DRAFT

SERIAL: BSEP 05-xxxx 10 CFR 54

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

Subject: Brunswick Steam Electric Plant, Unit Nos. 1 and 2
Docket Nos. 50325 and 50-324/License Nos. DPR71 and DPR-62
Response to Request for Additional Information - License Renewal

References:

1. Letter from Cornelius J. Gannon to the U. S. Nuclear Regulatory Commission (Serial: BSEP 04-0006), "Application for Renewal of Operating Licenses," dated October 18, 2004

2. Letter from U. S. Nuclear Regulatory Commission to Cornelius J. Gannon, "Request for Additional Information (RAI) Regarding Severe Accident Mitigation Alternatives for the Brunswick Steam Electric Plant, Units 1 and 2 (TAC Nos. MC4641 and MC4642), dated February 24, 2005

Ladies and Gentlemen:

In Reference 1, Carolina Power & Light Company, now doing business as Progress Energy Carolinas, Inc., requested the renewal of the operating licenses for the Brunswick Steam Electric Plant (BSEP), Unit Nos. 1 and 2, to extend the terms of their operating licenses an additional 20 years beyond the current expiration dates.

By Reference 2, the NRC issued a request for additional information (RAI) concerning the analysis of Severe Accident Mitigation Alternatives (SAMAs) performed in support of the BSEP License Renewal Application. The response to this RAI is enclosed.

Please refer any questions regarding this submittal to Mr. Mike Heath, Supervisor - License Renewal, at (910) 457-3487.

I declare, under penalty of perjury, that the foregoing is true and correct.
Executed on *[date of letter]*.

Sincerely,

Cornelius J. Gannon

MHF/mhf

Enclosure:

Response to Request for Additional Information (RAI) SAMA1

DRAFT

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Response to Request for Additional Information SAMA1

Background

On October 18, 2004, Carolina Power & Light Company (CP&L), now doing business as Progress Energy Carolinas, Inc., requested the renewal of the operating licenses for the Brunswick Steam Electric Plant (BSEP), Unit Nos. 1 and 2, to extend the terms of their operating licenses an additional 20 years beyond the current expiration dates. Appendix E of the License Renewal Application (LRA) consisted of the Applicant's Environmental Report – Operating License Renewal Stage (i.e., the ER). Appendix F of the ER contained the evaluation of Severe Accident Mitigation Alternatives (SAMA).

By letter dated February 24, 2005, the NRC provided a request for additional information (RAI) concerning the analysis of SAMAs performed in support of the BSEP LRA. The response to this RAI follows.

The following table contains the acronyms and abbreviations used in this enclosure.

ACRONYMS AND ABBREVIATIONS	
AC	Alternating Current
ATWS	Anticipated Transient Without Scram
BSEP	Brunswick Steam Electric Plant
BWR	Boiling Water Reactor
BWROG	Boiling Water Reactor Owners Group
CAFTA	Cutset and Fault Tree Analysis (Software)
CCF	Common Cause Failure
CDF	Core Damage Frequency
CET	Containment Event Tree
CP&L	Carolina Power & Light Company, a Progress Energy Company
CRD	Control Rod Drive
CsI	Cesium Iodide
CST	Condensate Storage Tank
DC	Direct Current
DHR	Decay Heat Removal
DW	Drywell
EAL	Emergency Action Level
EC	Engineering Change
ECCS	Emergency Core Cooling System
EDG	Emergency Diesel Generator
EF	Error Factor
EOP	Emergency Operating Procedure
EPU	Extended Power Uprate
ER	Environmental Report
ERIN	Erin Engineering and Research, Inc.
F&O	Facts and Observations
HCLPF	High Confidence in Low Probability Failure
HEP	Human Error Probability

ACRONYMS AND ABBREVIATIONS	
HRA	Human Reliability Analysis
HVAC	Heating, Ventilating, and Air Conditioning
ICC	Instrumentation and Control Circuitry
IPE	Individual Plant Examination
IPEEE	Individual Plant Examination – External Events
ISLOCA	Interfacing System Loss of Coolant Accident
LERF	Large Early Release Frequency
LOCA	Loss of Coolant Accident
LOSP	Loss of Offsite Power
LR	License Renewal
LRA	License Renewal Application
MACCS2	MELCOR Accident Consequences Code System, Version 2
MACR	Maximum Averted Cost Risk
MAAP	Modular Accident Analysis Program
NPSH	Net Positive Suction Head
PRA	Probabilistic Risk Analysis
PSA	Probabilistic Safety Assessment
RAI	Request for Additional Information
RCIC	Reactor Core Isolation Cooling
RDR	Real Discount Rate
RLE	Review Level Earthquake
RPV	Reactor Pressure Vessel
RRW	Risk Reduction Worth
SAMG	Severe Accident Management Guideline
SAMA	Severe Accident Mitigation Alternative
SBO	Station Blackout
SLC	Standby Liquid Control
SORV	Stuck Open Relief Valve
SRV	Safety Relief Valve
SW	Service Water
TAC	Technical Assignment Control (internal NRC work management tool)
UNCERT	Uncertainty Software Program
USI	Unresolved Safety Issue

NRC RAI SAMA1-1

The SAMA analysis is based on the most recent version of the Brunswick Steam Electric Plant (BSEP) Probabilistic Safety Assessment (PSA), i.e., the MOR03 model. Please provide the following information regarding this PSA model:

a. The Unit 2 PSA is used to quantify the risk for both Units 1 and 2. Characterize the major differences in the results form the Unit 1 and Unit 2 PSAs, and any plant design or operational differe3nces that may impact the SAMA analysis.

b. Provide the CDF contribution due to station blackout events and ATWS events.

c. Describe the evolution of the current Level 2 PSA relative to that described in the BSEP Individual Plant Examination (IPE). Include an explanation of the Level 2 metrics (last column) presented in the table in

Section F.2.1 of the Environmental Report (ER).

d. Provide a discussion of the Level 2 PSA models or assumptions that lead to the following results indicated in Table F 4 of the ER:

   i. the approximate 50 percent split of ATWS Class IV sequences between high/early and moderate early release categories,

   ii. the majority of Class IIIA sequences being assigned to the low/early release category, and

   iii. the relatively large fraction of Classes IA, IB and IIIC and the relatively small fraction of Class ID sequences being assigned to the intact containment release class.

e. Briefly describe the approach used to determine the source terms for each release category. Clarify whether new MAAP analyses were performed as part of the development of the current model and how the MAAP cases were selected to represent each release category (i.e., based on the frequency-dominant sequence in each category or on a conservative, bounding sequence). Clarify how the MAAP calculations used to determine the source terms relate to the MAAP calculations that were used to support the improved success criteria (as mentioned in Section F.2.3 of the ER).

f. Provide a breakdown of the annual population dose risk (person-rem/year) by containment release mode.

g. Section F.2 of the ER indicates that a major upgrade and replacement of the IPE models was-undertaken during 1998-2001 and that subsequent updates were made in 2001, 2002 and 2003. Provide a discussion, similar to that in Section F.2.1.1, of the major changes made in the 1998 and subsequent updates, and the resulting CDF and LERF for each update. Note that the internal events CDF cited in the August 9, 2001 extended power uprate (EPU) submittal was 2.55×10^{-5} per year. Include an explanation of why the CDF value of 5.49×10^{-5} per year based on MOR98R1 (as reported in Section F.2.1 of the ER) was not used.

h. It is stated that only 6 of 66 Level B facts and observations from the BWROG Peer Certification Review have been resolved in the version of the PSA used for the SAMA analysis. Provide additional information to substantiate the conclusion that no open issues would result in retention of a SAMA that was screened out based on the current PSA model results.

Response to NRC RAI SAMA1-1

Response to NRC RAI SAMA1-1, Item a

As indicated in Section F.2 of the SAMA analysis, the Unit 2 PRA model of record 2003, designated as "MOR03," was used for the risk quantification. The BSEP Unit 1 and 2 Probabilistic Risk Analysis (PRA) models for MOR03 are defined in BSEP Engineering Change (EC) documentation. Unit 2 MOR03 quantifies to an overall Core Damage Frequency (CDF) of 4.19E-5 per year compared to 4.41E-5 per year for Unit 1 MOR03. The Unit 2 PRA model which has been used for the SAMA analysis is also more advanced in EPU change implementation than the Unit 1 PRA model. The major design and operational differences between the unit PRA models relate to the Standby Liquid Control (SLC) system design and operation, and to turbine bypass capability.

The Unit 2 PRA model updated the success criteria for the SLC system from two out of two pump and explosive valve paths to one out of two pump and explosive valve paths. Changes to the SLC PRA logic for Unit 2 included incorporation of additional valves, removal of unnecessary heat tracing, and update of event failure data. These changes were based on Unit 2 modifications as described in BSEP EC documents that incorporated the use of a super pentaborate boron concentration and enhanced the system test path piping and valve arrangement. The comparable model changes were delayed for Unit 1 until the next PRA model update and would result in overall risk reduction.

The other PRA model difference is that the same turbine bypass success criteria is assumed for both units. The success criteria for Unit 2 reflects a larger number of available bypass valves, i.e., ten turbine bypass valves for Unit 2 compared to four turbine bypass valves for Unit 1. The bypass valves are an insignificant contributor to the overall CDF for Unit 2 and less than 0.06% for Unit 1.

There are some other minor design and operational differences that exist between the units (e.g., an alternate pump may be powered by Division I Alternating Current (AC) power versus Division II AC power such as the conventional Service Water (SW) pumps and slightly different locations of equipment as in the case of the Control Rod Drive (CRD) pumps in the Reactor Building), however these differences have no significant impact on the SAMA analysis.

Response to NRC RAI SAMA1-1, Item b

The CDF contribution due to Station Blackout (SBO) events and Anticipated Transient Without Scram (ATWS) events can be derived from the accident class distribution data for adjusted CDF provided in Table F-4 of the SAMA analysis. The SBO CDF contribution can be approximated by the IBE (i.e., early SBO) and IBL (i.e., late SBO) accident class CDF contributions, i.e., 1.56E-5 per year or about 37.2% of the overall CDF for Unit 2. The ATWS event CDF contribution is equivalent to the IVA (i.e., ATWS with RPV initially intact) and IVL (i.e., ATWS with RPV initially breached, e.g., LOCA and SORV) accident class CDF contributions, i.e., 3.3E-6 per year or about 7.9% of the overall CDF for Unit 2.

Response to NRC RAI SAMA1-1, Item c

The BSEP IPE Level 2 analysis was based on the results obtained for the BSEP IPE Level 1 analysis. The general process is described in the IPE as follows: "Each core damage sequence identified in the Level 1 analysis was examined, its functional characteristics identified, and a set of key accident sequences was defined. These key accident sequences each had unique characteristics which, in total, were shown to be representative of the Level 1 sequences. Each individual key sequence could then be used to represent groups of Level 1 sequences during the performance of the accident progression, containment response and source term assessments for BSEP. A plant-specific containment event tree (CET) was developed and later quantified to provide frequency estimates for each source term." The results of the BSEP IPE Level 2 analysis provided frequency estimates for five containment failure categories (intact and isolated containment, venting after core melt, containment failed late, containment failed early, and containment bypassed) corresponding to a reduced total CDF of 1.9E-5 per year. The reduced CDF was based on Level 2 thermal hydraulic analyses that accounted for the availability of the CRD System for mitigation of accident sequences involving loss of decay heat removal and ATWS. The details of the Level 2 analysis are described in the IPE report submitted for BSEP in 1992.

The evolution of the current Level 1 and Level 2 PRA models is shown in section F.2.1 of the SAMA analysis. Following the IPE Level 1 model upgrade and replacement in 1998-2001, the current Level 2 model was developed in stages by Erin Engineering and Research, Inc. (ERIN) as the Level 1 model was being updated. The Unit 2 Level 1 model was selected for use in the Level 2 model development. The current Level 2 model was based on a similar process to that described above for the IPE but differed in that a sequence accident class structure as shown in Table F-1 of the SAMA analysis and a new containment event tree was incorporated by ERIN. The initial Level 2 model corresponding to Unit 2 Level 1 MOR98 provided a capability to calculate Large Early Release Frequency (LERF). The model was subsequently extended to Level 2 capability for Unit 2 Level 1 MOR98R1 by allowing the potential to consider up to seven additional release categories. These models are documented in BSEP EC documentation. The current Level 2 model was updated for interface with Unit 2 Level 1 PRA for MOR03 during the SAMA analysis and included the potential to consider the twelve release categories as shown in Table F-4 of the SAMA analysis. Table F-4 provides a breakdown of the total CDF (4.19E-5 per year) into the intact containment contribution (1.81E-5 per year) and the total contribution of the twelve Level 2 release categories (2.38E-5 per year). This latter value is provided in the table in section F.2.1 of the Environmental Report for comparison with the IPE value of about 1.9E-5 per year where the intact containment contribution is about 1%.

<u>Response to NRC RAI SAMA1-1, Item d</u>

The response to this RAI is provided in three parts. Refer to Table F-4 of the BSEP Environmental Report.

Item d.i. ...the approximate 50 percent split of ATWS Class IV sequences between high/early and moderate early release categories,

The plant specific Modular Accident Analysis Program (MAAP) evaluation of the ATWS core melt progression has determined that the radionuclide release is strongly dependent upon the initial containment failure location. Refer to BSEP Calculation BNP-PSA-048, Rev. 2, "PRA Model Appendix K PDS MAAP Analysis."

The wetwell airspace failures result in radionuclide releases that are less than high. Either wetwell failures below the water line or drywell failures are found to result in high radionuclide releases. High is considered >10% CsI.

Therefore, the approximate 50 percent split of ATWS Class IV sequences between high/early and moderate/early release categories is primarily due to the probabilistic evaluation of the initial containment failure location.

Item d.ii. …the majority of Class IIIA sequences being assigned to the low/early release category, and

Class IIIA events are RPV overpressure and excessive Loss of Coolant Accidents (LOCAs) that are beyond the capacity of the Emergency Core Cooling System (ECCS). There is no collateral or consequential damage to the ECCS makeup system. Therefore, there is a high probability that ECCS is available. Therefore, these types of events generally lead to core damage, however, they occur with substantial water sources available. The availability of these water sources leads to:

- high probability of recovery of the core melt progression in-vessel, or
- recovery with debris in a "wet" drywell.

The release (low/early) is because for these cases a containment flood is initiated and the drywell must eventually be vented. For such sequences the debris is under water and the drywell sprays have generally been operating. This combination of events leads to a low release, but one that may occur early in time.

Item d.iii. …the relatively large fraction of Classes IA, IB and IIIC and the relatively small fraction of Class ID sequences being assigned to the intact containment release class.

The BSEP containment is unique among Mark I containments because of its construction material. The concrete drywell is a major difference relative to the freestanding steel shell of the other Mark I designs. As a result, the early shell melt-through containment failure mode due to debris contact (a key release pathway at other Mark I designs) is not applicable to BSEP. For BSEP, the dominant contributions are those that bypass containment, for example, Interfacing System LOCA (ISLOCA) or cause an "early" containment failure, for example, ATWS.

This means that loss of coolant makeup accidents represent relatively low contributors to LERF.

Class IA are sequences in which Safety Relief Valves (SRVs) are not operated in sufficient time to depressurize the Reactor Pressure Vessel (RPV) to allow adequate core cooling. Core damage and core melt progression result. The core melt progression leads to high radiation measurements in the containment which trigger Drywell (DW) spray manual initiation as directed by the BSEP Severe Accident Management Guidelines (SAMG) procedures. The continued failure to depressurize results in RPV breach. The approximate factor of 50% of the Class IA sequences that result in an intact containment (i.e., no failure and no venting) are due to the conditional probability of the crew depressurizing successfully during the core melt progression, i.e., after core damage but prior to the RPV breach at 2.3 hours, for example, MAAP Case BR0060. Refer to BSEP Calculation BNP-PSA-048, Rev. 2.

Class IB represents sequences for which an SBO has occurred. For these cases, RPV injection may be unavailable due to the unavailability of AC power plus additional failures.

However, during the core melt progression, the industry data used to characterize AC power recoveries has indicated that restoration of AC power occurs with a probability of approximately 50% during the in-vessel core melt progression. The Containment Event Tree (CET) models the restoration of AC power and the subsequent restoration of RPV injection before RPV breach. This combination of successes results in arresting the core melt progression in-vessel, i.e., a containment and RPV intact condition.

Class IIIC represents sequences that involve a LOCA or an Stuck Open Relief Valve (SORV) with failure of adequate core cooling. These sequences are due to:

- SORV with failure to depressurize in the Level 1 evaluation coupled with inadequate RPV makeup, or
- LOCAs coupled with inadequate RPV makeup.

The dominant contributors involve SORVs that depressurize the RPV but not until after core damage. Then, RPV makeup becomes available to provide injection to arrest the core melt progression in-vessel. Only modest credit for this termination of core melt progression is included, i.e., RPV injection success of approximately 0.5 is used for this evaluation.

Class ID sequences involve accident sequences for which no RPV injection is available leading directly to core damage at low RPV pressure. RPV depressurization is successfully completed. Little credit (90% failure) is given for repair or recovery of failed systems. Therefore, there are essentially no success states for preventing RPV breach and arresting the core melt progression in-vessel. The SAMGs therefore dictate containment flood and venting that leads to some radionuclide release when the debris is ex-vessel. Refer to 0SAMG-01, "SAMG Primary Containment Flooding Procedure," and 0SAMG-02, "Containment and Radioactivity Release Control Procedure."

Response to NRC RAI SAMA1-1, Item e

The SAMA evaluation and the supporting Level 2 assessment used as its foundation a set of plant specific MAAP calculations that were explicitly performed to support the detailed Level 2 evaluation of BSEP.

The MAAP calculations used to support the source terms are extensions of the Level 1 calculations that reflected failures to meet the Level 1 success criteria. The level of discrimination used in the Level 1 and the CETs results in reasonably fine levels of distinction among sequences and the use of the "upper" bound or "worst" case cutset within a CET sequences was generally used. There may, however, be even worse case assumptions that could be postulated that would further increase the source terms, e.g., containment failure size could be increased or decreased to produce higher releases.

Similarly, MAAP code variations in hydrogen production, core melt progression timing, or RPV breach failure mode could be modified to increase or decrease the source terms. As such, it can be concluded that the source terms are more representative of the accident sequence rather than upper bound estimates.

The Level 1 success criteria are set using BSEP Calculation BNP-PSA-048, Rev. 2. These success criteria make conservative representations of the sequences and cutsets, that is the MAAP cases are generally upper bound estimates that subsume the sequences and cutsets within a given accident class or Human Error Probability (HEP) timing evaluation within the modeling constraints of MAAP.

Response to NRC RAI SAMA1-1, Item f

Table F-12 from the BSEP ER provides a breakdown of the annual population dose risk for each of the release categories.

Response to NRC RAI SAMA1-1, Item g

The following table discusses the major changes incorporated during the PSA periodic model updates for 1998 and subsequent updates.

The PSA Level 1 and Level 2 models associated with MOR98R1 were not available during development of the EPU analysis and submittal. These models were being developed as part of the periodic model update during the same year as the EPU analysis development, and were completed in October 2001. However, acceptability of the MOR98 model for estimating the risk implication associated with EPU was discussed in the EPU supportive documentation and in response to NRC RAI 6-1 submitted by CP&L letter to the NRC (Serial: BSEP 01-0141), "Response To Request for Additional Information Regarding Request for License Amendments - Extended Power Uprate (NRC TAC Nos. MB2700 and MB2701)," dated November 30, 2001.

The EPU analysis is based the Level 1 and Level 2 controlled models available at the time, i.e., model of record MOR98 released for use on February 27, 2001. The MOR98 Level 1 model was originally updated from MOR98 to MOR98R1 on August 20, 2001.to address issues such as crediting the Direct Current (DC) chargers given battery failure. This model yielded a Unit 2 CDF of 5.49E-5/yr. However, several additional corrections were subsequently needed in the updated Level 1 model, and a modified MOR98R1, Unit 2 CDF = 4.92E-5/yr, was released on October 15, 2001. The Level 2 model corresponding to modified MOR98R1 was not completed until October 10, 2002 based on cutset results for Unit 2 CDF of 4.92E-5/yr.

As noted above, the primary difference between MOR98 and MOR98R1 involved removing credit for the DC battery chargers as alternative power supply source to the batteries. However, as noted above, this issue was addressed in Section C. 2.2 of Appendix C of the PSA Quality issues in the EPU supportive documentation. Section C.2.2 qualitatively discussed the impact of potential model changes on EPU.

The following table describes some of the changes associated with the PSA model updates.

Model	Issue	CDF U2 (/yr)	LERF U2 (/yr)	Description
MOR98 L1	2/27/01	2.54E-5		• Previous BSEP IPE model was replaced by individual models for Unit 1 and Unit 2 following a complete model upgrade. The new models are highly detailed, and include complete upgrades in event tree structure, system fault trees, dependency analysis, success criteria analysis, initiating event data, equipment data, common cause analysis, human reliability analysis, Human Reliability Analysis (HRA) dependencies analysis, loss of offsite power (LOSP) recovery. • Model Release: BNP-PSA-001, Rev. 1.
MOR98 L2	08/31/01		4.27E-6	• Level 2 model update corresponding to MOR98R1 cutsets. • LERF results calculated only • Model Release: BNP-PSA-050, Rev. 0.
MOR98R1 L1	10/15/01	4.92E-5		• Initial model changes address modeling issues associated with crediting the charger given battery failure issued August 20, 2001; Unit 2 CDF 5.49E-5/yr. • Model Release: BNP-PSA-001, Rev. 2, BNP-PSA-052, Rev. 0.
MOR98R1 L2	10/10/02		4.78E-6	• Level 2 model update corresponding to MOR98R1 cutsets. • Eight radionuclide release categories including LERF calculated. • Model Release: BNP-PSA-050, Rev. 1.
MOR02 L1	5/16/02	4.97E-5		• Updated Level 1 model, which addressed all the elements for periodic update including changes

Model	Issue	CDF U2 (/yr)	LERF U2 (/yr)	Description
				associated with the implementation of EPU on Unit 1. • Model changes included: ▪ The automatic bus transfer for the motor driven fire pump system model and database were replaced in the model of record by a manual switch transfer and the addition of new operator action, OPER-FPXFER. A HEP representing operator failure to close the motor driven fire pump transfer switch was estimated. The operator action was also placed in the HRA recovery rule file. ▪ The relief valve, 2-FP-RV2, was removed from the system model and the database, and recovery rule file. ▪ Conservative modeling of the load shedding risk impact was incorporated into the PSA model (i.e., LOCA load shed and generator trip load shed). Changes were made to the system models for AC power, condensate, circulating water, instrumentation and control circuitry (ICC), and heating, ventilating, and air conditioning (HVAC). ▪ Renamed gate G181 to ICC^G-PTC-N11AU2. ▪ Revisions were incorporated to the circular logic model, mutually exclusive file, flag files, recovery files and database. ▪ Credit was given for the refill of the fire pump day fuel tanks since this operator action in the model of record addressed by BSEP procedures. ▪ Credit was given for restoration of the nitrogen system during some plant down-power scenarios to allow an appropriate assessment of the risk impact of these evolutions. ▪ The appropriate gate logic was restored (missing) in the DC Power system fault tree model and the associated system database for the demand only scenarios involving DC power panels 12A and 12B. ▪ Corrected in the circular logic model for SW model initiation logic (missing). ▪ Corrected the SW system initiating event fault tree (several AND gates changed to OR gates). ▪ Corrected two typos in the HRA recovery file that resulted in incorrect recovery values. • Truncation of 2E-9/yr used for model quantification • Model Release: BNP-PSA-00, Rev. 3.
MOR02 L2			NA	
MOR03 L1	2/24/04	4.19E-5		• Updated Level 1 model, which incorporates changes

Model	Issue	CDF U2 (/yr)	LERF U2 (/yr)	Description
				associated with the implementation of EPU as applied to Unit 2. • Model changes addressed: ▪ Incorporated SLC boron enrichment modification for Unit 2 that improved success criteria from two pumps and two explosive, valves to one pump and one explosive valve. ▪ Incorporated HRA values associated with EPU ATWS scenarios. ▪ Updated loss of LOSP frequencies for each unit and the site, and updated relevant recovery rules for LOSP. ▪ Incorporated AC Power system fault tree model changes to correct the failure logic for Common Buses A and B. ▪ Incorporated changes to address overpressure success criterion in ATWS, and isolation transients. In addition, split fractions were added to the SORV models (#P1, #P2) to account for the actual number of valves demanded. • Changed naming scheme for pre-initiators HEP (new type code XHE-MN). • Changed gate logic TCS1G-TTRIP from OR gate to AND gate. • Updated various Common Cause Failure (CCF) values. • Added CRD under OR gate for power level control (lowered level) with Reactor Core Isolation Cooling (RCIC). • Changed data for battery unavailability based on current operating practices and system engineer estimates. • Renamed initiators to help identify applicable unit. • Changed truncation for model quantification from 2E-9/yr to 5E-10/yr • Upgraded to 32 bit Cutset and Fault Tree Analysis (CAFTA) software. • Model Release: BNP-PSA-001, Rev. 4.
MOR03 L2	(SAMA)		2.13E-6	• Level 2 update corresponds to MOR03 cutsets. • Twelve defined radionuclide release categories including LERF.
MOR04 L1	(DRAFT)			• Model update addressing Peer Certification Level B facts and observations. • Changes described in RAI – 1.h below.
MOR04 L2	(DRAFT)			• Level 2 update corresponding to MOR04 cutsets. .

Response to NRC RAI SAMA1-1, Item h

The SAMA analysis was based on the current model of record "MOR03" which existed at the time of the license renewal application. The current model is a subsequent update of PSA model MOR98R1 that was deemed acceptable by the peer review in that "all elements were consistently graded as sufficient for use in supporting risk informed decisions when combined with deterministic insights (i.e., a blended approach)". Resolution of the outstanding Level B facts and observations and update of MOR03 is still in progress. Much effort is being expended to resolve peer comments. Without the satisfactory completion of these changes, there is no qualified method for definitively answering the cost beneficial question raised by this RAI at this time. However, based on the nature of the modeling changes being considered and as discussed below, it is expected that there may be a small number of previously identified SAMAs that could change to cost beneficial or be further validated as cost beneficial.

The information included below addresses some of the major changes being made to address the Peer Review Certification comments, followed by an explanation of the impact on CDF and offsite consequences, and the potential to impact the overall SAMA conclusions.

The PSA model is being updated to address the remaining "B Level" facts and observations (F&Os) provided by BWROG Peer Certification team. The scope of this update includes resolution of the 60 outstanding peer review level B F&Os which encompass the issues summarized below. The primary issues associated with the "B Level" facts and observations that are being addressed by the model update are as follows:

1. Need to address SRV (safety/relief valve) reclosure in DHR (decay heat removal) sequences where containment pressurizes.
2. Need to address NPSH issues in scenarios involving failure of suppression pool cooling and successful containment venting.
3. Need to address reactor building environmental conditions in scenarios where containment failure occurs prior to core damage.
4. Need to address potential conservatisms in the model dealing with common cause failure double counting, HVAC modeling for the diesel generator cells, failure of DC initiating events, modeling of CRD (control rod drive) initiating events, and including ARI (alternate rod injection) for ATWS events, and excluding manual shutdowns.
5. Need to address potentially non-conservative loss of offsite power initiating event data. Note that the loss of offsite power initiating event frequency was updated for MOR03 in response to the peer review comments. However, data update to the latest industry standards remains to be done in the subsequent model update.
6. Need to refine the human error probability (HEP) estimates in the Human Reliability Analysis (HRA). The resolution of the HRA observations is expected to result in data enhancements by refining the bases used to define the HEPs and reducing the number of screening values used in the model.

The PSA model is being changed to more closely resemble the current NRC SDP (Significance Determination Process) event trees for BSEP associated with containment venting and late injection. The model is being changed to eliminate credit for late injection in sequences where all DHR has failed. The resultant changes to the model are intended to address SRV reclosure, NPSH issues, and the concerns about harsh environment in the reactor building after containment failure.

It has been confirmed that failure of CRD or loss of DC bus should be treated in the initiating event analyses. The selection of DC initiating events is being refined (eliminating some DC buses). Also, loss of 250 VDC is being added to the model to address potential common N/P bus failure. The CRD initiating events model is being retained (not excluded as recommended by the peer review team), but some refinements are being implemented in the logic to remove excess conservatism.

Several CCF (common cause failure) events for the support systems of the emergency diesel generators (EDG) are being removed from the model to more appropriately reflect component failure boundaries and to eliminate double counting. In addition, changes are being made to the success criteria for the EDG's HVAC to better depict its actual design bases and remove conservatisms (identified as overly conservative).

Updates are being performed to ATWS mitigation system reliability data (NUREG/CR-5500 Vol. 3), and logic changes are being incorporated to credit ARI.

The net result of all sequence modeling changes (e.g. SRV reclosure, NPSH, harsh environment) are expected to yield additional core damage sequences associated with loss of injection late, or complete loss of DHR (e.g. TQWZ). These sequences result in core damage and containment failure in time frames that exceed 30 hours from the event initiation. However, all of these TW (Class II) scenarios are being treated as intermediate time release categories based on inferred timing associated with the implementation of the Brunswick EALs (Emergency Action Levels) and the declaration of a General Emergency. It should be noted that modeling changes associated with the resolution of peer review facts and observations are expected to yield an increase in Class II sequences resulting in potential increase to release category H/I. This is a useful insight since it supports consideration of modifications that enhance the reliability of the DHR mitigation system. However, the following conservative modeling assumptions need to be considered in the evaluation of SAMAs:

1. All TW (Class II) sequences are assigned to the intermediate timing release categories (>6 hrs and <24 hrs) based on the inferred timing associated with the BSEP EALs. However, the supporting MAAP analysis (Ref. 1) indicates that core damage and containment failure is significantly delayed (> 24) in Class II sequences where CRD is available and would allow substantial time for operator actions.
2. The PSA model does not credit recovery of the condenser with the exception of LOOP scenarios (i.e. the probability of failing to restore offsite power is included in all LOOP sequences).
3. A conservative modeling error has been recently identified in the support systems for Hardened Wetwell Vent. The solenoid valves in the Nitrogen Backup system fail open on loss of power, and the power dependency should be removed from this model.
4. The Level 2 model uses screening values for some operator errors in sequences that currently do not significantly contribute to the release category profile.

As identified above, changes in the treatment of SRV re-closure and late containment injection are the issues that could yield risk increases for BSEP and potentially result in the retention of some SAMAs. The potential candidates for retention are believed to include those SAMAs that have averted cost-risks that are close to their costs of implementation, but were not positively identified as cost beneficial in baseline ER SAMA analysis. In addition, it is assumed that these SAMAs would have to have some impact on heat removal or late injection in order to have the potential to become cost beneficial. The type of SAMA modifications that would help mitigate these Class II sequences are expected to involve improving the reliability of DHR and providing injection water to the containment. It should be noted that Phase II SAMA Number 36 addresses some of these issues and is already considered cost beneficial (see SAMA Appendix F.6.24). Other SAMA candidates were considered as shown below:

- Phase II SAMA 6 is a procedural change that would provide guidance to energize any given 4kV emergency bus from any other 4kV emergency bus. However, the actual benefit of this change may be limited given that loss of DHR sequences are long evolutions in which the TSC and on-site staff would likely perform any 4kV cross-tie given that the hardware is in place to support it.

- Phase II SAMA 13 suggests installing an inter-unit CRD cross-tie. Implementation of SAMA 13 could help mitigate the consequences associated with the Class II sequences by delaying the onset of core damage and containment failure. However, the cross-tie introduces the potential to fail the CRD system on the opposite unit. In addition, it was always assumed that the reason for the initial CRD failure would not prevent that cross-tie from being performed. As a result, the actual benefit of this SAMA may be limited and it is not considered to be a candidate for retention.

- Phase II SAMA 34 suggests removing the switchyard's station battery dependence so that a means of aligning off-site power will be available when the station batteries are depleted. Recovery of AC power in loss of DHR scenarios appears to be a viable means of reducing risk and one that may be shown to be cost beneficial if the "B" F&Os were incorporated into the PRA.

Changes are being made to both the CRD and DC system initiating events. The changes to the CRD initiating event are expected to result in a significant reduction in the contribution for this initiator. The modeling changes to DC initiating events are expected to yield approximately the same absolute and relative contribution to the CDF initiating event risk profile. Since the contribution to CDF of these initiating events either is expected to reduce or remain practically unchanged, the consequences associated with these results would not be expected to result in the need to consider any additional SAMA modifications.

Changes to the EDG CCF and EDG HVAC success criteria are expected to result in a net reduction to the contribution of LOSP (loss of station offsite power) to the initiator distribution. The loss of offsite power frequencies are updated periodically to incorporate both plant and industry data. It should be noted that loss of offsite power frequencies that are used for MOR03 (i.e. used in the ER) include adjustment based upon peer review comments. The MOR03 site and unit loss of offsite power initiating frequencies are 2.3E-2/yr and 1.4E-2/yr versus the MOR98R1 site and unit loss of offsite power frequencies (reviewed by the certification team) of 1.5E-2/yr and 9.8E-3/yr. The removal of CCFs, and refinement in EDG cell HVAC success criteria tend to reduce the contribution of early core damage due to loss of offsite power and would not be expected to result in the need to consider any additional SAMA modifications.

Similarly, the net changes to ATWS data are expected to result in a significant reduction in LERF since ATWS scenarios previously contributed approximately 75% of LERF. The significant reduction in LERF represents a significant decrease in the radiological release consequences, and thus would not be expected to result in the need to consider any additional SAMA modifications. The lower contribution to LERF may even result in a potential elimination of SAMAs that were retained in the analysis.

NRC RAI SAMA1-2

Provide the following with regard to the treatment of external events in the SAMA analysis:

a. In section F.1.2.1.2 of the ER, Progress Energy states that "Based on a review of the IPEEE seismic results, no plant enhancements were identified and then not pursued based on cost concerns for Brunswick." Confirm whether there were any plant enhancements identified and not pursued for reasons other than cost. If so, provide a brief discussion.

b. The 1988 BSEP PSA included external events with a seismic contribution to CDF of $6.6x10^{-5}$ per year. This was characterized as a preliminary seismic risk assessment and it was stated "that with more refined ongoing and planned analysis of seismic events, the core damage results will be significantly reduced." Describe any follow-on seismic risk analyses undertaken on BSEP.

c. In Section F.1.2.1.5 of the ER, it is indicated that any averted cost-risk calculated for a SAMA is initially multiplied by two to account for the corresponding reduction in external events, and that insights from the external events evaluations are used, where appropriate, to modify the initial factor of two multiplier. However, a concluding sentence states that no adjustments have been made in the BSEP analysis to further alter the factor of two multiplier. Confirm that the averted cost-risk values reported for all SAMAs within Section F.6.1 of the ER include the factor of two. Identify those the SAMAs for which the factor was modified, if any.

Response to NRC RAI SAMA1-2

Response to NRC RAI SAMA1-2, Item a

By letter dated June 30, 1995 CP&L submitted to the NRC the BSEP Individual Plant Examination for External Events (IPEEE). Section 3.3 of the BSEP IPEEE indicates that there were no seismic vulnerability concerns at BSEP and no IPEEE seismic enhancements were suggested. Therefore, no IPEEE seismic enhancements were identified and then discarded for reasons other than cost.

Response to NRC RAI SAMA1-2, Item b

There have been no subsequent follow-on enhancements of the preliminary seismic risk analyses for BSEP that provide CDF calculations. However, a subsequent analysis of seismic events was performed for the BSEP IPEEE submittal using the Seismic Margins analysis as indicated in section F.1.2.1.2 of the SAMA analysis. This analysis assessed whether the plant is designed and constructed so that it can be safely shut down following a Review Level Earthquake (RLE). This study identified no seismic vulnerability concerns for BSEP. The IPEEE did indicate that a number of seismic outliers, which were identified either through the Unresolved Safety Issue (USI) A-46 or the IPEEE processes, were being resolved. These seismic outliers have been resolved for BSEP as confirmed in prior regulatory correspondence, i.e., BSEP letter to NRC (Serial: BSEP 98-0145), "Generic Letter 87-02, 'Verification of Seismic Adequacy of Electrical and Mechanical Equipment in Operating Plants, USI A-46,'" dated September 11, 1998, NRC TAC Nos. 69433 and 69434. As committed in Appendix A of the IPEEE, all seismic outliers (i.e., IPEEE and USI A-46) were resolved in a manner to satisfy the IPEEE assumptions and conclusions that the plant High Confidence in Low Probability Failure (HCLPF) is at least at the RLE of 0.3g.

Response to NRC RAI SAMA1-2, Item c

The BSEP SAMA methodology included an option to increase the external events contribution multiplier from two to a larger multiplier if it was determined that a given SAMA would have a much larger impact on external events risk than on internal events risk. However, the information that was available related to the external events models was limited, and no cases were identified where it was clear that increasing the multiplier to a factor greater than two was justified. As a result, all of the averted cost-risk calculations use a factor of two to account for external events contributions.

The PSA based calculations incorporate the factor of two by multiplying the averted cost-risk results yielded by model runs by two. All but four of the Phase 2 SAMAs are addressed in this manner. The four exceptions are those SAMAs that were identified based on the external events insights. An alternate means of quantifying the averted cost-risk for these SAMAs was required because the internal events model does not contain logic that is capable of measuring the impact of implementing these SAMAs. These SAMAs include:

- Phase 2 SAMA 30: Improve Alternate Shutdown Panel
- Phase 2 SAMA 31: Improve Alternate Shutdown Panel Training and Equipment
- Phase 2 SAMA 32: Add Automatic Fire Suppression System
- Phase 2 SAMA 33: Improve Fire Barriers Between Cabinets in the Cable Spreading Room

The averted cost-risk calculations for these SAMAs begin with the assumption that the external events risk is equivalent to the internal events risk. For BSEP, the internal events based Maximum Averted Cost-Risk (MACR) is approximately $4,794,000. It follows that the external events-based contribution to the MACR is also $4,794,000. The largest risk reduction possible for any SAMA that only impacts external events-based risk is, therefore, $4,794,000. In order to estimate the potential benefit of a SAMA that reduces external events risk, it is necessary to identify the portion of the total external events-based cost-risk that the SAMA would impact. This is performed using the information that is available in the IPEEE and some basic assumptions. For example, it is assumed that Internal Fires contribute 75 percent of the external events based risk (i.e., $3,595,500). If Control Room fires were determined to comprise 53.3 percent of all fire risk, and a SAMA was developed that would eliminate all Control Room fires, the averted cost-risk for the SAMA would be about $1,916,402. This method is considered to be capable of providing rough averted cost-risk estimates for the external events based SAMAs.

In the event that an external events based SAMA had the potential to impact the internal events results, the corresponding averted cost-risk calculation for the SAMA would have to account for the change in internal events risk. None of the BSEP external events based SAMAs have a measurable impact on the internal events results and this step is not required.

<u>NRC RAI SAMA1-3</u>

The MACCS2 analysis for BSEP is based on a reference BWR core inventory at end-of-cycle, scaled by the power level for BSEP. The calculations were based on a three-year fuel cycle (12 month reload) with an average power density for the assembly groups ranging from 24 to 30 MW/MTU. Current BWR fuel management practices use longer fuel cycles (time between refueling) and result in significantly higher fuel burnups. The use of the reference BW R core instead of a plant specific cycle could significantly underestimate the inventory of long-lived radionuclides important to population dose (such as Sr-90, Cs-134 and Cs-137), and thus impact the SAMA evaluation. Justify the adequacy of the SAMA identification and screening given the fuel enrichment and burnup expected at BSEP during the renewal period.

Response to NRC RAI SAMA1-3

A comparison was made with another plant to investigate the difference in the dose evaluation using the scaled MACCS2 initial core inventory vs. current plant-specific values. The MACCS2 calculation using the plant-specific core inventories yielded a maximum dose that was about 20% larger when compared to the case using the scaled inventories. The economic cost increase was only on the order of a few percent. As a way to investigate the potential sensitivity to using the scaled MACCS2 inventories, the results of the BSEP dose evaluation were increased by 20% and the economic cost by 3%. The resulting MACR increased by 6%. The Phase II SAMA results summarized in Section F.6.28 were reviewed assuming a 6% increase in the averted cost risk, and only two of the SAMAs showed that they would be potentially cost beneficial. These were Phase II SAMAs 13 and 34. Both of these were also identified as potentially cost beneficial as a result of the uncertainty analysis performed in Section F.7.1 and F.7.2.

NRC RAI SAMA1-4

Provide the following with regard to the SAMA identification and screening processes:

a. It is not clear-that all of the potential SAMAs identified in Sections F.5.1.3 - F.5.1.5 and in Tables F-13 and F-14 of the ER are included in Table F-15, e.g., specific SAMAs are not identified for several important events, such as events %TE_S, and OPER-ALTUNITXC in Table F-13. Provide a cross-reference between the potential SAMAS identified in these sections and tables and the SAMAs in Table F-15.

b. Briefly describe how the information in Table A-1 of the Addendum to Appendix F of the ER was used in the identification of SAMAs.

c. In Table F-15 of the ER, Phase I SAMA 38 is said to address the same issues as Phase I SAMA 27. However, SAMA 27 is indicated as "Not Used." Provide an evaluation for Phase I SAMA 38 (at 3 percent and 7 percent), including implementation costs.

Response to NRC RAI SAMA1-4

Response to NRC RAI SAMA1-4, Item a

The response to this RAI is provided in two parts. The first addresses the potential enhancements identified in Sections F.5.1.3 through F.5.1.5; the second, the potential enhancements identified in Tables F-13 and F-14.

Part 1: The following list provides the BSEP Phase 1 SAMA ID corresponding to each of the potential enhancements that were identified in sections F.5.1.3 through F.5.1.5:

- Diverse Emergency Diesel Generator (EDG) HVAC Logic (SAMA 17)
- Add Alternate/Manual Methods for Containment Venting (SAMA 38)
- Use Fire Water as a Backup for EDG Cooling (SAMA 40)
- Auto Re-Fill of the Condensate Storage Tank (CST) (SAMA 41)
- Use Fire Water as a Backup for Containment Spray (SAMA 42)
- Demonstrate RCIC Operation following Depressurization (SAMA 43)
- Enhance Emergency Operating Procedures (EOPs) to Include Control Band for Containment Venting (SAMA 44)
- Add another Diesel Generator (SAMA 25)
- Dedicated DC power supply for switchyard breakers (SAMA 39)
- Improve Alternate Shutdown Panel (SAMA 33)
- Improve Alternate Shutdown Panel Training and Communications Equipment (SAMA 34)
- Add Automatic Fire Suppression System (SAMA 35)
- Prohibit Transient Combustibles in the Cable Spreading Room and/or Require Fire Suppression Personnel to be Present During Work that May Cause a Fire (SAMA 36)
- Improve Fire Barriers between Cabinets in the Cable Spreading Room (SAMA 37)
- Add Alternate/Manual Methods for Containment Venting (SAMA 38)

Part 2: ER Tables F-13 and F-14 have been modified with the corresponding Phase 1 SAMA ID number next to each of the potential enhancements identified for each PSA event in the table: The modified tables are attached to this enclosure.

<u>Response to NRC RAI SAMA1-4, Item b</u>

While the importance lists from the BSEP PRA model were used to identify the areas with the greatest potential for yielding cost beneficial improvements, the importance results themselves did not necessarily provide insights into the types of changes that could be made. Table A-1 of the Addendum to Appendix F was used to fill this role.

Plant specific SAMAs could have been developed for BSEP without referencing previous industry work; however, review of the industry based SAMAs reduced the time required to complete the SAMA identification process and provided the benefit of introducing ideas that may not have been developed for BSEP in isolation. Given that, it was recognized that the industry based SAMAs included in Table A-1 did not always represent the most applicable enhancement for BSEP. The plant enhancements included in Table A-1 served as a starting point for BSEP and were refined based on plant specific requirements or replaced with lower cost alternatives. In some cases, none of the changes included in Table A-1 addressed the events important to BSEP, and it was necessary to develop completely new SAMAs.

Response to NRC RAI SAMA1-4, Item c

Phase I SAMA 38 proposes an alternate or manual method of containment venting, which was identified based on a review of BSEP PSA results and previous industry SAMAs. However, further review of the BSEP PSA model revealed that the treatment of containment venting in the BSEP PSA model is conservative and that plant enhancements related to containment venting could yield artificially high averted cost-risks. In order to more accurately assess the averted cost-risk associated with Phase I SAMA 38, it was necessary to create a new baseline model by removing the conservative bias in the model.

The table below identifies the change made to the baseline BSEP SAMA model to create the "RAI4c baseline model":

Changes to Create the RAI 4c Baseline Model from the SAMA Baseline Model	
Gate and / or Basic Event ID and Description	**Description of Change**
• IAN2G1166: FAILURE OF BOTTLED NITROGEN SUPPLY HEADER B	Deleted gate IAN2G213: LOSS OF POWER TO VALVE 5481

This change was made to account for the fact that solenoid valve SV-5481 fails open on loss of power. Previously, loss of power to SV-5481 was assumed to result in failure to supply the nitrogen header with flow from the Nitrogen Backup Supply; however, this change captures the "fail-safe" nature of the valve.

With respect to implementation of Phase I SAMA 38, the types of changes that might be considered include the following:

- Use of a portable air compressor to provide motive power to the air operated containment vent valves,
- Use of a portable generator to provide power to the solenoids controlling the vent valves,
- Use of both a portable air compressor and a generator to ensure that both air and power are available for supporting the vent function,

- Modify the vent valves such that they could be operated manually (without air or power),
- Install an alternate vent path.

Of the potential enhancements listed above, providing a means of aligning an alternate source of power and air to the vent valves has been selected to represent the implementation of Phase I SAMA 38 for this analysis. This incarnation of the SAMA is preferred over the other alternatives based on its potential effectiveness. Installation of an alternate vent path would require containment changes that would likely be too costly and local, manual operation of the vent valves may be precluded by the harsh environmental conditions that could exist in the scenarios when alternate containment venting is required.

In addition to providing alternate air and control power to the vent valves, this SAMA was also assumed to be capable of providing power to the containment isolation bypass circuitry.

Starting with the RAI 4c baseline model described above, the following model changes were performed to represent implementation of Phase I SAMA 38:

PHASE I SAMA 38 MODEL CHANGES

Gate and / or Basic Event ID and Description	Description of Change
CAC2G-V7-FTO: CONTAINMENT ATMOSPHERIC CONTROL VALVE CAC-V7 FAILS TO OPEN	•Add new AND gate AIR-ALTA •Add new AND gate PWR-ALTA •Delete gate CAC2G-521 •Delete gate CAC2G-ACP312AB
CAC2G-V216-FTO: NORMAL AND ALT PWR SUPPLY FOR CAC-V216 AIR SOLENOID VALVE FAIL	•Add new AND gate AIR-ALTB •Add new AND gate PWR-ALTB •Delete gate CAC2G-534 •Delete gate CAC2G-ACP312AB
CAC2G-499: LOSS OF POWER FROM 120 VAC DISTRIBUTION PANEL 31AB AT UNIT 1 OR 32AB AT UNIT 2	•Add new AND gate PWR-ALTC •Delete gate CAC2G-ACP312AB
CAC2G-497: FAILURE TO OVERRIDE PCIS GROUP 6 ISOLATION DIVISION II	•Add new AND gate PWR-ALTD •Delete gate CAC2G-ACP
AIR-ALTA: NORMAL AND ALTERNATE AIR SUPPLY FOR CAC-V7 FAIL	New AND gate with the following input gates: ○OP-ALT ○CAC2G-521

PHASE I SAMA 38 MODEL CHANGES	
Gate and / or Basic Event ID and Description	**Description of Change**
AIR-ALTB: NORMAL AND ALTERNATE AIR SUPPLY FOR V216 FAIL	New AND gate with the following input gates: ○OP-ALT ○CAC2G-534
PWR-ALTA: NORMAL AND ALT PWR SUPPLY FOR CAC-V7 AIR SOLENOID VALVE FAIL	New AND gate with the following input gates: ○OP-ALT ○CAC2G-ACP312AB
PWR-ALTB: NORMAL AND ALT PWR SUPPLY FOR CAC-V7 AIR SOLENOID VALVE FAIL	New AND gate with the following input gates: ○OP-ALT ○CAC2G-ACP312AB
PWR-ALTC: OP ALIGNS POWER TO OVERRIDE ISOLATION	New AND gate with the following input gates: ○OP-ALT ○CAC2G-ACP312AB
PWR-ALTD: OP ALIGNS POWER TO OVERRIDE ISOLATION	New AND gate with the following input gates: ○OP-ALT ○CAC2G-ACP
OP-ALT: OPERATOR FAILS TO ALIGN ALTERNATE MOTIVE SOURCE FOR VALVE	New HEP with failure probability of 5E-2.

In addition to these Level 1 model changes, the Level 2 model was reviewed to identify areas where improved venting capability would provide a risk reduction. This was required given that the venting changes directly impact Level 2 model functions that can operate independently from Level 1 results.

All sequences in the baseline Level 2 SAMA model containing vent failures were set to zero to conservatively estimate the reduction in the release category frequencies based on potential vent improvements. No effort was expended to update the Level 2 model based on the insights related to the “fail-safe” mode for SV-5481. Instead, the baseline SAMA model, in which venting is more important, was used to bound the potential risk reduction for SAMA 38. The only measurable change related to the elimination of containment vent failures in the Level 2 model was found to be in the LL/L release category frequency, which changed from 2.34E-7 to 0.0.

This insight was carried over to the cost-benefit calculations for SAMA 38 by reducing the frequency of the LL/L release category to 0.0 in the results representing the SAMA's implementation.

The model resulting from these changes will be referred to henceforth as the SAMA 38 model.

COST OF IMPLEMENTATION

No plant specific cost of implementation has been developed for Phase I SAMA 38. The cost of implementation for Phase II SAMA 1 has been used as a starting point to provide a rough estimate of the cost that could be expected assuming that the magnitude of the types changes for Phase I SAMA 38 and Phase II SAMA 1 are similar. In order to account for the use of a portable air compressor in addition to the portable generator considered in Phase II SAMA 1, the cost of implementation is doubled for Phase I SAMA 38 to yield $978,554. This does not include the increase in the cost of implementation for Phase II SAMA 1 described in RAI 5b to account for full dual unit implementation of that SAMA.

RESULTS

The net value for this SAMA is based on the delta between the RAI 4c baseline model and the SAMA 38 model. In order to clearly document the net value calculation for Phase I SAMA 38, the results for the RAI 4c baseline model and the SAMA 38 model are presented separately and then compared to calculate the net value.

RAI 4.c BASELINE MODEL RESULTS

The CDF for the RAI 4c baseline model is 4.07E-5/yr, the dose risk is 27.15 person-rem per year, and the Offsite Economic Cost-Risk is $43,166 per year. A further breakdown of this information is provided below according to release category. Note that the "containment intact" information is not included here and that the "total frequency" shown in the following table does not include that term.

RAI 4.c Baseline Model Results By Release Category

Rel. Cat.	**1-H/E**	**2-H/I**	**3-M/E**	**4-M/I**	**5-L/E**	**6-L/I**	**7-L/L**	**8-LL/I**	**9-LL/L**	**Total**
Freq.	2.13E-06	2.97E-06	1.62E-06	1.04E-05	3.31E-06	1.26E-08	2.01E-06	7.04E-08	2.34E-07	2.28E-05
Dose-Risk	5.50	7.16	1.83	11.54	1.06	0.00	0.01	0.01	0.04	27.15
OECR	$4,643	$18,087	$1,895	$17,368	$1,152	$1	$1	$4	$14	$43,166

SAMA 38 MODEL RESULTS

The CDF for the SAMA 38 model is 4.06E-5/yr, the dose risk is 26.96 person-rem per year, and the Offsite Economic Cost-Risk is $42,786 per year. A further breakdown of this information is provided below according to release category. Note that the "containment intact" information is not included here and that the "total frequency" shown in the following table does not include that term.

SAMA 38 Model Results By Release Category

Rel. Cat.	1-H/E	2-H/I	3-M/E	4-M/I	5-L/E	6-L/I	7-L/L	8-LL/I	9-LL/L	Total
Freq.	2.13E-06	2.91E-06	1.62E-06	1.04E-05	3.31E-06	8.55E-09	2.01E-06	7.04E-08	0.00E+00	2.25E-05
Dose-Risk	5.50	7.01	1.83	11.54	1.06	0.00	0.01	0.01	0.00	26.96
OECR	$4,643	$17,722	$1,895	$17,368	$1,152	$0	$1	$4	$0	$42,786

NET VALUE FOR SAMA 38

As shown in the results presented above, implementation of Phase I SAMA 38 yielded a minimal change in the CDF. The differences in the dose-risk and offsite economic cost-risk are also small and are likely beyond what would be considered a measurable change in plant risk; however, these changes were carried through the cost benefit calculations for demonstration purposes. As requested, the cost benefit calculation was performed using both the 7 percent real discount rate and the 3 percent real discount rate. The following two tables summarize these results:

SAMA 38 Net Value (7 percent real discount rate)

RAI4c Base Case: Cost-Risk for BSEP (site)	Cost-Risk for BSEP With SAMA Changes	Averted Cost-Risk	Cost of Implementation	Net Value
$9,028,000	$8,983,415	$44,585	$978,554	**-$933,969**

SAMA 38 Net Value (3 percent real discount rate)

RAI4c Base Case: Cost-Risk for BSEP (site)	Cost-Risk for BSEP With SAMA Changes	Averted Cost-Risk	Cost of Implementation	Net Value
$10,648,000	$10,590,528	$57,472	$978,554	**-$921,082**

The net values for both of the cases above are negative by almost $1 million and indicate that this SAMA is not a cost beneficial change for Brunswick. Given the small averted

cost-risk related to improving venting capability, no cost beneficial venting improvements are considered to be credible for BSEP.

<u>NRC RAI SAMA1-5</u>

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

a. Detailed descriptions of the PSA assumptions/modifications made to estimate the risk reduction are provided for each SAMA in Section F.6 of the ER. In order to accurately reflect the assumptions in the Summary table that is typically included in the staff's evaluation (see the summary table in prior EIS supplements for examples), provide a concise high-level statement for each SAMA that captures the assumed impact of the SAMA, e.g., eliminate all ISLOCA events; reduce RHR pump failure by a factor of two.

b. In Table F-16, the implementation cost for Phase II SAMA 1 is stated to be for a single unit site. However, the benefit estimate is based on the risk reduction achieved at both units. Even if only one portable DC generator is provided there may be some added cost for implementing the SAMA for both units. Provide an explanation.

c. The discussion of Phase II SAMA 13 indicates that this SAMA would not be beneficial for the loss of control rod drive (CRD) initiator but that there would be some benefit for other loss of makeup sequences. The benefit analysis indicates a 6.4 percent reduction in CDF and a 9.3 percent reduction in person-rem doses (dose risk). These reductions appear higher than expected considering that no CRD failures appear in the importance list of Table F-13. Please explain.

d. Phase II SAMA 18 is modeled by setting the loss of 4 kV bus initiators to zero and is stated to reduce the CDF by 3.1 percent. Figure F-2 of the ER indicates that the total CDF due to loss of AC "E"-bus (emergency bus) is 5.7 percent. Explain the difference. Also, discuss if eliminating the failure of an "E"-bus during other initiating events also makes a contribution to the estimated benefit for this SAMA.

e. The cost of implementing Phase II SAMA 31 is given as $250,000. This seems high for changes that appear to be limited to improved training and communications equipment. Provide a further explanation for this cost.

f. The description of the estimated benefit of Phase II SAMA 32 in Section F.6.21 of the ER indicates that only improvements in the North Central and North West areas elevation 20' of the reactor building were considered. Table F-16 indicates that the cost of implementation for this SAMA is based on work in additional fire areas (including the South area, the control room cabinets, and the Switchgear Rooms). Please reconcile these apparent inconsistencies and justify the cost estimate.

g. Information in Sections F.6.11.1 and F.6.28 of the ER indicate that Phase II SAMA 16 is not cost-beneficial. However, the entry in Table F-16 for this SAMA states that the cost of implementation is less than the averted cost-risk ($135,817), and that this SAMA has been retained for further evaluation. Clarify this apparent discrepancy.

h. Phase I SAMA 25 (5th Diesel Generator) is estimated in Table F-15 to cost more than $20M. This is presumably a safety-grade installation with permanent connections to the E-buses. Address the viability and costs of providing a non-safety grade installation with more expedient connections as an alternative.

Response to NRC RAI SAMA1-5

Response to NRC RAI SAMA1-5, Item a

Given the complexity of some of the BSEP SAMAs, a detailed review of the model change descriptions presented in the ER is required to understand the full scope of each SAMA's consequences. However, high level descriptions of the Phase 2 SAMAs have been provided in the following table in order to summarize the major issues addressed by each SAMA:

Phase 2 SAMA ID	SAMA Description	High Level Summary of the SAMA's Impact
1	Portable DC Generator	This SAMA increases the time available for AC power recovery from time to loss of turbine driven injection at battery depletion to the time to boildown to top of active fuel after loss of turbine driven injection at HCTL. It also allows the alignment of the portable generator to support DC loads in non-station blackout cases when the normal DC supply is unavailable. A lumped failure probability of 1E-2 is used to represent operator alignment errors and hardware failures of the portable generator.
3	Provide the Main Control Room With the Capability to Align the UAT to the "E" Buses	This SAMA reduces the manipulation time required to align the Unit Auxiliary Transformer to the "E" buses when a Loss of Offsite Power occurs due to failure of the Startup Auxiliary Transformer. The SAMA is assumed to reduce the HEP for the action is reduced from 1.8E-1 to 4.1E-2 based on reduced manipulation time and improved man-machine interface.
4	Direct Drive Diesel Injection Pump	This motor driven high flow, high pressure injection source supplements existing high pressure injection sources and is capable of operating in an SBO. The injection path is defined to be through an existing Feedwater injection line and Division II DC power is required for success. A lumped failure probability of 5E-2 is used to represent operator alignment errors and hardware failures of the pump.
5	Enhanced CRD Flow	The installation of higher output CRD pumps is assumed to result in an increase in the CRD injection flow rate such that it is capable of making up for boil-off even in the early time frame for transient sequences.

Phase 2 SAMA ID	SAMA Description	High Level Summary of the SAMA's Impact
6	Proceduralize all Potential 4kV AC Bus Cross-tie Actions	This SAMA assumes that the plant Abnormal Operating Procedures are updated such that instructions are available to provide power from any given emergency 4kV AC bus to any other emergency 4kV AC bus in accident conditions. The existing inter-divisional cross-tie HEP is used to represent the failure probability of the inter-unit cross-tie actions based on the procedure improvements (to previous inter-unit HEP considers only the existing procedural guidance). Complete dependence is assumed between all 4kV AC cross-tie actions.
10	Improved Procedures/Equipment to Prevent Boron Washout	This SAMA proposes an upgrade of the LPCI controls to allow more precise control over the injection flow rate in an ATWS. Based on a review of the HRA and assumed improvements in the man-machine interface, the HEP for the flow control action was reduced from 4.3E-2 to 3.4E-2. The corresponding dependent HEPs were also adjusted to account for the change in the base HEP.
11	Enhance the Main Control Room to Include the Capability to Perform 480v AC Substation Cross-tie	This SAMA improves the HEPs governing the 480v AC cross-tie actions by reducing the time required to perform the action and by improving man-machine interface of the controls used in the action. Based on a review of the HRA, the HEP for the cross-tie action was reduced from 6.9E-2 to 2.1E-2. The corresponding dependent HEPs were also adjusted to account for the change in the base HEP.
12	Enhance the Main Control Room to Include Capability to Align the Alternate DC Power Supply to Specific Panels	This SAMA reduces the HEPs governing the DC alternate power alignment actions by reducing the time required to perform the action and by improving man-machine interface of the controls used in the action. Based on a review of the HRA, the HEP for the alternate alignment action was reduced from 1.2E-1 to 8.4E-2. The corresponding dependent HEPs were also adjusted to account for the change in the base HEP.
13	Inter-Unit CRD Cross-tie	This SAMA credits the use of the opposite unit's CRD system as an additional means of providing high pressure injection. While not credited for preventing a Loss of CRD initiating event or for providing injection during an ATWS, the cross-tie is assumed to be capable of providing makeup for transient cases. A lumped failure probability of 5E-2 is used to represent operator alignment errors and hardware failures of the cross-tie flow path.
15	Diverse EDG HVAC Logic	The failures of EDG HVAC initiation due to malfunction of the logic systems are reduced through the addition of a redundant logic train. A lumped failure probability of 1E-2 is used to represent hardware and support system failures for the alternate logic train.
16	Diverse Swing DG Air Compressor	This SAMA provides a diverse, diesel driven air compressor that can be used to start any/all of the emergency diesel generators given a common cause failure of the normal starting system. Implementation of this SAMA is represented through the elimination of the common cause failure to start term of EDG Starting Air Compressors.

Phase 2 SAMA ID	SAMA Description	High Level Summary of the SAMA's Impact
17	Provide Alternate Feeds to Panels Supplied by DC Bus 2A-1	This SAMA assumed that it was possible to directly supply the loads for DC Bus 2A-1 with a portable generator given failure of the bus. This is different from Phase 2 SAMA 1 in that it only supplies the 2A-1 loads and can be used when the bus has failed. The alignment action is assigned the same 1.2E-1 failure probability that is used for similar alternate power source alignments used in the model. No additional changes were included for the generator hardware failures as they were considered to be small compared to the HEP.
18	Provide Alternate Feeds to Essential Loads Directly from an Alternate "E" Bus	Supplying power to directly to the loads of 4kV emergency buses from another 4kV bus allows for the operation of required equipment even after a bus failure. This was represented by eliminating the loss of emergency 4kV bus initiating events. Bus failures during other initiating events are negligible and were not addressed for modeling simplicity.
19	Provide an Alternate Means of Supplying the Instrument Air Header	This SAMA models the use of a portable compressor that can be used to mitigate a loss of the Instrument Air compressors (due to either compressor failure or support system failure). A lumped failure probability of 1E-2 is used to represent hardware and operator failures for the alignment of the portable compressor.
20	Enhance the Main Control Room to Include Capability to Swap AC Power Supplies to the Battery Chargers	Implementation of this SAMA allows the operator to swap AC supplies to the battery chargers from the control room. Based on similar actions included in the BSEP model, an HEP of 1E-2 is assigned to the action.
21	Enhance CRD Logic	This SAMA reduces the probability of loss of CRD system flow by allowing the automatic bypass of the drive path and suction filters given plugging/clogging. The bypass path failure probabilities include events for logic/support system failures (5E-4) and MOV failures (3E-3).
22	Install Self Cooled CRD Pumps	This SAMA is assumed to eliminate the cooling dependency for the CRD pumps.
25	Proceduralize Battery Charger High Voltage Shutdown Circuit Inhibit	Implementation of this procedure allows the operators to prevent the loss of the battery chargers as a DC source when the batteries have failed or are unavailable. The failure probability of 5E-2 is assigned to the HEP used to represent High Voltage Shutdown Circuit Inhibit.
29	Portable EDG Fuel Oil Transfer Pump	Use of the portable fuel oil transfer pump reduces the contribution of sequences including failure of the existing EDG fuel oil transfer pumps. A lumped failure probability of 1E-2 is used to represent hardware and operator failures for the alignment and operator of the portable fuel transfer pumps.
30	Improve Alternate Shutdown Panel	This SAMA is assumed to impact all control room fire scenarios and that the revised shutdown panel will improve operator reliability over the use of the current panel by a factor of five.
31	Improved Alternate Shutdown Training and Equipment	This SAMA is assumed to impact all control room fire scenarios and that the revised shutdown panel will improve operator reliability over the use of the current panel by ten percent.

Phase 2 SAMA ID	SAMA Description	High Level Summary of the SAMA's Impact
32	Add Automatic Fire Suppression System	Addition of an Automatic Fire Suppression system is assumed to be viable in the 20 foot elevation of the North Central and North West areas of the reactor building. The suppression system is assumed to be 95 percent effective in eliminating the risk of fires in these areas.
33	Improve Fire Barriers Between Cabinets in the Cable Spreading Room	Installing fire barriers between the cabinets in the cable spreading room is assumed to eliminate the risk associated with all fires in non-critical cabinets. The barriers are assumed to prevent the spread of fires to cabinets containing equipment required for the safe shutdown of the plant. Fire barriers are not assumed to prevent damage to equipment when fires start in critical cabinets.
34	Supplemental Power Supplies for Offsite Power Recovery After Battery Depletion During SBO	The supplemental power supplies would ensure that a means of operating the switchyard circuit breakers is available to recover offsite power after the station batteries have been depleted. This SAMA is represented by crediting the boildown and fuel heat-up time in the offsite power recovery calculations for long term SBO calculations (injection is lost at the time of battery depletion).
35	Use Firewater as a Backup for EDG Cooling	This SAMA reduces the contribution of most loss of EDG cooling sequences by crediting the alignment of Firewater to the EDG cooling system. A lumped failure probability of 1E-2 is used to represent the operator alignment errors and hardware failures of the Firewater cross-tie.
36	Use Firewater as a Backup for Containment Spray	Firewater is used in the Level 2 PSA model to reduce the probability of sequences including Containment Spray failures. A lumped failure probability of 5E-1 is used to represent the operator alignment errors and hardware failures of the Firewater cross-tie.
37	Low Pressure RCIC Operation	This SAMA credits operation of RCIC after HCTL depressurization when power is available for flow control. The operators are assumed to always be successful in implementing low pressure RCIC injection.

Response to NRC RAI SAMA1-5, Item b

The cost estimate developed by Progress Energy for Phase II SAMA 1 assumed that power cables were installed that could be used to align the portable generator to either unit; however, it was also assumed that the generator would only be used by one unit at a time. Given that the cost benefit was calculated based on the risk reduction for one unit and doubled to account for the improvement that would be expected in the second unit, simultaneous use of the generator is implied in the cost benefit calculation. The cost of implementation that was provided by Progress Energy is, therefore, conservative in that it yields an increased net value over what would exist if two generators were included in the cost of implementation.

The averted cost-risk for Phase II SAMA 1 is over $1.9 million, as documented in the BSEP ER. Even if the cost of implementation were doubled for this SAMA to account for complete dual unit implementation, the net value would still be $934,003. Excluding the second generator from the cost of implementation for Phase II SAMA 1 does not change the conclusion that it is a cost beneficial enhancement for BSEP.

Response to NRC RAI SAMA1-5, Item c

Several CRD failures and CRD support system failure events are, in fact, included in Table F-13. These events are the bases for the following SAMAs:

- Phase 1 SAMA 15, "Inter-unit CRD Cross-tie". This SAMA is based on initiating event %2TCRD. The RRW value for this event is 1.043.
- Phase 1 SAMA 23, "Enhance CRD Logic". This SAMA is based on events CRD2FLT-PG_S001A and CRD2FLT-PG_S003A. The RRW value for each of these events is 1.014.
- Phase 1 SAMA 24, "Install Self Cooled CRD Pumps". This SAMA is based on initiating event %2TRCC, which is represents loss of the system responsible for providing cooling to the CRD pumps and has an RRW value of 1.011.

While the events identified above are important contributors to the BSEP CDF risk profile, the importance of individual CRD components is limited by the CRD design and success criteria. Given that only one of the two CRD trains is required for success, the importance of any single component is low unless the opposite train has failed or is unavailable.

A more accurate indicator of the CRD system's importance to BSEP risk is the system level contribution to the CDF. Figure F-3 of the ER submittal indicates that the entire CRD system contributes between 5 and 10 percent of the BSEP CDF. This is consistent with the reduction in CDF shown for Phase 2 SAMA 13 (Phase 1 SAMA 15) as it reflects an additional means of providing the CRD function after system failure.

Finally, the content of NRC QuestionSAMA1-5, Item c, appears to indicate that a clarification of the impact of this SAMA is required. The description of Phase 2 SAMA 13 provided in Section F.6.9 of the ER submittal states that "no credit is allowed for mitigating the loss of CRD initiating event due to the time required to determine that the cross-tie would not introduce a common failure to the opposite unit". The meaning of this statement is that the inter-unit CRD cross-tie cannot be performed in time to prevent the occurrence of a Loss of CRD initiating event. It does not preclude the use of the CRD cross-tie to provide injection after the occurrence of the Loss of CRD initiating event.

Response to NRC RAI SAMA1-5, Item d

The 5.7 percent contribution to CDF indicated in Figure F-2 of the ER includes the emergency 480V AC buses, which are not addressed in Phase II SAMA 18.

Credit could be taken for Phase 2 SAMA 18 during other initiating events, but it yields no measurable change in the PSA results. This is due to the fact that the failure probability for an emergency bus over the 24 hour mission time analyzed when another initiator occurs is very low. Given that crediting Phase 2 SAMA 18 for non-initiator bus failures does not impact the results, the PSA modeling and description were simplified by excluding these scenarios.

Response to NRC RAI SAMA1-5, Item e

This cost estimate was developed by consultation with the plant staff. The individual components of the estimate were not quantified; as such, this estimate represents a best-estimate by the subject matter experts.

Considerations in this cost estimate include: new and upgraded communications equipment, procedure changes and associated validation, substantial operator training for all operating crews, dose cost, and continuing training.

Response to NRC RAI SAMA1-5, Item f

ER Table F-16 mentions possible improvements that might be attained by installation of automatic suppression systems in the control room cabinets and in the switchgear room. Changes in these areas were part of the full scope SAMA that was initially proposed.

Discussions of the benefits of automatic suppression systems in the control room cabinets and switchgear room are contained in section F.6.21, on page F-70; the benefits are characterized as "extremely limited" and "limited," respectively. Although not explicitly stated, these discussions qualitatively eliminated automatic suppression systems in the control room cabinets and switchgear room from further consideration. Quantification of the SAMA, therefore, was limited to improvements in the north central and northwest areas elevation 20’ of the Reactor Building.

The cost estimate, which was developed by the plant staff, is consistent with the averted cost-risk calculation in that it only accounts for changes to the north central and northwest areas elevation 20’ of the Reactor Building. Consideration was given to the hardware and labor costs related to the fire suppression equipment itself, the need to improve the leak tightness of the areas, and dual unit implementation.

As identified in the response to NRC RAI SAMA1-5, Item f, the text in Table F-16 describing the areas considered in the cost estimate are inconsistent with the areas considered in the calculation of the averted cost-risk. This is a result of not updating the cost estimate description in Table F-16 after analysis of the SAMA demonstrated that the scope of the SAMA should not include the control room cabinets or the switchgear room.

Response to NRC RAI SAMA1-5, Item g

The text in Table F-16 is based on an earlier revision of the SAMA evaluation and it was not updated to reflect the latest cost estimate information. Sections F.6.11.1 and F.6.28 of the ER include the current cost estimate and averted cost-risk calculation for the base-line evaluation of Phase 2 SAMA 16.

Response to NRC RAI SAMA1-5, Item h

Later

NRC RAI SAMA1-6

Section F.7.2 of the ER provides the results of an uncertainty analysis of the Level 1 PSA used for determining the benefit of various SAMAs. This indicates that the mean CDF is a factor of 2.11 greater than the point estimate CDF used in the SAMA evaluations and is only slightly less than the 95 percentile value.

a. Provide an assessment of the impact of using the mean CDF results on the cost benefit analysis and justify not considering these results in determining which SAMAs to retain for consideration.

b. Based on information in F.7.2, several events are assigned an error factor (EF) of 10.0. Depending on the event, this may be conservative and can skew the results (including the mean and 95th) toward higher values. Provide a more concise description (or listing) of exactly where and why these EFs were used. Provide an assessment of the impact on the uncertainty analyses results if an EF of 3 instead of 10 is assumed.

Response to NRC RAI SAMA1-6

Response to NRC RAI SAMA1-6, Item a

The baseline risk assessment utilizes point estimate values in the PRA model. This is the standard practice for the BSEP PRA. The analysis presented in Section F.7.2 was included to demonstrate the robustness of the conclusions by investigating the impact that a higher CDF value would have on the SAMA results. The 95th percentile value was computed in a bounding manner by inputting conservative error factors where needed to execute the UNCERT calculation. The reported "mean" CDF value should be considered as a parametric mean and not to be compared to the best estimate value obtained using the point estimate values.

Response to NRC RAI SAMA1-6, Item b

As indicated in section 7.2 of the SAMA analysis, the assumption was made that all failure events in the PRA database were distributed lognormal and to assign an EF of 10 when a CCF, initiator, operator action, or maintenance unavailability event did not have a pre-determined EF in the PRA model database. The use of an EF of 10 is reasonable as a means to acknowledge a high degree of statistical uncertainty in event frequencies in comparison with the actual EF data that was already available for most events in the PRA model and represented a convenient way to assess its influence on the cost-risk results for the SAMA uncertainty analysis. The BSEP PRA model contains about 7000 total events. Many of the events in the model database are assigned pre-determined EF values through type codes associated with the generic event frequency data sources. The event population noted above that was assigned an EF of 10 represented over 700 events which cannot be easily listed and assessed through an individual event review. Thus, the impact of arbitrary EF selection is more readily assessed through a sensitivity assessment of the affected population and its consequences as discussed below.

To demonstrate the impact of a reduction in EF, an assessment was made assuming a default EF of three. For this assessment, the CCF, initiator, operator action, or maintenance unavailability events with prior EF values at ten were reset to three. A comparison of the uncertainty results generated by UNCERT32 to those provided in section 7.2 of the SAMA analysis is provided in the table below. Also, provided in the table is a comparison of the cost-risk factor that was defined in the SAMA analysis as a ratio by which the 95th percentile CDF is greater than the CDF point estimate produced by the BSEP PSA. The reduction in the default EF to a value of three results in a smaller cost-risk factor of about 1.89.

Table – PRA Model Uncertainty Results Comparison

PARAMETER	VALUE (default EF = 10)	VALUE (default EF = 3)
Mean	$8.85x10^{-05}$	$5.14x10^{-05}$
5%	$1.86x10^{-05}$	$1.86x10^{-05}$
Median	$3.62x10^{-05}$	$3.19x10^{-05}$
95%	$9.83x10^{-05}$	$7.91x10^{-05}$
Standard Deviation	$3.62x10^{-03}$	$5.90x10^{-04}$
Cost-risk factor	2.35	1.89

The impact of the PRA model uncertainty assuming a default EF of three (cost-risk factor = 1.89) on the PHASE II cost-risk results is provided in the Table below. See the comparable table in F.7.2 of the SAMA analysis for EF =10. The reduction in EF value affected the prior cost effectiveness determination in the SAMA analysis assuming a cost-risk factor of 2.35 for only SAMA items 11 and 21. For these items, the net value result and conclusion is no different than that provided in the base SAMA analyses, i.e., no additional insight would have been obtained.

Table – PRA Model Uncertainty Impact on Phase II Results

Phase II SAMA ID	Cost of Implementation (C)	Base Averted Cost-Risk (S)	Net Value Base (S – C)	EF = 3 New Averted Cost- Risk for 95th percentile (S*)	EF = 3 New Net Value for 95th percentile (S* – C)	Change in Cost Effectiveness ?
1	$489,277	$1,912,557	$1,423,280	$3,614,733	$3,125,456	No
3	$434,775	$59,244	($375,531)	$111,971	($322,804)	No
4	$4,000,000	$1,299,690	($2,700,310)	$2,456,414	($1,543,586)	No
5	>>$1,000,000	$1,069,849	Large Negative	$2,022,015	Large Negative	No
6	$100,000	$63,969	($36,031)	$120,901	$20,901	Yes
10	$434,775	$74,834	($359,941)	$141,436	($293,339)	No
11	$434,775	$203,666	($231,109)	$384,929	($49,846)	No
12	$434,775	$133,035	($301,740)	$251,436	($183,339)	No
13	$836,870	$818,664	($18,206)	$1,547,275	$710,405	Yes
15	$200,000	$267,916	$67,916	$506,361	$306,361	No
16	$159,078	$135,817	($23,261)	$256,694	$97,616	Yes
17	$489,277	$1,566,562	$1,077,285	$2,960,802	$2,471,525	No
18	$434,775	$359,314	($75,461)	$679,103	$244,328	Yes

Table – PRA Model Uncertainty Impact on Phase II Results						
Phase II SAMA ID	**Cost of Implementation (C)**	**Base Averted Cost-Risk (S)**	**Net Value Base (S – C)**	**EF = 3 New Averted Cost- Risk for 95th percentile (S*)**	**EF = 3 New Net Value for 95th percentile (S* – C)**	**Change in Cost Effectiveness ?**
19	$489,277	$637,723	$148,446	$1,205,296	$716,019	No
20	$434,775	$165,307	($269,468)	$312,430	($122,345)	No
21	$500,000	$246,707	($253,293)	$466,276	($33,724)	No
22	$500,000	$153,398	($346,602)	$289,922	($210,078)	No
25	$50,000	$463,930	$413,930	$876,828	$826,828	No
29	$186,861	$250,281	$63,420	$473,031	$286,170	No
30	$1,531,855	$1,235,829	($290,026)	$2,335,717	$803,862	Yes
31	$250,000	$154,479	($95,521)	$291,965	$41,965	Yes
32	$750,000	$447,460	($302,540)	$845,699	$95,699	Yes
33	$100,000	$4,329	($95,671)	$8,182	($91,818)	No
34	$489,277	$485,509	($3,768)	$917,612	$428,335	Yes
35	$2,000,000	$80,442	($1,919,558)	$152,035	($1,847,965)	No
36	$100,000	$163,166	$63,166	$308,384	$208,384	No
37	$200,000	$51,963	($148,037)	$98,210	($101,790)	No

NRC RAI SAMA1-7

Provide the following with regard to the calculation of replacement power costs:

a. Provide the basis for the assumption (related to replacement power costs) that the remaining unit would have to be shut down after a core damage event.

b. Provide an assessment of the impact of this assumption on the results of the SAMA analysis, i.e., would certain cost-beneficial SAMAs no longer be cost-beneficial if this assumption were not made.

c. Provide a table showing the averted cost-risk (at 3 percent and 7 percent) for each Phase II SAMA assuming only one unit is affected (similar to the table on page F-85 of the ER).

Response to NRC RAI SAMA1-7

Response to NRC RAI SAMA1-7, Item a

The conservative assumption was made that a severe core damage event in one unit would result in shutting down the second unit. This was assumed to maximize the replacement power cost and provide a slightly conservative assessment of the MACR. If the second unit is assumed to continue to operate, the effect would be a factor of two reduction in the replacement power cost. This translates into a 15% reduction in the total MACR value.

Response to NRC RAI SAMA1-7, Item b

A 15% reduction in the MACRwill translate into a 15% reduction in the computed averted cost risk for the Phase II SAMAs summarized in Section F.6.28. This magnitude change would not change the status of the SAMAs in Section F.6.28.

Response to NRC RAI SAMA1-7, Item c

The following table shows the impact that a 15% reduction in the averted cost would have on the results of the 7% (base case) and 3% discount rate sensitivity analysis. As can be seen, Phase II SAMAs 16, 18 and 34 were shown to be marginally cost beneficial with the 3% discount rate; however, they are no longer cost beneficial if it is assumed that only one unit is shut down as a result of an accident in the other unit.

Phase II SAMA ID	Cost of Implemen-tation	Averted Cost- Risk (7% RDR)	Net Value (7% RDR)	Averted Cost- Risk (3% RDR)	Net Value (3% RDR)	Net Value Assuming Replacement Power Cost for a Single Unit (7% RDR)	Net Value Assuming Replacement Power Cost for a Single Unit (3% RDR)
1	$489,277	$1,912,557	$1,423,280	$2,257,193	$1,767,916	$1,136,396.45	$1,429,337.05
3	$434,775	$59,244	($375,531)	$72,304	($362,471)	($384,417.60)	($373,316.60)
4	$4,000,000	$1,299,690	($2,700,310)	$1,521,536	($2,478,464)	($2,895,263.50)	($2,706,694.40)
5	>>$1,000,000	$1,069,849	Large Negative	$1,229,341	Large Negative	Large Negative	Large Negative
6	$100,000	$63,969	($36,031)	$74,900	($25,100)	($45,626.35)	($36,335.00)
10	$434,775	$74,834	($359,941)	$94,912	($339,863)	($371,166.10)	($354,099.80)
11	$434,775	$203,666	($231,109)	$255,618	($179,157)	($261,658.90)	($217,499.70)
12	$434,775	$133,035	($301,740)	$161,750	($273,025)	($321,695.25)	($297,287.50)
13	$836,870	$818,664	($18,206)	$1,013,571	$176,701	($141,005.60)	$24,665.35
15	$200,000	$267,916	$67,916	$311,591	$111,591	$27,728.60	$64,852.35
16	$159,078	$135,817	($23,261)	$160,808	$1,730	($43,633.55)	($22,391.20)
17	$489,277	$1,566,562	$1,077,285	$1,802,691	$1,313,414	$842,300.70	$1,043,010.35
18	$434,775	$359,314	($75,461)	$439,307	$4,534	($129,358.10)	($61,364.05)
19	$489,277	$637,723	$148,446	$813,856	$324,579	$52,787.55	$202,500.60
20	$434,775	$165,307	($269,468)	$202,017	($232,758)	($294,264.05)	($263,060.55)
21	$500,000	$246,707	($253,293)	$286,785	($213,215)	($290,299.05)	($256,232.75)
22	$500,000	$153,398	($346,602)	$190,205	($309,795)	($369,611.70)	($338,325.75)
25	$50,000	$463,930	$413,930	$469,586	$419,586	$344,340.50	$349,148.10
29	$186,861	$250,281	$63,420	$291,778	$104,917	$25,877.85	$61,150.30
30	$1,531,855	$1,235,829	($290,026)	$1,466,290	($65,565)	($481,400.35)	($285,508.50)
31	$250,000	$154,479	($95,521)	$183,286	($66,714)	($118,692.85)	($94,206.90)
32	$750,000	$447,460	($302,540)	$530,904	($219,096)	($369,659.00)	($298,731.60)
33	$100,000	$4,329	($95,671)	$5,136	($94,864)	($96,320.35)	($95,634.40)
34	$489,277	$485,509	($3,768)	$567,352	$78,075	($76,594.35)	($7,027.80)
35	$2,000,000	$80,442	($1,919,558)	$93,088	($1,906,912)	($1,931,624.30)	($1,920,875.20)
36	$100,000	$163,166	$63,166	$228,001	$128,001	$38,691.10	$93,800.85
37	$200,000	$51,963	($148,037)	$64,884	($135,116)	($155,831.45)	($144,848.60)

NRC RAI SAMA1-8

The ER states that several cost-beneficial SAMAs exist that could be examined further. However, it is not clear which SAMAs will be further reviewed. Identify (list) which SAMAs Progress Energy plans to further evaluate, and describe the anticipated process for performing such an evaluation, e.g., the plant's action tracking system, or corrective action program.

Response to NRC RAI SAMA1-8

The plant will provide a further review for SAMA 1, Portable Generator for DC Power, and SAMA 25, Proceduralize Battery Charger High Voltage Shutdown Circuit Inhibit. This review is being conducted for the Plant Review Group and is being tracked by the BSEP action tracking system. The purpose of this review is to determine which of the SAMAs merit being considered for assignment as a plant three phase project.

NRC RAI SAMA1-9

Several low cost alternatives to major enhancements have been identified as potentially cost-beneficial in previous and current license renewal applications and might be applicable to BSEP. For the following SAMAs, provide a brief statement regarding the applicability/feasibility of the alternative for BSEP, and a further evaluation (similar to those evaluations provided in the ER) if the alternative could be potentially cost beneficial at BSEP:

- Provide means for alternate safe shutdown makeup pump room cooling, e.g., via fire protection system (Quad Cities, Phase II SAMA 1),
- Provide alternate ventilation for various rooms, e.g., using portable equipment or blocking open doors for RHR pump room, HPCS pump room, RCIC pump room (Nine Mile Point, Unit 2, SAMA 23),
- Enhance procedures to provide more specific guidance for loss of service water events (Nine Mile Point, Unit 2, SAMA 213),
- Reduce unit cooler contribution to emergency diesel generator unavailability through increased testing frequency or redundant cooling (Nine Mile Point, Unit 2, SAMA 221), and
- Enhance procedures to provide more specific guidance for loss of instrument air events (Nine Mile Point, Unit 2, SAMA 222).

Response to NRC RAI SAMA1-9

Alternate Safe Shutdown Makeup Pump Room Cooling

The Safe Shutdown Makeup Pump does not exist at BSEP, however, room cooling to the existing ECCS rooms is addressed in the ER Appendix F Addendum, Table A-1, for items #26 and #30. These items were considered in identifying potential SAMA candidates for BSEP, but since the functions did not appear as important contributors to risk for BSEP, they were not considered further. The emphasis of the SAMA evaluation is on potential modifications that can reduce the risk for BSEP.

Alternate Ventilation for Various Rooms

As described above, Table A-1 of the ER Appendix F Addendum included two items that addressed potential vulnerabilities with ECCS room cooling. Since these were not found to have a significant impact on BSEP-specific risk, they were not investigated further.

Enhance Procedures for Loss of Service Water Events

A review of the Level 2 PRA importance measures did reveal that loss of SW had a Risk Reduction Worth (RRW) equal to 1.017 and is listed in Table F-14. In addition, Phase I SAMA #31 discusses potential procedural changes to address failed SW. This Phase I item is then retained as Phase II SAMA #28.

As stated in Table F-16, "the BSEP abnormal operating procedures already include steps to isolate the discharge valves of any pumps that are not running; however, no credit is taken for this isolation action in the current BSEP PRA model. As this action is already directed, and because the importance of flow divergence is artificially inflated by model conservatisms, this SAMA is screened from further analysis".

Reduce Unit Cooler Contribution to Emergency Diesel Generator Unavailability

Table F-15 identifies Phase I SAMA #40 to address potential plant changes related to loss of EDG cooling. This SAMA is retained and is further investigated in Phase II SAMA #35.

As stated in Table F-16, "plant changes to allow alignment of the Firewater system for alternate EDG cooling provides a means of supporting EDG operation given loss of SW. For BSEP, the SW system is diverse and provides a reliable source of cooling to the EDGs, and the implementation of an alternate cooling method has a limited impact. The estimated averted cost-risk of this SAMA is $80,442. As this is less than the cost of implementation, it has been screened from further analysis".

Enhance Procedures for Loss of Instrument Air Events

This SAMA is identified in Table F-16 as a Phase II SAMA #19 and is initially considered to be cost beneficial. Section F.6.14.1 provides the following additional information:

> It should be noted that a modification is currently being developed for the Instrument Air System that will significantly alter the system configuration and reliability. The three reciprocating air compressors will be replaced with a single, more reliable compressor. A cross-tie will be installed, operable from the control room, vs the current manual cross-tie. The modified system is planned to be operated with the cross-tie valve open. The system will be able to provide instrument air to both BSEP units assuming the loss of one of the D compressors and one of the new replacement compressors. Without a fully developed model to evaluate the reliability of the revised system, the impact of this SAMA on plant risk after the modifications are made is difficult to determine. However, as the potential for common cause failure of the compressors in the revised system is considered to be a possible contributor to system failure, it may be appropriate to analyze the benefit of a portable compressor once the revised system is incorporated into the PSA model. This modification is planned for implementation in 2007.

Response to NRC RAI SAMA1-4, Item a), Part 2: Table F-13 Revised to Identify Corresponding Phase 1 SAMA ID Number

Event Name	Probability	RRW	Description	Potential SAMAs
%TE_S	2.30E-02	1.542	LOSS OF OFFSITE POWER (SITE)	Install protective covers on switchyard insulators to prevent salt-spray related shorts or proceduralize equipment wash-down after severe weather (SAMA 1).
%2T_T	2.70E+00	1.374	TURBINE TRIP INITIATOR	The application of the Maintenance Rule is considered to have improved plant operations through focused maintenance plans. PSA applications have also helped to identify areas for improvement in plant practices, equipment availability and operation. No credible, potentially cost effective means of further reducing the turbine trip frequency have been identified. The equipment and operator actions important to mitigating turbine trip initiators is judged to be addressed by the other components in this list.
BUSFAULT	3.90E-01	1.154	FRACTION OF LOSS OF BUS THAT ARE NON-RECOVERABLE	N/A
DCP2BAT-XXDEP2B	1.00E+00	1.151	BATTERY BANK 2B DEPLETION FOLLOWING LOSS OF POWER FROM CHARGER	Installation of a portable DC generator for alternate/long term DC availability (SAMA 2). Install an inter-unit DC cross-tie (SAMA 3).
DCP2BAT-XXDEP2A	1.00E+00	1.139	BATTERY BANK 2A DEPLETION FOLLOWING LOSS OF POWER FROM CHARGER	Installation of a portable DC generator for alternate/long term DC availability (SAMA 2). Install an inter-unit DC cross-tie (SAMA 3).
X-AC-12H	4.02E-02	1.133	LOSP RECOVERY 12 HOURS	Power recovery may be enhanced by providing the ability to align the UAT to the E-buses from the MCR (SAMA 4); however, this is represented by the event OPER-GENDISC. The potential to enhance Off-site power recovery procedures (SAMA 8) may be examined to determine if any realistic benefit could be attained through revisions, but LOOP recovery is governed by off-site conditions and actions. Additional on-site AC power is addressed elsewhere.

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Response to NRC RAI SAMA1-4, Item a), Part 2: Table F-13 Revised to Identify Corresponding Phase 1 SAMA ID Number

Event Name	Probability	RRW	Description	Potential SAMAs
X-AC-2H	1.33E-01	1.128	LOSP RECOVERY 2 HOURS	Power recovery may be enhanced by providing the ability to align the UAT to the E-buses from the MCR (SAMA 4); however, this is represented by the event OPER-GENDISC. The potential to enhance Off-site power recovery procedures (SAMA 8) may be examined to determine if any realistic benefit could be attained through revisions, but LOOP recovery is governed by off-site conditions and actions. Additional on-site AC power is addressed elsewhere.
SRV-DEMAND1	6.36E-01	1.127	7 OF 11 SRVS DEMANDED ISOLATION TRANSIENT	No SAMAs identified.
RCI2TDP-FR-RCTDP	2.30E-01	1.112	RCIC TURBINE-DRIVEN PUMP FAILS TO RUN	High pressure injection reliability could be improved through the addition of a direct drive diesel injection pump (SAMA 5).
EDG2DGN-FR-003	7.40E-02	1.106	DIESEL GENERATOR 3 FAILS TO RUN	Ensure all buses that can be cross-tied have procedures to perform cross-tie (proceduralize E3 to E4 cross-tie) (SAMA 7). Install an additional Diesel Generator (SAMA 25).
OPER-ALTUNITXC	1.00E+00	1.090	OPERATORS FAIL TO MANUALLY ALIGN POWER FROM OPPOSITE UNIT	Ensure all buses that can be cross-tied have procedures to perform cross-tie (SAMA 7).
%2T_C	1.80E-01	1.090	LOSS OF CONDENSER VACUUM	No SAMAs identified.
EDG2DGN-FR-004	7.40E-02	1.083	DIESEL GENERATOR 4 FAILS TO RUN	Ensure all buses that can be cross-tied have procedures to perform cross-tie (proceduralize E3 to E4 cross-tie) (SAMA 7). Install an additional Diesel Generator (SAMA 25).
X-AC-16H	2.49E-02	1.076	LOSP RECOVERY 16 HOURS	Power recovery may be enhanced by providing the ability to align the UAT to the E-buses from the MCR (SAMA 4); however, this is represented by the event OPER-GENDISC. The potential to enhance Off-site power recovery procedures (SAMA 8) may be examined to determine if any realistic benefit could be attained through revisions, but LOOP recovery is governed by off-site conditions and actions. Additional on-site AC power is addressed elsewhere.

Response to NRC RAI SAMA1-4, Item a), Part 2: Table F-13 Revised to Identify Corresponding Phase 1 SAMA ID Number

Event Name	Probability	RRW	Description	Potential SAMAs
DCP2REC-XXTRP2A1	1.00E+00	1.073	CHARGER 2A-1 TRIPS FOLLOWING TRANSIENT WITH BATTERY FAILURE	Ensure procedures and training exist to isolate failures and reload the buses. Installation of a portable DC generator for alternate/long term DC availability (SAMA 96, Table A-1). Install an inter-unit DC cross-tie (SAMA 127, Table A-1).
DCP2REC-XXTRP2B2	1.00E+00	1.072	CHARGER 2B-2 TRIPS FOLLOWING TRANSIENT WITH BATTERY FAILURE	Ensure procedures and training exist to isolate failures and reload the buses (appropriate BSEP procedures exist). Installation of a portable DC generator for alternate/long term DC availability (SAMA 2). Install an inter-unit DC cross-tie (SAMA 3).
EDG1DGN-FR-001	7.40E-02	1.070	DIESEL GENERATOR 1 FAILS TO RUN	Install an additional Diesel Generator (SAMA 25)
HPC2TDP-FR-HPTDP	7.40E-02	1.068	HPCI TURBINE-DRIVEN PUMP FAILS TO RUN	High pressure injection reliability could be improved through the addition of a direct drive diesel injection pump (SAMA 5). Maximizing CRD flow for high pressure injection is also a potential improvement (SAMA 6).
EDG1DGN-FR-002	7.40E-02	1.064	DIESEL GENERATOR 2 FAILS TO RUN	Install an additional Diesel Generator (SAMA 25)
%2T_DC2B2	2.90E-03	1.062	LOSS OF 125V DC PANEL 2B2	No suggestions.
SRV2SRV-CCF-511	7.57E-06	1.050	SUM OF CCF - ANY FIVE SRVs FAIL TO OPEN	Diversify SRVs by replacing some valves with valves of a different design (SAMA 9).
IAN2CKV-44ALL	4.50E-05	1.049	COMMON CAUSE FAILURE OF ALL SRV AIR CHECK VALVES TO OPEN	Diversify check valves by replacing some valves with valves of a different design or by installing bypass lines (SAMA 11).
IAN2CKV-443456	4.50E-05	1.049	COMMON CAUSE FAILURE OF CHECK VALVES V313, V314, V315 AND V316 TO OPEN	Diversify check valves by replacing some valves with valves of a different design or by installing bypass lines (SAMA 10).

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Response to NRC RAI SAMA1-4, Item a), Part 2: Table F-13 Revised to Identify Corresponding Phase 1 SAMA ID Number

Event Name	Probability	RRW	Description	Potential SAMAs
RPS2MBIND	1.00E-05	1.049	MECHANICAL BINDING OF CONTROL RODS	This failure is important for BSEP in combination with operator failure to control level to prevent boron washout. Improvements in boron injection will not significantly reduce risk. A potential enhancement is the improvement of EOPs to reduce the failure probability of injection control. An additional potential enhancement is the installation of a control system for LPCI that would allow the operators to dial in the desired flowrate and thereby improving the man-machine interface (SAMA 12).
OPER-480X2	1.00E+00	1.047	OPERATORS FAIL TO MANUALLY CONNECT UNIT 2 SUBSTATIONS E7 AND E8	Provide capability in the main control room to perform 480V AC substation X-tie (SAMA 13).
OPER-DCPALTDC2	1.00E+00	1.043	OPERATOR FAILS TO ALIGN DC BUS TO STANDBY DC POWER SUPPLY - UNIT2	Provide capability in the main control room to perform DC supply swap (SAMA 14).
%2TCRD	1.00E+00	1.043	LOSS OF CONTROL ROD DRIVE	An inter-unit CRD cross-tie could improve accident mitigation for this initiator (SAMA 15). Alternate boron injection methods are addressed for event "RPS2MBIND".
ICC2LPW-CF-XUALL	3.73E-06	1.041	CCF OF ALL XU POWER SUPPLY PANELS	Use of portable 120V AC generators could supply power to required panels (SAMA 16).
OPER-DILUTE	1.00E+00	1.040	OPERATOR FAILS TO PRECLUDE BORON WASHOUT DURING LOW PRESSURE INJECTION	A potential enhancement is the improvement of EOPs to reduce the failure probability of injection control. An additional potential enhancement is the installation of a control system for LPCI that would allow the operators to dial in the desired flowrate and thereby improving the man-machine interface (SAMA 12).
OPER-DGHMAN	1.00E+00	1.040	OPERATORS FAIL TO MANUALLY START EXHAUST FAN	Add a diverse logic set and thermocouple powered directly from the EDG (SAMA 17).
XOP-DGHMAN	6.10E-03	1.036	OPER-DGHMAN	Add a diverse logic set and thermocouple powered directly from the EDG (SAMA 17).

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Event Name	Probability	RRW	Description	Potential SAMAs
X-AC-1H	2.09E-01	1.035	LOSP RECOVERY 1 HOUR	Power recovery may be enhanced by providing the ability to align the UAT to the E-buses from the MCR (SAMA 4); however, this is represented by the event OPER-GENDISC. The potential to enhance Off-site power recovery procedures (SAMA 8) may be examined to determine if any realistic benefit could be attained through revisions, but LOOP recovery is governed by off-site conditions and actions. Additional on-site AC power is addressed elsewhere.
XOP-COM2-16	7.90E-03	1.034	OPER-DCPALTDC1 OPER-ALTUNITXC OR OPER-DCPALTDC1 OPER-ALTUNITXC	Installation of a portable DC generator for alternate/long term DC availability (SAMA 2) provides an additional option in this case.
%2T_M	7.30E-02	1.032	MSIV CLOSURE INITIATOR: T(M)	Digital instrumentation already incorporated. No suggestions.
CRD2SCRAM	6.00E-06	1.027	FAILURE OF CONTROL ROD DRIVE SCRAM VALVES	Alternate boron injection methods and injection flow control modifications for preventing boron dilution are potential enhancements (SAMA 12) and are addressed for event "RPS2MBIND".
DCP2REC-34A1A2B2	2.37E-07	1.026	COMMON CAUSE FAILURE OF CHARGER 2A-1, 2A-2 AND 2B-2	Installation of a portable DC generator for alternate/long term DC availability (SAMA 2). Install an inter-unit DC cross-tie (SAMA 3).
DCP2REC-24A1B2	5.20E-07	1.025	COMMON CAUSE FAILURE OF CHARGER 2A-1 AND 2B-2	Installation of a portable DC generator for alternate/long term DC availability (SAMA 2). Install an inter-unit DC cross-tie (SAMA 3).
%2TE_U2	1.40E-02	1.024	LOSS OF OFFSITE POWER TO UNIT 2	Implement procedures to spray down electrical component after sever weather to prevent shorting from salt spray (SAMA 1).
OPER-LLEVEL1	1.00E+00	1.023	OPERATOR FAILS TO CONTROL LOWERED WATER LEVEL WITH HPCI DURING ATWS	No suggestions.
EDG2DGN-TM-D003	1.40E-02	1.022	DIESEL GENERATOR 3 UNAVAILABLE DUE TO MAINTENANCE (AT POWER)	Ensure all buses that can be cross-tied have procedures to perform cross-tie (proceduralize E3 to E4 cross-tie) (SAMA 7). Install an additional Diesel Generator (SAMA 25).

Response to NRC RAI SAMA1-4, Item a), Part 2: Table F-13 Revised to Identify Corresponding Phase 1 SAMA ID Number

Event Name	Probability	RRW	Description	Potential SAMAs
X-AC-5H	9.30E-02	1.021	LOSP RECOVERY 5 HOURS	Power recovery may be enhanced by providing the ability to align the UAT to the E-buses from the MCR (SAMA 4); however, this is represented by the event OPER-GENDISC. The potential to enhance Off-site power recovery procedures (SAMA 8) may be examined to determine if any realistic benefit could be attained through revisions, but LOOP recovery is governed by off-site conditions and actions. Additional on-site AC power is addressed elsewhere.
XOP-ALTUNITXC1	7.00E-02	1.020	OPER-ALTUNITXC	Ensure all buses that can be cross-tied have procedures to perform cross-tie (proceduralize E3 to E4 cross-tie) (SAMA 7). Install an additional Diesel Generator (SAMA 25).
DCP0REC-44ALL	1.76E-07	1.019	COMMON CAUSE FAILURE OF BOTH UNIT 1 AND UNIT 2 CHARGERS	Installation of a portable DC generator for alternate/long term DC availability (SAMA 2).
XOP-DEPRESS	6.90E-03	1.019	OPER-DEPRESS	Alternate depressurization methods are not credited for BSEP. The following alternate depressurization paths are available given failure of the normal means: main condenser via the turbine bypass valves, main steam line drains, HPCI, RCIC, SJAE, RFP, RWCU in recirc mode, and RWCU in blowdown mode. Lack of credit in the model for these methods artificially inflates the importance of depressurization. Additional depressurization methods are not pursued further as the benefit is judged to be small considering the availability of the existing procedures to use the alternate pathways identified above.

Response to NRC RAI SAMA1-4, Item a), Part 2: Table F-13 Revised to Identify Corresponding Phase 1 SAMA ID Number

Event Name	Probability	RRW	Description	Potential SAMAs
OPER-DEPRESS	1.00E+00	1.019	OPERATOR FAILS TO MANUALLY INITIATE AND ALIGN LOW-PRESSURE SYSTEMS	Alternate depressurization methods are not credited for BSEP. The following alternate depressurization paths are available given failure of the normal means: main condenser via the turbine bypass valves, main steam line drains, HPCI, RCIC, SJAE, RFP, RWCU in recirc mode, and RWCU in blowdown mode. Lack of credit in the model for these methods artificially inflates the importance of depressurization. Additional depressurization methods are not pursued further as the benefit is judged to be small considering the availability of the existing procedures to use the alternate pathways identified above.
%2T_DC2A1	2.90E-03	1.019	LOSS OF 125V DC PANEL 2A1	Provide alternate feeds to buses supplied only by panel 2A-1 (SAMA 19).
DCP0BAT-44ALL	2.19E-07	1.018	COMMON CAUSE FAILURE OF UNIT 1 AND UNIT 2 BATTERIES	Installation of a portable DC generator for alternate/long term DC availability (SAMA 2).
X-AC-18H	1.96E-02	1.018	LOSP RECOVERY 18 HOURS	Power recovery may be enhanced by providing the ability to align the UAT to the E-buses from the MCR (SAMA 4); however, this is represented by the event OPER-GENDISC. The potential to enhance Off-site power recovery procedures (SAMA 8) may be examined to determine if any realistic benefit could be attained through revisions, but LOOP recovery is governed by off-site conditions and actions. Additional on-site AC power is addressed elsewhere.
%2TE_E4	2.00E-03	1.018	LOSS OF 4160V AC BUS E4	Provide capability to tie to individual 4kV loads from other E-buses (SAMA 20).
EDG2DGN-TM-D004	1.40E-02	1.018	DIESEL GENERATOR 4 UNAVAILABLE DUE TO MAINTENANCE (AT POWER)	Ensure all buses that can be cross-tied have procedures to perform cross-tie (proceduralize E3 to E4 cross-tie) (SAMA 7). Install an additional Diesel Generator (SAMA 25)
OPER-GENDISC	1.00E+00	1.017	OPERATORS FAIL TO ESTABLISH BACKFEED	Provide capability to perform the action from the MCR (SAMA 4).

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Event Name	Probability	RRW	Description	Potential SAMAs
ACP0BKR-44-1234	2.04E-04	1.016	COMMON CAUSE FAILURE OF AT LEAST ONE BREAKER FOR EACH E-BUS	These breakers are related to load sequencer operation for automatic start. Manual start actions would mitigate this failure and they are proceduralized, but not credited. The importance of this event is artificially inflated by not including the manual start actions for the EDGs and no SAMA is judged to be warranted to address this event.
OPER-LLEVEL2	1.00E+00	1.016	OPERATOR FAILS TO CONTROL LOWERED WATER LEVEL WITH RCIC DURING ATWS	No suggestions.
SRV2SRV-OO-F013L	1.70E-02	1.016	ADS SAFETY RELIEF VALVE B21-F013L FAILS TO RECLOSE	No suggestions.
SRV2SRV-OO-F013K	1.70E-02	1.016	ADS SAFETY RELIEF VALVE B21-F013K FAILS TO RECLOSE	No suggestions.
SRV2SRV-OO-F013J	1.70E-02	1.016	ADS SAFETY RELIEF VALVE B21-F013J FAILS TO RECLOSE	No suggestions.
SRV2SRV-OO-F013H	1.70E-02	1.016	ADS SAFETY RELIEF VALVE B21-F013H FAILS TO RECLOSE	No suggestions.
SRV2SRV-OO-F013G	1.70E-02	1.016	NON-ADS SAFETY RELIEF VALVE B21-F013G FAILS TO RECLOSE	No suggestions.
SRV2SRV-OO-F013F	1.70E-02	1.016	NON-ADS SAFETY RELIEF VALVE B21-F013F FAILS TO RECLOSE	No suggestions.
SRV2SRV-OO-F013E	1.70E-02	1.016	NON-ADS SAFETY RELIEF VALVE B21-F013E FAILS TO RECLOSE	No suggestions.
SRV2SRV-OO-F013D	1.70E-02	1.016	ADS SAFETY RELIEF VALVE B21-F013D FAILS TO RECLOSE	No suggestions.
SRV2SRV-OO-F013C	1.70E-02	1.016	ADS SAFETY RELIEF VALVE B21-F013C FAILS TO RECLOSE	No suggestions.
SRV2SRV-OO-F013B	1.70E-02	1.016	NON-ADS SAFETY RELIEF VALVE B21-F013B FAILS TO RECLOSE	No suggestions.

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Event Name	Probability	RRW	Description	Potential SAMAs
SRV2SRV-OO-F013A	1.70E-02	1.016	ADS SAFETY RELIEF VALVE B21-F013A FAILS TO RECLOSE	No suggestions.
EDG0DGN-44-EDGR	6.19E-04	1.016	COMMON CAUSE FAILURE OF 4 OF 4 DIESEL GENERATORS TO RUN	Installation of a portable DC generator for alternate/long term DC availability (SAMA 2). Install an additional Diesel Generator (SAMA 25)
XOP-ALTUNITXC	1.80E-02	1.016	OPER-ALTUNITXC AND NON-OPERS	Ensure all buses that can be cross-tied have procedures to perform cross-tie (proceduralize E3 to E4 cross-tie) (SAMA 7).
EDG1DGN-TM-D001	1.40E-02	1.015	DIESEL GENERATOR 1 UNAVAILABLE DUE TO MAINTENANCE (AT POWER)	Install an additional Diesel Generator (SAMA 25)
EDG2MDC-44SU2AC	1.22E-03	1.015	COMMON CAUSE FAILURE OF UNIT 2 DG AIR COMPRESSORS TO START	Add a diverse compressor that can be aligned to either unit (SAMA 18).
OPER-DC2BALT	1.00E+00	1.015	OPERATOR FAILS TO SWITCH CHARGER TO ALTERNATE AC POWER SUPPLY-UNIT 2	Provide MCR capability to perform action (SAMA 22).
DGH0TTE-LOTE1608	4.95E-02	1.014	THERMOSTAT TE-1608 FAILS LOW	Add a diverse logic set and thermocouple powered directly from the EDG (SAMA17).
%2TE_E8	2.00E-03	1.014	LOSS OF 480V AC SUBSTATION E8	Provide MCR capability to perform action to cross-tie to alternate 480v substation (if E8 not faulted) (SAMA 13).
OPER-FPS1	1.00E+00	1.014	OPERATOR FAILS TO ALIGN FIREWATER FOR COOLANT INJECTION FLOW (ONE UNIT)	Provide MCR capability to perform fire protection injection alignment. (The primary contributors to the importance of this event are flooding initiator %2TF7, scenarios requiring injection after containment failure, and injection after loss of AC power. SAMA 5 is considered to adequately address these issues in addition to enhancing high pressure injection capability. As a result, the MCR enhancement for Fire Water injection was not included on the final SAMA list.)

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Event Name	Probability	RRW	Description	Potential SAMAs
CRD2FLT-PG_S001A	8.23E-02	1.014	FILTER S001A PLUGGED	Provide logic to automatically open the alternate filter path and the bypass on high differential pressure across the running filter (SAMA 23)
CRD2FLT-PG_D003A	8.23E-02	1.014	CRD DRIVE WATER FILTER C11/C12-D003A PLUGS	Provide logic to automatically open the alternate filter path and the bypass on high differential pressure across the running filter (SAMA 23).
EDG1DGN-TM-D002	1.40E-02	1.014	DIESEL GENERATOR 2 UNAVAILABLE DUE TO MAINTENANCE (AT POWER)	Install an additional Diesel Generator (SAMA 25).
%2TE_E7	2.00E-03	1.013	LOSS OF 480V AC SUBSTATION E7	Provide MCR capability to perform action to cross-tie to alternate 480v substation (if E7 not faulted) (SAMA 13). Provide power to loads directly from other 480v substation (Given the low relative contribution of actual bus fault, %2TE_E7 is considered to be better addressed by the cross-tie, which is more versatile. Powering loads directly from other 480v AC substation is not included in the SAMA list.).
XOP-COM2-15	1.00E-02	1.013	OPER-LLEVEL2 OPER-DILUTE	Treated separately above.
EDG2DGN-24-DG34R	1.95E-03	1.012	COMMON CAUSE FAILURE TO RUN OF DIESEL GENERATORS 3 AND 4	Ensure all buses that can be cross-tied have procedures to perform cross-tie (proceduralize E3 to E4 cross-tie) (SAMA 7). Install an additional Diesel Generator (SAMA 25).
DCP2REC-LP2B2	1.06E-04	1.012	CHARGER 2B-2 FAILS	Installation of a portable DC generator for alternate/long term DC availability (SAMA 2). Install an inter-unit DC cross-tie (SAMA 3).
%2TE_E3	2.00E-03	1.012	LOSS OF 4160V AC BUS E3	Provide capability to tie to individual 4kV loads from other E-buses (SAMA 20).
DCP2BAT-24A1B2	1.45E-07	1.012	COMMON CAUSE FAILURE OF BATTERY 2A-1 AND 2B-2	Installation of a portable DC generator for alternate/long term DC availability (SAMA 2). Install an inter-unit DC cross-tie (SAMA 3).

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Event Name	Probability	RRW	Description	Potential SAMAs
FL-PT-N021-HI	1.00E+00	1.012	FLAG - N021 PRESSURE TRANSMITTERS FAILING HIGH	Operator actions already exist to back up the logic failure (manual alignment of the low pressure systems). No suggestions.
DCP2BAT-TM2A1	1.14E-04	1.011	BATTERY 2A-1 UNAVAILABLE DUE TO TEST OR MAINTENANCE	Installation of a portable DC generator for alternate/long term DC availability (SAMA 2). Install an inter-unit DC cross-tie (SAMA 3).
%2TRCC	1.00E+00	1.011	LOSS OF RBCCW	RBCCW is responsible for CRD pump cooling in the PSA. If the CRD pumps were self cooled, this dependence could be removed (SAMA 24).
XOP-DILUTE	4.30E-02	1.011	OPER-DILUTE	A potential enhancement is the improvement of EOPs to reduce the failure probability of injection control. An additional potential enhancement is the installation of a control system for LPCI that would allow the operators to dial in the desired flowrate and thereby improving the man-machine interface (SAMA 12).
DCP2BAT-TM2B2	1.14E-04	1.011	BATTERY 2B-2 UNAVAILABLE DUE TO TEST OR MAINTENANCE	Installation of a portable DC generator for alternate/long term DC availability (SAMA 2). Install an inter-unit DC cross-tie (SAMA 3).
DCP2REC-LP2A1	1.06E-04	1.011	CHARGER 2A-1 FAILS	Installation of a portable DC generator for alternate/long term DC availability (SAMA 2). Install an inter-unit DC cross-tie (SAMA 3).
%2TF14	3.50E-07	1.011	INTERNAL FLOOD TF14: FAILS CONDENSATE AND FLOODS CABLE SPREADING ROOM	No suggestions.
EDG2DGN-FS-003	6.30E-03	1.011	DIESEL GENERATOR 3 FAILS TO START	Install an additional Diesel Generator (SAMA 25).
DCP2REC-34A1B1B2	2.37E-07	1.011	COMMON CAUSE FAILURE OF CHARGER 2A-1, 2B-1 AND 2B-2	Installation of a portable DC generator for alternate/long term DC availability (SAMA 3). Install an inter-unit DC cross-tie (SAMA 3).

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Response to NRC RAI SAMA1-4, Item a), Part 2: Table F-13 Revised to Identify Corresponding Phase 1 SAMA ID Number

Event Name	Probability	RRW	Description	Potential SAMAs
ICC2PTT-CF-ECCSH	1.00E-05	1.01	CCF OF ALL ECCS PRESSURE TRANSMITTERS HIGH	Provide a manual override switch for the ECCS Low Pressure Permissive (SAMA 26).
ICC2INV-CF-XUALL	1.08E-06	1.01	CCF OF ALL XU PANEL POWER SUPPLY INVERTERS	Use of portable 120V AC generators could supply power to required panels (SAMA 16).
%2TIAN	1.00E+00	1.01	LOSS OF INSTRUMENT AIR	Provide a portable, diesel air compressor that can be connected to the air header (SAMA 21).
IAN2MDC-FR_CMPD	9.30E-01	1.01	AIR COMPRESSOR D FAILS TO RUN (ANNUAL)	Provide a portable, diesel air compressor that can be connected to the air header (SAMA 21).
EDG1DGN-24-DG12R	1.95E-03	1.01	COMMON CAUSE FAILURE TO RUN OF DIESEL GENERATORS 1 AND 2	Ensure all buses that can be cross-tied have procedures to perform cross-tie (proceduralize E3 to E4 cross-tie) (SAMA 7). Install an additional Diesel Generator (SAMA 25)

Response to NRC RAI SAMA1-4, Item a), Part 2: Table F-14 Revised to Identify Corresponding Phase 1 SAMA ID Number

Event Name	Probability	RRW	Description	Potential SAMAs
CAC2PHE-SC-INERT	9.90E-01	1.76	CONTAINMENT INERTED; VENTING NOT REQUIRED	N/A - success event.
TDI2XHE-TM-LPS1	9.00E-01	1.752	OPERATOR FAILS TO RECOVER LOW PRESSURE SYSTEMS	No suggestions. Means of decreasing the operator error rate for injection recovery are difficult to justify, especially after all efforts prior to RPV melt have failed.
CAC2AOV-FN-NOACP	1.00E+00	1.608	NO AC POWER AVAILABLE TO OPEN COMBUSTIBLE GAS VENT VALVES	In the event that AC power was available for venting, the containment would be inerted 99% of the time and venting would be required only 1% of the time. The RRW value implies a risk reduction that is not available. No changes suggested.
%TE_S	2.30E-02	1.565	LOSS OF OFFSITE POWER (SITE)	Addressed in the Level 1 RRW list or subsumed by a similar event.
%2T_T	2.70E+00	1.412	TURBINE TRIP INITIATOR	Addressed in the Level 1 RRW list or subsumed by a similar event.
ACP2XHE-TM-OFFLR	6.30E-01	1.329	OFFSITE AC POWER NOT RECOVERED DURING RX TIME FRAME (IBL)	Power recovery may be enhanced by providing the ability to align the UAT to the E-buses from the MCR (SAMA 4); however, this is represented by the event OPER-GENDISC. The potential to enhance Off-site power recovery procedures (SAMA 8) may be examined to determine if any realistic benefit could be attained through revisions, but LOOP recovery is governed by off-site conditions and actions. Additional on-site AC power is addressed elsewhere.
ACP2XHE-TM-ONSLR	1.00E+00	1.329	ONSITE EMERG. AC POWER NOT RECOV. DURING RX TIME FRAME (IBL)	Install a 5th, diverse diesel (SAMA 25).

Response to NRC RAI SAMA1-4, Item a), Part 2: Table F-14 Revised to Identify Corresponding Phase 1 SAMA ID Number

Event Name	Probability	RRW	Description	Potential SAMAs
ACP2XHE-TM-OFFSL	7.60E-01	1.329	OFFSITE AC POWER NOT RECOVERED DURING TD TIME FRAME (IBL)	Power recovery may be enhanced by providing the ability to align the UAT to the E-buses from the MCR (SAMA 4); however, this is represented by the event OPER-GENDISC. The potential to enhance Off-site power recovery procedures (SAMA 8) may be examined to determine if any realistic benefit could be attained through revisions, but LOOP recovery is governed by off-site conditions and actions. Additional on-site AC power is addressed elsewhere.
ACP2XHE-TM-ONSTL	1.00E+00	1.329	ONSITE EMERG. AC POWER NOT RECOV. DURING TD TIME FRAME (IBL)	Install a 5th, diverse diesel (SAMA 25).
RXM2XHE-TM-INJ	9.00E-01	1.319	OPERATOR FAILS TO RECOVER INJECTION BEFORE RPV MELT	No suggestions. Means of decreasing the operator error rate for injection recovery are difficult to justify, especially after all efforts prior to RPV melt have failed.
OPN2-DEP-OP5-SUC	8.50E-01	1.262	SUCCESSFUL RPV DEPRESSURIZATION (CLASS IBL)	N/A - success event.
BUSFAULT	3.90E-01	1.245	FRACTION OF LOSS OF BUS THAT ARE NON-RECOVERABLE	N/A
RXM2EST-NO-FAIL	1.00E+00	1.239	FAILURE OF RX (CLASS ID, II, IIIA, IV)	This vessel melt event is based on nature of the sequence in which it is used. Alternate injection systems, such as a direct drive diesel pump (SAMA 5), may be beneficial in reducing the magnitude of these types of sequences. However, crediting the current alternate systems should be reviewed prior to pursuing these methods.
OPER-ALTINJ	5.40E-01	1.218	OP FAILS TO ALIGN ALT. INJ. SOURCES IN LEVEL2	No suggestions. Means of decreasing the operator error rate for injection recovery are difficult to justify, especially after all efforts prior to RPV melt have failed.
OPN2-DEP-OP1-SUC	9.00E-01	1.197	SUCCESSFUL RPV DEPRESSURIZATION (CLASS IA)	N/A - success event.
TDI2XHE-TM-LPS2	1.00E+00	1.196	OPERATOR FAILS TO RECOVER LOW PRESSURE SYSTEMS	No suggestions. Means of decreasing the operator error rate for injection recovery are difficult to justify, especially after all

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Response to NRC RAI SAMA1-4, Item a), Part 2: Table F-14 Revised to Identify Corresponding Phase 1 SAMA ID Number

Event Name	Probability	RRW	Description	Potential SAMAs
OPER-ALTUNITXC	1.00E+00	1.175	OPERATORS FAIL TO MANUALLY ALIGN POWER FROM OPPOSITE UNIT	Addressed in the Level 1 RRW list or subsumed by a similar event.
EDG2DGN-FR-003	7.40E-02	1.153	DIESEL GENERATOR 3 FAILS TO RUN	Addressed in the Level 1 RRW list or subsumed by a similar event.
ACP2XHE-TM-OFFER	5.20E-01	1.15	OFFSITE AC POWER NOT RECOVERED DURING RX TIME FRAME (IBE)	Power recovery may be enhanced by providing the ability to align the UAT to the E-buses from the MCR (SAMA 4); however, this is represented by the event OPER-GENDISC. The potential to enhance Off-site power recovery procedures (SAMA 8) may be examined to determine if any realistic benefit could be attained through revisions, but LOOP recovery is governed by off-site conditions and actions. Additional on-site AC power is addressed elsewhere.
ACP2XHE-TM-ONSER	1.00E+00	1.15	ONSITE EMERG. AC POWER NOT RECOV. DURING RX TIME FRAME (IBE)	Install a 5th, diverse diesel (SAMA 25).
ACP2XHE-TM-OFFE	6.90E-01	1.15	OFFSITE AC POWER NOT RECOVERED DURING TD TIME FRAME (IBE)	Power recovery may be enhanced by providing the ability to align the UAT to the E-buses from the MCR (SAMA 4); however, this is represented by the event OPER-GENDISC. The potential to enhance Off-site power recovery procedures (SAMA 8) may be examined to determine if any realistic benefit could be attained through revisions, but LOOP recovery is governed by off-site conditions and actions. Additional on-site AC power is addressed elsewhere.
ACP2XHE-TM-ONSTE	1.00E+00	1.15	ONSITE EMERG. AC POWER NOT RECOV. DURING TD TIME FRAME (IBE)	Install a 5th, diverse diesel (SAMA 25).
DCP2BAT-XXDEP2B	1.00E+00	1.148	BATTERY BANK 2B DEPLETION FOLLOWING LOSS OF POWER FROM CHARGER	Addressed in the Level 1 RRW list or subsumed by a similar event.

Response to NRC RAI SAMA1-4, Item a), Part 2: Table F-14 Revised to Identify Corresponding Phase 1 SAMA ID Number

Event Name	Probability	RRW	Description	Potential SAMAs
X-AC-12H	4.02E-02	1.134	LOSP RECOVERY 12 HOURS	Addressed in the Level 1 RRW list or subsumed by a similar event.
SRV2ALT-DE-METH	1.00E+00	1.133	ALTERNATE DEPRESS. METHODS NOT CREDITED	Alternate depressurization methods are not credited for BSEP. The following alternate depressurization paths are available given failure of the normal means: main condenser via the turbine bypass valves, main steam line drains, HPCI, RCIC, SJAE, RFP, RWCU in recirc mode, and RWCU in blowdown mode. Lack of credit in the model for these methods artificially inflates the importance of depressurization. Additional depressurization methods are not pursued further as the benefit is judged to be small considering the availability of the existing procedures to use the alternate pathways identified above.
SRV2MCS-NO-PRES	9.00E-01	1.133	PRESSURE TRANSIENT DOES NOT FAIL MECHANICAL SYSTEMS	N/A - success event.
SRV2PHE-NO-CMP	2.50E-01	1.133	SRVs DO NOT FAIL OPEN DURING CORE MELT PROGRESSION	No suggestions for cost effective SRV improvement.
SRV2PHE-NO-TEMP	9.00E-01	1.133	HIGH PRIM SYS TEMP DOES NOT CAUSE FAIL OF RCS PRESS. BOUND	N/A - success event.
DCP2REC-XXTRP2A1	1.00E+00	1.133	CHARGER 2A-1 TRIPS FOLLOWING TRANSIENT WITH BATTERY FAILURE	Addressed in the Level 1 RRW list or subsumed by a similar event.
OPN2-DEP-OP7-SUC	9.50E-01	1.131	SUCCESSFUL RPV DEPRESSURIZATION (CLASS IBE)	N/A - success event.
%2T_DC2B2	2.90E-03	1.131	LOSS OF 125V DC PANEL 2B2	Addressed in the Level 1 RRW list or subsumed by a similar event.
DCP2REC-XXTRP2B2	1.00E+00	1.129	CHARGER 2B-2 TRIPS FOLLOWING TRANSIENT WITH BATTERY FAILURE	Addressed in the Level 1 RRW list or subsumed by a similar event.

Response to NRC RAI SAMA1-4, Item a), Part 2: Table F-14 Revised to Identify Corresponding Phase 1 SAMA ID Number

Event Name	Probability	RRW	Description	Potential SAMAs
X-AC-2H	1.33E-01	1.113	LOSP RECOVERY 2 HOURS	Addressed in the Level 1 RRW list or subsumed by a similar event.
OPER-DCPALTDC2	1.00E+00	1.113	OPERATOR FAILS TO ALIGN DC BUS TO STANDBY DC POWER SUPPLY - UNIT2	Addressed in the Level 1 RRW list or subsumed by a similar event.
NCN2PHE-NO-L1CNT	1.00E+00	1.112	LG CONT. FAILURE GIVEN CONT. FAILED IN LEVEL 1 (CLASS IV)	No suggestions.
DWT2PHE-SC-ATWS	9.90E-01	1.11	DW INTACT FOR ATWS EVENTS (CLASS IV)	N/A - success event.
WWB2PHE-NO-ATWS	5.00E-01	1.11	WW WATER SPACE FAILURE FOR ATWS EVENTS (CLASS IV)	No suggestions.
OPER-480X2	1.00E+00	1.11	OPERATORS FAIL TO MANUALLY CONNECT UNIT 2 SUBSTATIONS E7 AND E8	Addressed in the Level 1 RRW list or subsumed by a similar event.
EDG2DGN-FR-004	7.40E-02	1.105	DIESEL GENERATOR 4 FAILS TO RUN	Addressed in the Level 1 RRW list or subsumed by a similar event.
DCP2BAT-XXDEP2A	1.00E+00	1.098	BATTERY BANK 2A DEPLETION FOLLOWING LOSS OF POWER FROM CHARGER	Addressed in the Level 1 RRW list or subsumed by a similar event.
OPER-DEPRESS	1.00E+00	1.094	OPERATOR FAILS TO MANUALLY INITIATE AND ALIGN LOW-PRESSURE SYSTEMS	Addressed in the Level 1 RRW list or subsumed by a similar event.
XOP-COM2-16	7.90E-03	1.091	OPER-DCPALTDC1 OPER-ALTUNITXC OR OPER-DCPALTDC1 OPER-ALTUNITXC	Addressed in the Level 1 RRW list or subsumed by a similar event.
X-AC-16H	2.49E-02	1.09	LOSP RECOVERY 16 HOURS	Addressed in the Level 1 RRW list or subsumed by a similar event.
EDG1DGN-FR-001	7.40E-02	1.083	DIESEL GENERATOR 1 FAILS TO RUN	Addressed in the Level 1 RRW list or subsumed by a similar event.

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Event Name	Probability	RRW	Description	Potential SAMAs
SRV-DEMAND1	6.36E-01	1.079	7 OF 11 SRVS DEMANDED ISOLATION TRANSIENT	Addressed in the Level 1 RRW list or subsumed by a similar event.
EDG1DGN-FR-002	7.40E-02	1.074	DIESEL GENERATOR 2 FAILS TO RUN	Addressed in the Level 1 RRW list or subsumed by a similar event.
OPN2-DEP-OP8-SUC	9.80E-01	1.066	SUCCESSFUL RPV DEPRESSURIZATION (CLASS IVA)	N/A - success event.
RPS2MBIND	1.00E-05	1.064	MECHANICAL BINDING OF CONTROL RODS	Addressed in the Level 1 RRW list or subsumed by a similar event.
DCP0BAT-44ALL	2.19E-07	1.064	COMMON CAUSE FAILURE OF UNIT 1 AND UNIT 2 BATTERIES	Addressed in the Level 1 RRW list or subsumed by a similar event.
DCP1BAT-XXDEP1A	1.00E+00	1.056	BATTERY BANK 1A DEPLETION FOLLOWING LOSS OF POWER FROM CHARGER	Addressed in the Level 1 RRW list or subsumed by a similar event.
OPER-DILUTE	1.00E+00	1.052	OPERATOR FAILS TO PRECLUDE BORON WASHOUT DURING LOW PRESSURE INJECTION	Addressed in the Level 1 RRW list or subsumed by a similar event.
ICC2LPW-CF-XUALL	3.73E-06	1.044	CCF OF ALL XU POWER SUPPLY PANELS	Addressed in the Level 1 RRW list or subsumed by a similar event.
OPER-DEPRESSRPV	5.20E-01	1.043	OP FAILS TO DEPRESS BEFORE RPV FAILS GIVEN RPV DEPRESS. FAILED IN LVL1	Addressed in the Level 1 RRW list or subsumed by a similar event.
OPER-DGHMAN	1.00E+00	1.04	OPERATORS FAIL TO MANUALLY START EXHAUST FAN	Addressed in the Level 1 RRW list or subsumed by a similar event.
NCN2PHE-NO-LOWTM	5.70E-01	1.038	LG CONT. FAILURE AT LOW DW TEMP. (CLASS I, III WITH NO RPV BREACH OR CLASS II)	No suggestions.
DCP2REC-XXTRP2B1	1.00E+00	1.038	CHARGER 2B-1 TRIPS FOLLOWING TRANSIENT WITH BATTERY FAILURE	Addressed in the Level 1 RRW list or subsumed by a similar event.

Response to NRC RAI SAMA1-4, Item a), Part 2: Table F-14 Revised to Identify Corresponding Phase 1 SAMA ID Number

Event Name	Probability	RRW	Description	Potential SAMAs
CRD2SCRAM	6.00E-06	1.035	FAILURE OF CONTROL ROD DRIVE SCRAM VALVES	Addressed in the Level 1 RRW list or subsumed by a similar event.
OPER-GENDISC	1.00E+00	1.035	OPERATORS FAIL TO ESTABLISH BACKFEED	Addressed in the Level 1 RRW list or subsumed by a similar event.
XOP-DGHMAN	6.10E-03	1.033	OPER-DGHMAN	Addressed in the Level 1 RRW list or subsumed by a similar event.
X-AC-1H	2.09E-01	1.031	LOSP RECOVERY 1 HOUR	Addressed in the Level 1 RRW list or subsumed by a similar event.
DWT2PHE-NO-LOWTM	7.80E-01	1.031	DW NOT INTACT AT LOW DW TEMP (CLASS I, III WITH NO RPV BREACH OR CLASS II)	No suggestions.
DCP0REC-44ALL	1.76E-07	1.031	COMMON CAUSE FAILURE OF BOTH UNIT 1 AND UNIT 2 CHARGERS	Addressed in the Level 1 RRW list or subsumed by a similar event.
OPER-LLEVEL1	1.00E+00	1.03	OPERATOR FAILS TO CONTROL LOWERED WATER LEVEL WITH HPCI DURING ATWS	Addressed in the Level 1 RRW list or subsumed by a similar event.
NCN2PHE-LK-LOWTM	4.30E-01	1.03	SM CONT. FAILURE AT LOW DW TEMP. (CLASS I, III WITH NO RPV BREACH OR CLASS II)	No suggestions.
ACP2XHE-TM-POWER	1.00E+00	1.03	OPERATOR FAILS TO RESTORE AC POWER DURING BOIL-OFF	Alternate depressurization methods are not credited for BSEP. The following alternate depressurization paths are available given failure of the normal means: main condenser via the turbine bypass valves, main steam line drains, HPCI, RCIC, SJAE, RFP, RWCU in recirc mode, and RWCU in blowdown mode. Lack of credit in the model for these methods artificially inflates the importance of depressurization. Additional depressurization methods are not pursued further as the benefit is judged to be small considering the availability of the existing procedures to use the alternate pathways identified above.

Response to NRC RAI SAMA1-4, Item a), Part 2: Table F-14 Revised to Identify Corresponding Phase 1 SAMA ID Number

Event Name	Probability	RRW	Description	Potential SAMAs
OPER-FPS1	1.00E+00	1.029	OPERATOR FAILS TO ALIGN FIREWATER FOR COOLANT INJECTION FLOW (ONE UNIT)	Addressed in the Level 1 RRW list or subsumed by a similar event.
OPER-ALTINJ2	5.10E-01	1.029	OP FAILS TO ALIGN ALT. INJ. SOURCES IN LEVEL2	No suggestions. Means of decreasing the operator error rate for injection recovery are difficult to justify, especially after all efforts prior to RPV melt have failed.
%2TE_E4	2.00E-03	1.028	LOSS OF 4160V AC BUS E4	Addressed in the Level 1 RRW list or subsumed by a similar event.
X-AC-5H	9.30E-02	1.025	LOSP RECOVERY 5 HOURS	Addressed in the Level 1 RRW list or subsumed by a similar event.
X-AC-18H	1.96E-02	1.025	LOSP RECOVERY 18 HOURS	Addressed in the Level 1 RRW list or subsumed by a similar event.
OPER-DC2BALT	1.00E+00	1.025	OPERATOR FAILS TO SWITCH CHARGER TO ALTERNATE AC POWER SUPPLY-UNIT 2	Addressed in the Level 1 RRW list or subsumed by a similar event.
EDG2DGN-TM-D003	1.40E-02	1.024	DIESEL GENERATOR 3 UNAVAILABLE DUE TO MAINTENANCE (AT POWER)	Addressed in the Level 1 RRW list or subsumed by a similar event.
%2T_C	1.80E-01	1.024	LOSS OF CONDENSER VACUUM	Addressed in the Level 1 RRW list or subsumed by a similar event.
EDG0DGN-44-EDGR	6.19E-04	1.023	COMMON CAUSE FAILURE OF 4 OF 4 DIESEL GENERATORS TO RUN	Addressed in the Level 1 RRW list or subsumed by a similar event.
%2TE_U2	1.40E-02	1.022	LOSS OF OFFSITE POWER TO UNIT 2	Addressed in the Level 1 RRW list or subsumed by a similar event.
%2TF14	3.50E-07	1.022	INTERNAL FLOOD TF14: FAILS CONDENSATE AND FLOODS CABLE SPREADING ROOM	Addressed in the Level 1 RRW list or subsumed by a similar event.
OPER-LLEVEL2	1.00E+00	1.021	OPERATOR FAILS TO CONTROL LOWERED WATER LEVEL WITH RCIC DURING ATWS	Addressed in the Level 1 RRW list or subsumed by a similar event.

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Response to NRC RAI SAMA1-4, Item a), Part 2: Table F-14 Revised to Identify Corresponding Phase 1 SAMA ID Number

Event Name	Probability	RRW	Description	Potential SAMAs
XOP-ALTUNITXC	1.80E-02	1.021	OPER-ALTUNITXC AND NON-OPERS	Addressed in the Level 1 RRW list or subsumed by a similar event.
XOP-ALTUNITXC1	7.00E-02	1.02	OPER-ALTUNITXC	Addressed in the Level 1 RRW list or subsumed by a similar event.
EDG2MDC-44SU2AC	1.22E-03	1.019	COMMON CAUSE FAILURE OF UNIT 2 DG AIR COMPRESSORS TO START	Addressed in the Level 1 RRW list or subsumed by a similar event.
CNT2CNT-CO-BYPSS	1.00E+00	1.019	CONTAINMENT ISOLATION FAILURE (CLASS V)	Provide redundant and diverse limit switches to each containment isolation valve (SAMA 29).
OPER-SWRHR-C	1.00E+00	1.018	OPERATORS FAIL TO LOCALLY CLOSE THE SW VALVES FOR FW INJECTION	No suggestions. Means of decreasing the operator error rate for injection recovery are difficult to justify, especially after all efforts prior to RPV melt have failed.
XOR-SWRHR-C	1.00E-01	1.018	OPER-SWRHR-C	Addressed as independent event.
ACP0BKR-44-1234	2.04E-04	1.017	COMMON CAUSE FAILURE OF AT LEAST ONE BREAKER FOR EACH E-BUS	Addressed in the Level 1 RRW list or subsumed by a similar event.
XOP-COM2-15	1.00E-02	1.017	OPER-LLEVEL2 OPER-DILUTE	Addressed in the Level 1 RRW list or subsumed by a similar event.
%2TCSW	1.00E+00	1.017	LOSS OF CONVENTIONAL SERVICE WATER	No suggestions.
RCI2TDP-FR-RCTDP	2.30E-01	1.017	RCIC TURBINE-DRIVEN PUMP FAILS TO RUN	Addressed in the Level 1 RRW list or subsumed by a similar event.
%2TF7	1.55E-05	1.017	INTERNAL FLOOD TF7: FAILS ALL PUMPS AT -17 LEVEL	Install a direct drive diesel injection pump and locate it outside of the flood areas (SAMA 5). Investigate credit for injection with the fire water system (Fire Water injection is credited).
OPER-SWRHR-O	1.00E+00	1.016	OPERATORS FAIL TO LOCALLY OPEN THE DISCHARGE VALVES FOR RHR INJECTION	No suggestions. Means of decreasing the operator error rate for injection recovery are difficult to justify, especially after all efforts prior to RPV melt have failed.
XOR-SWRHR-O	1.00E-01	1.016	OPER-SWRHR-O	Addressed as independent event.

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Response to NRC RAI SAMA1-4, Item a), Part 2: Table F-14 Revised to Identify Corresponding Phase 1 SAMA ID Number

Event Name	Probability	RRW	Description	Potential SAMAs
EDG2DGN-TM-D004	1.40E-02	1.016	DIESEL GENERATOR 4 UNAVAILABLE DUE TO MAINTENANCE (AT POWER)	Addressed in the Level 1 RRW list or subsumed by a similar event.
EDG2DGN-24-DG34R	1.95E-03	1.016	COMMON CAUSE FAILURE TO RUN OF DIESEL GENERATORS 3 AND 4	Addressed in the Level 1 RRW list or subsumed by a similar event.
DGH0TTE-LOTE1608	4.95E-02	1.016	THERMOSTAT TE-1608 FAILS LOW	Addressed in the Level 1 RRW list or subsumed by a similar event.
%2TE_E8	2.00E-03	1.016	LOSS OF 480V AC SUBSTATION E8	Addressed in the Level 1 RRW list or subsumed by a similar event.
%2TCRD	1.00E+00	1.016	LOSS OF CONTROL ROD DRIVE	Addressed in the Level 1 RRW list or subsumed by a similar event.
DCP2BAT-24A1B2	1.45E-07	1.015	COMMON CAUSE FAILURE OF BATTERY 2A-1 AND 2B-2	Addressed in the Level 1 RRW list or subsumed by a similar event.
SWS2MDP-33_CSW2	7.59E-03	1.015	COMMON CAUSE FAILURE OF ALL UNIT 2 CSW PUMPS TO RUN	Investigate potential improvements in the inter-unit SW cross-ties (SAMA 30).
%2T_DC2A1	2.90E-03	1.014	LOSS OF 125V DC PANEL 2A1	Addressed in the Level 1 RRW list or subsumed by a similar event.
XOP-DILUTE	4.30E-02	1.014	OPER-DILUTE	Addressed in the Level 1 RRW list or subsumed by a similar event.
EDG1DGN-TM-D001	1.40E-02	1.014	DIESEL GENERATOR 1 UNAVAILABLE DUE TO MAINTENANCE (AT POWER)	Addressed in the Level 1 RRW list or subsumed by a similar event.
DCP2BAT-TM2A1	1.14E-04	1.013	BATTERY 2A-1 UNAVAILABLE DUE TO TEST OR MAINTENANCE	Addressed in the Level 1 RRW list or subsumed by a similar event.
SRV2SRV-OO-F013A	1.70E-02	1.013	ADS SAFETY RELIEF VALVE B21-F013A FAILS TO RECLOSE	Addressed in the Level 1 RRW list or subsumed by a similar event.
SRV2SRV-OO-F013B	1.70E-02	1.013	NON-ADS SAFETY RELIEF VALVE B21-F013B FAILS TO RECLOSE	Addressed in the Level 1 RRW list or subsumed by a similar event.

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Event Name	Probability	RRW	Description	Potential SAMAs
SRV2SRV-OO-F013C	1.70E-02	1.013	ADS SAFETY RELIEF VALVE B21-F013C FAILS TO RECLOSE	Addressed in the Level 1 RRW list or subsumed by a similar event.
SRV2SRV-OO-F013D	1.70E-02	1.013	ADS SAFETY RELIEF VALVE B21-F013D FAILS TO RECLOSE	Addressed in the Level 1 RRW list or subsumed by a similar event.
SRV2SRV-OO-F013E	1.70E-02	1.013	NON-ADS SAFETY RELIEF VALVE B21-F013E FAILS TO RECLOSE	Addressed in the Level 1 RRW list or subsumed by a similar event.
SRV2SRV-OO-F013F	1.70E-02	1.013	NON-ADS SAFETY RELIEF VALVE B21-F013F FAILS TO RECLOSE	Addressed in the Level 1 RRW list or subsumed by a similar event.
SRV2SRV-OO-F013G	1.70E-02	1.013	NON-ADS SAFETY RELIEF VALVE B21-F013G FAILS TO RECLOSE	Addressed in the Level 1 RRW list or subsumed by a similar event.
SRV2SRV-OO-F013H	1.70E-02	1.013	ADS SAFETY RELIEF VALVE B21-F013H FAILS TO RECLOSE	Addressed in the Level 1 RRW list or subsumed by a similar event.
SRV2SRV-OO-F013J	1.70E-02	1.013	ADS SAFETY RELIEF VALVE B21-F013J FAILS TO RECLOSE	Addressed in the Level 1 RRW list or subsumed by a similar event.
SRV2SRV-OO-F013K	1.70E-02	1.013	ADS SAFETY RELIEF VALVE B21-F013K FAILS TO RECLOSE	Addressed in the Level 1 RRW list or subsumed by a similar event.
SRV2SRV-OO-F013L	1.70E-02	1.013	ADS SAFETY RELIEF VALVE B21-F013L FAILS TO RECLOSE	Addressed in the Level 1 RRW list or subsumed by a similar event.
SWS2XVN-OC-V442	2.11E-05	1.013	MANUAL VALVE 2 SW V442 FAILS TO REMAIN OPEN	Addressed in the Level 1 RRW list or subsumed by a similar event.
XOP-FPS1	9.60E-02	1.013	OPER-FPS1	Addressed in the Level 1 RRW list or subsumed by a similar event.
ACP0TFM-LP-E8	3.12E-05	1.013	TRANSFORMER 4160/480 E4 TO E8 FAILURE NO POWER	Provide capability in the main control room to perform 480V AC substation X-tie (SAMA 13).
%2TE_E7	2.00E-03	1.012	LOSS OF 480V AC SUBSTATION E7	Addressed in the Level 1 RRW list or subsumed by a similar event.
%2TE_E3	2.00E-03	1.012	LOSS OF 4160V AC BUS E3	Addressed in the Level 1 RRW list or subsumed by a similar event.

Response to NRC RAI SAMA1-4, Item a), Part 2: Table F-14 Revised to Identify Corresponding Phase 1 SAMA ID Number

Event Name	Probability	RRW	Description	Potential SAMAs
OPER-FWS-INJ	1.00E+00	1.012	OPERATORS FAIL TO PROPERLY CONTROL CONDENSATE INJECTION FLOW RATE	No suggestions.
EDG1DGN-TM-D002	1.40E-02	1.012	DIESEL GENERATOR 2 UNAVAILABLE DUE TO MAINTENANCE (AT POWER)	Addressed in the Level 1 RRW list or subsumed by a similar event.
EDG1DGN-24-DG12R	1.95E-03	1.012	COMMON CAUSE FAILURE TO RUN OF DIESEL GENERATORS 1 AND 2	Addressed in the Level 1 RRW list or subsumed by a similar event.
OPER-WVDHR	1.00E+00	1.012	OPERATORS FAIL TO INITIATE WETWELL VENTING FOR DHR	No suggestions.
XOP-WVDHR	1.50E-03	1.012	OPER-WVDHR	No suggestions.
SWS2CKV-OO-V22	5.40E-04	1.012	CHECK VALVE SW V-22 FAILS TO CLOSE	Proceduralize MOV closure from the control room and back-up local operations to isolate flow diversion (SAMA 31).
XOP-DEPRESS	6.90E-03	1.012	OPER-DEPRESS	Addressed in the Level 1 RRW list or subsumed by a similar event.
DCP2BAT-TM2B2	1.14E-04	1.011	BATTERY 2B-2 UNAVAILABLE DUE TO TEST OR MAINTENANCE	Addressed in the Level 1 RRW list or subsumed by a similar event.
ICC2INV-CF-XUALL	1.08E-06	1.011	CCF OF ALL XU PANEL POWER SUPPLY INVERTERS	Addressed in the Level 1 RRW list or subsumed by a similar event.
EDG0DGN-34-D123R	2.94E-04	1.011	COMMON CAUSE FAILURE TO RUN OF DIESEL GENERATORS 1, 2 AND 3	Addressed in the Level 1 RRW list or subsumed by a similar event.
EDG0DGN-34-D124R	2.94E-04	1.011	COMMON CAUSE FAILURE TO RUN OF DIESEL GENRATORS 1, 2 AND 4	Addressed in the Level 1 RRW list or subsumed by a similar event.
EDG0DGN-34-D134R	2.94E-04	1.011	COMMON CAUSE FAILURE TO RUN OF DIESEL GENERATORS 1, 3 AND 4	Addressed in the Level 1 RRW list or subsumed by a similar event.

Response to NRC RAI SAMA1-4, Item a), Part 2: Table F-14 Revised to Identify Corresponding Phase 1 SAMA ID Number

Event Name	Probability	RRW	Description	Potential SAMAs
EDG0DGN-34-D234R	2.94E-04	1.011	COMMON CAUSE FAILURE TO RUN OF DIESEL GENERATORS 2, 3 AND 4	Addressed in the Level 1 RRW list or subsumed by a similar event.
XOP-GENDISC	1.80E-01	1.011	OPER-GENDISC	Addressed in the Level 1 RRW list or subsumed by a similar event.
XOP-COM2-14	1.60E-02	1.01	OPER-LLEVEL1 OPER-DILUTE	Addressed in the Level 1 RRW list or subsumed by a similar event.
EDG2DGN-FS-003	6.30E-03	1.01	DIESEL GENERATOR 3 FAILS TO START	Addressed in the Level 1 RRW list or subsumed by a similar event.
OPER-480X1	1.00E+00	1.01	OPERATORS FAIL TO MANUALLY CONNECT UNIT1 SUBSTATIONS E5 AND E6	Provide capability in the main control room to perform 480V AC substation X-tie (SAMA 13).