a multiplier of 12 to account for the external events contributors in the SAMA analysis.

With regard to the impact of the larger external events multiplier on the Phase I and II analyses, both phases would be affected. In the Phase I analysis, the larger external events multiplier would increase the value of the MMACR, which could result in the retention of SAMAs that were previously screened from further analysis. In the Phase II analysis, the larger external events multiplier would increase the SAMA specific averted cost-risk values, which may result in the identification of additional cost beneficial SAMAs. In order to address the impact on the "final" SAMA screenings, the impact of the use of the 95th percentile PRA results is also examined in conjunction with the increased external events multiplier.

Phase I Impact

While the use of the external events multiplier of 12 will increase the MMACR and may prevent the screening of some of the higher cost modifications, the impact on the overall SAMA results due to the retention of the higher cost SAMAs for Phase II analysis is typically small. This is due to the fact that the benefit obtained from the implementation of those SAMAs must be extremely large in order to be cost beneficial. Because the MMACR calculations scale linearly with external events multiplier, the revised MMACR can be determined by multiplying the original MMACR by the ratio of the new external events multiplier to the original external events multiplier:

$$MMACR_{12EEX} = MMACR_{base} \times 12 / 2 = \$682,000 \times 6 = \$4,092,000$$

As documented in Section E.7.2 of the ER, the use of the 95th percentile PRA results will increase the MMACR by a factor of 2.18, which results in a value of \$8,920,560 (\$4,092,000 x 2.18 = \$8,920,560). The SAMAs that were initially screened in the Phase I analysis have been re-examined using the revised 95th percentile MMACR of \$8,920,560 to identify SAMAs that would be retained for the Phase II analysis. Those SAMAs that were previously screened because their costs of implementation exceeded \$500,000 are now retained if their costs of implementation are less than \$8,920,560 million (Section E.5.2 of the ER identifies that \$500,000 was used as the Phase I screening value for CR-3). Because some of the SAMAs that were originally screened in the Phase I analysis used rough cost estimates that only indicated that they would exceed certain values, revised cost estimates have been assigned to these SAMAs to aid in this evaluation. The following table provides the updated Phase I screening results for those SAMAs that were initially screened in the Phase I analysis:

SAMA Number	SAMA Title	SAMA Description	Cost Estimate	Retained for Phase II
8	Temp pump to replace RWP	Provide a temporary pump or pump of alternate design and suction supply which can be aligned to supply cooling water in lieu of RWP	$500,000	Yes
26	Install separate and independent EFIC cooling system	Install separate independent cooling for EFIC (consider DC power, self-powered fans)	Browns Ferry SAMA analysis estimated the cost of installing a redundant train of room cooling for RHR, CS, and the EDGs to be $6 million per unit. For CR-3, the cooling train would have to be independent and battery powered. Because the TVA estimate addresses 3 areas compared with the single area for CR-3, the estimate has been divided by 3. A cost estimate of $2 million is used for this application.	Yes
14	Automate SG level control requirements for SBLOCA	This is in respect to HRA event QHUEFW9Y, "Operators fail to raise OTSGs level." This is needed for small LOCA response. Proposed SAMA, automate level control.	The Farley SAMA analysis estimated that a digital Feedwater Upgrade would cost about $900,000. This is considered to be similar in scope to automating SG level control for small LOCAs.	Yes
37	DH HX strainers	Add removable strainers ahead of heat exchangers	$600,000	Yes
1	Automate EFIC/inverter backup cooling	Automate alignment of dedicated chilled water system to cool inverters and EFIC when required	$1,000,000	Yes
7	New AFW suction source and pump	Add a new independent AFW source and pump	$5,000,000	Yes
16	Enhance procedures and make design changes as required to facilitate crosstying trains of DH, DHCC, etc.	With respect to SMMDHCCB, "DHCCC train B faults." (same for A, same for similar failures in other systems). Proposed SAMA: Proceduralize crosstying between train A and train B of MU, DH, DHCC trains at appropriate suction / discharge points.	$5,000,000	Yes

SAMA Number	SAMA Title	SAMA Description	Cost Estimate	Retained for Phase II
18	*Add another EDG*	*With respect to BE ADGES3BM, "EGDG-1B in maintenance." (same for A) Proposed SAMA: add another EDG.*	*The cost of installing an additional EDG ranges greatly depending on the application, size, and the organization implementing the change. For example, the Farley SAMA analysis used an estimate of $74,500,000 while the Prairie Island SAMA analysis estimated a cost of $8,000,000 for a single SBO EDG. While the Prairie Island application is for a swing EDG that may not include the auto start capability that may be desirable for preventing RCP seal LOCAs, it is used as a lower bound estimate.*	*Yes*
13	*Add additional train of DH, of diverse design*	*This is in respect to BE LPM001A, DHP-1A train in maintenance. (similar for B train) Add an additional train or "maintenance" train of diverse design.*	*No industry estimates have been identified for installing a complete, diverse train of DH, but the Calvert Cliffs SAMA analysis includes an estimate of $5,000,000-$10,000,000 for the installation of an independent HPSI pump. An independent HPSI pump does not address the heat removal function of a DH train or the diverse piping requirements, but $10,000,000 is used as a lower bound estimate for this analysis. Even though it is expected that the actual implementation cost may be closer to $50 million, this SAMA has been retained for Phase II analysis to clearly demonstrate its low averted cost-risk.*	*Yes, for demonstration purposes*

SAMA Number	SAMA Title	SAMA Description	Cost Estimate	Retained for Phase II
52	*Install parallel flowpath for DHR drop line*	*This is in respect to BE LMMDHRSF, which was an important contributor (RRW > 1.02) for sequences leading to Release Category 4C*	*This requires an additional interface in the RCS with MOVs and controls in the MCR. This is similar in nature to the cross-ties proposed in SAMA 16 and the $5,000,000 estimate is also applied to this SAMA.*	*Yes*

All of the SAMAs that were previously screened in the Phase I analysis would be retained for Phase II evaluation when the external events multiplier of 12 is used in conjunction with the 95th percentile PSA results.

Phase II Impact

The same process used to scale up the MMACR to account for the external events multiplier of 12 can be used for the averted cost-risk estimates for each of the Phase II SAMAs. This includes those SAMAs that were originally evaluated in the ER's Phase II analysis as well as the SAMAs that were originally screened in the Phase I analysis. For the SAMAs that were originally screened in the Phase I analysis, however, Phase II quantifications are required.

The exception to this is that SAMA 49 must be re-quantified using the assumptions about the external events contributions identified in RAI question 3c.

These quantifications and their results are provided below. It should be noted that the intermediate and final results documented in this RAI response have been rounded for presentation purposes. The actual calculations that were performed for the Phase II quantifications may include additional significant digits that are not apparent in the documentation. Consequently, it may not be possible to exactly reproduce the Phase II evaluations using the intermediate results that are presented in this response. For example, the sum of the baseline dose-risk across all release categories is 3.77 person-rem/yr when summing the values presented in the results table; however, because extra digits not shown in the table were used in the actual summation, a slightly higher result of 3.79 person-rem/yr was obtained. These differences are negligible.

SAMA 49: Upgrade Fire Compartment Barriers

The original quantification of SAMA 49 was based on the assumption that the internal and external events risks were approximately equal and that the external events contributions were distributed among the different external events contributors in proportion to their CDFs. The basis of the external events multiplier of 12 in RAI question 3c is that the external events CDF is directly proportional to the internal events component of the MACR.

It follows, therefore, that the averted cost-risk for SAMA 49 can be estimated by multiplying the internal events MACR by the ratio of the Battery Charger Room 3A fire CDF to the internal events CDF:

$341,000 x 1.49E-05 / 4.95E-06 = $1,026,444

This result, in conjunction with the $150,000 Cost of Implementation (COI) that was estimated for this SAMA in the ER, can be used to recalculate the net value for SAMA 49:

SAMA 49 Net Value

Averted Cost-Risk	***COI***	***Net Value***
$1,026,444	*$150,000*	*$876,444*

The net value for this SAMA is the averted cost-risk minus the COI, or $876,444 ($1,026,444 - $150,000 = $876,444).

<u>SAMA 8: Provide a Temporary Pump to Provide a Backup Supply of Cooling Water in Lieu of Raw Water Pump</u>

The Nuclear Services and Decay Heat Seawater (RW) system is comprised of two sub-systems, the Nuclear Services Sea Water (SW) portion (cooling the Nuclear Service Closed Cycle Cooling system) and the Decay Heat portion (cooling the decay heat closed cycle cooling system – DC and eventually the decay heat system – DH). The function for RW-DC is what is addressed by this particular SAMA.

The RW-DC system is safety-related and serves as the primary means of transferring heat from the DH system to the ultimate heat sink (Gulf of Mexico). The RW-SW is an open system comprised of two trains each providing cooling to the associated DC train. Although the RW-DC and RW-SW systems are two different systems, the pumps share a common suction pit (one per train) and inlet piping along with common piping returning the water to the ultimate heat sink (see Figure 1).

The RW-DC pumps take suction from the pit and discharge through the tube side of a single pass tube and shell heat exchangers (DCHE-1A and DCHE-1B). This provides cooling for the Decay Heat Closed Cycle Cooling system. After the water leaves the heat exchangers, it is returned to the ultimate heat sink through an underground flume to the discharge canal. Each train is designed to supply 100% of the cooling water needed for removal of the heat load from essential equipment during emergency conditions.

The primary function of the RW-DC system is to remove reactor decay heat following normal plant shutdown. When the DH system is placed in service during a normal plant cooldown, the corresponding RW-DC train is placed in service. The system is aligned for operation while in standby; therefore, once the RW-DC pump is started and the pump discharge check valve opens, the system provides the needed cooling. For emergency operation, the RW-DC pumps receive an ES start signal on either low RCS pressure or high reactor building pressure. The RW-DC system is in an ES alignment while in *standby and upon receiving the actuation signal, the RW-DC pumps begin supplying the required flow.*

The purpose of this particular SAMA is to provide a backup raw water pump capable of supplying sea water to either of the DH system coolers (DCHE-1A(B)). Since the pump is assumed to be of a different design, it was assumed that the motive power for this alternate pump would be supplied by an air-cooled diesel engine, so as not to rely on any of the support dependencies normally used by the RW-DC pumps RWP-3A(B). The suction source for this pump would come from the same common suction pit as is used by the normal standby pumps. A crosstie just upstream of the RWP-3A(B) pump discharge valves would need to be installed with normally closed manual valves between the two trains, such that this alternate diesel-driven pump could supply either, but not both, of the two DHCCC trains (see Figure 1). A connection to this crosstie from the discharge of the proposed backup RW-DC pump would need to also be installed, the discharge of which would also consist of a manual discharge valve (normally open) and a check valve to prevent backflow from any of the already installed RW-DC pumps should they be in a running condition.

Assumptions

1. *The HEP event that was used for this SAMA analysis was assumed to be similar in nature to the event used for SAMA 10 in Section E.6.4 of the Environmental Report, which was assigned a failure probability on the order of 1E-2.*

2. *Any dependencies between the new HEP event postulated for this SAMA and other existing HEPs in the PRA model were assumed to be negligible. This is a conservative assumption that will tend to bound the risk benefits.*

3. *In modeling this SAMA, it was assumed that the component failure probabilities obtained from NUREG/CR-6928 would be applicable.*

PRA Model Changes to Model SAMA

To calculate the consequences of implementation of this SAMA, the logic beneath gates S800 and S800AH was modified to account for this proposed backup RW-DC system. Also, to separate the decay heat cooler faults from the RWP failures that were under OR gate S920, two new gates were created, i.e., S920_1 for non-DCH faults and S920_2 for DCH faults. That is, a backup RW pump would not be able to mitigate any failures associated with heat exchanger faults associated with components DCHE-1A and DCHE-1B. Similarly, the logic structure under OR gate S800_X for recirculation mode was also modified to allow recovery of RW-DC using this backup RW pump.

To better illustrate the logic changes made, Figures 2a through 2c represent that portion of the original logic of the CR-3 PRA model that was considered applicable to this SAMA, and Figures 3a through 3c represent the additional and modified logic that was used to simulate implementation of this SAMA.

The table below shows the new basic events and their probabilities that were included in the PRA model to represent this SAMA implementation:

SAMA 8 New Basic Events

Basic Event	Description	Probability	Comments
SHUSAMA8X	FAILURE OF OPERATOR TO ALIGN FOR ALTERNATE RWP OPERATION	1E-02	HEP assigned a failure probability based on what was used for SAMA 10.
SPMSAMA8F	FAILURE OF ALTERNATE RWP TO RUN (DIESEL-DRIVEN)	2.28E-03	Failure to run based on (NRC 2007) and 24 hour mission time.
SPMSAMA8A	FAILURE OF ALTERNATE RWP TO START (DIESEL-DRIVEN)	3.88E-03	Failure probability based on (NRC 2007).
SXVSAMA8N	FAILURE OF MANUAL VALVE TO OPEN	7.43E-04	Failure probability based on (NRC 2007).

SAMA 8 Conceptual Design

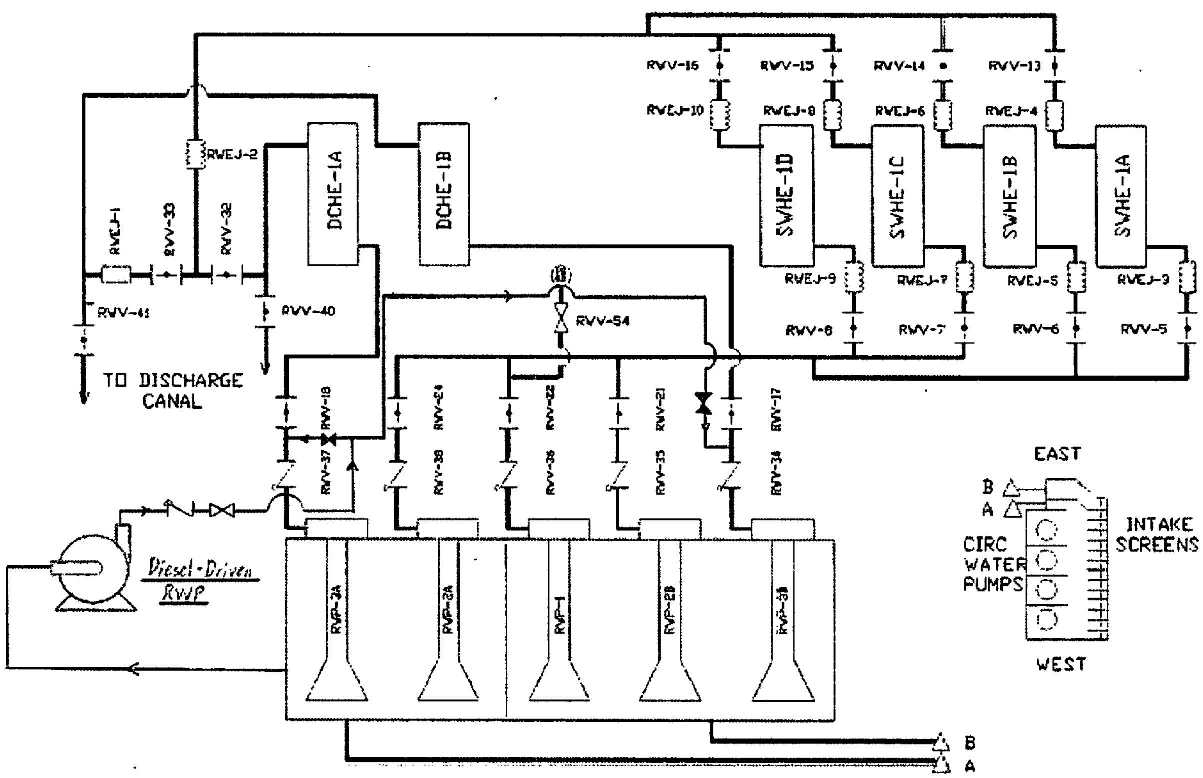

FIGURE 1
SAMA 8 CONCEPTUAL DESIGN

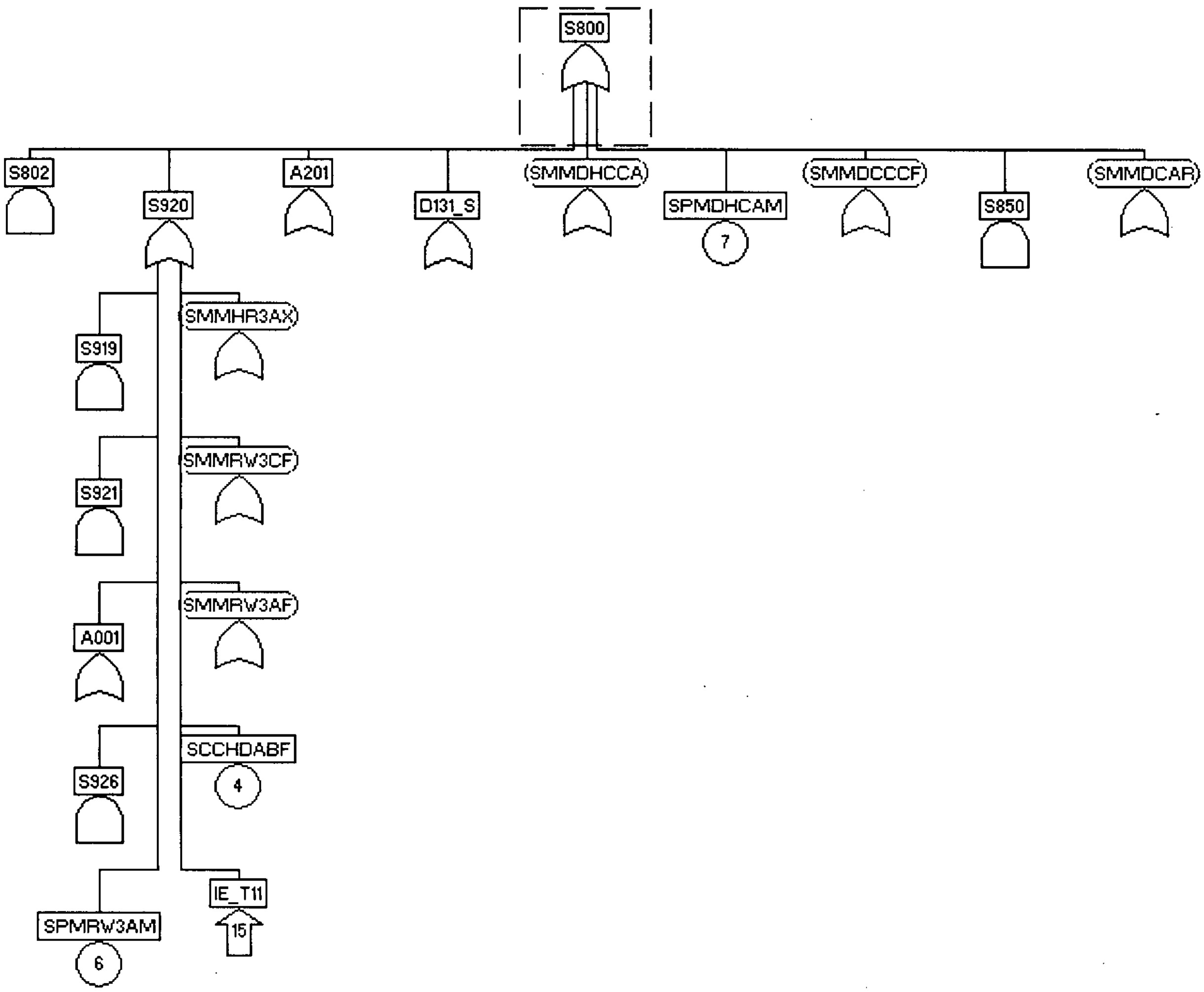

FIGURE 2a
DEPICTION OF ORIGINAL FAULT TREE LOGIC FOR GATE S800

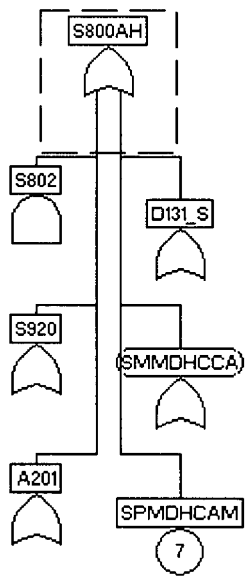

FIGURE 2b
DEPICTION OF ORIGINAL FAULT TREE LOGIC FOR GATE S800AH

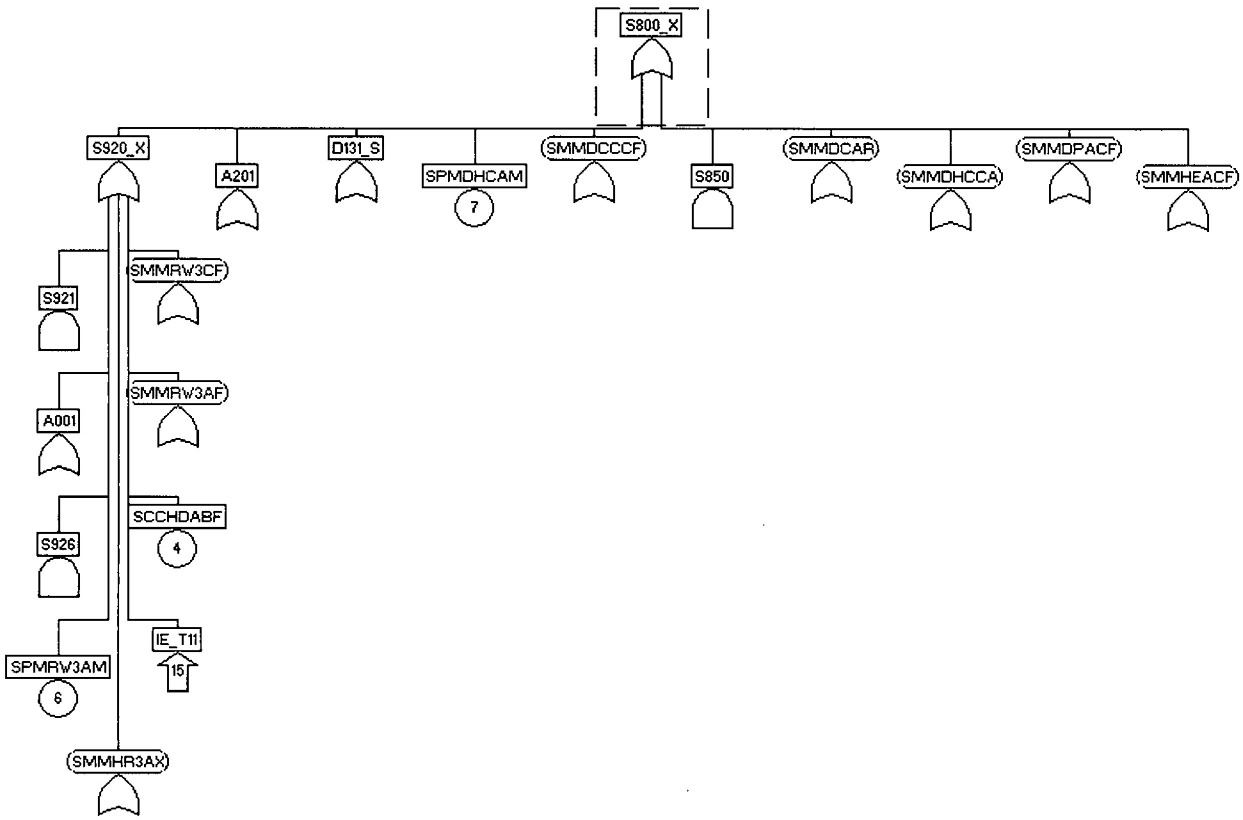

FIGURE 2c
DEPICTION OF ORIGINAL FAULT TREE LOGIC FOR GATE S800_X

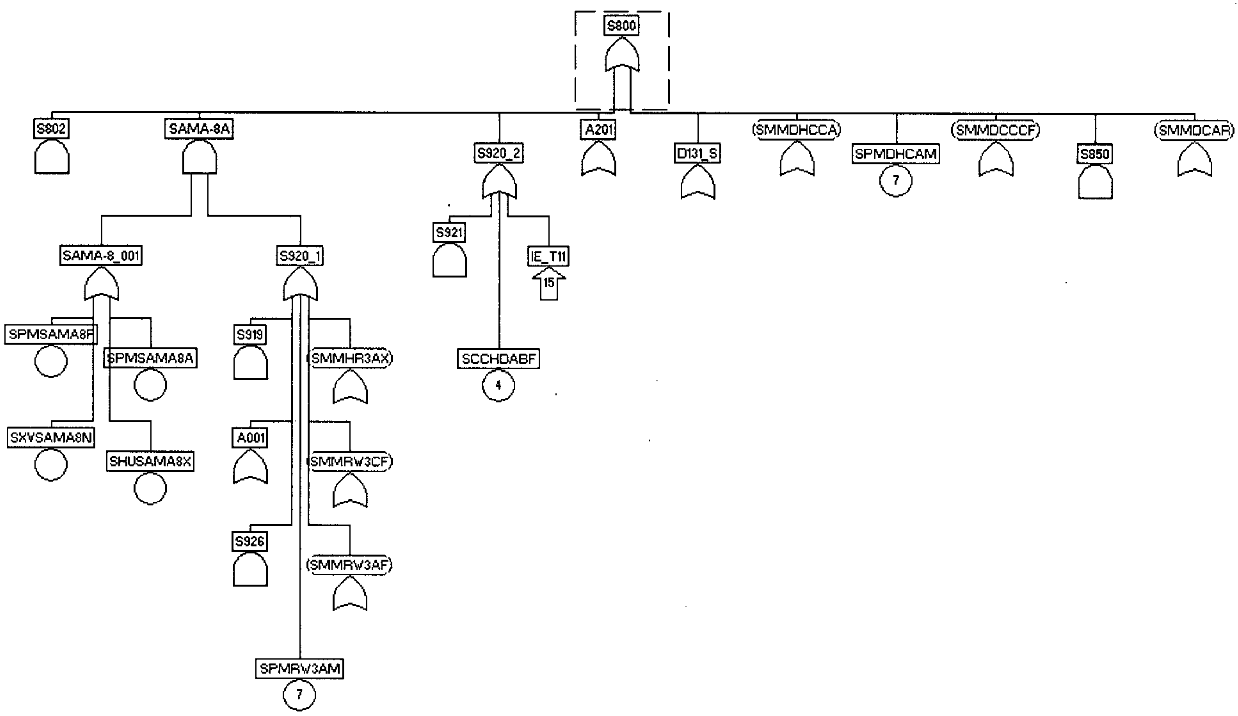

FIGURE 3a
DEPICTION OF FAULT TREE LOGIC USED TO SIMULATE IMPLEMENTATION OF SAMA 8 FOR GATE S800

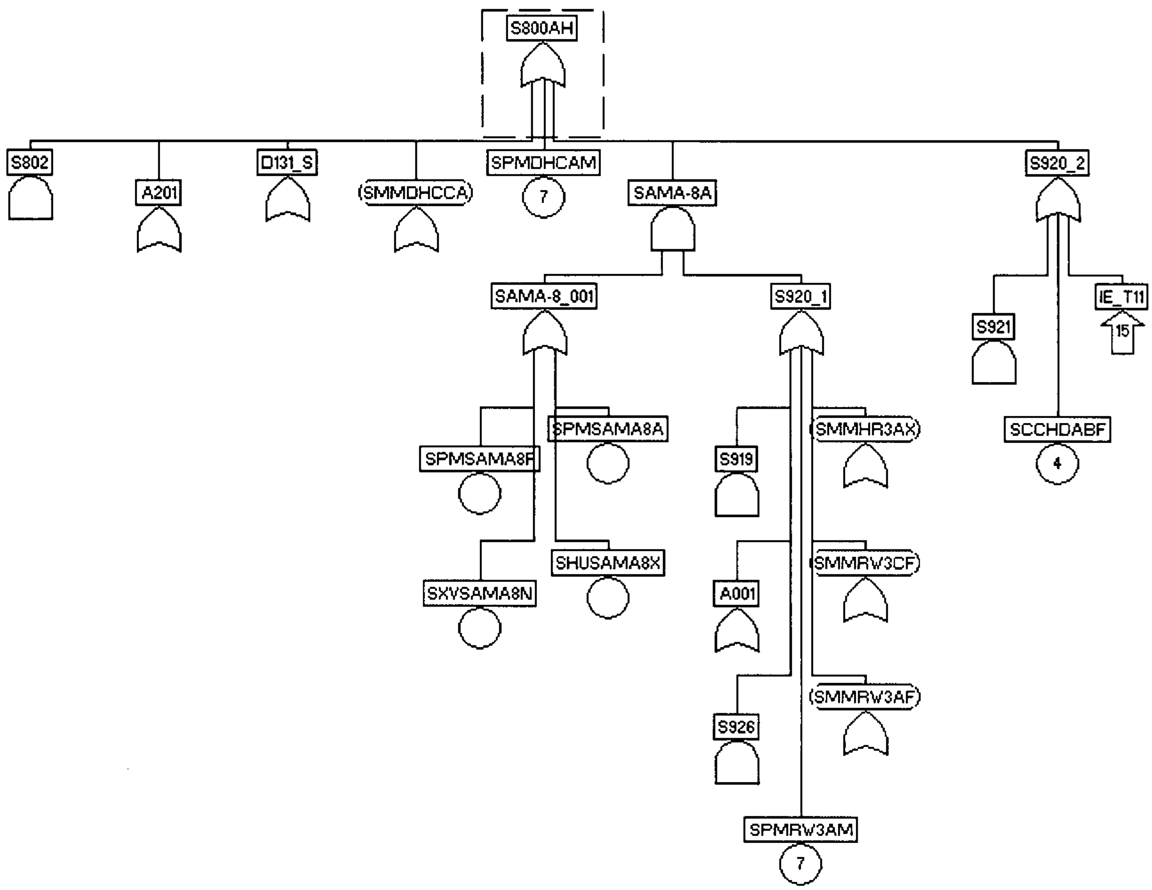

FIGURE 3b
DEPICTION OF FAULT TREE LOGIC USED TO
SIMULATE IMPLEMENTATION OF SAMA 8 FOR GATE S800AH

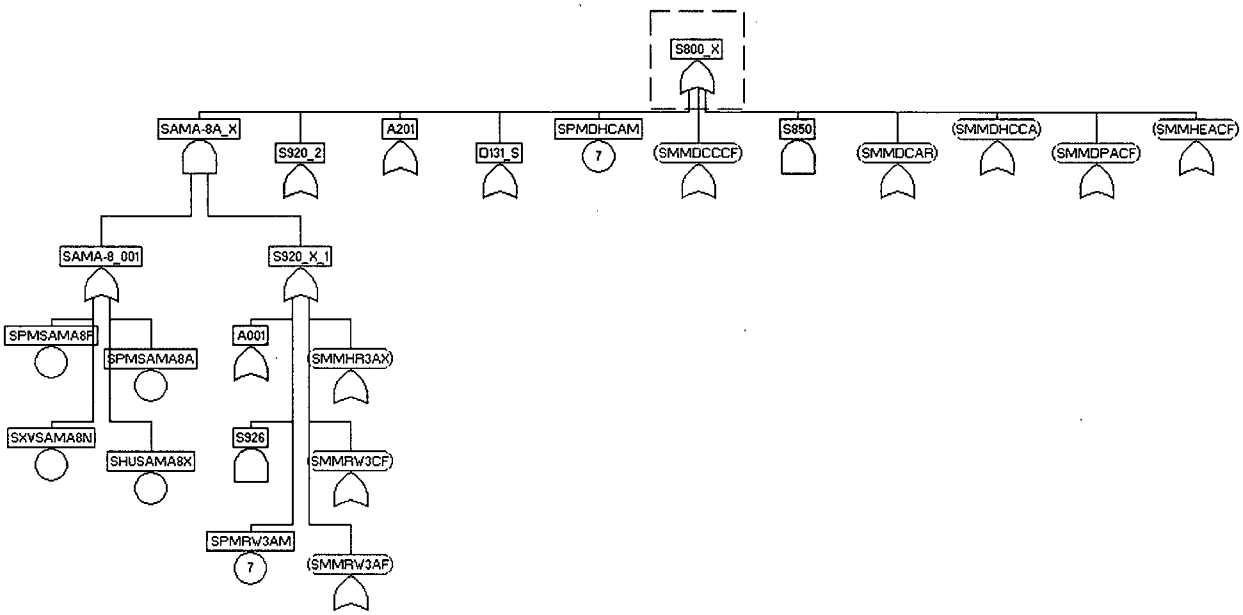

FIGURE 3c
DEPICTION OF FAULT TREE LOGIC USED TO
SIMULATE IMPLEMENTATION OF SAMA 8 FOR GATE S800_X

Results of SAMA Quantification

Implementation of this SAMA yielded a moderate reduction in CDF, but only a relatively small change in the Dose-Risk, and Offsite Economic Cost-Risk (OECR). The results are summarized in the following table for CR-3:

	CDF	***Dose-Risk***	***OECR***
Base Value	*4.95E-06*	*3.79*	*$6,624*
SAMA Value	*3.86E-06*	*3.75*	*$6,582*
Percent Change	*22.1%*	*1.1%*	*0.6%*

A further breakdown of the Dose-Risk and OECR information is provided in the table below according to release category:

Release Category	***IC1***	***RC1***	***RC1A***	***RC1B***	***RC1AB***	***RC2***	***RC2B***	***RC3***	***RC3B***	***RC4C***	***RC5C***	***Total***
$Frequency_{BASE}$	*4.10E-06*	*2.44E-08*	*4.71E-10*	*1.59E-08*	*1.25E-09*	*8.43E-10*	*3.46E-09*	*2.46E-07*	*1.57E-07*	*3.44E-07*	*5.15E-08*	***4.95E-06***
$Frequency_{SAMA}$	*3.04E-06*	*1.89E-08*	*4.02E-10*	*1.30E-08*	*9.88E-10*	*6.82E-10*	*2.57E-09*	*2.29E-07*	*1.56E-07*	*3.43E-07*	*5.13E-08*	***3.86E-06***
$Dose\text{-}Risk_{BASE}$	*0.04*	*0.01*	*0.00*	*0.03*	*0.00*	*0.00*	*0.01*	*0.07*	*0.30*	*2.57*	*0.74*	***3.79***
$Dose\text{-}Risk_{SAMA}$	*0.03*	*0.00*	*0.00*	*0.03*	*0.00*	*0.00*	*0.01*	*0.07*	*0.30*	*2.56*	*0.74*	***3.75***
$OECR_{BASE}$	*$0*	*$1*	*$0*	*$29*	*$2*	*$7*	*$27*	*$15*	*$679*	*$4,855*	*$1,009*	***$6,624***
$OECR_{SAMA}$	*$0*	*$0*	*$0*	*$24*	*$2*	*$6*	*$20*	*$14*	*$673*	*$4,836*	*$1,006*	***$6,582***

This information was used as input to the cost-benefit calculation. The results of this calculation are provided in the following table:

SAMA 8 Net Value

Base Case Cost-Risk	***Revised Cost-Risk***	***Averted Cost-Risk***	***COI***	***Net Value***
$4,092,000	*$3,734,028*	*$357,972*	*$500,000*	*-$142,028*

The SAMA 8 results indicate a moderate reduction in CDF with relatively small changes in dose-risk and offsite economic consequences. Even though the cost of implementation is $500,000, the net value for this SAMA is -$142,028 ($357,972 - $500,000 = -$142,028).

SAMA 26: Install a Separate and Independent EFIC Room Cooling System

The EFW Initiation and Control (EFIC) system provides for automatic initiation of the Emergency Feedwater System when needed and contains the logic circuitry responsible for appropriate feedwater valve isolation and alignment. Once EFW is initiated, its controls are governed by the EFIC system.

If the HVAC system responsible for cooling the rooms containing the EFIC cabinets and electronic components is unavailable, the system is assumed to fail due to overheating. This SAMA provides for an alternate and independent backup room cooling system for both trains of the EFIC system.

Assumptions

For both EFIC rooms A and B, a single point estimate of the unavailability for each postulated backup system was assumed that would take into account all possible failure modes, which would include mechanical, electrical, and operator actions.

PRA Model Changes to Model SAMA

To calculate the consequences of implementation of this SAMA, a new AND gate (Q141_SAMA26) was inserted one level above OR gate Q141. Gate Q141_SAMA26 is modeled as an input to OR gate Q032 and OR gate Q082. The inputs to AND gate Q141_SAMA26 are the original Q141 gate logic and the new postulated SAMA event SAMA26-EFIC-B, which represents the unavailability for the EFIC room B HVAC backup system.

Likewise, for train A of EFIC, a new AND gate was created (Q140_SAMA26), which contained the original Q140 gate logic and the new SAMA event SAMA26-EFIC-A as inputs. Gate Q140_SAMA26 is modeled as an input to AND gate Q149.

SAMA 26 New Basic Events

Basic Event	Description	Probability	Comments
SAMA26-EFIC-A	HVAC BACKUP FOR EFIC ROOM A FAILS	1E-02	Assumed unavailability to account for all possible failure mechanisms, including operator actions, for this HVAC backup system.
SAMA26-EFIC-B	HVAC BACKUP FOR EFIC ROOM B FAILS	1E-02	Assumed unavailability to account for all possible failure mechanisms, including operator actions, for this HVAC backup system.

Results of SAMA Quantification

Implementation of this SAMA yielded a moderate reduction in CDF, but only a relatively small change in the Dose-Risk, and Offsite Economic Cost-Risk (OECR). The results are summarized in the following table for CR-3:

	CDF	Dose-Risk	OECR
Base Value	4.95E-06	3.79	$6,624
SAMA Value	3.73E-06	3.52	$6,151
Percent Change	24.5%	7.1%	7.1%

A further breakdown of the Dose-Risk and OECR information is provided in the table below according to release category:

Release Category	IC1	RC1	RC1A	RC1B	RC1AB	RC2	RC2B	RC3	RC3B	RC4C	RC5C	Total
$Frequency_{BASE}$	4.10E-06	2.44E-08	4.71E-10	1.59E-08	1.25E-09	8.43E-10	3.46E-09	2.46E-07	1.57E-07	3.44E-07	5.15E-08	**4.95E-06**
$Frequency_{SAMA}$	3.15E-06	2.37E-08	3.90E-10	1.06E-08	6.57E-10	4.64E-10	3.00E-09	9.61E-08	5.26E-08	3.45E-07	5.15E-08	**3.73E-06**
$Dose\text{-}Risk_{BASE}$	0.04	0.01	0.00	0.03	0.00	0.00	0.01	0.07	0.30	2.57	0.74	**3.79**
$Dose\text{-}Risk_{SAMA}$	0.03	0.00	0.00	0.02	0.00	0.00	0.01	0.03	0.10	2.57	0.74	**3.52**
$OECR_{BASE}$	$0	$1	$0	$29	$2	$7	$27	$15	$679	$4,855	$1,009	**$6,624**
$OECR_{SAMA}$	$0	$1	$0	$20	$1	$4	$23	$6	$227	$4,860	$1,009	**$6,151**

This information was used as input to the cost-benefit calculation. The results of this calculation are provided in the following table:

SAMA 26 Net Value

Base Case Cost-Risk	Revised Cost-Risk	Averted Cost-Risk	COI	Net Value
$4,092,000	$3,536,400	$555,600	$2,000,000	-$1,444,400

The SAMA 26 results indicate a moderate reduction in CDF with relatively small changes in dose-risk and offsite economic consequences. Given the cost of implementation of $2,000,000, the net value for this SAMA is -$1,444,400 ($555,600 - $2,000,000 = -$1,444,400).

SAMA 14: Automate Steam Generator Level Controls for Small LOCA

Operators are directed by procedure to establish OTSG levels at 80-90% (or achieve adequate flow) given a loss of adequate subcooling margin. The relevant sequences for this operator action involve a small-break LOCA where not enough water is lost out of the break to remove decay heat. Therefore, enhanced primary-to-secondary heat transfer is needed to remove the balance of the decay heat. For other scenarios, such as a loss of all RCPs, EFIC automatically controls to the natural circulation level. The operators are directed to raise secondary water level in the steam generators to 80-90% by selecting the ISCM setpoint. If the level is not achieved, the minimal criterion is to achieve the flow rates dictated by the EOP's. To improve the reliability of this action, this SAMA simulates the use of automatic controls to accomplish this action of raising OTSG water level.

Assumptions

To simulate the use of automatic controls, it was assumed that the operator failure probability could be reduced to simulate the use of more reliable automatic controls.

PRA Model Changes to Model SAMA

The only change made to the PRA model to simulate implementation of this SAMA was the reduction of the failure probability of QHUEFW9Y from 2.7E-3 to 2.7E-6. This failure reduction conservatively bounds the risk benefit by implying that automatic controls are three orders of magnitude more reliable than an operator using manual control.

Results of SAMA Quantification

Implementation of this SAMA yielded a small reduction in CDF, Dose-Risk, and Offsite Economic Cost-Risk (OECR). The results are summarized in the following table for CR-3:

	CDF	**Dose-Risk**	**OECR**
Base Value	*4.95E-06*	*3.79*	*$6,624*
SAMA Value	*4.79E-06*	*3.78*	*$6,610*
Percent Change	*3.2%*	*0.3%*	*0.2%*

A further breakdown of the Dose-Risk and OECR information is provided in the table below according to release category:

Release Category	**IC1**	**RC1**	**RC1A**	**RC1B**	**RC1AB**	**RC2**	**RC2B**	**RC3**	**RC3B**	**RC4C**	**RC5C**	**Total**
$Frequency_{BASE}$	4.10E-06	2.44E-08	4.71E-10	1.59E-08	1.25E-09	8.43E-10	3.46E-09	2.46E-07	1.57E-07	3.44E-07	5.15E-08	**4.95E-06**
$Frequency_{SAMA}$	3.95E-06	2.31E-08	3.30E-10	1.57E-08	1.23E-09	8.42E-10	3.27E-09	2.45E-07	1.57E-07	3.44E-07	5.13E-08	**4.79E-06**
$Dose\text{-}Risk_{BASE}$	0.04	0.01	0.00	0.03	0.00	0.00	0.01	0.07	0.30	2.57	0.74	**3.79**
$Dose\text{-}Risk_{SAMA}$	0.04	0.00	0.00	0.03	0.00	0.00	0.01	0.07	0.30	2.57	0.74	**3.78**
$OECR_{BASE}$	$0	$1	$0	$29	$2	$7	$27	$15	$679	$4,855	$1,009	**$6,624**
$OECR_{SAMA}$	$0	$1	$0	$29	$2	$7	$25	$15	$677	$4,849	$1,005	**$6,610**

This information was used as input to the cost-benefit calculation. The results of this calculation are provided in the following table:

SAMA 14 Net Value				
Base Case Cost-Risk	**Revised Cost-Risk**	**Averted Cost-Risk**	**COI**	**Net Value**
$4,092,000	*$4,037,472*	*$54,528*	*$900,000*	*-$845,472*

The SAMA 14 results indicate a small reduction in CDF, dose-risk and offsite economic consequences. Given a cost of implementation of $900,000, the net value for this SAMA is -$845,472 ($54,528 - $900,000 = -$845,472).

SAMA 37: Install Removable Strainers Upstream of Decay Heat Coolers to Mitigate Common Cause Plugging Concerns

The Decay Heat Seawater (RW) system is responsible for providing cooling water to the decay heat closed cycle heat exchangers DCHE-1A and DCHE-1B, which serve as the ultimate heat sink for removal of decay heat during shutdown cooling or emergency conditions. Since DCHE-1A and DCHE-1B are susceptible to common cause failure due to plugging from debris, this SAMA provides an option to remediate this possible failure via use of removable strainers upstream of the heat exchangers to capture any possible debris and prevent the heat exchangers from being plugged.

One possible design for these upstream strainers would be that of a duplex arrangement, in which it is possible for the operator to swap from one in-line strainer to another without having to breach the decay heat seawater system.

Assumptions

To reduce the susceptibility of both DCHE-1A and DCHE-1B to plugging failure, it was assumed that an equipment operator could easily swap to a clean strainer, e.g., via duplex strainer arrangement, for one or both of the affected decay heat seawater trains with enough time available to avert any possible core damage.

PRA Model Changes to Model SAMA

The only change made to the PRA model to simulate implementation of this SAMA was the reduction of the failure probability of SCCHDABF from 2.39E-4 to 2.39E-6. This failure reduction conservatively bounds the risk benefit by implying that common cause plugging of both DCHE-1A and DCHE-1B can be reduced by two orders of magnitude by means of an equipment operator manually controlling strainer configuration to avoid debris from stopping the flow of cooling water to these heat exchangers.

Results of SAMA Quantification

Implementation of this SAMA yielded a small reduction in CDF, Dose-Risk, and Offsite Economic Cost-Risk (OECR). The results are summarized in the following table for CR-3:

	CDF	**Dose-Risk**	**OECR**
Base Value	4.95E-06	3.79	$6,624
SAMA Value	4.78E-06	3.79	$6,619
Percent Change	3.4%	0.1%	0.1%

A further breakdown of the Dose-Risk and OECR information is provided in the table below according to release category:

Release Category	**IC1**	**RC1**	**RC1A**	**RC1B**	**RC1AB**	**RC2**	**RC2B**	**RC3**	**RC3B**	**RC4C**	**RC5C**	**Total**
$Frequency_{BASE}$	4.10E-06	2.44E-08	4.71E-10	1.59E-08	1.25E-09	8.43E-10	3.46E-09	2.46E-07	1.57E-07	3.44E-07	5.15E-08	**4.95E-06**
$Frequency_{SAMA}$	3.94E-06	2.29E-08	4.55E-10	1.57E-08	1.24E-09	8.42E-10	3.26E-09	2.45E-07	1.57E-07	3.44E-07	5.16E-08	**4.78E-06**
$Dose\text{-}Risk_{BASE}$	0.04	0.01	0.00	0.03	0.00	0.00	0.01	0.07	0.30	2.57	0.74	**3.79**
$Dose\text{-}Risk_{SAMA}$	0.04	0.00	0.00	0.03	0.00	0.00	0.01	0.07	0.30	2.57	0.74	**3.79**
$OECR_{BASE}$	$0	$1	$0	$29	$2	$7	$27	$15	$679	$4,855	$1,009	**$6,624**
$OECR_{SAMA}$	$0	$0	$0	$29	$2	$7	$25	$15	$678	$4,850	$1,012	**$6,619**

This information was used as input to the cost-benefit calculation. The results of this calculation are provided in the following table:

SAMA 37 Net Value

Base Case Cost-Risk	Revised Cost-Risk	Averted Cost-Risk	COI	Net Value
$4,092,000	*$4,037,916*	*$54,084*	*$600,000*	*-$545,916*

The SAMA 37 results indicate a small reduction in CDF, dose-risk, and offsite economic consequences. Based on the $600,000 cost of implementation, the net value for this SAMA is -$545,916 ($54,084 - $600,000 = -$545,916).

SAMA 1: Automate EFIC/Inverter Backup Cooling Alignment

During normal operation, the control complex Chilled Water (CH) system is in operation with one pump and one chiller in operation. The control complex CH is normally aligned to provide cooling water to such heat loads as the Control Complex ventilation system cooling coils, Reactor Building penetration HVAC cooling coils, and the EFIC room HVAC cooling coils (AHHE-43, 44).

Another chilled water system, the "Appendix R" Chilled Water subsystem, consists of a chiller, a chilled water pump, a chilled water surge tank, and the isolation and control valves required for system operation. Chilled water is pumped from the aligned heat loads through the chiller, and back to the aligned heat loads. During normal operation, the Appendix R CH subsystem supplies Turbine Building switchgear room air handling unit cooling coils (AHHE-10A, 10B), but can also be manually aligned to cool the EFIC room HVAC cooling coil (AHHE-44). Certain multiple failures of the control complex CH system are assumed to lead to failure of the EFIC system, which eventually results in loss of all EFW. An available option to cool critical equipment important to the operation of EFW is the use of this Appendix R CH system.

The purpose of this SAMA is to investigate whether improving the capability of the Appendix R Chilled Water subsystem by assuming automatic realignment will provide a cost beneficial option.

Assumptions

It was assumed that a reduction in the failure probability of a single human error probability (HEP) event would be a satisfactory simulation of the addition of automatic controls and realignment capability for the Appendix R Chilled Water subsystem. This implies that any unavailability representing mechanical, electrical, and other support systems necessary for this SAMA could be adequately estimated via this "lumped parameter" approach in determining the possible risk benefits.

PRA Model Changes to Model SAMA

To calculate the consequences of implementation of this SAMA, the failure probability of HEP event JHUCHP2R in the PRA model was reduced from 1.0 to 1E-4. Also, to prevent the use of JHUCHP2Z, which is a recovery event for this human action in the quantification recovery rules file, the appropriate command lines in the recovery rules *were delineated as comments so as to prevent appending this non-recovery event with a probability 0.05 to any newly generated cutsets for this SAMA quantification.*

Results of SAMA Quantification

Implementation of this SAMA yielded a small reduction in CDF, Dose-Risk, and Offsite Economic Cost-Risk (OECR). The results are summarized in the following table for CR-3:

	CDF	**Dose-Risk**	**OECR**
Base Value	4.95E-06	3.79	$6,624
SAMA Value	4.33E-06	3.57	$6,218
Percent Change	12.4%	5.8%	6.1%

A further breakdown of the Dose-Risk and OECR information is provided in the table below according to release category:

Release Category	**IC1**	**RC1**	**RC1A**	**RC1B**	**RC1AB**	**RC2**	**RC2B**	**RC3**	**RC3B**	**RC4C**	**RC5C**	**Total**
$Frequency_{BASE}$	4.10E-06	2.44E-08	4.71E-10	1.59E-08	1.25E-09	8.43E-10	3.46E-09	2.46E-07	1.57E-07	3.44E-07	5.15E-08	**4.95E-06**
$Frequency_{SAMA}$	3.70E-06	2.43E-08	4.50E-10	1.41E-08	1.04E-09	6.48E-10	3.25E-09	1.30E-07	6.56E-08	3.45E-07	5.15E-08	**4.33E-06**
$Dose\text{-}Risk_{BASE}$	0.04	0.01	0.00	0.03	0.00	0.00	0.01	0.07	0.30	2.57	0.74	**3.79**
$Dose\text{-}Risk_{SAMA}$	0.04	0.00	0.00	0.03	0.00	0.00	0.01	0.04	0.13	2.57	0.74	**3.57**
$OECR_{BASE}$	$0	$1	$0	$29	$2	$7	$27	$15	$679	$4,855	$1,009	**$6,624**
$OECR_{SAMA}$	$0	$1	$0	$26	$2	$6	$25	$8	$283	$4,858	$1,010	**$6,218**

This information was used as input to the cost-benefit calculation. The results of this calculation are provided in the following table:

SAMA 1 Net Value

Base Case Cost-Risk	**Revised Cost-Risk**	**Averted Cost-Risk**	**COI**	**Net Value**
$4,092,000	$3,750,708	$341,292	$1,000,000	-$658,708

The SAMA 1 results indicate a small reduction in CDF, dose-risk, and offsite economic consequences. Based on a cost of implementation of $1,000,000, the net value for this SAMA is -$658,708 ($341,292 - $1,000,000 = -$658,708).

SAMA 7: Install a Separate and Independent AFW Source and Pump as a Backup to the EFW System

This SAMA investigates the implementation of a separate and independent train of auxiliary feedwater (AFW). Given that EFW pumps EFP-1, -2, and -3 of the EFW system and FWP-7 of the existing AFW system are all unavailable, this SAMA would provide another means of providing feedwater to both steam generators during *emergency conditions. This backup AFW system is postulated to have an independent suction source capable of satisfying long-term cooling requirements and rely on support systems that are totally independent of existing plant systems, such that common cause failure mechanisms with other plant equipment would be practically non-existent.*

Assumptions

It was assumed that the unavailability of this alternate AFW backup system could be represented by a single basic event. That is, any unavailability representing mechanical, electrical, and other support systems necessary for this SAMA could be adequately estimated via this "lumped parameter" approach in determining the possible risk benefits.

PRA Model Changes to Model SAMA

To calculate the consequences of implementation of this SAMA, a new event (SAMA7-AFW-BU) was added to AND gates @BS01 (LOSS OF ALL PRIMARY-SECONDARY COOLING) and @B03 (FAILURE OF EFW / AFW) that represents the overall unavailability of this postulated independent AFW backup system. An unavailability of 1E-03 was chosen to conservatively bound the risk benefit that might be achieved given the implementation of such a system.

SAMA 7 New Basic Event

Basic Event	Description	Probability	Comments
SAMA7-AFW-BU	FAILURE OF ALTERNATE AFW BACKUP SYSTEM (SAMA 7)	1E-03	Assumed unavailability to account for all possible failure mechanisms, including operator actions, for this backup AFW system.

Results of SAMA Quantification

Implementation of this SAMA yielded a moderate reduction in CDF, but only a relatively small change in the Dose-Risk, and Offsite Economic Cost-Risk (OECR). The results are summarized in the following table for CR-3:

	CDF	Dose-Risk	OECR
Base Value	4.95E-06	3.79	$6,624
SAMA Value	3.05E-06	3.36	$5,885
Percent Change	38.4%	11.3%	11.2%

A further breakdown of the Dose-Risk and OECR information is provided in the table below according to release category:

Release Category	IC1	RC1	RC1A	RC1B	RC1AB	RC2	RC2B	RC3	RC3B	RC4C	RC5C	Total
$Frequency_{BASE}$	4.10E-06	2.44E-08	4.71E-10	1.59E-08	1.25E-09	8.43E-10	3.46E-09	2.46E-07	1.57E-07	3.44E-07	5.15E-08	**4.95E-06**
$Frequency_{SAMA}$	2.61E-06	2.15E-08	2.73E-10	5.33E-09	1.04E-10	2.42E-10	2.56E-09	6.88E-09	7.26E-11	3.43E-07	5.15E-08	**3.05E-06**
$Dose\text{-}Risk_{BASE}$	0.04	0.01	0.00	0.03	0.00	0.00	0.01	0.07	0.30	2.57	0.74	**3.79**
$Dose\text{-}Risk_{SAMA}$	0.03	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00	2.57	0.74	**3.36**
$OECR_{BASE}$	$0	$1	$0	$29	$2	$7	$27	$15	$679	$4,855	$1,009	**$6,624**
$OECR_{SAMA}$	$0	$0	$0	$10	$0	$2	$20	$0	$0	$4,842	$1,010	**$5,885**

This information was used as input to the cost-benefit calculation. The results of this calculation are provided in the following table:

SAMA 7 Net Value

Base Case Cost-Risk	Revised Cost-Risk	Averted Cost-Risk	COI	Net Value
$4,092,000	$3,220,956	$871,044	$5,000,000	-$4,128,956

The SAMA 7 results indicate a moderate reduction in CDF with relatively small changes in dose-risk and offsite economic consequences. Based on a cost of implementation of $5,000,000, the net value for this SAMA is -$4,128,956 ($871,044 - $5,000,000 = -$4,128,956).

SAMA 16: Implement Design and Procedural Changes for Crosstying Trains of the Decay Heat and Decay Heat Closed Cooling Systems

The function of the Decay Heat (DH) system is to provide the ability to inject borated water into the reactor coolant system given a LOCA condition. It also provides the ability to recirculate coolant that accumulates in the reactor building sump following depletion of the Borated Water Storage Tank (BWST). In sump recirculation mode, at depressurized conditions, the DH pumps can inject water directly back into the reactor coolant system, or at higher pressures, to the suction of the Makeup (MU) pumps for high pressure recirculation. Reactor decay heat is removed via the DH coolers DHHE-1A and DHHE-1B. These heat exchangers are in turn cooled by the Decay Heat Closed Cycle Cooling (DHCCC) system via heat exchangers DCHE-1A and DCHE-1B.

Based on the following basic events obtained from a review of the Level 1 CDF importance list, this SAMA attempts to simulate the ability to cross-connect the DH and DHCCC systems to improve the continued availability of these systems. It is important to note that even though some of the listed events exhibited a RRW of < 1.02, they were nonetheless included for the purpose of showing train symmetry.

Basis Event	RRW	Description
LMMDV42F	1.031	FAILURE OF TRAIN A RECIRC VALVE DHV-42
LMMDV43F	1.033	FAILURE OF TRAIN B RECIRC VALVE DHV-43
LMMDV11F	1.031	TRAIN A RECIRC VALVE DHV-11 FAILS
LMMDV12F	1.033	TRAIN B RECIRC VALVE DHV-12 FAILS
SMMDHCCA	1.018	DHCCC TRAIN A FAULTS
SMMDHCCB	1.025	DHCCC TRAIN B FAULTS
SPMDHCAM	1.013	DHCCC TRAIN A IN MAINTENANCE
SPMDHCBM	1.025	DHCCC TRAIN B IN MAINTENANCE

Assumptions

In order to attempt to maximize the perceived benefit of being able to crosstie the DH and DHCCC systems, it was assumed that the risk benefit may be bounded by logically combining existing events under new logical AND gates. That is, no consideration was given to any new operator or manual actions that might tend to deflate the risk benefit.

PRA Model Changes to Model SAMA

To calculate the consequences of implementation of this SAMA, the following logic changes were made to the PRA model:

- *A new AND gate labeled SAMA16-L001 using existing modular events LMMDV42F and LMMDV43F as inputs was created. This AND gate was then used to replace these events where they originally existed in the PRA model.*
- *A new AND gate labeled SAMA16-L002 using existing modular events LMMDV11F and LMMDV12F as inputs was created. This AND gate was then used to replace these events where they originally existed in the PRA model.*
- *A new AND gate labeled SAMA16-S001 using existing modular events SMMDHCCA and SMMDHCCB as inputs was created. This AND gate was then used to replace these events where they originally existed in the PRA model.*
- *To simulate the ability of being able to cross-connect DHCCC trains when one is in maintenance, each maintenance event (SPMDHCAM for train A and SPMDHCBM for train B) was reduced by a factor of 10 since it would be expected that some, but not all, maintenance activities on the DHCCC system would afford the opportunity of using the opposite train's equipment.*

Results of SAMA Quantification

Implementation of this SAMA yielded a small reduction in CDF, Dose-Risk, and Offsite Economic Cost-Risk (OECR). The results are summarized in the following table for CR-3:

	CDF	Dose-Risk	OECR
Base Value	4.95E-06	3.79	$6,624
SAMA Value	4.14E-06	3.76	$6,603
Percent Change	16.4%	0.7%	0.3%

A further breakdown of the Dose-Risk and OECR information is provided in the table below according to release category:

Release Category	***IC1***	***RC1***	***RC1A***	***RC1B***	***RC1AB***	***RC2***	***RC2B***	***RC3***	***RC3B***	***RC4C***	***RC5C***	***Total***
$Frequency_{BASE}$	*4.10E-06*	*2.44E-08*	*4.71E-10*	*1.59E-08*	*1.25E-09*	*8.43E-10*	*3.46E-09*	*2.46E-07*	*1.57E-07*	*3.44E-07*	*5.15E-08*	***4.95E-06***
$Frequency_{SAMA}$	*3.32E-06*	*1.81E-08*	*3.79E-10*	*1.47E-08*	*1.18E-09*	*8.16E-10*	*2.57E-09*	*2.25E-07*	*1.57E-07*	*3.44E-07*	*5.13E-08*	***4.14E-06***
$Dose\text{-}Risk_{BASE}$	*0.04*	*0.01*	*0.00*	*0.03*	*0.00*	*0.00*	*0.01*	*0.07*	*0.30*	*2.57*	*0.74*	***3.79***
$Dose\text{-}Risk_{SAMA}$	*0.03*	*0.00*	*0.00*	*0.03*	*0.00*	*0.00*	*0.01*	*0.07*	*0.30*	*2.57*	*0.74*	***3.76***
$OECR_{BASE}$	*$0*	*$1*	*$0*	*$29*	*$2*	*$7*	*$27*	*$15*	*$679*	*$4,855*	*$1,009*	***$6,624***
$OECR_{SAMA}$	*$0*	*$0*	*$0*	*$27*	*$2*	*$7*	*$20*	*$14*	*$677*	*$4,850*	*$1,006*	***$6,603***

This information was used as input to the cost-benefit calculation. The results of this calculation are provided in the following table:

SAMA 16 Net Value				
Base Case Cost-Risk	***Revised Cost-Risk***	***Averted Cost-Risk***	***COI***	***Net Value***
$4,092,000	*$3,829,788*	*$262,212*	*$5,000,000*	*-$4,737,788*

The SAMA 16 results indicate a small reduction in CDF, dose-risk and offsite economic consequences. Based on a cost of implementation is $5,000,000, the net value for this SAMA is -$4,737,788 ($262,212 - $5,000,000 = -$4,737,788).

<u>SAMA 18: Install an Additional Emergency Diesel Generator to Provide an Additional AC Power Source</u>

This SAMA investigates the proposed installation of an additional emergency diesel generator (EDG) to help reduce the contribution to core damage due to scenarios involving the loss of backup AC power. Implementation of this SAMA will be modeled in the PRA as a new event with an overall unavailability that is meant to capture all mechanical, electrical, and operator failures, while also creating a bounding estimate of the perceived risk benefit. This additional EDG is assumed to be independent of other plant support systems, so as to minimize any common cause failure mechanisms, e.g., use of an air-cooled diesel engine instead of one requiring a heat exchanger cooled by the plant's component cooling water system.

<u>Assumptions</u>

1. *It was assumed that the unavailability of this backup EDG could be represented by a single basic event. That is, any unavailability representing mechanical, electrical, and other support systems necessary for this SAMA could be adequately estimated via this "lumped parameter" approach in determining the possible risk benefits.*

2. *As a means of simplifying the revised model logic, while at the same time providing a bounding estimate of the risk benefit for this SAMA analysis, it was*

assumed that this backup EDG could hypothetically be used to supply both 4,160 VAC Engineered Safeguards buses simultaneously.

PRA Model Changes to Model SAMA

To calculate the consequences of implementation of this SAMA, the following PRA model logic was utilized:

- *A new AND gate for train A was created (SAMA18_001) with inputs that include existing OR gate A401 and the SAMA event SAMA18-EDG-BU, which represents the unavailability for this backup EDG.*
- *A new AND gate for train B was created (SAMA18_002) with inputs that include existing OR gate A451 and event SAMA18-EDG-BU.*
- *Gate SAMA18_001 is used as an input to existing gates A002 (4160V ES BUS 3A SUPPLY FAULTS) and SDR072 (LOSP occurs with no power from DG 3A).*
- *Gate SAMA18_002 is used as an input to existing gates A052 (4160V ES BUS 3B SUPPLY FAULTS) and SDR074 (LOSP occurs with no power from DG 3B).*

An unavailability of 1E-03 was chosen for event SAMA18-EDG-BU to conservatively bound the risk benefit that might be achieved given the installation of a new backup EDG.

SAMA 18 New Basic Event

Basic Event	Description	Probability	Comments
SAMA18-EDG-BU	FAILURE OF BACKUP EDG (SAMA 18)	1E-03	Assumed unavailability to account for all possible failure mechanisms, including operator actions, for this backup AC power source.

Results of SAMA Quantification

Implementation of this SAMA yielded a small reduction in CDF, Dose-Risk, and Offsite Economic Cost-Risk (OECR). The results are summarized in the following table for CR-3:

	CDF	Dose-Risk	OECR
Base Value	4.95E-06	3.79	$6,624
SAMA Value	4.59E-06	3.62	$6,313
Percent Change	7.2%	4.5%	4.7%

A further breakdown of the Dose-Risk and OECR information is provided in the table below according to release category:

Release Category	IC1	RC1	RC1A	RC1B	RC1AB	RC2	RC2B	RC3	RC3B	RC4C	RC5C	Total
$Frequency_{BASE}$	4.10E-06	2.44E-08	4.71E-10	1.59E-08	1.25E-09	8.43E-10	3.46E-09	2.46E-07	1.57E-07	3.44E-07	5.15E-08	**4.95E-06**
$Frequency_{SAMA}$	3.89E-06	2.43E-08	4.54E-10	1.05E-08	6.50E-10	6.92E-10	3.35E-09	1.73E-07	8.95E-08	3.44E-07	5.14E-08	**4.59E-06**
$Dose\text{-}Risk_{BASE}$	0.04	0.01	0.00	0.03	0.00	0.00	0.01	0.07	0.30	2.57	0.74	**3.79**
$Dose\text{-}Risk_{SAMA}$	0.04	0.00	0.00	0.02	0.00	0.00	0.01	0.05	0.17	2.57	0.74	**3.62**
$OECR_{BASE}$	$0	$1	$0	$29	$2	$7	$27	$15	$679	$4,855	$1,009	**$6,624**
$OECR_{SAMA}$	$0	$1	$0	$19	$1	$6	$26	$11	$387	$4,855	$1,008	**$6,313**

This information was used as input to the cost-benefit calculation. The results of this calculation are provided in the following table:

SAMA 18 Net Value				
Base Case Cost-Risk	**Revised Cost-Risk**	**Averted Cost-Risk**	**COI**	**Net Value**
$4,092,000	$3,864,948	$227,052	$8,000,000	-$7,772,948

The SAMA 18 results indicate a small reduction in CDF, dose-risk and offsite economic consequences. Based on a cost of implementation is $8,000,000, the net value for this SAMA is -$7,772,948 ($227,052 - $8,000,000 = -$7,772,948).

SAMA 13: Add an Additional Train of Decay Heat Removal Cooling of Diverse Design

The decay heat removal (DHR or DH) system provides normal heat removal operation following plant cool down and provides low pressure makeup following a loss of coolant accident (LOCA) in both the low pressure injection (LPI) and both low and high pressure recirculation (LPR, HPR) modes of operation.

The DH system consists of two pumps, two heat exchangers, and a borated water storage tank (BWST). Interconnecting piping, motor-operated control and isolation valves are required for normal and emergency system operation.

The DH system is comprised of two independent and redundant cooling trains. Each train is capable of providing 100% of the heat removal requirements for a normal reactor shutdown, as well as for LOCA emergency cooling. Each train may take suction from the BWST, the reactor building sump, or the Reactor Coolant System (RCS) B hot leg via the decay heat drop line. Each DH heat exchanger is cooled by its own decay heat closed cycle cooling (DHCCC) system train.

This SAMA investigates the proposed installation of an additional train of DHR of diverse design to increase reliability and availability of the DHR function, and also to minimize any common cause related failure mechanisms. Implementation of this SAMA will be modeled in the PRA as a new event with an overall unavailability that is meant to capture all mechanical, electrical, and operator failures, while also creating a bounding estimate of the perceived risk benefit. This additional train of DHR is assumed to be independent of other plant support systems, e.g., use of a diesel-driven air-cooled pump and a DHR heat exchanger with a different means of heat removal, such as via radiative *cooling instead of the conventional convection method. Multiple available suction sources for primary inventory control would also be part of this SAMA design so as to increase the success of a borated water source, rather than solely relying on the single BWST that currently exists.*

Assumptions

It was assumed that the unavailability of this backup DHR train could be represented by a single basic event. That is, any unavailability representing mechanical, electrical, and other support systems necessary for this SAMA could be adequately estimated via this "lumped parameter" approach in determining the possible risk benefits.

PRA Model Changes to Model SAMA

To calculate the consequences of implementation of this SAMA, the following PRA model logic was utilized:

- *The new backup DHR SAMA event (SAMA13-DHR-BU) was used as a new input to the following AND gates:*
  - *H3630 - LOSS OF SUCTION FLOW TO MUP-1A*
  - *H3730 - LOSS OF SUCTION FLOW TO MUP-1B*
  - *L102 - LOSS OF FLOW FROM BOTH LPI TRAINS*
- *The following new gate logic was added to the PRA model:*
  - *A new AND gate was created (SAMA13_001) with existing OR gate L001 and new SAMA event SAMA13-DHR-BU as inputs. Gate SAMA13_001 is used as an input to OR gate @AU1.*
  - *A new AND gate was created (SAMA13_002) with existing OR gate L201 and new SAMA event SAMA13-DHR-BU as inputs. Gate SAMA13_002 is used as an input to OR gate @GR02.*

An unavailability of 1E-03 was chosen for event SAMA13-DHR-BU to conservatively bound the risk benefit that might be achieved given the installation of a new diverse train of DHR.

SAMA 13 New Basic Event

Basic Event	Description	Probability	Comments
SAMA13-EDG-BU	*FAILURE OF BACKUP DHR (SAMA 13)*	*1E-03*	*Assumed unavailability to account for all possible failure mechanisms, including operator actions, for this backup AC power source.*

Results of SAMA Quantification

Implementation of this SAMA yielded a moderate reduction in CDF, but only a relatively small change in the Dose-Risk, and Offsite Economic Cost-Risk (OECR). The results are summarized in the following table for CR-3:

	CDF	Dose-Risk	OECR
Base Value	*4.95E-06*	*3.79*	*$6,624*
SAMA Value	*3.36E-06*	*3.61*	*$6,342*
Percent Change	*32.1%*	*4.8%*	*4.3%*

A further breakdown of the Dose-Risk and OECR information is provided in the table below according to release category:

Release Category	IC1	RC1	RC1A	RC1B	RC1AB	RC2	RC2B	RC3	RC3B	RC4C	RC5C	Total
$Frequency_{BASE}$	4.10E-06	2.44E-08	4.71E-10	1.59E-08	1.25E-09	8.43E-10	3.46E-09	2.46E-07	1.57E-07	3.44E-07	5.15E-08	**4.95E-06**
$Frequency_{SAMA}$	2.60E-06	1.09E-08	2.88E-10	1.42E-08	1.19E-09	8.43E-10	1.59E-09	1.99E-07	1.57E-07	3.26E-07	5.14E-08	**3.36E-06**
$Dose\text{-}Risk_{BASE}$	0.04	0.01	0.00	0.03	0.00	0.00	0.01	0.07	0.30	2.57	0.74	**3.79**
$Dose\text{-}Risk_{SAMA}$	0.03	0.00	0.00	0.03	0.00	0.00	0.01	0.06	0.30	2.43	0.74	**3.61**
$OECR_{BASE}$	$0	$1	$0	$29	$2	$7	$27	$15	$679	$4,855	$1,009	**$6,624**
$OECR_{SAMA}$	$0	$0	$0	$26	$2	$7	$12	$12	$678	$4,595	$1,008	**$6,342**

This information was used as input to the cost-benefit calculation. The results of this calculation are provided in the following table:

SAMA 13 Net Value

Base Case Cost-Risk	Revised Cost-Risk	Averted Cost-Risk	COI	Net Value
$4,092,000	*$3,487,992*	*$604,008*	*$10,000,000*	*-$9,395,992*

The SAMA 13 results indicate a moderate reduction in CDF with relatively small dose-risk and offsite economic consequences. Based on a cost of implementation of $10,000,000, the net value for this SAMA is -$9,395,992 ($604,008 - $10,000,000 = -$9,395,992).

SAMA 52: Install a Parallel Flow Path for the Decay Heat Removal Drop Line

During power operations, the Decay Heat (DH) system is normally in standby and aligned for automatic actuation in the Low Pressure Injection (LPI) mode of operation. This configuration allows the system to automatically align to deliver water from the BWST to the reactor vessel through the core flood nozzle penetrations. During a normal plant cooldown, the DH system is placed in operation after reactor coolant temperature has been reduced to 280°F. The system takes suction from the decay heat drop line and delivers it through the DH heat exchangers and back through the Core Flood (CF) nozzle penetrations.

This SAMA investigates the proposed installation of an additional parallel flow path similar to the existing DH drop line. Implementation of this SAMA will be modeled in the PRA as a new event with an overall unavailability that is meant to capture all *mechanical, electrical, and operator failures, while also creating a bounding estimate of the perceived risk benefit.*

Assumptions

1. *It was assumed that the unavailability of this parallel flow path could be represented by a single basic event. That is, any unavailability representing mechanical, electrical, and other support systems necessary for this SAMA could be adequately estimated via this "lumped parameter" approach in determining the possible risk benefits.*
2. *Since the additional flow path can also act as an additional ISLOCA contributor, to account for a possible increase in offsite risk, the ISLOCA initiating frequency was increased by a factor of 1.2 (20% increase). Therefore, the initiating event frequency for IE_V (ISLOCA - DHR DROP LINE AND INJECTION LINES) was redefined as (1.2 * 5.14E-08) = 6.17E-08.*

PRA Model Changes to Model SAMA

To calculate the consequences of implementation of this SAMA, the following PRA model logic was utilized:

- *A new AND gate was created (SAMA52_001) with inputs that include existing OR gate L207 and the SAMA event SAMA52-DROP-BU, which represents the unavailability for this backup drop line.*
- *OR gate L207 was originally used as an input to gates AI604, AI607, and L201, but AND gate SAMA52_001 is now used in place of OR gate L207 as an input to these gates.*

An unavailability of 1E-03 was chosen for event SAMA52-DROP-BU to conservatively bound the risk benefit that might be achieved given the installation of a new parallel drop line.

SAMA 52 New Basic Event

Basic Event	*Description*	*Probability*	*Comments*
SAMA52-DROP-BU	*FAILURE OF BACKUP DROPLINE (SAMA 52)*	*1E-03*	*Assumed unavailability to account for all possible failure mechanisms, including operator actions, for this backup DH drop line.*

Results of SAMA Quantification

Implementation of this SAMA yielded a very small reduction in CDF, a slight increase in dose risk, and a very small decrease in Offsite Economic Cost-Risk (OECR). The results are summarized in the following table for CR-3:

	CDF	*Dose-Risk*	*OECR*
Base Value	*4.95E-06*	*3.79*	*$6,624*
SAMA Value	*4.94E-06*	*3.82*	*$6,606*
Percent Change	*0.2%*	*-0.8% (increase)*	*0.6%*

A further breakdown of the Dose-Risk and OECR information is provided in the table below according to release category:

Release Category	**IC1**	**RC1**	**RC1A**	**RC1B**	**RC1AB**	**RC2**	**RC2B**	**RC3**	**RC3B**	**RC4C**	**RC5C**	**Total**
$Frequency_{BASE}$	4.10E-06	2.44E-08	4.71E-10	1.59E-08	1.25E-09	8.43E-10	3.46E-09	2.46E-07	1.57E-07	3.44E-07	5.15E-08	**4.95E-06**
$Frequency_{SAMA}$	4.10E-06	2.44E-08	4.70E-10	1.59E-08	1.25E-09	8.43E-10	3.46E-09	2.45E-07	1.57E-07	3.29E-07	6.18E-08	**4.94E-06**
$Dose\text{-}Risk_{BASE}$	0.04	0.01	0.00	0.03	0.00	0.00	0.01	0.07	0.30	2.57	0.74	**3.79**
$Dose\text{-}Risk_{SAMA}$	0.04	0.01	0.00	0.03	0.00	0.00	0.01	0.07	0.30	2.46	0.89	**3.82**
$OECR_{BASE}$	$0	$1	$0	$29	$2	$7	$27	$15	$679	$4,855	$1,009	**$6,624**
$OECR_{SAMA}$	$0	$1	$0	$29	$2	$7	$27	$15	$677	$4,637	$1,210	**$6,606**

This information was used as input to the cost-benefit calculation. The results of this calculation are provided in the following table:

SAMA 52 Net Value

Base Case Cost-Risk	**Revised Cost-Risk**	**Averted Cost-Risk**	**COI**	**Net Value**
$4,092,000	*$4,097,508*	*-$5,508*	*$5,000,000*	*-$5,005,508*

The SAMA 52 results indicate a very small reduction in CDF and Offsite Economic consequences with a slight increase in dose risk. For this SAMA, the risk reductions based on the availability of the alternate DHR drop line were counterbalanced by the increase in risk related to the introduction of an additional high pressure/low pressure interface. The cost of implementation has been estimated to be $5,000,000, which results in a net value of -5,005,508 (-$5,508 - $5,000,000 = -$5,005,508).

Results Summary

The results of the Phase II quantifications using the external events multiplier of 12 and the point estimate PRA results are summarized in the table below.

Phase II Results Summary
(EE Multiplier of 12, Point Estimate PRA results)

SAMA ID	Cost of Implementation	Averted Cost Risk (EE x 2, PE PRA)	Net Value (EE x 2, PE PRA)	Averted Cost Risk (EE x 12, PE PRA)	Net Value (EE x 12, PE PRA)
34	$50,000	$94,706	$44,706	$568,236	$518,236
33	$50,000	$15,384	-$34,616	$92,304	$42,304
9	$50,000	$16,128	-$33,872	$96,768	$46,768
10	$50,000	$29,502	-$20,498	$177,012	$127,012
38	$50,000	$11,998	-$38,002	$71,988	$21,988
3	$350,000	$23,490	-$326,510	$140,940	-$209,060
6	$400,000	$19,782	-$380,218	$118,692	-$281,308
5	$500,000	$39,040	-$460,960	$234,240	-$265,760
17	$500,000	$27,332	-$472,668	$163,992	-$336,008
11	$250,000	$8,894	-$241,106	$53,364	-$196,636
15	$300,000	$24,684	-$275,316	$148,104	-$151,896
4	$250,000	$30,058	-$219,942	$180,348	-$69,652
35	$700,000	$259,090	-$440,910	$1,554,540	$854,540
51	$100,000	$76,776	-$23,224	$460,656	$360,656
49	$150,000	$89,132	-$60,868	$1,026,444	$876,444
8	$500,000	NA	NA	$357,972	-$142,028
26	$2,000,000	NA	NA	$555,600	-$1,444,400
14	$900,000	NA	NA	$54,528	-$845,472
37	$600,000	NA	NA	$54,084	-$545,916
1	$1,000,000	NA	NA	$341,292	-$658,708
7	$5,000,000	NA	NA	$871,044	-$4,128,956
16	$5,000,000	NA	NA	$262,212	-$4,737,788
18	$8,000,000	NA	NA	$227,052	-$7,772,948
13	$10,000,000	NA	NA	$604,008	-$9,395,992
52	$5,000,000	NA	NA	-$5,508	-$5,005,508

Use of the external events multiplier of 12 in place of the multiplier of 2 results in the reclassification of 7 of the original Phase II SAMAs as cost beneficial (SAMAs 33, 9, 10, 38, 35, 51, and 49). Of the 10 SAMAs that were retained for Phase II analysis based on the transition to the external events multiplier of 12, none were cost beneficial.

In order to assess the impact on the "final" SAMA screenings, the use of the 95th percentile PRA results must be considered. As documented in Section E.7.2 of the ER, the averted point estimate based cost-risk values can be multiplied by 2.18 to account for the impact of the use of the 95th percentile PRA results. The updated net values are summarized in the following table:

Phase II Results Summary
(EE Multiplier of 12, 95th Percentile PRA results)

SAMA ID	Cost of Implementation	Averted Cost Risk (EE x 12, PE PRA)	Net Value (EE x 12, PE PRA)	Averted Cost Risk (EE x 12, 95th Percentile)	Net Value (EE x 12, 95th Percentile)
34	$50,000	$568,236	$518,236	$1,238,754	$1,188,754
33	$50,000	$92,304	$42,304	$201,223	$151,223
9	$50,000	$96,768	$46,768	$210,954	$160,954
10	$50,000	$177,012	$127,012	$385,886	$335,886
38	$50,000	$71,988	$21,988	$156,934	$106,934
3	$350,000	$140,940	-$209,060	$307,249	-$42,751
6	$400,000	$118,692	-$281,308	$258,749	-$141,251
5	$500,000	$234,240	-$265,760	$510,643	$10,643
17	$500,000	$163,992	-$336,008	$357,503	-$142,497
11	$250,000	$53,364	-$196,636	$116,334	-$133,666
15	$300,000	$148,104	-$151,896	$322,867	$22,867
4	$250,000	$180,348	-$69,652	$393,159	$143,159
35	$700,000	$1,554,540	$854,540	$3,388,897	$2,688,897
51	$100,000	$460,656	$360,656	$1,004,230	$904,230
49	$150,000	$1,026,444	$876,444	$2,237,648	$2,087,648
8	$500,000	$357,972	-$142,028	$780,379	$280,379
26	$2,000,000	$555,600	-$1,444,400	$1,211,208	-$788,792
14	$900,000	$54,528	-$845,472	$118,871	-$781,129
37	$600,000	$54,084	-$545,916	$117,903	-$482,097
1	$1,000,000	$341,292	-$658,708	$744,017	-$255,983
7	$5,000,000	$871,044	-$4,128,956	$1,898,876	-$3,101,124
16	$5,000,000	$262,212	-$4,737,788	$571,622	-$4,428,378
18	$8,000,000	$227,052	-$7,772,948	$494,973	-$7,505,027
13	$10,000,000	$604,008	-$9,395,992	$1,316,737	-$8,683,263
52	$5,000,000	-$5,508	-$5,005,508	-$12,007	-$5,012,007

When the external events multiplier of 12 is used in conjunction with the 95th percentile PRA results, 4 additional SAMAs have positive net values (5, 15, 4, and 8). The total number of SAMAs that could be classified as cost beneficial when the external events multiplier of 12 is used in conjunction with the 95th percentile PRA results is 12 (SAMAs 34, 33, 9, 10, 38, 5, 15, 4, 35, 51, 49, and 8). The use of the 95th percentile PRA results is not, however, considered to provide the most realistic assessment of the cost effectiveness of a SAMA.

3.e *Status of three USI A-46 topics:*

1) *Safety Evaluation Report for Unresolved Safety Issue (USI) A-46 Program Implementation at Crystal River Unit 3 (TAC No. M69440), identified two USI A-46 outliers, MTSW-3A, 480V Turbine Auxiliary Bus A, and MTSW-3C, 480V Reactor Auxiliary Bus A. Resolution of these two outliers had been deferred, and they were included in the CR-3 Corrective Action Program. All field work associated with this equipment has been completed, and this action was closed in October 2001.*

2) *The five outliers associated with differences between the caveats in generic implementation procedure (GIP)-2 and those in the plant-specific procedure (PSP) were resolved and the corrective action program action was closed in 2001.*

3) *Abnormal procedure (AP)-961 has been revised and this action was closed in October 2000.*

4. Provide the following information concerning the MACCS2 analyses:

a. Section 2.12.1 of the Environmental Report states that "*Progress Energy plans to increase CR-3's licensed power level and electrical output by approximately 20 percent in an Extended Power Uprate (EPU) scheduled to be carried out during fall 2009 and fall 2011 refueling outages.*" Operation at this higher power level could impact the results of the SAMA evaluation due to the higher fission product inventory and replacement power costs associated with the EPU. Provide a revised SAMA analysis (baseline and uncertainty) assuming operation at the uprated power level.

b. Section E.3.2 states that county growth rates were applied to the year 2000 population to develop the SECPOP2000 population sector distribution.

i. Section E.3.2 does not discuss transient population. Clarify whether transient population was considered in the analysis. If a transient population was not considered, either provide a justification/rationale for not including this or estimate the potential impact on the population dose risk and the SAMA evaluation.

ii. Provide the year 1990 Emergency Planning Zone (EPZ) population used for the evacuation study.

c. The MACCS2 analysis yielded a total population dose risk (PDR) and off-site economic cost risk (OECR) of 3.98 person-rem/year and 6,950 $/year, respectively, as reported in Table E.3-7. However, per Section E.4.6, the Phase I and II SAMA evaluations utilized a PDR and OECR of 3.79 person-rem/year and 6,624 $/year, respectively. Clarify the discrepancy and, if necessary, provide a revised SAMA evaluation.

Response

4.a *The PRA model for CR-3 uprate is still in development and as a result information on the impact of the SAMA analysis due to the power uprate is not available.*

4.b.i *The transient population was not included in the analysis because its effects on the dose and cost risk are inconsequential. This was demonstrated by performing a conservative Level-3 calculation that included transients. Transients were identified at two State Parks within the EPZ, Crystal River Preserve State Park and Crystal River Archeological State Park. Crystal River Preserve State Park is immediately south of the CR-3 site/Crystal River Energy Complex, and lies almost entirely within the EPZ. Crystal River Archeological State Park is a small property completely surrounded by the Crystal River Preserve State Park and is accessed using the same roads. It is completely within the EPZ. The monthly numbers of visitors to the parks for July 2007 to June 2009 were obtained from the Florida DEP Recreation and Parks Management. There were 1708 visitors per day during March 2009, the maximum visitation month during those years. Those 1708 visitors were adjusted to an equivalent year-2036 transient population of 3200 using the same growth rate as the residential population near the parks. It is noted that many of the park visitors would be EPZ residents and are thus double counted in this analysis. Although no other transient population of similar size or larger was identified within the EPZ, the residential population within this zone was increased by 10% to bound the presence of miscellaneous transients. The base case evacuation speed was reduced by 19.4% to reflect the like increase in EPZ population resulting from the assumed transients; this assumes that all evacuation routes would be saturated.*

These conservative assumptions result in an increase in the base case dose-risk and cost-risk of 2.0% and 0.7%. Considering only the documented maximum monthly park visitations, the dose- and cost-risks increase by 1.1% and 0.1% from the base case. These small increases are not of consequence in the SAMA evaluation.

4.b.ii *The 1990 Emergency Planning Zone (EPZ) population is 15,065.*

4.c *The apparent discrepancy may best be explained using the following information that was provided in Section E.2.2.3 of the SAMA report:*

> *Although the same PRA model was used as the model-of-record (MOR2006) for quantification of the proposed Phase 2 SAMAs, the reported base value for CDF (4.95E-6) was slightly different due to the SAMA quantifications being performed at a higher truncation limit of 1E-11 for a more efficient evaluation of multiple PRA model changes. The model-of-record result for CDF (4.99E-6) was performed at a truncation of 1E-12, which would tend to yield a slightly higher value for CDF. Additionally, two different yet valid methods of quantification were used. The model-of-record results were produced using EOOS software and the SAMA quantifications were performed using PRAQUANT software. In using PRAQUANT, each of the core damage accident sequences were individually quantified to retain plant damage states in order to account for all Level 2 release categories. At any event, the important aspect to note is that all SAMA calculations made use of the same method of quantification so that the relative cost difference between proposed SAMAs and the base MMACR value were kept consistent to give an appropriate relative basis for comparison.*

5. Provide the following with regard to the SAMA identification and screening process:

   a. Section E.5.1.7 identifies the 4.16 kV Switchgear Bus Room 3A, along with Battery Charger Room 3A, as being significant contributors to the fire CDF based on the IPEEE (i.e., 17% and 36%, respectively). IPEEE Section 1.4 also identifies 4.16 kV Switchgear Bus Room 3B as having a CDF similar to Room 3A. The uncertainty analysis for SAMA 49, Upgrade Fire Barriers in Battery Charger Room 3A, shows this SAMA to be cost beneficial. Provide justification for why a SAMA(s) for the 4.16 kV Switchgear Bus Rooms 3A and 3B should not be considered and evaluated.

   b. Table E.5-1, Level 1 Importance List Review, identifies SAMA 5 as a mitigation strategy for event QHUFWP7Y, however Section E.6.8 does not identify that event as being mitigated by SAMA 5. Clarify this discrepancy.

   c. Table E.5-1, Level 1 Importance List Review, identifies event HHUMPSBY, OPERATORS FAIL TO START STANDBY MAKEUP PUMP, as having an RRW value of 1.059 and a failure probability of 1.0E+00. It is further stated that a SAMA was not formulated because the current procedures and training are believed to be adequate to start and align the standby makeup pumps. Explain why the failure probability for this event is 1.0E+00 if the procedures and training related to this event are adequate. Provide further justification for why a SAMA that improves procedures and training, or provides for a hardware modification, is not applicable.

   d. Table E.5-1, Level 1 Importance List Review, identifies event APWNR01R, BOTH EDGS FTS, BOTH EFPS FTS, as having an RRW value of 1.044 and a probability of 6.40E-01. This failure denotes the likelihood that AC power will not be recovered in time for specified failures. It was further stated that "*No specific SAMA was identified to change the AC power non-recovery value but a SAMA was identified to provide an additional EDG*". The SAMA identified was SAMA 18 at an estimated cost of more than $5,000,000.

      i. Provide further justification for why a SAMA to enhance procedures and training is not considered.

      ii. Provide an evaluation of the costs and benefits of providing AC power from one of the other Crystal River power plants (Crystal River 1 and 2).

   e. Table E.5-1, Level 1 Importance List Review, identifies event HHUMBACY, OPERATOR FAILS TO SWITCH MUP-1B POWER SOURCE, as having an RRW value of 1.027 and a probability of 1.0E+00. This event is described as failure to locally swap power supply to the "swing" pump. Proposed SAMA 15 is described as providing remote control room capability to realign power to pump MUP-1B. The cost of this SAMA was estimated to be $400,000 and was determined not to be cost beneficial. Provide an evaluation of the costs and benefits of developing local manual swap-over procedures and training (or enhancing procedures and training if they exist) in lieu of SAMA 15.

   f. Table E.5-1 identifies several initiating events for which no SAMA was identified to reduce probability, but for which "basic events relating to mitigation are addressed separately." Identify the basic events and associated SAMAs that mitigate these initiating events, including: IE_S (small break LOCA), IE_R (steam generator tube rupture), IE_T11 (loss of intake), IE_T3 (loss of offsite power), IE_T1 (reactor trip), IE_T8 (loss of 4160V ES Bus 3A), IE_A (large break LOCA), IE_T16 (loss of makeup), IE_T2 (loss of main feedwater), and IE_T10 (loss of NSCCC).

g. Section E.5.1 states that industry Phase II SAMAs were reviewed for potential applicability to CR-3, but does not identify the specific nuclear plants reviewed. Section E.11 references the SAMA analyses for Calvert Cliffs, Robinson, and Brunswick nuclear power plants. Clarify if these were the plants for which the industry Phase II SAMA review was performed, and if there were other plants included in the review. Also clarify whether any of the Phase I SAMAs were identified as a result of the CR-3 review of these other SAMA analyses.

h. Section 4.20 states that approximately 25 Phase I SAMAs were identified for consideration in the SAMA analysis. Table E.5-3 lists and describes each of these Phase I SAMAs. The SAMA numbers for these SAMAs range from 1 to 52, are not consecutive, and do not correspond to the SAMA ID Numbers for the industry SAMAs identified in Addendum 1. This suggests that a pre-screening of the identified SAMAs occurred prior to the Phase I screening. Clarify the process used to develop the Phase I SAMAs. Furthermore, on p. E.7-3 it is stated that the Phase I screening process involved qualitative disposition of 9 SAMAs. Based on review of Table E.5-3 and the discussion in Section E.5.2, it appears that: (1) the Phase I screening was quantitative rather the qualitative, and (2) 10 SAMAs were screened out versus 9. Clarify the Phase I screening process.

Response

5.a *As documented in E.7.2.3 of the ER, SAMA 49 was only cost beneficial when the 95th percentile PRA results were considered. The corresponding averted cost-risk was determined to be $194,594, which was $44,594 greater than the estimated implementation cost of $150,000. SAMAs for 4160V ES Switchgear Bus Rooms 3A and 3B were not considered in the ER given that they would clearly not have been cost beneficial based on the external events contributions that were assumed in the ER. For example, the 4160V ES Switchgear Bus Room 3A CDF (7.31E-06/yr) is only 49 percent of the Battery Charger Room 3A CDF (1.49E-05/yr), which would correlate to an averted cost-risk of $95,469 given that the averted cost-risk scales linearly with CDF for the external events SAMAs.*

If a larger external events contribution is assumed (as suggested in RAI question 3c), then the fire scenarios could no longer be considered "low contributors" and it would not necessarily be possible to preclude the SAMAs for the 4160V ES Switchgear Bus Rooms from consideration. However, the results of the IPEEE are based on very limited credit for the existing Thermo-Lag fire barriers. The credit taken for Thermo-Lag is key to determining whether or not a SAMA to improve the fire barriers would be effective. If credit is taken for the existing Thermo-Lag barriers, a SAMA to improve the fire barriers would have very little impact on the CDF.

The benefit of the fire barriers in the 4160V ES Switchgear Bus Rooms, whether they are Thermo-Lag or "improved" fire barriers, would be to prevent damage to the cables from the opposite division that are routed through the room. A fire in one of the switchgear rooms will result in the loss of one division of power, so improvements to the *fire barriers for cables within the division of the initiating fire would have limited effectiveness, but protecting cables from the opposite division could have a large impact on risk. For cases in which fire suppression fails, the cross-division cables would be failed regardless of the fire barriers used; however, when fire suppression is successful, the fire barriers are an effective means of preventing damage. For the CR-3 IPEEE, the dominant contributors are cases in which fire suppression was successful because such limited credit was taken for Thermo-Lag (a high probability of cable damage is combined with the high probability of suppression system success). Current fire modeling techniques would credit Thermo-Lag for preventing cable damage in these scenarios and indicate that the risk from cross-divisional cable damage is overstated in the IPEEE.*

Fire barrier improvements in the 4160V ES Switchgear Bus Rooms could be suggested as SAMAs and they could be shown to be cost effective using the external events multiplier of 12 and the IPEEE Thermo-Lag assumptions; however, the IPEEE is not considered to be the most appropriate tool for such an evaluation. CR-3 is currently updating the plant's fire model and the insights from the model will be used to identify areas for potential improvements, which may include the fire barriers in the 4160V ES Switchgear Bus Rooms.

5.b *See response to RAI 6.d.*

5.c *HHUMPSBY is assigned a value of 1.0E+00 in the cutset file after the HRA recovery rule file has evaluated the dependency with other operator actions and assigned the recovery factor. The actual HRA values assigned to HHUMPSBY is given in the table below based upon various situations.*

HHUMPSBY	*OPERATORS FAIL TO START NON-ES SELECTED MAKEUP PUMP*	*5e-1*
HHUMPSBY (T)	*OPERATORS FAIL TO START NON-ES SELECTED MAKEUP PUMP (TRANSIENTS)*	*8.6e-3*

In general, SAMAs to "improve procedures and training" are not useful unless a specific problem with the procedures/training has been identified.

The CR-3 operators are already trained on the use of the makeup (HPI) pumps and no procedure deficiencies have been identified. The relatively high failure probability for the non-transient version of the action is based on the limited time that is available to perform the pump start and is not a function of the quality of the plant procedures and training programs.

For the transient version of the action, the HRA documentation identifies that explicit guidance is not provided to start the non-ES selected makeup pump, but that the EOPs direct the operators to ensure that at least one train of HPI is running. Starting the standby pump would satisfy the EOP requirement to ensure one train of HPI is running; therefore, the HEP meets the requirements of the EOPs.

In conclusion, enhancing the plant procedures and/or training program would have a negligible impact on the HEPs for starting the standby makeup pump.

5.d.i *Procedure changes are low cost SAMAs that can be an effective means of reducing risk; however, a procedure change (or improved training) must target a specific weakness in order for it to impact the plant. No such weaknesses have been identified in the power restoration procedures at CR-3. In addition, even if changes were made to the training program or procedures to address a specific issue, the power recovery probability used in the PRA is data based and the improvements would not be reflected in the PRA model. Consequently, there would be no measurable benefit related to any potential improvements related to procedure/training enhancements.*

5.d.ii *The other Crystal River power plants, Units 1, 2, 4, and 5, already provide power to the CR-3 switchyard. In order to gain any additional benefit from these plants, a dedicated line would have to be laid in conjunction with the installation of a new transformer. New connections to the CR-3 emergency buses would also have to be added. Because the loss of offsite power events that would require the use of the dedicated line would likely be caused by a weather related event, the dedicated line would have to be buried to ensure power would be available in such an event.*

The Calvert Cliffs SAMA analysis estimated the cost of installing a connection to an alternate offsite power source to be significantly greater than $25,000,000. An alternate SAMA in the Calvert Cliffs analysis estimated that the cost of burying the offsite power lines would also be significantly greater than $25,000,000. While the Calvert Cliffs SAMA analysis does not specify the length of the new transmission line that was the basis for the $25,000,000 implementation cost, the CR-3 configuration has been reviewed and the Calvert Cliffs implementation cost is not unreasonable for CR-3. The major factors considered in the CR-3 design include:

- *The addition of one or more transformers to reduce the voltage of the offsite source to 4kV AC,*
- *There are plans to decommission Units 1 and 2, implying that the dedicated line would have to be run from either Unit 4 or 5,*
  - *Units 4 and 5 are farther from Unit 3 than Units 1 and 2,*
  - *A significant amount of asphalt and concrete exist where the buried line would be installed, which complicates cable burial.*
- *None of the other Crystal River units are black start units, which means that additional steps would have to be taken to ensure that the dedicated line would be available when it was required.*

With regard to the potential benefit of implementing this SAMA, it would be essentially the same as installing an additional EDG (SAMA 18). The response to RAI 3.d documents that the averted cost-risk for SAMA 18 is only $494,973 even when an external events multiplier of 12 is used in conjunction with the 95th percentile PRA results. Even if the cost of installing the buried, dedicated line from Crystal River Unit 4 (or 5) was assumed to be half of the Calvert Cliffs estimate, the net value would be highly negative:

$494,973 - $12,500,000 = -$12,005,027

This type of change would not be cost beneficial for CR-3.

5.e *During the quantification process, the non independent HRA events are assigned a value of 1.0. The recovery factor that is added to the cutset is based upon which HRA events appear and their dependency upon each other. The MOR06 value for HHUMBACY is 2.8E-1.*

In general, SAMAs to "improve procedures and training" are not useful unless a specific problem with the procedures/training has been identified.

The CR-3 operators are already trained on the action to align the alternate power source to MUP-1B and no procedure deficiencies have been identified. The high failure probability for the action is based on the long manipulation time relative to the time available rather than the quality of the plant procedures and training programs. Enhancements to the procedures and training program would have a negligible impact on the HEP and as suggested in SAMA 15, the most effective means of reducing the HHUMBACY HEP would be to simplify the alignment process through physical changes.

5.f *In order to document the correlation between the initiating events identified in this RAI to the basic events that were included in Table E.5-1 of the ER, a new table (Table RAI-5.f) has been created. This table maps each of these initiating events to the basic events included in Table E.5-1.*

The mapping process was performed by isolating the cutsets relevant to each of the identified initiating events and extracting all of the associated basic events with RRW values greater than 1.02. In all cases, the basic events that were identified had already been dispositioned in Table E.5-1 of the ER. Table RAI-5.f provides a list of these basic events, grouped by initiating event, and the original ER text related to the event disposition.

Table RAI-5.f: Correlation of Basic Events to Initiating Events				
Initiator	**Associated Basic Event**	**RRW**	**Description**	**SAMA Disposition**
IE_S	RHUPORVY	1.09	OPERATORS FAILS TO OPEN PORV FOR PRESSURE RELIEF	Important action for LOOP, LOFW, etc. Related SAMA identified to auto open PORV: SAMA 35
IE_S	HHUHPRCY	1.07	OPERATORS FAIL TO SWITCH FROM HIGH PRESSURE INJECTION TO RECIRCULATION	Operator action to switch to recirculation. Related SAMA has been identified to automate switchover: SAMA 3.
IE_S	SPMRW3BM	1.06	RWP-3B IN MAINTENANCE	Unavailability / failure of raw water pump. A SAMA has been identified to supply water to the system from an alternate source: SAMA 8.
IE_S	LPM001BM	1.04	DHP-1B TRAIN IN MAINTENANCE	This is a basic event representing a decay heat removal pump being out of service for testing and maintenance. A SAMA was proposed to provide a diverse or maintenance spare train: SAMA 13.
IE_S	LPM001AM	1.04	DHP-1A TRAIN IN MAINTENANCE	This is a basic event representing a decay heat removal pump train being failed or out of service. Proposed SAMA: provide a redundant/ diverse spare or a maintenance spare DH train: SAMA 13.
IE_S	LMMDHPBF	1.04	FAILURE OF DHP-1B AND ITS VALVES	This is a basic event representing a decay heat removal pump train being failed or out of service. Proposed SAMA: provide a redundant/ diverse spare or maintenance spare DH train, which could also be substituted for a failed train: SAMA 13.
IE_S	LMMDHPAF	1.04	FAILURE OF DHP-1A AND ITS VALVES	This is a basic event representing a decay heat removal pump train being failed or out of service. Proposed SAMA: add an additional DH train: SAMA 13.
IE_S	LMMDV43F	1.04	FAILURE OF TRAIN B RECIRC VALVE DHV-43	Basic event representing inability to open sump valve for recirculation. Proposed SAMAs: proceduralize either manual operation of the valve or crosstying of LHI suction: SAMA 16, 33.
IE_S	LMMDV12F	1.03	TRAIN B RECIRC VALVE DHV-12 FAILS	Basic event represents inability to open valve to supply HHSI/ MUP from LHI. Proposed SAMA: proceduralize either manual operation of the valve or crosstying of MUP suction: SAMA 9, 16
IE_S	LMMDV42F	1.03	FAILURE OF TRAIN A RECIRC VALVE DHV-42	Basic event representing inability to open sump valve for recirculation. Proposed SAMA: proceduralize either manual operation of the valve or crosstying of LHI suction: SAMA 16, 33.
IE_S	LMMDV11F	1.03	TRAIN A RECIRC VALVE DHV-11 FAILS	Basic event represents inability to open valve to supply HHSI/ MUP from LHI. Proposed SAMA: proceduralize either manual operation of the valve or crosstying of MUP suction: SAMA 9, 16.
IE_S	SPMRW3AM	1.03	RWP-3A IN MAINTENANCE	Unavailability / failure of raw water pump. A SAMA has been identified to supply water to the system from an alternate source: SAMA 8.

Table RAI-5.f: Correlation of Basic Events to Initiating Events				
Initiator	**Associated Basic Event**	**RRW**	**Description**	**SAMA Disposition**
IE_S	QHUEFW9Y	1.03	OPERATORS FAIL TO RAISE OTSGs LEVEL	This is an operator action required to ensure adequate “boiler-condenser” mode cooling during small LOCAs. Suggested SAMA: automate level control setpoint change: SAMA 14
IE_S	ZHUCOM1Z	1.03	COND PROB OF RHUPORVY GIVEN QHUEFW9Y	This is a conditional operator error probability, the likelihood that operators will fail to open a PORV given that they failed to raise OTSG level. A SAMA has been identified to automate the change in OTSG level setpoint. Automating that action would allow greater focus on the second action. No further SAMA is suggested.
IE_S	SMMDHCCB	1.03	DHCCC TRAIN B FAULTS	Module containing various decay heat closed cooling system failures. Proposed SAMA: proceduralize crosstying of DHCC trains: SAMA 16.
IE_S	SMMRW3BF	1.03	RWP-3B PUMP TRAIN FAILS TO OPERATE	Unavailability / failure of raw water pump. A SAMA has been identified to supply water to the system from an alternate source: SAMA 8.
IE_R	FLG_X	1.79	TAG EVENT - LONG TERM COOLING (HPR/LPR/REFILL)	This is not a basic event, but a tag identifying sequences involving recirc/ refill. Basic events for those sequences are addressed separately.
IE_R	RHUPORVY	1.09	OPERATORS FAILS TO OPEN PORV FOR PRESSURE RELIEF	Important action for LOOP, LOFW, etc. Related SAMA identified to auto open PORV: SAMA 35
IE_R	QMMEFP3F	1.07	EFP-3 PUMP TRAIN FAILS TO RUN	Basic event for EFW pump FTR. SAMA related to EFW / AFW has been identified, to provide an independent train: SAMA 7.
IE_R	QHUFWP7Y	1.06	OPERATORS FAIL TO START FWP-7	Oper. action to start AFW pump FWP-7. SAMAs related to EFW/AFW have been identified, to provide autostart of FWP-7, and to provide an additional train of AFW/ EFW: SAMAs 5, 7.
IE_R	RHUCOOLY	1.06	OPERATORS FAIL COOLDOWN VIA OTSG	Operator action to cool down on SGTR. Some actions can be improved by improving procedures and training, however the CR-3 procedures and training are believed to be adequate.
IE_R	ZHUCOM2Z	1.05	COND PROB OF RHUPORVY GIVEN RHUCOOLY	This is the conditional probability of failure to open a PORV given failure to initiate cooldown. No SAMA was identified to reduce the likelihood of failure at one action presuming that operators failed to take another action.
IE_R	QMMEFP2F	1.04	EFP-2 FAILS TO CONTINUE TO RUN	A SAMA has been idenftifed related to AFW / EFW, to provide an additional train: SAMA 7.
IE_R	SPLT_RA	1.04	SGTR OCCURS ON OTSG-A <SPLIT FRACTION>	Split fraction, no SAMA required.
IE_R	SPLT_RB	1.04	SGTR OCCURS ON OTGS-B <SPLIT FRACTION>	Split fraction, no SAMA required.

Table RAI-5.f: Correlation of Basic Events to Initiating Events				
Initiator	**Associated Basic Event**	**RRW**	**Description**	**SAMA Disposition**
IE_R	SPLT_RA	1.04	SGTR OCCURS ON OTSG-A <SPLIT FRACTION>	Split fraction, no SAMA required.
IE_R	PMMICSAH	1.03	OTSG A LEVEL CONTROL FAULTS	This module contains basic event failures which could lead to OTSG overfeed. Proposed SAMA: add redundant /diverse level controls: SAMA 17.
IE_R	PMMICSBH	1.03	OTSG B LEVEL CONTROL FAULTS	This module contains basic event failures which could lead to OTSG overfeed. Proposed SAMA: add redundant /diverse level controls: SAMA 17.
IE_R	HCCMV44N	1.03	COMMON CAUSE FAILURE OF MUV-23, MUV-24, MUV-25, AND MUV-26 TO OPEN	Common-cause failure of makeup valves. Proposed SAMA: Proceduralize manual operation of these valves, which would address most modes of common-cause failure: SAMA 10.
IE_R	PMMICSCC	1.02	ICS COMMON MODE FAULTS	This module contains basic event failures which could lead to OTSG overfeed. Proposed SAMA: provide redundant /diverse level controls (SAMA 17).
IE_T11	FLG_HVAC	1.37	HVAC REQUIRED DUE TO AVAILABILITY OF AC POWER	This is not a basic event but a tag identifying sequences where HVAC is required, primarily to provide cooling for EFW controls. Basic events for those sequences are addressed separately.
IE_T11	FLG_QHUEFWMR	1.33	OPERATORS FAIL TO MANUALLY OPEN CONTROL VALVE	This is not a basic event but a tag identifying sequences where HVAC is failed, control systems are potentially failed, and operator actions to manually operate valves might be helpful. Events for those sequences are addressed separately, however a SAMA is proposed to provide procedures and training for manual operation of the affected valves (EFV-55, -56, -57, -58): SAMA 34
IE_T11	QSPLHVAC	1.33	SPLIT FRACTION - VALVES FAIL CLOSED ON LOSS OF HVAC	This is not a basic event but a split fraction. Related basic events are addressed separately.
IE_T11	FLG_SW	1.24	TAG EVENT - LOSS OF NORMAL SW	This is not a basic event, but a tag identifying sequences involving loss of service water. Basic events for those sequences are addressed separately.
IE_T11	JHUCHP2R	1.14	OPERATORS FAIL TO USE DEDICATED CHILLED WATER SYSTEM	Operator action related to importance of HVAC / cooling to EFW / EFIC. Related SAMAs have been identified to provide automated replacement of some of the functions, to manually perform some of the functions potentially lost (operate EFV-55, ...-58), or to provide a substitute for the potentially affected AFW/ EFW equipment: SAMAs 1, 26, 34.

Table RAI-5.f: Correlation of Basic Events to Initiating Events				
Initiator	Associated Basic Event	RRW	Description	SAMA Disposition
IE_T11	QHUFW7EY	1.12	OPERATORS FAIL TO START FWP-7 BEFORE PORV LIFTS	Operator action to manually align FWP-7 AFW pump. Related SAMAs have been identified to provide autostart of FWP-7 as well as to install an alternative AFW/ EFW train with automatic start: SAMAs 4, 7.
IE_T11	QPMFWP7M	1.11	FWP-7 IN MAINTENANCE	AFW Pump FWP-7, related SAMA has been identified to provide an alternate AFW/EVW train. Also a SAMA has been identified to reduce maintenance downtime for FWP-7: SAMAs 5, 7.
IE_T11	JHUCHP2Z	1.11	JHUCHP2R	Sequence-specific substitution for JHUCHP2R. See discussion related to that action.
IE_T11	QMMEFP3F	1.07	EFP-3 PUMP TRAIN FAILS TO RUN	Basic event for EFW pump FTR. SAMA related to EFW / AFW has been identified, to provide an independent train: SAMA 7.
IE_T11	RMMRCVSC	1.07	SAFETY RELIEF VALVE FAILS TO CLOSE (STEAM RELIEF)	SRV FTC. No SAMA directly related to this event was identified however SAMAs related to mitigating systems have been identified.
IE_T11	QHUFWP7Y	1.06	OPERATORS FAIL TO START FWP-7	Oper action to start AFW pump FWP-7. SAMAs related to EFW/AFW have been identified, to provide autostart of FWP-7 and to provide an additional train of AFW/ EFW: SAMAs 5, 7.
IE_T11	FLG_TBQR	1.05	TAG EVENT - STUCK OPEN RELIEF AFTER B	This is a tag event intended to identify sequences involving a stuck-open relief valve. The basic events related to those sequences are evaluated separately.
IE_T11	QMMEFP2F	1.04	EFP-2 FAILS TO CONTINUE TO RUN	A SAMA has been identified related to AFW / EFW, to provide an additional train: SAMA 7.
IE_T11	QMMCST	1.03	FAILURE OF CST WATER SUPPLY	Module representing various CST failure modes. Proposed SAMA: proceduralize use of alternate water sources in event of CST failure: SAMA 38.
IE_T3	FLG_HVAC	1.37	HVAC REQUIRED DUE TO AVAILABILITY OF AC POWER	This is not a basic event but a tag identifying sequences where HVAC is required, primarily to provide cooling for EFW controls. Basic events for those sequences are addressed separately.
IE_T3	FLG_QHUEFWMR	1.33	OPERATORS FAIL TO MANUALLY OPEN CONTROL VALVE	This is not a basic event but a tag identifying sequences where HVAC is failed, control systems are potentially failed, and operator actions to manually operate valves might be helpful. Events for those sequences are addressed separately, however a SAMA is proposed to provide procedures and training for manual operation of the affected valves (EFV-55, -56, -57, -58): SAMA 34
IE_T3	QSPLHVAC	1.33	SPLIT FRACTION - VALVES FAIL CLOSED ON LOSS OF HVAC	This is not a basic event but a split fraction. Related basic events are addressed separately.

Table RAI-5.f: Correlation of Basic Events to Initiating Events				
Initiator	**Associated Basic Event**	**RRW**	**Description**	**SAMA Disposition**
IE_T3	FLG_SW	1.24	TAG EVENT - LOSS OF NORMAL SW	This is not a basic event, but a tag identifying sequences involving loss of service water. Basic events for those sequences are addressed separately.
IE_T3	JHUCHP2R	1.14	OPERATORS FAIL TO USE DEDICATED CHILLED WATER SYSTEM	Operator action related to importance of HVAC / cooling to EFW / EFIC. Related SAMAs have been identified to provide automated replacement of some of the functions, to manually perform some of the functions potentially lost (operate EFV-55, ...-58), or to provide a substitute for the potentially affected AFW/ EFW equipment: SAMAs 1, 26, 34.
IE_T3	QMMEFP3F	1.07	EFP-3 PUMP TRAIN FAILS TO RUN	Basic event for EFW pump FTR. SAMA related to EFW / AFW has been identified, to provide an independent train: SAMA 7.
IE_T3	HHUMPSBY	1.06	OPERATOR FAILS TO START STANDBY MAKEUP PUMP	Operator action to start / align standby makeup pump. Some actions can be improved by improving procedures and training, however the CR-3 procedures and training are believed to be adequate.
IE_T3	APWNR01R	1.04	BOTH EDGS FTS, BOTH EFPS FTS	This is a calculated value denoting the likelihood that AC power will not be recovered in time for the specified failures. No specific SAMA was identified to change the AC power nonrecovery value but a SAMA was identified to provide an additional EDG: SAMA 18.
IE_T3	HHUINJAY	1.04	OPERATORS FAIL TO SWITCH MUV-23/24 TO BACKUP POWER	Operator action to supply backup power to high head injection valves. A SAMA was identified to proceduralize manual alignment: SAMA 10.
IE_T3	ADGES3BM	1.02	EGDG-1B IN MAINTENANCE	Proposed SAMA: add another EDG (SAMA 18).
IE_T3	ADGEG1CF	1.02	EGDG-1C FAILS TO RUN	Proposed SAMA: add another EDG (SAMA 18).
IE_T3	HHUINJBY	1.02	OPERATORS FAIL TO SWITCH MUV-25/26 TO BACKUP POWER	Proposed SAMA, proceduralize manual operation of these valves (SAMA 10).
IE_T3	AHUEG1CY	1.02	OPERATORS FAIL TO START AND ALIGN EGDG-1C	Proposed SAMA: add another EDG (SAMA 18).
IE_T1	FLG_X	1.79	TAG EVENT - LONG TERM COOLING (HPR/LPR/REFILL)	This is not a basic event, but a tag identifying sequences involving recirc/ refill. Basic events for those sequences are addressed separately.
IE_T1	FLG_HVAC	1.37	HVAC REQUIRED DUE TO AVAILABILITY OF AC POWER	This is not a basic event but a tag identifying sequences where HVAC is required, primiarily to provide cooling for EFW controls. Basic events for those sequences are addressed separately.

Table RAI-5.f: Correlation of Basic Events to Initiating Events				
Initiator	**Associated Basic Event**	**RRW**	**Description**	**SAMA Disposition**
IE_T1	FLG_QHUEFWMR	1.33	OPERATORS FAIL TO MANUALLY OPEN CONTROL VALVE	This is not a basic event but a tag identifying sequences where HVAC is failed, control systems are potentially failed, and operator actions to manually operate valves might be helpful. Events for those sequences are addressed separately, however a SAMA is proposed to provide procedures and training for manual operation of the affected valves (EFV-55, -56, -57, -58): SAMA 34
IE_T1	QSPLHVAC	1.33	SPLIT FRACTION - VALVES FAIL CLOSED ON LOSS OF HVAC	This is not a basic event but a split fraction. Related basic events are addressed separately.
IE_T1	FLG_SW	1.24	TAG EVENT - LOSS OF NORMAL SW	This is not a basic event, but a tag identifying sequences involving loss of service water. Basic events for those sequences are addressed separately.
IE_T1	JHUCHP2R	1.14	OPERATORS FAIL TO USE DEDICATED CHILLED WATER SYSTEM	Operator action related to importance of HVAC / cooling to EFW / EFIC. Related SAMAs have been identified to provide automated replacement of some of the functions, to manually perform some of the functions potentially lost (operate EFV-55, ...-58), or to provide a substitute for the potentially affected AFW/ EFW equipment: SAMAs 1, 26, 34.
IE_T1	QHUFW7EY	1.12	OPERATORS FAIL TO START FWP-7 BEFORE PORV LIFTS	Operator action to manually align FWP-7 AFW pump. Related SAMAs have been identified to provide autostart of FWP-7 as well as to install an alternative AFW/ EFW train with automatic start: SAMAs 4, 7.
IE_T1	QPMFWP7M	1.11	FWP-7 IN MAINTENANCE	AFW Pump FWP-7, related SAMA has been identified to provide an alternate AFW/EVW train. Also a SAMA has been identified to reduce maintenance downtime for FWP-7: SAMAs 5, 7.
IE_T1	JHUCHP2Z	1.11	JHUCHP2R	Sequence-specific substitution for JHUCHP2R. See discussion related to that action.
IE_T1	QMMEFP3F	1.07	EFP-3 PUMP TRAIN FAILS TO RUN	Basic event for EFW pump FTR. SAMA related to EFW / AFW has been identified, to provide an independent train: SAMA 7.
IE_T1	HHUHPRCY	1.07	OPERATORS FAIL TO SWITCH FROM HIGH PRESSURE INJECTION TO RECIRCULATION	Operator action to switch to recirculation. Related SAMA has been identified to automate switchover: SAMA 3.
IE_T1	RMMRCVSC	1.07	SAFETY RELIEF VALVE FAILS TO CLOSE (STEAM RELIEF)	SRV FTC. No SAMA directly related to this event was identified however SAMAs related to mitigating systems have been identified.
IE_T1	QHUFWP7Y	1.06	OPERATORS FAIL TO START FWP-7	Oper action to start AFW pump FWP-7. SAMAs related to EFW/AFW have been identified, to provide autostart of FWP-7 and to provide an additional train of AFW/ EFW: SAMAs 5, 7.

Table RAI-5.f: Correlation of Basic Events to Initiating Events				
Initiator	**Associated Basic Event**	**RRW**	**Description**	**SAMA Disposition**
IE_T1	HHUMPSBY	1.06	OPERATOR FAILS TO START STANDBY MAKEUP PUMP	Operator action to start / align standby makeup pump. Some actions can be improved by improving procedures and training, however the CR-3 procedures and training are believed to be adequate.
IE_T1	SPMRW3BM	1.06	RWP-3B IN MAINTENANCE	Unavailability / failure of raw water pump. A SAMA has been identiifed to supply water to the system from an alternate source: SAMA 8.
IE_T1	FLG_TBQR	1.05	TAG EVENT - STUCK OPEN RELIEF AFTER B	This is a tag event intended to idenfiy sequences involving a stuck-open relief valve. The basic events related to those sequences are evaluated separately.
IE_T1	QMMEFP2F	1.04	EFP-2 FAILS TO CONTINUE TO RUN	A SAMA has been idenftifed related to AFW / EFW, to provide an additional train: SAMA 7.
IE_T1	SCCHDABF	1.04	COMMON CAUSE FAILURE OF HXs DCHE-1A AND DCHE-1B PLUGGED	Proposed SAMA, add removable strainers ahead of heat exchangers: SAMA 37.
IE_T1	FLG_PHURMFWR	1.03	OPERATORS FAIL TO RECOVER MFW	This is a flag event. Related basic events are considered separately.
IE_T1	RCCDRODA	1.03	MECH FAILURE OF ENOUGH CONTROL RODS TO DROP	Part of ATWS initiating event logic. No relevant SAMA identified.
IE_T1	QHUEFT2Y	1.03	OPERATORS FAIL TO CROSSTIE EFW SOURCES	SAMAs have been identified to provide additional makeup / suction supplies to AFW and EFW: SAMAS 7, 38.
IE_T1	PMMICSAH	1.03	OTSG A LEVEL CONTROL FAULTS	This module contains basic event failures which could lead to OTSG overfeed. Proposed SAMA: add redundant /diverse level controls: SAMA 17.
IE_T1	PMMICSBH	1.03	OTSG B LEVEL CONTROL FAULTS	This module contains basic event failures which could lead to OTSG overfeed. Proposed SAMA: add redundant /diverse level controls: SAMA 17.
IE_T1	ADGES3BM	1.02	EGDG-1B IN MAINTENANCE	Proposed SAMA: add another EDG (SAMA 18).
IE_T1	HHUINJBY	1.02	OPERATORS FAIL TO SWITCH MUV-25/26 TO BACKUP POWER	Proposed SAMA, proceduralize manual operation of these valves (SAMA 10).
IE_T1	MTC	1.02	MTC GREATER THAN 95%	Essentially a split fraction identifying the fraction of the time the moderator temperature coefficient is too high to sufficiently limit an ATWS event. No SAMA identified.
IE_T1	PMMICSCC	1.02	ICS COMMON MODE FAULTS	This module contains basic event failures which could lead to OTSG overfeed. Proposed SAMA: provide redundant /diverse level controls (SAMA 17).
IE_T1	AHUEG1CY	1.02	OPERATORS FAIL TO START AND ALIGN EGDG-1C	Proposed SAMA: add another EDG (SAMA 18).

Table RAI-5.f: Correlation of Basic Events to Initiating Events				
Initiator	**Associated Basic Event**	**RRW**	**Description**	**SAMA Disposition**
IE_T8	FLG_X	1.79	TAG EVENT - LONG TERM COOLING (HPR/LPR/REFILL)	This is not a basic event, but a tag identifying sequences involving recirc/ refill. Basic events for those sequences are addressed separately.
IE_T8	FLG_HVAC	1.37	HVAC REQUIRED DUE TO AVAILABILITY OF AC POWER	This is not a basic event but a tag identifying sequences where HVAC is required, primiarily to provide cooling for EFW controls. Basic events for those sequences are addressed separately.
IE_T8	FLG_HVAC	1.37	HVAC REQUIRED DUE TO AVAILABILITY OF AC POWER	This is not a basic event but a tag identifying sequences where HVAC is required, primiarily to provide cooling for EFW controls. Basic events for those sequences are addressed separately.
IE_T8	FLG_QHUEFWMR	1.33	OPERATORS FAIL TO MANUALLY OPEN CONTROL VALVE	This is not a basic event but a tag identifying sequences where HVAC is failed, control systems are potentially failed, and operator actions to manually operate valves might be helpful. Events for those sequences are addressed separately, however a SAMA is proposed to provide procedures and training for manual operation of the affected valves (EFV-55, -56, -57, -58): SAMA 34
IE_T8	QSPLHVAC	1.33	SPLIT FRACTION - VALVES FAIL CLOSED ON LOSS OF HVAC	This is not a basic event but a split fraction. Related basic events are addressed separately.
IE_T8	JHUCHP2R	1.14	OPERATORS FAIL TO USE DEDICATED CHILLED WATER SYSTEM	Operator action related to importance of HVAC / cooling to EFW / EFIC. Related SAMAs have been identified to provide automated replacement of some of the functions, to manually perform some of the functions potentially lost (operate EFV-55, ...-58), or to provide a substitute for the potentially affected AFW/ EFW equipment: SAMAs 1, 26, 34.
IE_T8	QHUFW7EY	1.12	OPERATORS FAIL TO START FWP-7 BEFORE PORV LIFTS	Operator action to manually align FWP-7 AFW pump. Related SAMAs have been identified to provide autostart of FWP-7 as well as to install an alternative AFW/ EFW train with automatic start: SAMAs 4, 7.
IE_T8	QPMFWP7M	1.11	FWP-7 IN MAINTENANCE	AFW Pump FWP-7, related SAMA has been identified to provide an alternate AFW/EVW train. Also a SAMA has been identified to reduce maintenance downtime for FWP-7: SAMAs 5, 7.
IE_T8	JHUCHP2Z	1.11	JHUCHP2R	Sequence-specific substitution for JHUCHP2R. See discussion related to that action.
IE_T8	QMMEFP3F	1.07	EFP-3 PUMP TRAIN FAILS TO RUN	Basic event for EFW pump FTR. SAMA related to EFW / AFW has been identified, to provide an independent train: SAMA 7.
IE_T8	RMMRCVSC	1.07	SAFETY RELIEF VALVE FAILS TO CLOSE (STEAM RELIEF)	SRV FTC. No SAMA directly related to this event was identified however SAMAs related to mitigating systems have been identified.

Table RAI-5.f: Correlation of Basic Events to Initiating Events				
Initiator	**Associated Basic Event**	**RRW**	**Description**	**SAMA Disposition**
IE_T8	QHUFWP7Y	1.06	OPERATORS FAIL TO START FWP-7	Oper action to start AFW pump FWP-7. SAMAs related to EFW/AFW have been identified, to provide autostart of FWP-7 and to provide an additional train of AFW/ EFW: SAMAs 5, 7.
IE_T8	SPMRW3BM	1.06	RWP-3B IN MAINTENANCE	Unavailability / failure of raw water pump. A SAMA has been identiifed to supply water to the system from an alternate source: SAMA 8.
IE_T8	FLG_TBQR	1.05	TAG EVENT - STUCK OPEN RELIEF AFTER B	This is a tag event intended to idenfiy sequences involving a stuck-open relief valve. The basic events related to those sequences are evaluated separately.
IE_T8	QMMEFP2F	1.04	EFP-2 FAILS TO CONTINUE TO RUN	A SAMA has been idenftifed related to AFW / EFW, to provide an additional train: SAMA 7.
IE_T8	LPM001BM	1.04	DHP-1B TRAIN IN MAINTENANCE	This is a basic event representing a decay heat removal pump being out of service for testing and maintenance. A SAMA was proposed to provide a diverse or maintenance spare train: SAMA 13.
IE_T8	HHUINJAY	1.04	OPERATORS FAIL TO SWITCH MUV-23/24 TO BACKUP POWER	Operator action to supply backup power to high head injection valves. A SAMA was identified to proceduralize manual alignment: SAMA 10.
IE_T8	QMMCST	1.03	FAILURE OF CST WATER SUPPLY	Module representing various CST failure modes. Proposed SAMA: proceduralize use of alternate water sources in event of CST failure: SAMA 38.
IE_T8	FLG_PHURMFWR	1.03	OPERATORS FAIL TO RECOVER MFW	This is a flag event. Related basic events are considered separately.
IE_T8	RCCDRODA	1.03	MECH FAILURE OF ENOUGH CONTROL RODS TO DROP	Part of ATWS initiating event logic. No relevant SAMA identified.
IE_T8	HHUMBACY	1.03	OPERATORS FAIL TO SWITCH MUP-1B POWER SOURCE IN	Failure to locally swap power supply to "swing" pump. Proposed SAMA: provide remote switching capability: SAMA 15.
IE_T8	MTC	1.02	MTC GREATER THAN 95%	Essentially a split fraction identifying the fraction of the time the moderator temperature coefficient is too high to sufficiently limit an ATWS event. No SAMA identified.
IE_A	FLG_X	1.79	TAG EVENT - LONG TERM COOLING (HPR/LPR/REFILL)	This is not a basic event, but a tag identifying sequences involving recirc/ refill. Basic events for those sequences are addressed separately.
IE_A	SPMRW3BM	1.06	RWP-3B IN MAINTENANCE	Unavailability / failure of raw water pump. A SAMA has been identified to supply water to the system from an alternate source: SAMA 8.
IE_A	LPM001BM	1.04	DHP-1B TRAIN IN MAINTENANCE	This is a basic event representing a decay heat removal pump being out of service for testing and maintenance. A SAMA was proposed to provide a diverse or maintenance spare train: SAMA 13.

Table RAI-5.f: Correlation of Basic Events to Initiating Events				
Initiator	**Associated Basic Event**	**RRW**	**Description**	**SAMA Disposition**
IE_A	LPM001AM	1.04	DHP-1A TRAIN IN MAINTENANCE	This is a basic event representing a decay heat removal pump train being failed or out of service. Proposed SAMA: provide a redundant/ diverse spare or a maintenance spare DH train: SAMA 13.
IE_A	LMMDHPBF	1.04	FAILURE OF DHP-1B AND ITS VALVES	This is a basic event representing a decay heat removal pump train being failed or out of service. Proposed SAMA: provide a redundant/ diverse spare or maintenance spare DH train, which could also be substituted for a failed train: SAMA 13.
IE_A	SCCHDABF	1.04	COMMON CAUSE FAILURE OF HXs DCHE-1A AND DCHE-1B PLUGGED	Proposed SAMA, add removable strainers ahead of heat exchangers: SAMA 37.
IE_A	LMMDHPAF	1.04	FAILURE OF DHP-1A AND ITS VALVES	This is a basic event representing a decay heat removal pump train being failed or out of service. Proposed SAMA: add an additional DH train: SAMA 13.
IE_A	LMMDV43F	1.04	FAILURE OF TRAIN B RECIRC VALVE DHV-43	Basic event representing inability to open sump valve for recirculation. Proposed SAMAs: proceduralize either manual operation of the valve or crosstying of LHI suction: SAMA 16, 33.
IE_A	SPMRW3AM	1.03	RWP-3A IN MAINTENANCE	Unavailability / failure of raw water pump. A SAMA has been identified to supply water to the system from an alternate source: SAMA 8.
IE_A	LMMDV42F	1.03	FAILURE OF TRAIN A RECIRC VALVE DHV-42	Basic event representing inability to open sump valve for recirculation. Proposed SAMA: proceduralize either manual operation of the valve or crosstying of LHI suction: SAMA 16, 33.
IE_A	LHULPRCY	1.03	OPERATORS FAIL TO GO TO LOW PRESSURE RECIRCULATION	Failure of operators to align plant for recirculation. Proposed SAMA: automate switchover to recirculation: SAMA 3.
IE_A	SPMDHCBM	1.03	DHCCC TRAIN B IN MAINTENANCE	Module containing various decay heat closed cooling system failures. Proposed SAMA: proceduralize crosstying of DHCC trains: SAMA 16.
IE_T16	FLG_HVAC	1.37	HVAC REQUIRED DUE TO AVAILABILITY OF AC POWER	This is not a basic event but a tag identifying sequences where HVAC is required, primarily to provide cooling for EFW controls. Basic events for those sequences are addressed separately.
IE_T16	FLG_QHUEFWMR	1.33	OPERATORS FAIL TO MANUALLY OPEN CONTROL VALVE	This is not a basic event but a tag identifying sequences where HVAC is failed, control systems are potentially failed, and operator actions to manually operate valves might be helpful. Events for those sequences are addressed separately, however a SAMA is proposed to provide procedures and training for manual operation of the affected valves (EFV-55, -56, -57, -58): SAMA 34
IE_T16	QSPLHVAC	1.33	SPLIT FRACTION - VALVES FAIL CLOSED ON LOSS OF HVAC	This is not a basic event but a split fraction. Related basic events are addressed separately.

Table RAI-5.f: Correlation of Basic Events to Initiating Events				
Initiator	**Associated Basic Event**	**RRW**	**Description**	**SAMA Disposition**
IE_T16	FLG_SW	1.24	TAG EVENT - LOSS OF NORMAL SW	This is not a basic event, but a tag identifying sequences involving loss of service water. Basic events for those sequences are addressed separately.
IE_T16	JHUCHP2R	1.14	OPERATORS FAIL TO USE DEDICATED CHILLED WATER SYSTEM	Operator action related to importance of HVAC / cooling to EFW / EFIC. Related SAMAs have been identified to provide automated replacement of some of the functions, to manually perform some of the functions potentially lost (operate EFV-55, ...-58), or to provide a substitute for the potentially affected AFW/ EFW equipment: SAMAs 1, 26, 34.
IE_T16	QHUFW7EY	1.12	OPERATORS FAIL TO START FWP-7 BEFORE PORV LIFTS	Operator action to manually align FWP-7 AFW pump. Related SAMAs have been identified to provide autostart of FWP-7 as well as to install an alternative AFW/ EFW train with automatic start: SAMAs 4, 7.
IE_T16	QPMFWP7M	1.11	FWP-7 IN MAINTENANCE	AFW Pump FWP-7, related SAMA has been identified to provide an alternate AFW/EVW train. Also a SAMA has been identified to reduce maintenance downtime for FWP-7: SAMAs 5, 7.
IE_T16	JHUCHP2Z	1.11	JHUCHP2R	Sequence-specific substitution for JHUCHP2R. See discussion related to that action.
IE_T16	QMMEFP3F	1.07	EFP-3 PUMP TRAIN FAILS TO RUN	Basic event for EFW pump FTR. SAMA related to EFW / AFW has been identified, to provide an independent train: SAMA 7.
IE_T16	RMMRCVSC	1.07	SAFETY RELIEF VALVE FAILS TO CLOSE (STEAM RELIEF)	SRV FTC. No SAMA directly related to this event was identified however SAMAs related to mitigating systems have been identified.
IE_T16	QHUFWP7Y	1.06	OPERATORS FAIL TO START FWP-7	Oper action to start AFW pump FWP-7. SAMAs related to EFW/AFW have been identified, to provide autostart of FWP-7 and to provide an additional train of AFW/ EFW: SAMAs 5, 7.
IE_T16	HHUMPSBY	1.06	OPERATOR FAILS TO START STANDBY MAKEUP PUMP	Operator action to start / align standby makeup pump. Some actions can be improved by improving procedures and training, however the CR-3 procedures and training are believed to be adequate.
IE_T16	FLG_TBQR	1.05	TAG EVENT - STUCK OPEN RELIEF AFTER B	This is a tag event intended to identify sequences involving a stuck-open relief valve. The basic events related to those sequences are evaluated separately.
IE_T16	QMMEFP2F	1.04	EFP-2 FAILS TO CONTINUE TO RUN	A SAMA has been identified related to AFW / EFW, to provide an additional train: SAMA 7.
IE_T16	QMMCST	1.03	FAILURE OF CST WATER SUPPLY	Module representing various CST failure modes. Proposed SAMA: proceduralize use of alternate water sources in event of CST failure: SAMA 38.

Table RAI-5.f: Correlation of Basic Events to Initiating Events

Initiator	Associated Basic Event	RRW	Description	SAMA Disposition
IE_T16	RCCDRODA	1.03	MECH FAILURE OF ENOUGH CONTROL RODS TO DROP	Part of ATWS initiating event logic. No relevant SAMA identified.
IE_T16	QHUEFT2Y	1.03	OPERATORS FAIL TO CROSSTIE EFW SOURCES	SAMAs have been identified to provide additional makeup / suction supplies to AFW and EFW: SAMAS 7, 38.
IE_T16	PMMICSAH	1.03	OTSG A LEVEL CONTROL FAULTS	This module contains basic event failures which could lead to OTSG overfeed. Proposed SAMA: add redundant /diverse level controls: SAMA 17.
IE_T16	PMMICSBH	1.03	OTSG B LEVEL CONTROL FAULTS	This module contains basic event failures which could lead to OTSG overfeed. Proposed SAMA: add redundant /diverse level controls: SAMA 17.
IE_T16	PMMICSCC	1.02	ICS COMMON MODE FAULTS	This module contains basic event failures which could lead to OTSG overfeed. Proposed SAMA: provide redundant /diverse level controls (SAMA 17).
IE_T2	FLG_X	1.79	TAG EVENT - LONG TERM COOLING (HPR/LPR/REFILL)	This is not a basic event, but a tag identifying sequences involving recirc/ refill. Basic events for those sequences are addressed separately.
IE_T2	QHUFW7EY	1.12	OPERATORS FAIL TO START FWP-7 BEFORE PORV LIFTS	Operator action to manually align FWP-7 AFW pump. Related SAMAs have been identified to provide autostart of FWP-7 as well as to install an alternative AFW/ EFW train with automatic start: SAMAs 4, 7.
IE_T2	QPMFWP7M	1.11	FWP-7 IN MAINTENANCE	AFW Pump FWP-7, related SAMA has been identified to provide an alternate AFW/EVW train. Also a SAMA has been identified to reduce maintenance downtime for FWP-7: SAMAs 5, 7.
IE_T2	QMMEFP3F	1.07	EFP-3 PUMP TRAIN FAILS TO RUN	Basic event for EFW pump FTR. SAMA related to EFW / AFW has been identified, to provide an independent train: SAMA 7.
IE_T2	HHUHPRCY	1.07	OPERATORS FAIL TO SWITCH FROM HIGH PRESSURE INJECTION TO RECIRCULATION	Operator action to switch to recirculation. Related SAMA has been identified to automate switchover: SAMA 3.
IE_T2	RMMRCVSC	1.07	SAFETY RELIEF VALVE FAILS TO CLOSE (STEAM RELIEF)	SRV FTC. No SAMA directly related to this event was identified however SAMAs related to mitigating systems have been identified.
IE_T2	FLG_TBQR	1.05	TAG EVENT - STUCK OPEN RELIEF AFTER B	This is a tag event intended to identify sequences involving a stuck-open relief valve. The basic events related to those sequences are evaluated separately.
IE_T2	QMMEFP2F	1.04	EFP-2 FAILS TO CONTINUE TO RUN	A SAMA has been identified related to AFW / EFW, to provide an additional train: SAMA 7.
IE_T2	SCCHDABF	1.04	COMMON CAUSE FAILURE OF HXs DCHE-1A AND DCHE-1B PLUGGED	Proposed SAMA, add removable strainers ahead of heat exchangers: SAMA 37.

Table RAI-5.f: Correlation of Basic Events to Initiating Events				
Initiator	**Associated Basic Event**	**RRW**	**Description**	**SAMA Disposition**
IE_T2	QMMCST	1.03	FAILURE OF CST WATER SUPPLY	Module representing various CST failure modes. Proposed SAMA: proceduralize use of alternate water sources in event of CST failure: SAMA 38.
IE_T2	RCCDRODA	1.03	MECH FAILURE OF ENOUGH CONTROL RODS TO DROP	Part of ATWS initiating event logic. No relevant SAMA identified.
IE_T2	QHUEFT2Y	1.03	OPERATORS FAIL TO CROSSTIE EFW SOURCES	SAMAs have been identified to provide additional makeup / suction supplies to AFW and EFW: SAMAS 7, 38.
IE_T2	PMMICSAH	1.03	OTSG A LEVEL CONTROL FAULTS	This module contains basic event failures which could lead to OTSG overfeed. Proposed SAMA: add redundant /diverse level controls: SAMA 17.
IE_T2	PMMICSBH	1.03	OTSG B LEVEL CONTROL FAULTS	This module contains basic event failures which could lead to OTSG overfeed. Proposed SAMA: add redundant /diverse level controls: SAMA 17.
IE_T2	HCCMV44N	1.03	COMMON CAUSE FAILURE OF MUV-23, MUV-24, MUV-25, AND MUV-26 TO OPEN	Common-cause failure of makeup valves. Proposed SAMA: Proceduralize manual operation of these valves, which would address most modes of common-cause failure: SAMA 10.
IE_T2	MTC	1.02	MTC GREATER THAN 95%	Essentially a split fraction identifying the fraction of the time the moderator temperature coefficient is too high to sufficiently limit an ATWS event. No SAMA identified.
IE_T2	PMMICSCC	1.02	ICS COMMON MODE FAULTS	This module contains basic event failures which could lead to OTSG overfeed. Proposed SAMA: provide redundant /diverse level controls (SAMA 17).
IE_T10	FLG_HVAC	1.37	HVAC REQUIRED DUE TO AVAILABILITY OF AC POWER	This is not a basic event but a tag identifying sequences where HVAC is required, primarily to provide cooling for EFW controls. Basic events for those sequences are addressed separately.
IE_T10	FLG_QHUEFWMR	1.33	OPERATORS FAIL TO MANUALLY OPEN CONTROL VALVE	This is not a basic event but a tag identifying sequences where HVAC is failed, control systems are potentially failed, and operator actions to manually operate valves might be helpful. Events for those sequences are addressed separately, however a SAMA is proposed to provide procedures and training for manual operation of the affected valves (EFV-55, -56, -57, -58): SAMA 34
IE_T10	QSPLHVAC	1.33	SPLIT FRACTION - VALVES FAIL CLOSED ON LOSS OF HVAC	This is not a basic event but a split fraction. Related basic events are addressed separately.

Table RAI-5.f: Correlation of Basic Events to Initiating Events				
Initiator	**Associated Basic Event**	**RRW**	**Description**	**SAMA Disposition**
IE_T10	FLG_SW	1.24	TAG EVENT - LOSS OF NORMAL SW	This is not a basic event, but a tag identifying sequences involving loss of service water. Basic events for those sequences are addressed separately.
IE_T10	JHUCHP2R	1.14	OPERATORS FAIL TO USE DEDICATED CHILLED WATER SYSTEM	Operator action related to importance of HVAC / cooling to EFW / EFIC. Related SAMAs have been identified to provide automated replacement of some of the functions, to manually perform some of the functions potentially lost (operate EFV-55, ...-58), or to provide a substitute for the potentially affected AFW/ EFW equipment: SAMAs 1, 26, 34.
IE_T10	QHUFW7EY	1.12	OPERATORS FAIL TO START FWP-7 BEFORE PORV LIFTS	Operator action to manually align FWP-7 AFW pump. Related SAMAs have been identified to provide autostart of FWP-7 as well as to install an alternative AFW/ EFW train with automatic start: SAMAs 4, 7.
IE_T10	QPMFWP7M	1.11	FWP-7 IN MAINTENANCE	AFW Pump FWP-7, related SAMA has been identified to provide an alternate AFW/EVW train. Also a SAMA has been identified to reduce maintenance downtime for FWP-7: SAMAs 5, 7.
IE_T10	JHUCHP2Z	1.11	JHUCHP2R	Sequence-specific substitution for JHUCHP2R. See discussion related to that action.
IE_T10	QHUFWP7Y	1.06	OPERATORS FAIL TO START FWP-7	Oper action to start AFW pump FWP-7. SAMAs related to EFW/AFW have been identified, to provide autostart of FWP-7 and to provide an additional train of AFW/ EFW: SAMAs 5, 7.
IE_T10	HHUMPSBY	1.06	OPERATOR FAILS TO START STANDBY MAKEUP PUMP	Operator action to start / align standby makeup pump. Some actions can be improved by improving procedures and training, however the CR-3 procedures and training are believed to be adequate.
IE_T10	SPMRW3BM	1.06	RWP-3B IN MAINTENANCE	Unavailability / failure of raw water pump. A SAMA has been identified to supply water to the system from an alternate source: SAMA 8.
IE_T10	QMMCST	1.03	FAILURE OF CST WATER SUPPLY	Module representing various CST failure modes. Proposed SAMA: proceduralize use of alternate water sources in event of CST failure: SAMA 38.
IE_T10	SMMDHCCB	1.03	DHCCC TRAIN B FAULTS	Module containing various decay heat closed cooling system failures. Proposed SAMA: proceduralize crosstying of DHCC trains: SAMA 16.
IE_T10	SMMRW3BF	1.03	RWP-3B PUMP TRAIN FAILS TO OPERATE	Unavailability / failure of raw water pump. A SAMA has been identified to supply water to the system from an alternate source: SAMA 8.
IE_T10	SPMDHCBM	1.03	DHCCC TRAIN B IN MAINTENANCE	Module containing various decay heat closed cooling system failures. Proposed SAMA: proceduralize crosstying of DHCC trains: SAMA 16.

5.g *The SAMA analyses for the referenced plants were reviewed to determine any insights that might be gained from what other utilities had proposed as potential cost-beneficial SAMAs. This review that was subjectively performed did not reveal any new insights than what had already been identified from the importance list review regarding potential SAMAs that would be of benefit to Crystal River Unit 3. As such, no detailed explanation of this process was necessary since it was not considered to provide any additional value to this SAMA analysis. The most important insight in identification of SAMAs for Crystal River Unit 3 was from the review of the plant-specific PRA importance lists that provided more valuable information with regard to assessing potential SAMAs that would be cost beneficial.*

The one industry SAMA that was chosen to apply to Crystal River Unit 3 was SAMA 49, which involved the improvement of fire barriers to reduce the risk due to fire hazards in the plant. This was identified from SAMA ID #248 in Addendum 1.

5.h *None of the SAMA ID numbers for the industry SAMAs identified in Addendum 1 were used. The listing of SAMA IDs was initially meant to consist of a consecutive numbering scheme, but during the review process of the basic event importance lists during the Phase I process, there were some SAMA numbers that were either subsumed into other identified SAMAs or determined that no SAMA was necessary, such as due to the event being a logical flag. However, to prevent having to renumber the SAMAs already identified, it was determined to not renumber the entire list so as to prevent possible configuration management errors when working with other personnel across different organizations.*

According to Table E.5-3, the actual total number of Phase I SAMAs that were finally identified as being qualitatively screened was in fact ten. It was quite possible that earlier in the process that perhaps only nine were identified as candidates for being screened, but that an additional SAMA was later added to the list and the description on page E.7-3 not updated.

The Phase I screening process involved a comparison of the implementation costs with the perceived risk benefit and was explained in Section E.5.2. For convenience, the main points of this review process are reiterated below:

a) Applicability to the Plant: If a proposed SAMA does not apply to the CR-3 design, it is not retained.

b) Engineering Judgment: Using extensive plant knowledge and sound engineering judgment, potential SAMAs are evaluated based on their expected maximum cost and dose benefits; those that are deemed not beneficial are screened from further analysis.

The SAMA identification process is focused on the identification of plant enhancements to address plant specific risk. Accordingly, the CR-3 PRA was the primary source of information used to develop the SAMA list. Specifically, the importance list is analyzed item by item using cutset analysis to determine the main risk contributors for each basic event and methods to mitigate the main risk contributors for each basic event are devised. An industry SAMA list, such as the one provided in NEI 05-01, is typically consulted to aid in the development of SAMAs. In many cases, other plants have *identified general types of plant enhancements that could be used to address the issues raised in the importance list review. These general enhancements are then tailored to address plant specific issues, as required, and included on the SAMA list. This practice reduces the effort required for SAMA development and helps to ensure potentially reasonable changes are not overlooked in the SAMA development process. In many cases, however, the industry SAMA list does not include a plant enhancement that is applicable to the risk contributor in question and an entirely new SAMA is developed based on plant-specific needs. The result of the process is a list of SAMAs that can impact the important risk contributors for the plant.*

In addition to the importance list review, which is performed for both the Level 1 and Level 2 contributors, previous plant specific risk analyses (including the IPE and IPEEE) are reviewed to determine if any previously identified plant improvements remain unimplemented. Any unimplemented plant enhancement would be a candidate for consideration as a potential SAMA.

Beyond the IPEEE plant enhancement review noted above, the results of the external events analyses were reviewed to determine if any other potentially cost effective plant enhancements may exist that were not identified during the IPEEE process. This review is generally difficult given that IPEEEs typically lack detailed quantitative information for many of the external events initiators, but the major risk contributors are examined to identify the types of changes that could be used to mitigate risk.

The potentially cost effective SAMAs from a set of selected submittals are also reviewed to identify potentially cost beneficial changes that may have been overlooked in the plant specific SAMA identification process. The majority of the sites chosen for this type review are usually of a similar design to the plant being analyzed as the SAMAs have a better chance of being relevant; however, at least one dissimilar plant is included to introduce an alternate set of potential changes. There is no formal review process used to evaluate the cost effective SAMAs from these plants; the analyst qualitatively assesses the SAMAs to identify changes that impact risk areas that were not the focus of the plant specific importance list review. The objective is to identify reasons why those types of changes are not relevant to the plant being analyzed. In addition, SAMAs that address common risk areas using different methods are also considered to determine if they could be used in place of an existing SAMA. The use of these industry SAMA analyses is similar to the use of the generic SAMA list, but it provides a means of maintaining a link to the latest industry thinking without forcing a formal analysis of an ever growing SAMA list.

In summary, the CR-3 SAMA identification process primarily used the PRA to focus resources on developing plant changes that would most effectively reduce plant risk. The process also relies on previous industry analyses to gain further insight and help ensure other important applicable SAMA designs are not overlooked. This is considered to be the most effective and prudent method of generating a plant's SAMA list.

6. Provide the following with regard to the Phase II cost-benefit evaluations:

   a. Section E.6 introduction states that CR-3 specific implementation cost estimates were developed by plant personnel, and footnote 1 to Table E.5-3 states that "*Cost estimates provided/validated by CR-3.*" Section E.5.1.1 further states that procedural changes have previously been estimated to cost about $50,000. Beyond this, no further basis is provided for implementation cost estimates. Provide a general explanation of the basis for CR-3-specific SAMA implementation cost estimates developed by plant personnel.

   b. For a number of the Phase II SAMAs listed in Table E.6-1, the information provided does not sufficiently describe the associated modifications and what is included in the cost estimate. Provide a more detailed description of both the modifications and the cost estimates for Phase II SAMAs 4, 5, 15, 35, and 49.

   c. Analysis of SAMA 49, Upgrade Fire Barriers in Battery Charger Room 3A (Section E.6.15), assumes a 13.1 percent risk reduction. This is based on two assumptions: 1) the contribution of Battery Charger Room 3A to the total (external + internal) CDF is 26.3 percent and 2) the external event CDF approximately equals the internal events CDF. However, IPEEE Section 1.4 indicates that the CDF for this room (1.49E-05 per year) is 149 percent of the internal event (including internal flooding) risk (about 1.0E-05 per year). Justify the benefit estimate for this SAMA (see related RAIs 3.a - 3.d).

   d. Table E.5-1, Level 1 Importance List Review, identifies potential SAMAs 5 and 7 to address event QHUFWP7Y, OPERATORS FAIL TO START FWP-7. But Table E.5-2, Level 2 Importance List Review for RRW Greater than 1.02, identifies potential SAMA 4 to address this same event, QHUFWP7Y. Neither SAMA 4 nor SAMA 5's benefit evaluation considers the risk reduction related to event QHUFWP7Y. Since SAMA 5 improves maintenance unavailability, it appears that SAMA 4, Automatic Start of Auxiliary Feedwater Pump (FWP-7) When Required, is the appropriate SAMA to address QHUFWP7Y. Clarify which SAMA(s) were considered to address event QHUFWP7Y, and explain why the risk reduction associated with mitigation of event QHUFWP7Y is not credited in the analysis of SAMA 4.

   e. SAMA 16 (enhance procedures and make design changes as required to facilitate crosstying trains of DH, DHCC, etc.) has an estimated cost of $5M. This cost appears high for what appears to be mostly a procedure issue. Justify the cost estimate for this SAMA.

   f. Section E.7.2.1 states that no additional Phase I SAMAs were retained for further analysis as a result of the uncertainty analysis using the 95th percentile CDF. Using the 95th percentile CDF results in a Modified Maximum Averted Cost-Risk (MMACR) of $1.4 million ($682,000 x 2.1). This is more than a factor of 2 greater than the cost estimates for Phase I SAMAs 8, 14, 26, 37, and 52. Provide a Phase II evaluation of these SAMAs.

<u>Response</u>

6.a *Initial cost estimates were developed during the identification of Phase 1 and Phase 2 SAMAs to establish the list of potentially cost effective SAMAs. These were forwarded to CR-3 engineering personnel for further review. This review consisted of an evaluation* *of each SAMA from the perspective of what actions would be required in each case to actually implement it. This involved determining what new equipment would have to be installed, how it would be housed, how it would be interconnected with plant systems, and generally how large or small the SAMA implementation would be. Based on this scoping effort, an estimate was provided based on benchmarking to other projects of similar size. This effort was not expected to be precise, but was expected to provide a ballpark evaluation of the size and scope of the proposed SAMA.*

6.b SAMA 4 evaluates the risk benefit of changing Auxiliary Feedwater Pump FWP-7 from manual to automatic operation for providing a back-up means of supplying feedwater to the OTSGs in the event the automated EFW system in unavailable. Providing automatic operation of this pump would require detection of loss of main feedwater and low flow from the EFW flow instrumentation. It further assumes that normal power is available and does not include auto-starting the backup power source.

SAMA 5 addresses possible improvement in Auxiliary Feedwater Pump FWP-7 unavailability. To better evaluate this SAMA, a 7-year unavailability review was performed to determine the significant contributors to pump unavailability. Excluding a modification performed to install an alternate power feed to the pump, unavailability was 0.9 during the period and was mostly associated with surveillances. One significant failure was identified with a bearing failure in 2000 and the cause for that failure was addressed. With such a low unavailability, there were no readily identifiable actions short of major equipment replacements that would materially impact pump operation and it would not be certain that major equipment replacements would have a positive impact. The estimate for this SAMA assumed that major hardware modifications would be required.

SAMA 15 simulates the ability to remotely realign the power supply for make-up pump MUP-1B in lieu of local manipulations from outside the control room. The make-up and purification (MUP) system provides for inventory and water chemistry control of the reactor coolant, and for emergency makeup (high pressure injection or HPI). The system consists of three makeup pumps that are powered from two trains of engineered safeguard (ES) 4160 VAC electrical buses. MUP-1A is powered from train A of electrical power and MUP-1C is powered from train B. MUP-1B acts as a swing pump that can be powered from either 4160 VAC bus, but must be manually realigned. The $300,000 estimated cost for this SAMA is based on the need to install equipment that would allow remote alignment of either train to MUP-1C including controls and breakers necessary to operate the equipment in a manner that protects both trains.

SAMA 35 attempts to automate the process of cooling down the plant and performing what the operators would normally do when opening the PORV for manual pressure control. The RCS pilot-operated electromatic relief valve (PORV) is normally designed to open to relieve RCS pressure during overpressure conditions, due to exceeding a pressure setpoint or by remote operation. A solenoid energizes to open the PORV, and deenergizes to allow the PORV to close. In certain plant scenarios, such as during plant transients that cause an excessive increase in RCS pressure, e.g., loss of main feedwater, the operator may be required to manually open the PORV from the control room to prevent challenging the safety relief valves. The cost for this SAMA was based on the need to provide safety related power and the complexity of the automated controls required to provide adjustable band control of the PORVs.

SAMA 49 addresses upgrading the fire barrier protection in Battery Charger Room 3A in the same manner that Battery Charger Room 3B had been upgraded to meet the requirements of 10 CFR 50 Appendix R. As stated in E.6.15, the $150,000 cost for this upgrade was a benchmark estimate based on previous work to upgrade Battery Charger Room 3B.

6.c *As stated in RAI question 6.b, the benefit for SAMA 49 was based, in part, on the assumption that the internal and external events risks are approximately equal. If it is assumed, as suggested in RAI question 3.c, that the external events multiplier should be based directly on the external events CDF, then the averted cost-risk would be larger than what was estimated in the ER.*

As documented in the response to RAI 3.d, the averted cost-risk for SAMA 49 could be estimated by multiplying the internal events MACR by the ratio of the Battery Charger Room 3A fire CDF to the internal events CDF:

$341,000 x 1.49E-05 / 4.95E-06 = $1,026,444

Note that the internal events CDF of 4.95E-06/yr includes internal flooding contributions.

Given that this SAMA was already determined to be cost beneficial based on an implementation cost of $150,000, re-quantifying the averted cost-risk of this SAMA in this way would not alter the conclusions about SAMA 49; it still has a positive net value ($1,026,444 - $150,000 = $876,444).

6.d *Although SAMAs 4, 5, and 7 are all related to improving the reliability and redundancy of the EFW system, it would be more appropriate to identify event QHUFWP7Y with SAMA 4, which was created to postulate auto-start of FWP-7. To model SAMA 4, the failure probability for HEP event QHUFW7EY (OPERATORS FAIL TO START FWP-7 BEFORE PORV LIFTS) was reduced from a value of 1.0 to 1E-5 in the PRA basic event database. Also, in the recovery rules file, the recovery event QHUFW7EZ was commented out so as not to append this recovery event with a failure probability of 2.6E-02 to cutsets containing QHUFW7EY. Since event QHUFW7EY had a higher RRW value (RRW=1.115) than QHUFWP7Y (RRW=1.063), it was implied that the latter event would be bounded by evaluation of the former event.*

6.e *Implementation of SAMA 16 would involve both changes to operating procedures and modifications to plant safety systems as noted in the discussion of SAMAs 16 and 52 under SAMA RAI 3.d above. Therefore, the cost is increased above that required for a procedure issue alone.*

6.f *The Phase II evaluations of SAMAs 8, 14, 26, 37, and 52 are documented in the response to RAI question 3.d using the external events multiplier of 12. The results are summarized in the table below for both the point estimate PRA results and the 95th percentile PRA results.*

Phase II Results Summary for RAI 6.f (EE Multiplier of 12)

SAMA ID	***Cost of Implementation***	***Averted Cost Risk (EE x 12, PE PRA)***	***Net Value (EE x 12, PE PRA)***	***Averted Cost Risk (EE x 12, 95th Percentile)***	***Net Value (EE x 12, 95th Percentile)***
8	*$500,000*	*$357,972*	*-$142,028*	*$780,379*	*$280,379*
26	*$2,000,000*	*$555,600*	*-$1,444,400*	*$1,211,208*	*-$788,792*
14	*$900,000*	*$54,528*	*-$845,472*	*$118,871*	*-$781,129*
37	*$600,000*	*$54,084*	*-$545,916*	*$117,903*	*-$482,097*
52	*$5,000,000*	*-$5,508*	*-$5,005,508*	*-$12,007*	*-$5,012,007*

Of the SAMAs identified for evaluation in this RAI question, none are potentially cost beneficial when the point estimate PRA results are used in conjunction with the external events multiplier of 12. When the 95th percentile PRA results are applied in conjunction with the external events multiplier of 12, only SAMA 8 was determined to be potentially cost beneficial.

7. Section 4.20 states that “Progress Energy will consider the four SAMAs using the appropriate CR-3 design process.” Describe the “CR-3 design process” and clarify how the four SAMAs, and any other SAMAs determined to be potentially cost-beneficial in response to these RAIs, are evaluated using this process.

<u>Response</u>

An action within the CR-3 Corrective Action Program will be used to track the evaluation of the potentially cost-beneficial SAMAs identified by the CR-3 License Renewal Environmental Report and subsequent RAI responses. This evaluation will provide a more detailed analysis of the actions required to implement the SAMAs and the costs for implementation. Those SAMAs that remain as potentially cost-beneficial SAMAs will be forwarded to the Project Review Group (PRG). The PRG will determine which of the potentially cost-beneficial SAMAs merit further study or implementation. If all or some of the potentially cost-beneficial SAMAs are accepted by the PRG they will be entered into the Long Range Plan and tracked from that point as a project.