ATTACHMENT F

KEWAUNEE POWER STATION SEVERE ACCIDENT MITIGATION ALTERNATIVES

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ACRONYMS USED IN ATTACHMENT F

ACC	accumulator injection
AFW	auxiliary feed water
ALOP	auxiliary lube oil pump
ATWS	anticipated transient without scram
AOSC	Averted Onsite Costs
CCW	component cooling water
CDF	core damage frequency
CET	Containment Event Tree
CST	condensate storage tank
DHR	decay heat removal
DBD	design basis documents
ECCS	emergency core cooling system
EDG	emergency diesel generator
EOP	emergency operating procedures
EPZ	Emergency Planning Zone
F&Os	Facts and Observations
HEP	human error probability
HPI	high pressure injection
HPCI	high pressure coolant injection
HPR	high pressure recirculation
HRA	human reliability analysis
HVAC	heating ventilation and air-conditioning system
IPE	Individual Plant Examination
IPEEE	Individual Plant Examination for External Events
IPEOP	integrated plant emergency operating procedures
ISLOCA	interfacing systems LOCA
KPS	Kewaunee Power Station
LER	Large, Early Releases
LERF	large early release frequency
LOCA	loss-of-coolant accident
LOSP	loss of offsite power
LPI	low pressure injection
LPR	low pressure recirculation
MAAP	modular accident analysis program

MACCS2	MELCOR Accident Consequences Code System Version 2
MACR	maximum averted cost-risk
MCC	motor control center
MDP	motor driven pump
MFW	main feedwater
MLOCA	medium LOCA
MOV	motor operated valve
MSIV	main steam isolation valve
NEI	Nuclear Energy Institute
NPV	Net Present Value
NRC	U.S. Nuclear Regulatory Commission
PDS	Plant Damage States
PRA	Probabilistic Risk Assessment
PORV	power operated relief valve
PWR	pressurized water reactor
RAI	requests for additional information
RCP	reactor coolant pump
RCIC	reactor core isolation cooling
RCS	reactor coolant system
RHR	residual heat removal
RMST	reactor makeup storage tank
RWST	refueling water storage tank
SAMA	severe accident mitigation alternatives
SBO	station blackout
SG	steam generator
SGTR	steam generator tube rupture
SLOCA	small LOCA
STC	source term category
SWS	service water system
TSC	technical support center
TDP	turbine driven pump
TMI	Three Mile Island
VCT	volume control tank
WCGS	Wolf Creek Generating Station
WOG	Westinghouse Owners Group

ATTACHMENT F

KPS SEVERE ACCIDENT MITIGATION ALTERNATIVES

The severe accident mitigation alternatives (SAMA) analysis discussed in Section 4.20 of the Environmental Report is presented below.

F.1 METHODOLOGY

The methodology selected for this analysis is based on the Nuclear Energy Institute's (NEI's) SAMA Analysis Guidance Document (Reference F-1) and involves identifying SAMA candidates that have the highest potential for reducing plant risk and determining whether or not the implementation of those candidates is beneficial on a cost-risk reduction basis. The metrics chosen to represent plant risk include the core damage frequency (CDF), the dose-risk, and the off-site economic cost-risk. These values provide a measure of both the likelihood and consequences of a core damage event. The SAMA process consists of the following steps:

- Kewaunee Power Station (KPS) Probabilistic Risk Assessment (PRA) Model – Use the KPS Internal Events PRA model as the basis for the analysis (Section F.2). Incorporate external events contributions as described in Section F.4.5.

- Level 3 PRA Analysis – Use KPS Level 1 and 2 Internal Events PRA output and site-specific meteorology, demographic, land use, and emergency response data as input in performing a Level 3 PRA (Section F.3) using the MELCOR Accident Consequences Code System Version 2 (MACCS2) (Reference F-2).

- Baseline Risk Monetization – Use the analysis techniques specified in Reference F-1 to calculate the monetary value of the unmitigated KPS severe accident risk. This becomes the maximum averted cost-risk (MACR) that is possible (Section F.4).

- Phase I SAMA Analysis – Identify potential SAMA candidates based on the KPS PRA, Individual Plant Examination (IPE), Individual Plant Examination for External Events (IPEEE), and documentation from the industry and NRC. Screen out Phase I SAMA candidates that are not applicable to the KPS design or are of low benefit in pressurized water reactors (PWRs) such as KPS, candidates that have already been implemented at KPS or whose benefits have been achieved at KPS using other means, and candidates whose estimated cost exceeds the possible MACR (Section F.5).

- Phase II SAMA Analysis – Calculate the risk reduction attributable to each remaining SAMA candidate and compare to a more detailed cost analysis to identify the net cost-benefit. PRA insights are also used to screen SAMA candidates in this phase (Section F.6).

- Sensitivity Analysis – Evaluate how changes in the SAMA analysis assumptions might affect the cost-benefit evaluation (Section F.7).

- Conclusions – Summarize results and identify conclusions (Section F.8).

The steps outlined above are described in more detail in the subsections of this appendix.

F.2 KPS PRA MODEL

The KPS PRA includes Level 1, Level 2, and Level 3 PRA models for internal events, including internal flooding. The current Level 1 PRA model provides results for CDF, large early release frequency (LERF), and individual accident sequence frequencies. Systems such as containment spray and containment fan coil units that could have a significant impact on containment performance are included in the Level 1 PRA model. The Level 2 PRA model determines the physical and chemical phenomena that affect the performance of the containment and other radiological release mitigation features to quantify accident behavior and release of fission products to the environment. The Level 2 PRA model makes use of the accident sequence results from the Level 1 PRA model. The Level 3 PRA model evaluates the offsite consequences that result from severe accidents and containment radiological releases. The Level 3 PRA model uses the source term characteristics generated by the Level 2 PRA model.

F.2.1 KPS PRA Model Used For SAMA Analysis

The internal events model used for the KPS SAMA analysis is version K101AASAMA, which was completed in May 2007, and included changes to the Level 1 and Level 2 PRA models. The Level 2 PRA model is described in Section F.2.4. Changes to the Level 1 model included restructuring the Level 1 event trees to support using the revised Level 2 PRA model, revising service water modeling for some internal flooding scenarios, and incorporating logic changes needed to address internal flooding-related design changes that are planned for completion prior to the license renewal period.

The restructuring of the Level 1 event trees was performed to keep the number of sequences within the limits of the computer code used to perform the Level 2 PRA analysis. Changes made included removing nodes used to evaluate the status of containment isolation, now evaluated in the Level 2 PRA models and adding a node to evaluate large early release frequency (LERF). These event tree changes did not affect core damage frequency results directly. However, because of the quantification methodology, some additional cutsets that would be considered non-minimal were created.

The service water model change ensured that accident sequences involving internal flooding events caused by service water that progressed to the point of generating a safety injection signal did not credit use of the service water header that caused the initial flooding.

Changes are included in the SAMA PRA model to reflect four design changes that reduce the risk from internal flooding. These design changes were presented to the NRC at Region III offices on November 30, 2006. Details of the meeting are provided under ADAMS Accession Number ML063460495.

Three of these changes have been completed: installation of flood detection instruments and alarms in the auxiliary building; installation of a watertight door between safeguards alley and the auxiliary building; and installation of spray shields on service water piping in safeguards alley.

The fourth change, elevating supply breakers from the main safety-related buses to certain safety related MCCs in the auxiliary building, would be scheduled in the future when the associated bus can be taken out of service. In the meantime, an alternate project, re-routing a wire to the Turbine Building Fan Coil Unit B breaker to increase the flood failure height, has had an additional CDF reduction benefit. Thus, the SAMA PRA model is conservative with respect to evaluating the risk reduction of potential SAMAs.

The results of the Level 1 PRA model quantification produce a CDF of $7.7x10^{-5}$ per year and a LERF of $9.5x10^{-6}$ per year as determined from the sum of the minimal cutsets. When determined from the sum of event tree sequence values, the Level 1 PRA model produces a CDF of $8.1x10^{-5}$ per year and a LERF of $9.9x10^{-6}$ per year. The frequency obtained from the sum of the event tree sequence frequency values is higher because non-minimal cutsets would be included.

The major contributors to the KPS CDF and the relative percentage contribution of each to total CDF are shown in Table F-1 by initiating event. As shown in Table F-1, no single initiating event dominates CDF risk. However, internal flooding events considered as a group dominate, with service water-related events most important. SBO sequences contribute 13.6% to total CDF. ATWS sequences contribute less than 1% to total CDF. A listing of basic events with a Fussell-Vesely importance of greater than 0.5% with respect to CDF is included as Table F-3.

The major contributors to the KPS LERF and the relative percentage contribution of each to total LERF are shown in Table F-2 by initiating event. As shown in Table F-2, the contribution of initiating events with respect to LERF is dominated by steam generator tube rupture initiating events, which contribute 19.3% to overall LERF. These initiating events, by definition, create a direct bypass of containment. Interfacing systems LOCA (ISLOCA) initiating events also create a direct bypass of containment and contribute 1.6% to overall LERF. The other initiating events listed contribute to LERF through accident sequences that cause induced steam generator tube ruptures. SBO sequences contribute 24.4% to total LERF. ATWS sequences contribute less than 1% to total LERF. A listing of basic events with a Fussell-Vesely importance of greater than 0.5% with respect to LERF is included as Table F-8.

F.2.2 Level 1 PRA Model Changes Since the IPE Submittal

The KPS PRA model has been updated various times since the IPE submittal (Reference F-3). A history of the KPS PRA is summarized below.

F.2.2.1 Level 1 PRA Model Changes Since the IPE Submittal

The KPS IPE model was completed in December 1992 in response to Generic Letter 88-20. The fault tree linking approach was used and all event trees and fault trees were developed based on plant drawings and procedures. The model included detailed fault tree models of all front line (accident mitigating) systems and their support systems (Electrical, Air, etc.). The model also included detailed event trees which delineated accident sequences based primarily on the temporal response of the systems needed to mitigate the initiating event. The model submitted for the IPE produced a CDF of $6.6x10^{-5}$ per year. LERF was not calculated in the IPE model.

As part of the NRC review of the KPS IPE model, several requests for additional information (RAIs) were generated. In response to these RAIs, several changes were made to the IPE model. The most significant changes were related to incorporation of a new human reliability analysis (HRA) method. The revised IPE model was completed in June of 1996 and produced a CDF of $1.1x10^{-4}$ per year.

The KPS PRA model was updated again in January 1997. The major changes incorporated in this update include crediting operator action to refill the refueling water storage tank (RWST) and modeling alternate cooling for air compressors. Also, air accumulators were added to the models for several air-operated valves and the need to stop residual heat removal (RHR) pumps when operating on min-flow was removed. These revisions produced a CDF of 3.9×10^{-5} per year and LERF of 2.2×10^{-6} per year.

In April 1998, the KPS PRA model was updated to remove asymmetric modeling. Specifically, in all previous models, when normally-operating systems were running, the A-train was assumed to be in operation and the B-train was assumed to be in standby. In this update, logic was added to allow for the probability that any train was operating or in standby. Also, previous models assumed specific locations for LOCA initiators or specific trains for support system initiating events. These asymmetries were removed as part of this update. Other minor plant changes were also incorporated into the model. These revisions produced a CDF of 3.6×10^{-5} per year and LERF of 1.9×10^{-6} per year.

The next major model update occurred in December 2001 when the PRA model software was converted from the GRAFTER code to the WinNUPRA code. Also as part of this update, plant failure data and initiating event data were updated. This update included consideration of the replacement steam generators. These changes resulted in a CDF of 4.1×10^{-5} per year and LERF of 4.8×10^{-6} per year. It was this model revision that was used for the Westinghouse Owners Group (WOG) peer review in June 2002.

Another update of the PRA model was completed in August 2003. As part of that update, the WOG seal LOCA model was incorporated and all important human error probabilities (HEPs) were reevaluated. All thermal-hydraulic code runs for Level 2 success criteria were re-run reflecting the plant power uprate. The medium LOCA and interfacing system LOCA event tree models were updated. Credit for low-pressure injection was removed from the medium LOCA event and credit for RWST refill and closure of valves against high differential pressure was removed from the ISLOCA event. The steam line break event tree was revised to include pressurized thermal shock potential. A quantitative shutdown model was added and numerous peer review comments were resolved. These changes resulted in a CDF of 3.0×10^{-5} per year and LERF 5.3×10^{-6} per year.

In December 2004, the KPS PRA model was updated with several changes. The need to stop safety injection after a steam line break was added, as was the dependence of letdown on component cooling water (CCW). Power recovery and 480 VAC bus cross-ties were modeled. Also, success criteria were updated to include the power uprate and a revised internal flooding model was incorporated. These changes resulted in a CDF of 7.2×10^{-4} per year and LERF 5.0×10^{-6} per year.

The KPS model was updated in June 2006 to include a new internal flooding model, which included recent plant changes made to address flooding concerns. This update also included revised diesel-generator reliability data and incorporated modeling of reactor coolant system (RCS) cooldown and depressurization following RCP seal LOCAs as a means to avoid core damage. These changes resulted in a CDF of 2.7×10^{-4} per year and LERF 5.7×10^{-6} per year.

In December 2006, another update to the KPS model was completed. This update included modeling of flood barriers put in place to protect the RHR pumps. Also, operator actions to address flood-induced loss of battery room, AFW room and switchgear room ventilation were added to the model. Procedure changes to address service water isolation were incorporated into the model and several conservatisms with respect to isolation were modeled in a more realistic manner. These changes resulted in a CDF of 1.3×10^{-4} per year and LERF 7.0×10^{-6} per year.

The update used in this application was the K101AASAMA model as discussed in Section F.2.1 above.

F.2.3 External Events

The KPS external events PRA model was developed originally as part of the KPS Individual Plant Examination for External Events (IPEEE) submittal (Reference F-4). Minor updates to the model have been performed since the submittal and are summarized in the sections that follow. The current total CDF from external events is estimated at 4.7E-05 per year or less.

F.2.3.1 Internal Fires

The KPS IPEEE (Reference F-4) initially quantified the risk from internal fires. Fire risk was evaluated using a PRA that incorporated features of the FIVE methodology. For example, the FIVE methodology was used to determine initiating frequencies for fires in the various zones and the screening criterion from FIVE (1.0E-06 per year) was used in the analysis.

The IPEEE models were revised in response to requests for additional information from the NRC. The control room and cable spreading room were added as a result of addressing NRC RAIs. In the IPEEE, all human error probabilities (HEPs) from the base Level 1 PRA model were multiplied by 10 for use in the fire model. This approach to estimating the HEPs for fire sequences was subsequently replaced by a more event-specific methodology from Reference F-22. Initiating event frequencies and severity factors from Reference F-22 were also applied. Fire-induced accident sequences had a calculated CDF of 1.8E-04 per year. No recommended improvements were identified in the IPEEE. Table F-17 describes SAMAs related to fire.

The fire PRA models have not been updated, in general, since the IPEEE SER (Reference F-5). However, when the plant failure data and HEPs were updated, these updates carried through to the fire model. Finally, the conservative modeling via COMPBRN-IIIe, which was used in the IPEEE, was replaced by the more realistic MAGIC code for Auxiliary Feedwater (AFW) Pump Room B, which had been the dominant risk contributor. The total CDF and LERF from fire-induced accident sequences are now calculated to be 1.39E-04 and 4.90E-08 respectively. Table F-22 provides the CDF and LERF by fire zone.

The fire PRA model has several conservatisms that are summarized here. First, initiating events reflect old data, which does not take into account improved housekeeping practices implemented subsequent to the IPEEE. Second, although current procedures allow reliance on multiple trains of equipment and offsite power, the model uses the fire coping strategies in place at the time of the IPEEE submittal, which credited only one train and did not rely on offsite power. Third, if a cable tray is damaged, it is assumed that all cables within the tray are damaged. Fourth, a comparison between the older COMPBRN-IIIe results for AFW Pump Room B and the current MAGIC results show that COMPBRN-IIIe is highly conservative and damage in other areas is likely overestimated. Finally, for all areas except AFW Pump Room B, the most severe fire in a room is assumed to apply to the entire initiating frequency of the room.

Subsequent to completion of the IPEEE fire models, changes to plant procedures were made that significantly reduced the risk of fire-induced accident sequences. However, the plant fire PRA models were not updated to include the effect of these procedural changes. An assessment of the effects of the procedure changes on fire risk was performed and determined that explicit modeling of the procedure changes in the IPEEE models would reduce fire risk by at least a factor of five. Therefore, a more appropriate value for fire-induced CDF would be 3.6E-05 per year.

F.2.3.2 Seismic Events

Seismic events were evaluated initially as part of the KPS IPEEE (Reference F-4) using a seismic PRA. The IPEEE seismic PRA model was conservative in that, for components with a seismic capacity of greater than a screening value, a conservative surrogate value was used. This surrogate value was used for most components in the plant. Core damage frequency (CDF) from seismic events was calculated to be 1.1E-05 per year. No recommended improvements were identified in the IPEEE other than resolution of some seismic outliers, which have been corrected. Table F-17 describes recommended SAMAs related to seismic effects (SAMAs 140 and 141).

Subsequent to the IPEEE, some small changes were made to the model. Existing seismically rugged air accumulators were added to the model. This change allowed for a post-seismic-event air supply to pressurizer power operated relief valves, thereby allowing credit for primary feed and bleed. The conservative HEPs from the IPEEE were replaced with a more realistic model that adjusts HEPs based on ground motion and location (i.e., control room or local). The total CDF and LERF from seismic-induced accident sequences are now calculated to be 1.04E-05 and 5.15E-06 per year respectively.

F.2.3.3 Other External Events

The other external events analysis of the IPEEE determined that each of the initiators considered could be screened out using the IPEEE screening criterion (CDF > 1E-6). Thus, external events other than fires or seismic were determined in the IPEEE to be negligible contributors to overall core damage. No revisions of this methodology have occurred.

No recommended improvements were identified in the IPEEE. Table F-17 describes recommended SAMAs related to other external events.

F.2.4 Level 2 Model

The Level 2 PSA model used for the SAMA analysis was developed in the IPE. The Level 2 PRA model was updated in Revision 0403 of the PRA in 2004, and updated again in May 2007 using version K101ASAMA of the Kewaunee WinNUPRA model. The 2007 model was developed in such a way that the conditional probability of each Level 2 endstate is constant, given a plant damage state. Therefore, even as the Level 1 models are updated (and modified for SAMA analyses), the Level 2 models (e.g., containment event tree) do not require updating since they remain constant. Since the model used was the same as in the Level 1 analysis described previously, the freeze date, failure and unavailability data, etc. are all the same as described previously. Level 2 comments from the Westinghouse Owner's Group Peer Certification were resolved prior to the latest Level 2 update.

The most significant updates to the Level 2 models in the 2007 update were:

- Consideration of induced steam generator tube rupture (SGTR) for sequences with relatively high RCS pressure and one or more dry steam generators
- Separating SGTR events into those that are large, early releases vs. those that are not (previously all were considered large, early), and
- Performing many sensitivity analyses to test the importance of many assumptions in the Level 2 analysis.
- In addition, the 2007 update modified the Level 1 WinNUPRA event trees, fault trees and data such that large, early release frequency (LERF) cutsets could be generated. This update to the WinNUPRA model resulted in the model called K101AASAMA.

The KPS Level 1/Level 2 interface was developed to ensure that all intersystem dependencies were captured. The Level 1 event trees were expanded to include systems relevant to the Level 2 analysis, such as containment isolation and containment fan coil units. These "bridge trees" permit calculation of core damage frequency (CDF), but also provide endstates that can be binned directly into plant damage states (PDSs) that identify the status of all systems relevant to the Level 2 analysis. The Kewaunee PDS binning includes considerations such as:

- Is the containment bypassed as part of the initiating event?
- What is the RCS pressure at the time of core damage?
- Are the Steam Generators dry at the time of core damage?
- Are containment sprays and/or fan coil units available?

Each PDS is then analyzed through the Level 2 containment event tree (CET) to probabilistically evaluate the phenomenological progression of the damaged core. The end states of the CET are then examined for considerations of timing and magnitude of the releases, with similar results being binned into Release Categories.

The KPS CET is provided as Figure F-1. The release category diagram is provided as Figure F-2. Note that the frequencies of the end states are not provided in the figures because they vary for each PDS.

The release category frequencies and fission product release fractions are provided in Table F-6. The selection of MAAP cases used to represent each release category was initially made in the KPS IPE by selecting one or more dominant frequency sequence contributing to the category, and conservatively selecting the highest release fractions from each group to represent the entire category. Because the most conservative result was used in each case, the Level 2 updates did not revise the sequence selection to represent the release categories. The selection from the IPE is still conservatively considered representative. The only exception is that in the most recent update, because internal floods were found to dominate the CDF and most notably Release Category 4, the Release Category 4 fractions were recalculated using a representative flooding scenario (MAAP case KE2FLD02). In addition, a new case was analyzed for STC 14 to calculate releases from SGTR in which the secondary side was isolated (non-LER).

The release categories were categorized for the purpose of identifying large, early releases (LER), since LERs are generally considered the most significant. Large is defined as involving the rapid, unscrubbed release of airborne aerosol fission products to the environment. Early is defined as occurring before the effective implementation of the off-site emergency response and protective actions. Quantitatively, from Table F-6, this qualitative definition can be categorized as:

Early = Release begins within 6 hours of the time from the declaration of a general emergency. Note that the analysis was generally conservative in not declaring an emergency until the time of core damage or the time of containment failure, whichever occurred first.

Large = 10% or greater of the volatile fission products (higher of CsI or CsOH) are released

Small = Less than 10% of the volatile fission products are released

The 14 release categories and their frequencies are summarized in Table F-7. Release categories 7, 9, 12 and 13 were categorized as LERs. Note that although large containment isolation failure (RCs 7 and 9) only had 6.9% of CsI released, they were still conservatively binned into large, early releases. Based on the quantitative characterization presented above, the Kewaunee releases can be categorized as:

Release characterization	Frequency (per yr)	Percent of Total
Containment intact (RCs 1, 8)	2.71E-5	33.6
Small, early (RCs 6, 10, 11, 14)	3.41E-6	4.2
Large, early (RCs 7, 9, 12, 13)	9.57E-6	11.8
Late (RCs 2, 3, 4, 5)	4.07E-5	50.4

The dominant release category groups are containment intact (33.4%) and late containment failure (50.4%). The latter is dominated by the flooding events, which also dominate the core damage frequency at Kewaunee. The large, early releases are dominated by SGTR sequences, which include both SGTR initiating events and induced SGTR.

The Level 2 importance analysis (for large, early releases) is provided as Table F-8. The basic events listed are those with a Fussell-Vesely value of 5E-3 or larger.

F.2.4.1 Level 2 PRA Model Changes Since the IPE Submittal

The KPS IPE model was completed in December 1992 in response to Generic Letter 88-20. In 1997, LERF was added to the KPS PRA models. The Level 2 PRA model was updated in Revision 0403 of the PRA in 2004, and updated again in May 2007 using version K101ASAMA of the Kewaunee WinNUPRA model. The IPE analyses utilized a modified version of MAAP 3.0b, Revision 18 for many Level 2 calculations. The 2004 update to the Level 2 included reanalysis of the IPE MAAP cases using MAAP version 4.0.5, including an update to the fission product releases for the various release categories and giving credit for in-vessel recovery of a damaged core (Three Mile Island (TMI) scenario).

F.2.5 Model Review Summary

The KPS December 2001 PRA Model was used for the WOG Peer Review in June 2002. The final report for the review was issued in December 2002. The general summary reads in part, "All of the technical elements were graded as sufficient to support applications requiring the capabilities of a grade 2, e.g., risk ranking applications. The Kewaunee PRA thus provides an appropriate and sufficiently robust tool to support such activities as Maintenance Rule implementation, supported as necessary by deterministic insights and plant expert panel input."

Table F-4 shows the grades of the individual PRA Elements recorded by the Peer Review Team. Table F-5 discusses the status/resolution of each of the Category A and B Facts and Observations (F&Os)."

The Peer Review Report also credits items of strength in the KPS PRA.

Some PRA Strengths:

- Good process for identifying and addressing human action dependencies.

- Good treatment of common cause in initiating event fault tree quantification. The common cause modeling is consistent with industry standards with respect to the selection of component failure mode groups and parameters are referenced to acceptable sources. The Kewaunee PRA also accurately incorporated the common cause failure modes into the fault trees used to quantify support system initiating event frequencies.

- Good data analysis and update process, including rules for Bayesian updating. The data analysis was traceable with respect to the generic and plant specific data used, and the Bayesian update methodology used in the quantification process. A significant amount of plant specific data was used in the development of initiating event frequencies, component failure rates, and maintenance unavailabilities.

- Experienced, in-house capability for performing best-estimate T/H analyses using modular accident analysis program MAAP; expanding the role for incorporating this capability into the PRA process.

- PRA personnel have significant experience working at the plant in a variety of functional groups, including operations, and there is frequent interaction with the Point Beach PRA group.

- Good access of PRA group to plant and plant personnel.

In the final report for the Peer Review, five Level A and 49 Level B facts and observations (F&Os) were identified. Three of the Level B F&Os were related to maintenance and update of the model and do not have any impact on the model results. Since the Peer Review, all A and B Level F&Os except two have been resolved either through upgrading documentation, model changes, or both. The first remaining, unresolved, F&O relates to including loss of HVAC as a separate initiating event. Within that F&O, it is stated that evidence exists that loss of HVAC would not result in a reactor trip, but that a basis for the conclusion needs to be documented. The second unresolved F&O relates to not documenting the basis for room cooling requirements when HVAC was not modeled as a support system for components. In the current model, room cooling is modeled as a required support system for all components unless calculations show that HVAC is not needed.

The KPS PRA model is updated frequently to maintain it consistent with the as-built, as-operated plant to incorporate improved thermal hydraulic results, and to incorporate PRA improvements. The updates have involved a cooperative effort including both licensee personnel and consultant support. As part of model change, the documentation affected by the incorporated changes is updated accordingly per Dominion procedures. Included in the documentation update is an independent review and approval of each revised document.

F.3 KPS LEVEL 3 PRA MODEL

The MACCS2 code (Reference F-2) was used to perform the Level 3 PRA for KPS. The input parameters given with the MACCS2 "Sample Problem A," which included the COMIDA2 food model (Reference F-6), formed the basis for the present analysis. These generic values were supplemented with parameters specific to KPS and the surrounding area. Site-specific data included population distribution, economic parameters, and agricultural production. Parameters describing the costs of evacuation, relocation and decontamination were escalated from the time of their formulation (1986) to present (February 2007) costs. Plant-specific release data included the time-activity distribution of nuclide releases and release frequencies. The behavior of the population during a release (evacuation parameters) was based on plant and site-specific set points (i.e., declaration of a general emergency) and evacuation time estimates (Reference F-6). These data were used in combination with site and region-specific meteorology to simulate the probability distribution of impact risks (exposure and economic) to the surrounding (within 50 miles) population from the 12 evaluated source term category (STC) releases at KPS.

F.3.1 Population

The population distribution was based on the 2000 census as accessed by SECPOP2000 (Reference F-7). The baseline population was determined for each of the sixteen directions and each of ten concentric distance rings with outer radii at 1, 2, 3, 4, 5, 10, 20, 30, 40 and 50 miles surrounding the site. The transient population within ten miles of the site, based on Reference F-6, was included. County growth rates were applied to estimate the population distribution at the year 2033. The resulting population distribution surrounding the KPS site for the site 0-10 mile and 10-50 mile radii are shown in Figure F-3 and Figure F-4 respectively.

F.3.2 Economy and Agriculture

MACCS2 requires the spatial distribution of certain agriculture and economic data (fraction of land devoted to farming, annual farm sales, fraction of farm sales resulting from dairy production, and property value of farm and non-farm land) in the same manner as the population. This was again done by applying the SECPOP2000 program, changing the regional economic data format to comply with MACCS2 input requirements. In this case, SECPOP2000 was used to access data from the 1997 National Census of Agriculture; the version 3.12.01 data file accessed by SECPOP2000 for that information, COUNTY97.DAT, was revised by filling its "notes" parameter so that data from the proper county is associated with the site. The counties surrounding the site have county codes less than 955 and are not affected by the county codes greater than that number not being sequential in COUNTY97.DAT. The program's specification of crop production parameters for the 50-mile region (e.g, fraction of farmland devoted to grains, vegetables, etc.) was also applied.

Area-wide farm wealth was calculated from the 2002 National Census of Agriculture county statistics (Reference F-8) for farmland, building and machinery. Only the fraction of each county within 50-miles of KPS was considered. The non-farm wealth was similarly calculated from 2003 Wisconsin tax assessments (Reference F-9). However, the non-farm wealth value based on tax assessments was less than that determined from the SECPOP2000 non-farm land property value (see previous paragraph); therefore, in the interest of conservatism, the latter was used.

In addition, generic economic data that is applied to the region as a whole were revised from the MACCS2 sample problem input in order to account for cost escalation since 1986, the year that input was first specified. A factor of 1.85, representing cost escalation from 1986 to February 2007 was applied to parameters describing cost of evacuating and relocating people, land decontamination, and property condemnation.

F.3.3 Nuclide Release

The core inventory corresponds to the end-of-cycle values for KPS operating at 1772 MWt, as determined by the ORIGEN2 code. A scaling factor of 1.006 was then applied to represent operation at 1782.6 MWt (Reference F-10). Two typos in the latter reference were corrected: Cs-237 was changed to Cs-137 and the activities of Kr-85 and Kr-85m were reversed. Table F-9 gives the estimated KPS core inventory.

Release frequencies, nuclide release fractions (of the core inventory), shown in Table F-10, and the time distribution of the release (described in Table F-10 for noble gases and Cs) were analyzed to determine the sum of the exposure (50-mile dose) and economic (50-mile economic costs) risks from accident sequences representing 12 source term categories (also given in Table F-10). Each accident frequency was chosen to represent the set of similar accident releases. KPS nuclide release categories, as determined by the MAAP computer code, were related to the MACCS categories as shown in Table F-11. Release duration periods were defined which represented the time distribution of each category's releases. Release inventories of each of the two chemical forms of the Cs and Te releases, as given by the MAAP code output, were incorporated into the nuclide release fractions.

The containment vessel has an inner diameter of 105 feet, with a cylinder shell thickness of 1.5 inches. The top of containment is 180.5 feet above grade. All releases were modeled as occurring at top of containment; the shield building surrounding the containment was neglected for purposes of initial release plume size and height. The thermal content of each of the releases was assumed to be the same as ambient, i.e., buoyant plume rise was not modeled. Each of these assumptions was considered in sensitivity analyses, presented as the last subheading in this section.

F.3.4 Evacuation

Reactor trip for each sequence was taken as time zero relative to the core containment response times. A general emergency is declared when plant conditions degrade to the point where it is judged that there is a credible risk to the public; it was assumed here that the declaration would coincide with the onset of core damage. Table F-12 shows the resulting declaration times. A general emergency declaration time corresponding to the time of core uncovery was considered in sensitivity analyses, presented as the last subheading in this section.

The MACCS2 User's Guide input parameters of 95 percent of the population within 10 miles of the plant (Emergency Planning Zone, (EPZ)) evacuating and 5 percent not evacuating were employed. These values are conservative relative to the NUREG-1150 study, which assumed evacuation of 99.5 percent of the population within the Emergency Planning Zone (Reference F-11).

The evacuees are assumed to begin evacuation 80 minutes (Reference F-6, 50% of population begins evacuating) after a general emergency has been declared at an evacuation radial speed of 1.34 m/sec. This speed is derived from the projected time to evacuate the entire EPZ under adverse weather conditions during the year 2000, the year of the evacuation study. Thus, this speed corresponds to the greatest evacuation time projected in the current evacuation study. The evacuation speed was projected to year 2033 conditions by conservatively assuming that all of the roads in 2000 transported traffic at their maximum throughput and that no new roads would be constructed (although the roads would be maintained at 2000 conditions). The 2033 evacuation speed was then the 2000 speed multiplied by the ratio of 2000 to projected 2033 EPZ (10-mile) populations. That estimated 2033 evacuation speed, 1.16 m/sec, was used in the risk analysis and is considered to result in a conservatively high evacuation time. The evacuation speed was considered further in the sensitivity analyses presented in the last subheading in this section.

F.3.5 Meteorology

Annual sequential hourly meteorology data sets from 2002 through 2004 were supplied for use in MACCS2 (Reference F-12). The wind and stability data were collected onsite. The precipitation data was from near Sturgeon Bay, Wisconsin, approximately 40 miles north of KPS; that site was the closest weather station to KPS collecting hourly precipitation. Seasonal morning and afternoon mixing heights were determined for each year from National Weather Service radiosonde measurements at Green Bay, Wisconsin. The wind speed in the data sets, as supplied, had been "powered to the top of containment"; the power law exponents, a function of stability class, were supplied (Reference F-12). The wind speed data, as used in MACCS2, were converted to 10-meter wind speed heights, using those same exponents. This data manipulation was considered further in the sensitivity analyses presented in the last subheading in this section.

The 2002 met data were found to result (see subsequent discussion of sensitivity analysis) in the largest dose and within 0.2% of the largest economic cost risk and, in the interest of conservatism, were used to determine the annual risks in the next subheading.

F.3.6 MACCS2 Results

The resulting annual risk from the analyzed KPS releases is provided in Table F-13.

The largest consequences (i.e., assuming the event takes place) are from source term categories (STCs) 11, 12, and 13. However, the frequencies of the release for the former two (see Table F-10) are two orders of magnitude less than that from the latter. 63% of the total baseline dose risk and 78% of the cost risk is from STC-13. Adding the risk from the greatest release frequency STC, STC-04, to that of STC-13 illustrates that 95% of the total risk (dose and cost) is from STC-13 and STC-04. The total KPS risk was found to be due chiefly to its Cs release.

The annual baseline population dose risk within 50 miles of KPS is calculated to be 30.19 person-rem per year. The total annual economic risk was calculated at $49,700 per year.

F.3.7 Sensitivity Analysis

Perturbations to some MACCS2 inputs were investigated to determine their effects on annual risk. Among the parameters analyzed, release height, release heat, evacuation time and speed, height of wind speed measurements, and meteorological data year have been discussed previously. The effect of building wake on the risk was determined because the building shell surrounding the containment vessel was neglected for this purpose and the proximity of other site buildings to the KPS containment introduces uncertainty as to local air flow around these buildings.

Severe meteorological conditions in the last spatial segment of the model domain (40-50 miles) were chosen to assure conservatively high impacts and risks. Most especially, perpetual rainfall was imposed on this segment so that a conservatively large quantity of the nuclides released in each scenario was deposited (via wet deposition) within the model domain.

Table F-14 gives the sensitivity of the risk to the choice of these parameters. The table also discusses the reason for considering that parameter and the result. Other than imposing the above described meteorological condition on the 40-50 mile distance interval, the site risks to severe accidents vary <7% as a result of any of the considered parameter changes. The baseline modeling conservatism of specifying rainfall in the spatial ring from 40-50 miles is seen to more than balance any increases that might be due to alternative specification of release parameters.

F.4 BASELINE RISK MONETIZATION

This section explains how Dominion calculated the monetized value of the status quo (i.e., accident consequences without SAMA implementation). Dominion also used this analysis to establish the maximum benefit that could be achieved if all risk for KPS reactor operation were eliminated. Note that these calculations use as the base frequency the sum of the frequency values from each of the 14 STCs. This frequency, 8.089E-05 per year, is higher than the sum of the frequency values of the minimal cutsets, 7.73E-05 per year given in Section 2.1. The STC frequency sum is higher because some accident sequences that comprise a STC frequency contain cutsets that are non-minimal to other accident sequences.

F.4.1 Offsite Exposure Cost

The baseline annual off-site exposure risk costs were converted to dollars using the methodology given in Reference F-1. Expected offsite doses are presented in Table F-15. Costs associated with these doses were calculated using the following equation:

$$APE = \left(F_S D_{PS} - F_A D_{PA}\right) R \frac{1-e^{-rt_f}}{r} \tag{1}$$

where:

APE = present value of averted public exposure ($),

R = monetary equivalent of unit dose, ($2000/person-rem),

$F_S D_{PS}$ = baseline accident offsite dose frequency (30.19 person-rem per year from Table F-15),

$F_A D_{PA}$ = accident offsite dose frequency after mitigation (0 person-rem per year),

r = real discount rate (7% per year),

t_f = years remaining until end of facility life (20 years of license renewal period).

Using the values given above:

APE = (30.19 person-rem per year–0)*($2000/person-rem)* ((1 – e$^{-(0.07*20)}$)/(0.07 per year))

APE = *$649,864*

F.4.2 Off-Site Economic Cost Risk

The baseline annual off-site economic risk costs were converted to dollars using the methodology given in Reference F-1. Annual expected offsite economic risk is shown in Table F-16. The present value of these costs over the license renewal period was calculated as follows:

$$AOC = \left(F_S P_{DS} - F_A P_{DA}\right)\frac{1-e^{-rt_f}}{r} \qquad (2)$$

where:

AOC = present value of averted offsite property damage casts ($),

$F_S P_{DS}$ = baseline accident frequency ($49,700 per year from Table F-16),

$F_A P_{DA}$ = accident frequency after mitigation (0 events per year),

r = real discount rate (7% per year),

t_f = years remaining until end of facility life (20 years of license renewal period).

Using the values given above:

AOC = ($49,700 per year – 0) * (1 – e $^{-(0.07 * 20)}$) / (0.07 per year)

AOC = *$534,916*

F.4.3 On-Site Exposure Cost Risk

Occupational health was evaluated using the methodology of Reference F-1, which involves separately evaluating immediate and long-term doses. Immediate exposure occurs at the time of the accident and during the immediate management of the emergency. Long-term exposure is associated with the cleanup and refurbishment or decommissioning of the damaged facility. The value of avoiding both types of exposure must be considered when evaluating risk.

The occupational exposure associated with severe accidents was estimated to be 23,300 person-rem/accident. This value includes a short-term component of 3,300 person-rem/accident and a long-term component of 20,000 person-rem/accident. These estimates are consistent with the "best estimate" values presented in Section 4.3 of Reference F-1. In calculating base risk, the accident-related onsite exposures were calculated using the best estimate exposure components applied over the on-site cleanup period. For onsite cleanup, the accident-related on-site exposures were calculated over a 10-year cleanup period. Cost associated with immediate dose, long-term dose and total dose are calculated below.

F.4.3.1 Averted Immediate Occupational Exposure Costs

Per the guidance of Reference F-1, costs associated with immediate occupational doses from an accident were calculated using the following equation:

$$W_{IO} = \left(F_S D_{IOS} - F_A D_{IOA}\right) R \frac{1 - e^{-rt_f}}{r} \tag{3}$$

where:

W_{IO} = present value of averted immediate occupational exposure ($),

F_S = baseline accident frequency (8.089E-05 events per year from Table F-7),

F_A = accident frequency after mitigation (0 events per year),

D_{IOS} = baseline expected immediate onsite dose (3300 person-rem/event),

D_{IOA} = expected occupational exposure after mitigation (3300 person-rem/event),

R = monetary equivalent of unit dose, ($2000/person-rem),

r = real discount rate (7% per year),

t_f = years remaining until end of facility life (20 years of license renewal period).

Using the values given above:

W_{IO} = ((8.089E-05 events per year) * (3300 person-rem/event) – 0) * ($2000/person-rem) * (1 – e $^{-(0.07 * 20)}$) / (0.07 per year)

W_{IO} = *$5746*

F.4.3.2 Averted Long-Term Occupational Exposure Costs

Per the guidance of Reference F-1, costs associated with long-term occupational doses from an accident were calculated using the following equation:

$$W_{LTO} = \left(F_S D_{LTOS} - F_A D_{LTOA}\right) R * \frac{1-e^{-rt_f}}{r} * \frac{1-e^{-rm}}{rm} \tag{4}$$

where:

W_{LTO} = present value of averted long-term occupational exposure ($),

F_S = baseline accident frequency (8.089E-05 events per year from Table F-7),

F_A = accident frequency after mitigation (0 events per year),

$D_{LTO\,S}$= baseline expected long-term onsite dose (20,000 person-rem/event),

D_{LTOA} = expected occupational exposure after mitigation (20,000 person-rem/event),

R = monetary equivalent of unit dose, ($2000/person-rem),

r = real discount rate (7% per year),

m = years over which long-term doses accrue (10 years)

t_f = years remaining until end of facility life (20 years of license renewal period).

Using the values given above:

W_{LTO} = ((8.089E-05 events per year) * (20,000 person-rem/event) – 0) * ($2000/person-rem) * ((1 – e $^{-(0.07 * 20)}$) / (0.07 per year) * ((1 – e $^{-(0.07 * 10)}$) / ((0.07 per year) * (10 years))

W_{LTO} = *$25,044*

F.4.3.3 Total Averted Occupational Exposure Costs

As described above, the total cost associated with averted occupational exposure, AOE, is the sum of the costs associated with averted immediate exposure and the costs associated with the averted long-term exposure.

$$AOE = W_{IO} + W_{LTO} \tag{5}$$

Using the values given above:

AOE = $5746 + $25,044

AOE = *$30,790*

F.4.4 Averted Onsite Costs (AOSC)

Reference F-1 defines three types of costs associated with onsite property damage from an accident: cleanup and decontamination, long-term replacement power, and repair and refurbishment. The value of avoiding each of these types of costs must be considered when evaluating risk. Total averted onsite property damage costs is the sum of the three types of costs. Calculation of onsite property damage costs is detailed in the sections that follow.

F.4.4.1 Averted Cleanup and Decontamination Costs

The estimated cleanup cost for severe accidents was defined in Reference F-1, Section 4.4, to be \$1.5E+09/accident (undiscounted). Using the value of \$1.5E+09/event and assuming, as in Reference F-1, that the total sum is paid in equal installments over a ten year period, the present value of those ten payments for cleanup and decontamination costs for the cleanup period can be calculated as follows:

$$PV_{CD} = \left(\frac{C_{CD}}{m}\right)\left(\frac{1-e^{-rm}}{r}\right) \tag{6}$$

where:

PV_{CD} = present value of averted onsite cleanup costs exposure over cleanup period (\$),

C_{CD} = total value of averted onsite cleanup costs (\$),

r = real discount rate (7% per year),

m = years over which long-term doses accrue (10 years)

PV_{CD} = ((\$1.5E+09/event) / (10 years)) * ((1 – e $^{-(0.07 * 10)}$) / 0.07)

PV_{CD} = \$1.0787E+09

The present value of the costs over the cleanup period must be considered over the period of license renewal. The net present value of averted cleanup costs over the license renewal period can be calculated as follows:

$$U_{CD} = \left(F_S - F_A\right) PV_{CD} \frac{1 - e^{-rt_f}}{r} \tag{7}$$

where:

U_{CD} = present value of averted onsite cleanup costs ($),

F_S = baseline accident frequency (8.089E-05 events per year from Table F-7),

F_A = accident frequency after mitigation (0 events per year),

PV_{CD} = present value of averted onsite cleanup costs exposure over cleanup period ($),

r = real discount rate (7% per year),

t_f = years remaining until end of facility life (20 years of license renewal period).

Using the values given above:

U_{CD} = (8.089E-05 events per year – 0) * ($1.0787E+09) * (1 – $e^{-(0.07 * 20)}$) / (0.07 per year)

U_{CD} = *$939,128*

F.4.4.2 Averted Replacement Power Costs

Replacement power costs, U_{RP}, are an additional contributor to onsite costs and can be calculated in accordance with Reference F-1 Section 4.4. Since replacement power will be needed for that time period following a severe accident until the end of the expected generating plant life, long-term power replacement calculations have been used. KPS has a net electrical output of 556 MWe (Reference F-10).

Replacement power cost calculations performed in Reference F-1 are based on the 910 MWe reference plant. In applying the methodology used in Reference F-1 to KPS, the equation was scaled down for the 556 MWe output of KPS. For discount rates between 5% and 10%, Reference F-1 recommends that the present value of replacement power be calculated as follows:

$$PV_{RP} = \left(\frac{\left(\$1.2E+8\right)\dfrac{(Rated\, power)}{(910MWe)}}{r} \right) \left(1-e^{-rt_f}\right)^2 \tag{8}$$

where:

PV_{RP} = present value of replacement power for a single event ($),

r = real discount rate (7% per year),

t_f = years remaining until end of facility life (20 years of license renewal period),

Rated Power = 556 MWe.

Using the values given above:

PV_{RP} = (1.2E+08 *(556 MWe / 910 MWe)) / (0.07 per year) * $(1 – e^{-(0.07 * 20)})^2$

PV_{RP} = $5.945E+08

To obtain the expected costs of a single event over the license renewal period, the following equation is used:

$$U_{RP} = \left(F_S - F_A\right)\frac{PV_{RP}}{r}\left(1-e^{-rt_f}\right)^2 \tag{9}$$

where:

U_{RP} = present value of averted onsite cleanup costs ($),

F_S = baseline accident frequency (8.089E-05 events per year from Table F-7),

F_A = accident frequency after mitigation (0 events per year),

PV_{RP} = present value of replacement power for a single event ($),

r = real discount rate (7% per year),

t_f = years remaining until end of facility life (20 years of license renewal period).

Using the values given above:

U_{RP} = (8.089E-05 per year - 0) * (($5.945E +08) / (0.07 per year)) * $(1 – e^{-(0.07 * 20)})^2$

U_{RP} = $389,963

F.4.4.3 Averted Repair and Refurbishment Costs

It is assumed that the plant would not be repaired or refurbished; therefore, these costs are zero.

F.4.4.4 Total Averted Onsite Costs (AOSC)

Total averted onsite cost is the sum of cleanup and decontamination costs, replacement power costs, and the repair and refurbishment costs. Total averted onsite costs are calculated as follows:

$$AOSC = U_{CD} + U_{RP} + 0 \quad (10)$$

AOSC = $939,128 + $389,963

AOSC = *$1,329,091*

F.4.5 Total Unmitigated Baseline Risk

As described in Reference F-1, the total present worth net value of public risk is calculated according to the following formula:

$$NPV = (APE + AOC + AOE + AOSC) \quad (11)$$

Using the values calculated in the Sections 4.1 to 4.4, total baseline risk is calculated:

NPV = ($649,864 + $534,916 + $30,790 + $1,329,091)

NPV = *$2,544,661*

This value can be viewed as the maximum risk benefit attainable if all core damage scenarios from internal events are eliminated over the 20-years license renewal period. This benefit, however, does not consider the risk posed by external events such as seismic events, fires, high winds, etc.

As described in Section 2.3, the total CDF from external events is expected to be less than 4.7E-05 per year or 61% of the CDF from internal events. Since the models for external events cannot be easily quantified using the current PRA models, the total benefit will be doubled to account for the potential benefit that could be achieved by reducing the risk from external events. Therefore, the maximum available benefit used will be:

NPV = $2,544,661 * 2

NPV = *$5,089,322*

F.5 PHASE 1 SAMA ANALYSIS

The Phase 1 SAMA analysis includes the development of the initial SAMA list and a coarse screening process. This screening process eliminated those candidates that are not applicable to the plant's design or are too expensive to be cost beneficial even if the risk of on-line operations were completely eliminated. The following subsections provide additional details of the Phase 1 process.

F.5.1 SAMA Identification

The list of SAMA items evaluated for KPS is given in Table F-17. The process used to identify these SAMA items is described below.

The first source used to identify SAMA items is Reference F-1. Generic industry SAMAs that are to be considered are the 153 items that are identified in Table 14 of Reference F-1. Next, the license renewal applications for several recent submittals were reviewed and any SAMA items identified as potentially having a positive cost-benefit ratio were identified and added to the list of items to be evaluated. The plants reviewed were Ginna (Reference F-13), Palisades (Reference F-14), Point Beach (Reference F-15), Millstone Unit 2 (Reference F-16), Wolf Creek (Reference F-17), and Harris (Reference F-18). The review of these plant license renewal submittals resulted in the addition of 14 SAMA items for consideration.

Identification of KPS-specific items began with a review of the importance analysis of the core damage cutsets shown in Table F-3. Each basic event with a Fussell-Vesely importance of greater than 0.5%, for a total of 149 basic events, was reviewed to identify any potential SAMAs. Twenty-four of the basic events, such as complement events or constants, have no physical meaning and can be excluded. A listing of the basic events, their importance, and their disposition with respect to SAMA items is given in Table F-3. Of the remaining 125 basic events, some would be addressed by items being considered from the generic SAMA items and others would be eliminated with more detailed modeling. In total, 16 new SAMA items (items 168 through 183 on Table F-17) were generated from the basic event importance review.

In addition to the basic event importance review, the top 200 cutsets were reviewed to identify any basic events that were not included as part of the importance analysis review. The top 200 cutsets contribute a total of 5.07E-05 per year or 65% of total CDF. Basic events identified in the top 200 cutsets that are not included as part of the importance analysis review are shown in Table F-18. This list of events does not include basic events such as constants used to facilitate the quantification process or basic events automatically generated as part of the quantification process. Of the 47 basic events identified in Table F-18, two additional SAMA items, (items 188 and 189 of Table F-17) were identified.

Additional KPS-specific sources reviewed include the original KPS Individual Plant Examination (IPE) (Reference F-3) and the KPS Individual Plant Examination for External Events (IPEEE) (Reference F-4). The list of potential plant improvements from Section 6.3 of Reference F-3 was reviewed and four additional SAMA items (items 184 through 187) were added. No potential improvements were identified from the IPEEE analyses. The USI A-46 review found 12 installations of "bad actor" relays at KPS. All 12 relays were replaced with a design change that was completed in June 1997.

As a result of the reviews described above, 189 potential SAMAs were identified. A complete listing is contained in Table F-17.

F.5.2 Phase 1 Screening Process

The initial list of potential SAMAs was developed from a wide range of sources related to many plant designs. Some of the items on the list were identified relatively recently, while others were identified some time ago. Given the wide diversity in age and sources of the potential SAMAs, an initial screening is performed to identify the subset of potential SAMAs that warranted a detailed evaluation.

Potential SAMAs to be examined in detail are identified by exception. That is, a screening process is used to remove potential SAMAs from consideration. Any potential SAMAs not screened will undergo more detailed evaluation.

As described in Reference F-1, SAMA items can be screened for several reasons. First, items were screened that were not applicable to KPS. For example, the flow control valves for the turbine-driven auxiliary feed water (AFW) pump are motor-operated so an item to install air accumulators for the valves would not apply. Items screened as not applicable are indicated as "Not Applicable" in the "Qualitative Screening" column of Table F-17. A total of 21 items were screened as not applicable.

Next, items were identified that were effectively implemented. Items screened as effectively implemented are indicated as "Already Implemented" in the "Qualitative Screening" column of Table F-17. A total of 45 items were identified as being effectively implemented at KPS. The reason for screening as "Already Implemented" is provided in Table F-17.

Other SAMA items were screened because they would not be feasible to implement. An item could be not feasible because the change could only be implemented during the construction phase. Another reason that an item could be not feasible is that the cost to implement the SAMA clearly would exceed the maximum benefit possible (calculated in Section F.4). Items screened as infeasible to implement are indicated with "Excessive Imp. Cost" in the "Qualitative Screening" column of Table F-17. A total of 28 potential SAMAs were screened as not feasible.

Reference F-1 allows items to be screened if they would be of low benefit. An item is of low benefit if it is from a non-risk-significant system and a change in reliability would have negligible impact on the risk profile. Items screened as being of low benefit are indicated as "Very Low Benefit" in the "Qualitative Screening" column of Table F-17. A total of 31 items were identified as being of low benefit at KPS. The reason for screening as "Very Low Benefit" is provided in Table F-17.

Although allowed by Reference F-1, no items were screened as "Combined." For this analysis, each item not screened as above was retained in Table F-17. The benefit and cost evaluations in the sections that follow then examine the impacts of the items. If appropriate, the items were combined during the benefit or cost evaluations. When items were combined as providing the same benefit, a note indicating which were analyzed together is provided in Table F-17.

After screening the initial list, a total of 64 items remain to be evaluated for potential benefit in reducing risk. Items not screened are indicated with "Needs Further Eval" in the "Qualitative Screening" column of Table F-17.

F.6 PHASE 2 SAMA ANALYSIS

For each of the potential benefits not screened, an analysis was performed to determine if the item would show a positive benefit if implemented. To perform this analysis, the potential benefits associated with implementing each of the items are estimated. Then the costs that would be incurred with implementation are evaluated. Finally, the costs are compared with the benefits. Any SAMA item with benefits that exceed costs is a candidate for implementation.

In evaluating the benefits, a precisely described modification was not necessarily considered because exact design details would only be defined once an option is chosen. Rather, SAMA benefit evaluation was performed using bounding techniques to estimate any risk reduction that would be possible. For example, evaluation of the SAMA to install an additional component cooling water pump bounded the risk reduction possible by assuming that implementation of the SAMA would entirely eliminate the failure of component cooling water pumps.

Evaluation of potential benefits is performed using the methodology described in Reference F-1 and, in general, is performed as follows. First the potential reduction in CDF, if any, was estimated. Next, the reduction in source term release was estimated. Finally, the potential benefit to offsite consequences was determined and presented in monetary terms.

The potential reduction in CDF was usually evaluated by modifying and quantifying the KPS Level 1 internal events PRA model. However, for some potential SAMA items, other techniques, such as changes to the Level 2 model, could be used. Specifics of how reductions in CDF were evaluated are provided in the subsections that follow.

Estimation of source-term changes was typically performed by quantifying the KPS Level 2 PRA model. For most evaluations, the model was simply requantified using the updated Level 1 PRA model. However, for some evaluations, the Level 2 model was changed to represent implementation of the SAMA evaluated. Specifics of how the Level 2 PRA model was used to quantify source term changes are provided in the subsections that follow.

As described in Section F.3, the results of the Level 3 model are offsite exposure and offsite property costs associated in each STC. The calculation of offsite dose and offsite property loss value is performed by multiplying the STC frequencies by the dose/property loss associated with that STC. Once the potential changes in dose and property loss are determined, they can be converted to monetary terms as described in Section F.4.

A summary of the benefit evaluation for each of the potential SAMAs not screened is provided in the sections below and listed in Table F-19.

Also for each of the potential SAMAs not screened, an estimate of the minimum costs associated with implementation was made. In estimating the costs, estimates were established for certain standard costs.

First, a simple design change would have a minimum cost of $100,000 for completing and assembling the design change package paperwork, performing one or two simple calculations, and minor drawing revisions. This assumes a mix of Dominion and contractor people and does not include any support group (document control, information technology, etc) costs. This also excludes any work associated with procurement of materials, job planning, or installation. Complex design changes would cost considerably more.

Second, a simple procedure change would have a minimum cost of $50,000 for preparation, review, approval, training, and implementation. Complex procedure changes or changes involving emergency operating procedures would cost more.

The cost evaluations for specific SAMAs are summarized in the sections that follow and listed in Table F-19.

For each of the potential SAMAs not screened, a cost-benefit evaluation is performed. Reference F-1 defines the present worth of averted public risk by implementing a plant enhancement as:

NPV = (APE + AOC + AOE + AOSC) – COE.

Total averted costs (TAC) are represented by the expression:

TAC = (APE + AOC + AOE + AOSC).

Each of the terms is defined in Section F.4.

F.6.1 SAMA 1, SAMA 3, SAMA 5, SAMA 6, SAMA 74 – Improve Availability and Reliability of DC Power

The goal of these SAMAs is to extend the time that DC power is available following a loss of AC power to a battery charger. In the extreme case, implementation of this SAMA could eliminate all dependency of DC power on AC power thereby ensuring that DC power is available to instrumentation and controls needed in a station blackout situation. These SAMAs were modeled by assuming that AC power to the safety-related battery chargers, BRA-108 and BRB-108, was completely available.

The results of the above modeling produced the following results:

STC Frequency = 8.088E-005 with the following contributions from each STC:

1	1.499E-006
2	0.000E+000
3	0.000E+000
4	4.056E-005
5	1.971E-007
6	5.081E-009
7	2.730E-008
8	2.563E-005
9	0.000E+000
10	0.000E+000
11	1.217E-007
12	1.546E-007
13	9.399E-006
14	3.282E-006

The frequency of each STC above is multiplied by the conditional dose from Table F-15 that is associated with each STC to obtain the expected dose for each STC. Then the expected dose values are summed to obtain the total expected dose after implementation of the SAMAs, or 30.18 person-rem per year.

Similarly, the frequency of each STC above is multiplied by the conditional property damage value from Table F-16 that is associated with each STC to obtain the expected property damage value for each STC. Then the expected property damage values are summed to obtain the total expected damage after implementation of the SAMAs, or $49,684 per year.

The benefit of implementing these SAMAs is then calculated as shown in Section F.4. The results of each of these calculations as well as that of the total averted costs are shown in Table F-19 under the column labelled "SAMA 1." The present value of total averted costs from internal events for implementing these SAMAs is \$539. This amount is then doubled to account for the potential reduction in risk from external events resulting in a total potential benefit of \$1078.

As described above, implementation of these SAMAs would extend the time that DC power would remain available following a loss of AC power to the battery chargers. Alternatives could include providing additional batteries, installation of a diesel-powered battery charger, or temporary connections from non-safety batteries to the safety-related batteries.

Implementation of any one of these SAMAs would require procedure changes. Using the standard costs for these tasks described in Section F.6, implementation of this alternative would cost a minimum of \$50,000, even before any hardware or installation costs are included. Since the benefit for these SAMAs, calculated above, is much less than this value, no further evaluation of costs is performed.

The total averted costs of these SAMAs are \$1078. Implementation of any of these alternatives would cost a minimum of \$50,000, even before any hardware or installation costs are included. Therefore, the present worth can be calculated as:

$$\text{NPV} \leq \$1078 - \$50{,}000$$

$$\text{NPV} \leq -\$48{,}922$$

Since the present worth is negative, implementation of any of these SAMAs would not be cost beneficial.

F.6.2 SAMA 19, SAMA 20 – Provide Backup Cooling to EDGs

The goal of these SAMAs is to improve availability of emergency AC power supplies by providing a redundant and diverse source of cooling to the emergency diesel generators EDGs. In the extreme case, implementation of this SAMA could eliminate all dependency of the EDGs on cooling water. These SAMAs were modeled by assuming that no service water is required for the EDGs. Modelling of this SAMA considered only cooling to the EDGs. Other equipment that required service water for cooling was assumed to be not affected by this SAMA. Therefore, even though loss of service water would not fail the EDGs, loss of service water would still result in loss of cooling to other equipment. As a result, loss of service water to the EDGs would no longer result in a station blackout and an immediate transition to ECA-0.0 would not occur. However, loss of cooling to plant rooms, particularly, the 480 VAC switchgear rooms, would cause a loss of RCP seal cooling that cannot be recovered. Although additional procedures could be developed to address switchgear room cooling requirements when temporary diesel cooling is used, the results shown below indicate that the benefits of the proposed SAMAs are minimal so an evaluation of the added complexity of the additional procedure steps is not evaluated further.

The results of the above modeling produced the following results:

STC Frequency = 8.252E-005 with the following contributions from each STC:

1	1.553E-006
2	0.000E+000
3	0.000E+000
4	4.159E-005
5	2.014E-007
6	5.192E-009
7	2.790E-008
8	2.643E-005
9	0.000E+000
10	0.000E+000
11	1.217E-007
12	1.543E-007
13	9.170E-006
14	3.268E-006

The frequency of each STC above is multiplied by the conditional dose from Table F-16 that is associated with each STC to obtain the expected dose for each STC. Then the expected dose values are summed to obtain the total expected dose after implementation of the SAMAs, or 29.92 person-rem per year.

Similarly, the frequency of each STC above is multiplied by the conditional property damage value from Table F-16 that is associated with each STC to obtain the expected property damage value for each STC. Then the expected property damage values are summed to obtain the total expected damage after implementation of the SAMAs, or $48,759 per year.

The benefit of implementing these SAMAs is then calculated as shown in Section F.4. The results of each of these calculations as well as that of the total averted costs are shown in Table F-19 under the column labelled "SAMA 19." The present value of total averted costs for implementing these SAMAs is a negative value of $11,489. Since the net benefits would be negative, there is no need for doubling to account for external events.

As described above, implementation of these SAMAs would provide a back-up means to cool the diesel-generators should the service water system fail to provide cooling as required. Implementation of such a change would require a design change to install connections to the backup cooling supply. In addition, emergency operating, abnormal, and maintenance procedures would need to be written and implemented for use of the system. Then training classes for Operations staff would be provided on these new systems and procedures.

Using the standard costs for a procedure change shown in Section F.6, implementation of this alternative would cost a minimum of $50,000, even before engineering and hardware costs are considered. Since the net benefit for this SAMA, calculated above is small or even potentially negative, a detailed evaluation of costs is not performed.

Since implementation of these SAMAs would result in an increase in CDF, no benefit could be derived from implementation and the SAMAs would not be beneficial.

F.6.3 SAMA 21 – Develop Procedures to Repair 4kVAC Breakers

The goal of this SAMA is to improve recovery of offsite power by providing direction to repair breakers that failed following a reactor trip and caused a subsequent loss of offsite power. This SAMA was modeled by setting the failure probability for circuit breakers supplying the safety-related buses 5 and 6 to zero.

The results of the above modeling produced the following results:

STC Frequency = 8.076E-005 with the following contributions from each STC:

1	1.497E-006
2	0.000E+000
3	0.000E+000
4	4.048E-005
5	1.969E-007
6	5.074E-009
7	2.726E-008
8	2.561E-005
9	0.000E+000
10	0.000E+000
11	1.217E-007
12	1.545E-007
13	9.385E-006
14	3.283E-006

The frequency of each STC above is multiplied by the conditional dose from Table F-15 that is associated with each STC to obtain the expected dose for each STC. Then the expected dose values are summed to obtain the total expected dose after implementation of the SAMAs, or 30.13 person-rem per year.

Similarly, the frequency of each STC above is multiplied by the conditional property damage value from Table F-16 that is associated with each STC to obtain the expected property damage value for each STC. Then the expected property damage values are summed to obtain the total expected damage after implementation of the SAMAs, or $49,614 per year.

The benefit of implementing these SAMAs is then calculated as shown in Section F.4. The results of each of these calculations as well as that of the total averted costs are shown in Table F-19 under the column labelled "SAMA 21." The present value of total averted costs for implementing these SAMAs is $4,311. This amount is then doubled to account for the potential reduction in risk from external events resulting in a total potential benefit of $8,622.

As described above, implementation of this SAMA would stage spare breakers and provide procedures so that the operators could more easily recover power to the safety buses during SBO events if breaker failure caused the initial power loss.

Implementation of the SAMA would require that emergency operating, abnormal, and maintenance procedures be written and implemented for breaker replacement. Then training classes for Operations and Maintenance staff would be provided on these new procedures. Using the standard costs for a procedure change shown in Section F.6, the costs to implement this SAMA would cost a minimum of $50,000 even before any hardware costs are included, although much of the needed hardware could already be available in stores. Since the benefit for this SAMA, calculated above is much less than this value, no further evaluation of costs is performed.

The total averted costs of this SAMA are $8,622. Implementation of this alternative would cost a minimum of $50,000, even before any hardware or installation costs are included. Therefore, the present worth can be calculated as:

$$\text{NPV} \leq \$8,622 - \$50,000.$$

$$\text{NPV} \leq -\$41,378.$$

Since the present worth is negative, implementation of this SAMA would not be cost beneficial.

F.6.4 SAMA 26 – Provide Additional Diesel-Powered Safety Injection Pump

The goal of this SAMA is to lower the chance of core damage following a small loss-of-coolant accident (LOCA) or station blackout (SBO) by providing a redundant and diverse source of makeup that is independent of existing AC power sources. This SAMA was modeled by assuming that RCP seals and safety injection pumps would not fail.

The results of the above modeling produced the following results:

STC Frequency = 4.797E-005 with the following contributions from each STC:

1	8.517E-007
2	0.000E+000
3	0.000E+000
4	2.169E-005
5	1.050E-007
6	2.893E-009
7	1.554E-008
8	1.428E-005
9	0.000E+000
10	0.000E+000
11	1.217E-007
12	1.305E-007
13	7.557E-006
14	3.212E-006

The frequency of each STC above is multiplied by the conditional dose from Table F-15 that is associated with each STC to obtain the expected dose for each STC. Then the expected dose values are summed to obtain the total expected dose after implementation of the SAMA, or 22.17 person-rem per year.

Similarly, the frequency of each STC above is multiplied by the conditional property damage value from Table F-16 that is associated with each STC to obtain the expected property damage value for each STC. Then the expected property damage values are summed to obtain the total expected damage after implementation of the SAMA, or $39,377 per year.

The benefit of implementing these SAMAs is then calculated as shown in Section F.4. The results of each of these calculations as well as that of the total averted costs are shown in Table F-19 under the column labelled "SAMA 26." The present value of total averted costs for implementing these SAMAs is $837,116. This amount is then doubled to account for the potential reduction in risk from external events resulting in a total potential benefit of $1,674,232.

As described above, implementation of this SAMA would remove the dependence of RCS inventory control on electric power so that loss of electric power would not lead to the inability to mitigate a LOCA.

Implementation of this SAMA would require that a pump, which can operate independently of normal AC power sources, be provided. In addition, motive power for the pump must be independent of AC sources. Options to power the pump could include a direct-drive diesel-powered pump, a diesel-generator to supply an AC powered pump, or a DC motor-driven pump supplied by a battery of sufficient capacity to allow operation of the pump for a significant time period.

Cost estimates to implement this SAMA range, depending on such variables as existing space and the need for a new Class I building, from a low of over $2,000,000 provided in the Cook SAMA analysis (Reference F-19) through $5,000,000 in the V. C. Summer SAMA (Reference F-20), and over $10,000,000 in the Millstone 3 SAMA analysis (Reference F-16). This analysis will use the lowest of these three values, $2,000,000, as a lower-bound estimate for scoping.

As quantified above, the total averted costs of this SAMA are $1,674,232. Implementation of this alternative would cost a minimum of $2,000,000. Therefore, the present worth can be calculated as:

NPV ≤ $1,674,232– $2,000,000.

NPV ≤ -$325,768.

Since the present worth is negative, implementation of this SAMA would not be cost beneficial.

F.6.5 SAMA 31 – Provide for Manual Alignment to ECCS Recirculation

The goal of this SAMA is to reduce the likelihood of failure of ECCS recirculation by providing the ability to recover, with manual actions, mechanical failures that prevent the switch to emergency core cooling system (ECCS) recirculation. This SAMA was modeled by assuming that electric power is not required for the valves needed to switch to ECCS recirculation.

The results of the above modeling produced the following results:

STC Frequency = 8.088-005 with the following contributions from each STC:

1	1.498E-006
2	0.000E+000
3	0.000E+000
4	4.057E-005
5	1.971E-007
6	5.081E-009
7	2.730E-008
8	2.562E-005
9	0.000E+000
10	0.000E+000
11	1.217E-007
12	1.546E-007
13	9.402E-006
14	3.284E-006

The frequency of each STC above is multiplied by the conditional dose from Table F-15 that is associated with each STC to obtain the expected dose for each STC. Then the expected dose values are summed to obtain the total expected dose after implementation of the SAMA, or 30.19 person-rem per year.

Similarly, the frequency of each STC above is multiplied by the conditional property damage value from Table F-16 that is associated with each STC to obtain the expected property damage value for each STC. Then the expected property damage values are summed to obtain the total expected damage after implementation of the SAMA, or $49,700 per year.

The benefit of implementing these SAMAs is then calculated as shown in Section F.4. The results of each of these calculations as well as that of the total averted costs are shown in Table F-19 under the column labelled “SAMA 31.” The present value of total averted costs for implementing these SAMAs is $181. This amount is then doubled to account for the potential reduction in risk from external events resulting in a total potential benefit of $362.

As described above, implementation of this SAMA would provide a means to recover failures that prevent the switchover to ECCS recirculation from inside the control room. Implementation of this SAMA would provide procedural guidance and plant modifications necessary to effect the switch to recirculation outside the control room if hardware failures prevent completing the actions from inside the control room.

This analysis will consider only the costs associated with the procedure changes needed to implement the SAMA. Using the standard costs for a procedure change shown in Section F.6, the costs to implement this SAMA would cost a minimum of $50,000 even before any hardware or engineering costs are included. Since the benefit for this SAMA is much less than this value, no further evaluation of costs is performed..

As quantified above, the total averted costs of this SAMA is \$362. Implementation of this alternative would cost a minimum of \$50,000. Therefore, the present worth can be calculated as:

NPV $\leq$ \$362 – \$50,000.

NPV $\leq$ -\$49,638.

Since the present worth is negative, implementation of this SAMA would not be cost beneficial.

F.6.6 SAMA 32 – Provide Automatic Alignment to ECCS Recirculation

The goal of this SAMA is to reduce the likelihood of failure of ECCS recirculation by eliminating operator actions needed to switch to ECCS recirculation on depletion of the RWST. This SAMA was modeled by setting to zero the HEPs associated with ECCS recirculation.

The results of the above modeling produced the following results:

STC Frequency = 7.961E-005 with the following contributions from each STC:

1	1.466E-006
2	0.000E+000
3	0.000E+000
4	4.056E-005
5	1.930E-007
6	4.996E-009
7	2.685E-008
8	2.444E-005
9	0.000E+000
10	0.000E+000
11	1.217E-007
12	1.546E-007
13	9.359E-006
14	3.282E-006

The frequency of each STC above is multiplied by the conditional dose from Table F-15 that is associated with each STC to obtain the expected dose for each STC. Then the expected dose values are summed to obtain the total expected dose after implementation of the SAMA, or 30.09 person-rem per year.

Similarly, the frequency of each STC above is multiplied by the conditional property damage value from Table F-16 that is associated with each STC to obtain the expected property damage value for each STC. Then the expected property damage values are summed to obtain the total expected damage after implementation of the SAMA, or \$49,506 per year.

The benefit of implementing this SAMA is then calculated as shown in Section F.4. The results of each of these calculations as well as that of the total averted costs are shown in Table F-19 under the column labelled "SAMA 32." The present value of total averted costs for implementing these SAMAs is \$25,608. This amount is then doubled to account for the potential reduction in risk from external events resulting in a total potential benefit of \$51,216.

As described above, implementation of this SAMA would automate the switchover of ECCS to recirculation, thereby eliminating operator error as a failure mode for recirculation. Automating the switchover to recirculation would require that new controls and alarms be installed along with changes to emergency operating procedures (EOPs), maintenance and surveillance procedures and Technical Specifications.

Implementation of this SAMA would require a plant modification. Using the standard costs for a modification shown in Section F.6, implementation of this alternative would cost a minimum of $100,000. Since the benefit for this SAMA is much less than this value, no further evaluation of costs is performed.

As quantified above, the total averted costs of this SAMA are $51,216. Implementation of this alternative would cost a minimum of $100,000, even before any hardware or installation costs are included. Therefore, the present worth can be calculated as:

$$\text{NPV} \leq \$51{,}216 - \$100{,}000.$$

$$\text{NPV} \leq -\$48{,}784$$

Since the present worth is negative, implementation of this SAMA would not be cost beneficial.

F.6.7 SAMA 46 – Add a Service Water Pump

The goal of this SAMA is to improve the availability of cooling water. This SAMA was modeled by setting the failure probability of service water pumps to zero. That is, the fault tree logic for service water pump failures was disconnected from the service water fault trees.

The results of the above modeling produced the following results:

STC Frequency = 6.649E-005 with the following contributions from each STC:

1	1.333E-006
2	0.000E+000
3	0.000E+000
4	3.144E-005
5	1.556E-007
6	4.117E-009
7	2.212E-008
8	2.187E-005
9	0.000E+000
10	0.000E+000
11	1.217E-007
12	1.546E-007
13	8.161E-006
14	3.221E-006

The frequency of each STC above is multiplied by the conditional dose from Table F-15 that is associated with each STC to obtain the expected dose for each STC. Then the expected dose values are summed to obtain the total expected dose after implementation of the SAMA, or 25.65 person-rem per year.

Similarly, the frequency of each STC above is multiplied by the conditional property damage value from Table F-16 that is associated with each STC to obtain the expected property damage value for each STC. Then the expected property damage values are summed to obtain the total expected damage after implementation of the SAMAs or $43,283 per year.

The benefit of implementing these SAMAs is then calculated as shown in Section F.4. The results of each of these calculations as well as that of the total averted costs are shown in Table F-19 under the column labelled "SAMA 46." The present value of total averted costs for implementing this SAMA is $408,902. This amount is then doubled to account for the potential reduction in risk from external events resulting in a total potential benefit of $817,804.

As described above, implementation of this SAMA would improve the availability of service water cooling. Implementation of this SAMA would require an additional pump as well as power and control circuitry be installed.

Cost estimates to implement this SAMA range, depending on such variables as existing space and need for a new Class I building, from a low of over $2,700,000 provided in the Cook SAMA analysis (Reference F-19) through $5,900,000 in the V. C. Summer SAMA (Reference F-20), to over $10,000,000 in the Millstone 3 SAMA analysis (Reference F-16). This analysis will use the lowest of these three values, $2,700,000 as a lower-bound estimate for scoping.

As quantified above, the total averted costs of this SAMA are $817,804. Implementation of this alternative would cost a minimum of $2,700,000. Therefore, the present worth can be calculated as:

$$\text{NPV} \leq \$817{,}804 - \$2{,}700{,}000.$$

$$\text{NPV} \leq -\$1{,}882{,}196$$

Since the present worth is negative, implementation of this SAMA would not be cost beneficial.

F.6.8 SAMA 50, SAMA 162, SAMA 163 – Enhance Loss of Cooling Water Procedures

The goal of these SAMAs is to reduce the probability of reactor coolant pump (RCP) seal failure following a loss of CCW or service water. The reduction in seal failure probability will occur because the revised loss of CCW procedure will direct that RCS temperature be reduced expeditiously and RCP seal failures are less likely when the RCS is colder. These SAMAs were modeled by setting to 1.0E-04 the failure probability of the basic event that represents failure of operator action to initiate RCS cool down in response to a loss of seal cooling.

The results of the above modeling produced the following results:

STC Frequency = 8.059E-005 with the following contributions from each STC:

1	1.499E-006
2	0.000E+000
3	0.000E+000
4	4.028E-005
5	1.971E-007
6	5.062E-009
7	2.720E-008
8	2.563E-005
9	0.000E+000
10	0.000E+000
11	1.217E-007
12	1.546E-007
13	9.391E-006
14	3.283E-006

The frequency of each STC above is multiplied by the conditional dose from Table F-15 that is associated with each STC to obtain the expected dose for each STC. Then the expected dose values are summed to obtain the total expected dose after implementation of these SAMAs, or 30.10 person-rem per year.

Similarly, the frequency of each STC above is multiplied by the conditional property damage value from Table F-16 that is associated with each STC to obtain the expected property damage value for each STC. Then the expected property damage values are summed to obtain the total expected damage after implementation of these SAMAs, or $49,622 per year.

The benefit of implementing these SAMAs is then calculated as shown in Section F.4. The results of each of these calculations as well as that of the total averted costs are shown in Table F-19 under the column labelled "SAMA 50." The present value of total averted costs for implementing these SAMAs is $7,716. This amount is then doubled to account for the potential reduction in risk from external events resulting in a total potential benefit of $15,432.

As described above, implementation of these SAMAs would reduce the probability of RCP seal failure following a loss of CCW or service water. Implementation of any one of these SAMAs would require procedure changes. Using the standard costs for a procedure change shown in Section F.6, implementation of this alternative would cost a minimum of $50,000. Since the benefit for these SAMAs is much less than this value, no further evaluation of costs is performed.

As quantified above, the total averted costs of these SAMAs are $15,432. Implementation of this alternative would cost a minimum of $50,000. Therefore, the present worth can be calculated as:

NPV ≤ $15,432 – $50,000.

NPV ≤ -$34,568.

Since the present worth is negative, implementation of any of these SAMAs would not be cost beneficial.

F.6.9 SAMA 55 – Install Independent RCP Seal Injection System With Dedicated Diesel

The goal of this SAMA is to remove the dependence of reactor coolant pump seal injection on component cooling water (CCW) and electric power. By providing an independent and diverse seal injection system with a dedicated and independent diesel-backed power supply, the chances of RCP seal failure, given a loss of cooling, would be substantially reduced, even under station blackout conditions. This SAMA was modeled by setting to zero the failure probability of charging to RCP seals.

The results of the above modeling produced the following results:

STC Frequency = 5.414E-005 with the following contributions from each STC:

1	1.197E-006
2	0.000E+000
3	0.000E+000
4	1.942E-005
5	1.633E-007
6	3.289E-009
7	1.767E-008
8	2.102E-005
9	0.000E+000
10	0.000E+000
11	1.217E-007
12	1.546E-007
13	8.785E-006
14	3.249E-006

The frequency of each STC above is multiplied by the conditional dose from Table F-15 that is associated with each STC to obtain the expected dose for each STC. Then the expected dose values are summed to obtain the total expected dose after implementation of the SAMA, or 24.38 person-rem per year.

Similarly, the frequency of each STC above is multiplied by the conditional property damage value from Table F-16 that is associated with each STC to obtain the expected property damage value for each STC. Then the expected property damage values are summed to obtain the total expected damage after implementation of the SAMA, or $44,904 per year.

The benefit of implementing this SAMA is then calculated as shown in Section F.4. The results of each of these calculations as well as that of the total averted costs are shown in Table F-19 under the column labelled "SAMA 55." The present value of total averted costs for implementing this SAMA is $626,294. This amount is then doubled to account for the potential reduction in risk from external events resulting in a total potential benefit of $1,252,588.

As described above, implementation of this SAMA would remove the dependence of RCP seal injection on CCW and electric power so that loss of either CCW or electric power does not lead to a RCP seal LOCA.

Implementation of this SAMA would require that a pump, which can operate independently of an external cooling source, be provided. In addition, motive power for the pump must be independent of AC sources. Options to power the pump could include a direct-drive diesel-powered pump or a diesel-generator to supply an AC powered pump.

Cost estimates to implement this SAMA range, depending on a number of variables, from a low of \$2,000,000 provided in the Cook SAMA analysis (Reference F-19) through \$2,500,000 in the V. C. Summer SAMA (Reference F-20), to over \$10,000,000 in the Millstone 3 SAMA analysis (Reference F-16). This analysis will use the lowest of these three values, \$2,000,000 as a lower-bound estimate for scoping.

As quantified above, the total averted costs of this SAMA are \$1,252,588. Implementation of this alternative would cost a minimum of \$2,000,000. Therefore, the present worth can be calculated as:

NPV ≤ \$1,252,588 – \$2,000,000.

NPV ≤ -\$747,412.

Since the present worth is negative, implementation of this SAMA would not be cost beneficial.

F.6.10 SAMA 56 – Install Independent RCP Seal Injection System Without Dedicated Diesel

The goal of this SAMA is to minimize the dependence of reactor coolant pump seal injection on CCW and charging. By providing an independent and diverse seal injection system, the chances of RCP seal failure, given a loss of cooling, would be substantially reduced. However, because the postulation is that no backup power supply is provided, the system would provide no benefit under station blackout conditions. This SAMA is similar to the case analyzed for SAMA 55 except that no benefit would be provided for station blackout conditions. This SAMA was modeled by setting to zero the failure probability of charging to RCP seals for all accident scenarios except station blackout.

The results of the above modeling produced the following results:

STC Frequency = 5.775E-005 with the following contributions from each STC:

1	1.235E-006
2	0.000E+000
3	0.000E+000
4	2.180E-005
5	1.684E-007
6	3.534E-009
7	1.899E-008
8	2.168E-005
9	0.000E+000
10	0.000E+000
11	1.217E-007
12	1.546E-007
13	9.321E-006
14	3.281E-006

The frequency of each STC above is multiplied by the conditional dose from Table F-15 that is associated with each STC to obtain the expected dose for each STC. Then the expected dose values are summed to obtain the total expected dose after implementation of the SAMA, or 26.01 person-rem per year.

Similarly, the frequency of each STC above is multiplied by the conditional property damage value from Table F-16 that is associated with each STC to obtain the expected property damage value for each STC. Then the expected property damage values are summed to obtain the total expected damage after implementation of the SAMA, or $47,526 per year.

The benefit of implementing this SAMA is then calculated as shown in Section F.4. The results of each of these calculations as well as that of the total averted costs are shown in Table F-19 under the column labelled "SAMA 56." The present value of total averted costs for implementing this SAMA is $502,352. This amount is then doubled to account for the potential reduction in risk from external events resulting in a total potential benefit of $1,004,704.

As described above, implementation of this SAMA would remove the dependence of RCP seal injection on CCW so that loss of either CCW or service water does not lead to a RCP seal LOCA.

Implementation of this SAMA would require that a pump that can operate independently of an external cooling source be provided.

Cost estimates to implement this SAMA range, depending on a number of variables, from a low of $1,000,000 provided in the Cook SAMA analysis (Reference F-19) through $2,500,000 in the V. C. Summer SAMA (Reference F-20), to over $5,000,000 in the Millstone 3 SAMA analysis (Reference F-16). However, the Cook SAMA analysis used a very low estimate that would restore an abandoned pump to service without the need to install additional piping as would be required at KPS. Therefore, engineering judgment is used to estimate that the costs would be at least 50% higher to engineer and install additional piping. This analysis will use the low Cook estimate increased by 50% or $1,500,000 as a lower-bound estimate for scoping.

As quantified above, the total averted costs of this SAMA are $1,004,704. Implementation of this alternative would cost a minimum of $1,500,000. Therefore, the present worth can be calculated as:

NPV ≤ $$1,004,704 – $1,500,000.

NPV ≤ -$495,296.

Since the present worth is negative, implementation of this SAMA would not be cost beneficial.

F.6.11 SAMA 58 – Install Improved RCP Seals

The goal of this SAMA is to remove the dependence of reactor coolant pump seal integrity on support systems. This SAMA would replace the existing RCP seals with an improved design that does not require seal cooling. This SAMA uses the same modeling changes as SAMA 55, above. That is, the SAMA was modeled by setting to zero the failure probability of charging to RCP seals.

Since modeling of this SAMA is the same as for SAMA 55, the results are the same and the total averted costs are $626,294. This amount is then doubled to account for the potential reduction in risk from external events resulting in a total potential benefit of $1,252,588. These results are shown in Table F-19 under the column labelled "SAMA 56."

As described above, implementation of this SAMA would eliminate any need for RCP seal cooling. RCP seals were replaced during October 2006 using seals that were similar to the previously installed seals. The cost to replace seals in October 2006 was $1,423,000. Replacement of the existing seal design with seals of an improved design would likely involve significant additional engineering costs. However, since the benefit for this SAMA, calculated above, is much less than this value, no further evaluation of costs is performed.

As quantified in above, the total averted costs of this SAMA are $1,251,926. Implementation of this alternative would cost a minimum of $1,423,000. Therefore, the present worth can be calculated as:

NPV ≤ $1,251,926 – $1,423,000.

NPV ≤ -$171,074.

Since the present worth is negative, implementation of this SAMA would not be cost beneficial.

F.6.12 SAMA 59 – Install an Additional CCW Pump

The goal of this SAMA is to reduce the likelihood that a loss of CCW will lead to a RCP seal LOCA. This SAMA would add an additional CCW pump that could provide flow given a loss of the two currently-installed CCW pumps. This SAMA was modeled by setting to zero the failure probability of CCW pumps.

The results of the above modeling produced the following results:

STC Frequency = 6.091E-005 with the following contributions from each STC:

1	9.941E-007
2	0.000E+000
3	0.000E+000
4	3.294E-005
5	1.399E-007
6	3.744E-009
7	2.011E-008
8	1.510E-005
9	0.000E+000
10	0.000E+000
11	1.217E-007
12	1.546E-007
13	8.204E-006
14	3.232E-006

The frequency of each STC above is multiplied by the conditional dose from Table F-15 that is associated with each STC to obtain the expected dose for each STC. Then the expected dose values are summed to obtain the total expected dose after implementation of the SAMA, or 26.05 person-rem per year.

Similarly, the frequency of each STC above is multiplied by the conditional property damage value from Table F-16 that is associated with each STC to obtain the expected property damage value for each STC. Then the expected property damage values are summed to obtain the total expected damage after implementation of the SAMA, or $43,618 per year.

The benefit of implementing this SAMA is then calculated as shown in Section F.4. The results of each of these calculations as well as that of the total averted costs are shown in Table F-19 under the column labelled "SAMA 59." The present value of total averted costs for implementing this SAMA is $490,314. This amount is then doubled to account for the potential reduction in risk from external events resulting in a total potential benefit of $980,628.

As described above, implementation of this SAMA would improve the availability of CCW. Implementation of this SAMA would require an additional pump as well as power and control circuitry be installed.

While not identical, the CCW pumps are similar in capacity to the service water pumps. Cost estimates to replace service water pumps at KPS were estimated. As part of that evaluation, a replacement pump, including required testing, was estimated to cost $415,000. A replacement motor was estimated to cost $300,000. Although these components are slightly larger than would be required for a CCW pump, these costs are considered adequate for SAMA cost estimating purposes. In addition, engineering costs for replacing existing service water pumps were estimated to be $500,000. Installation costs were not addressed in the estimates. In addition, a new circuit breaker for the new CCW pump would be required, diesel loading calculations, room heatup calculations, and accident analyses would be required but these costs were not included in the ESW pump replacement costs. Because consideration of only the pump, motor, and engineering costs, $1,215,000, greatly exceed the benefit calculated and because total costs to implement this SAMA are clearly much higher, a detailed cost estimate is not performed.

As quantified above, the total averted costs of this SAMA are $980,628. Implementation of this alternative would cost a minimum of $1,215,000. Therefore, the present worth can be calculated as:

$$\text{NPV} \leq \$980{,}628 - \$1{,}215{,}000.$$

$$\text{NPV} \leq -\$234{,}372.$$

Since the present worth is negative, implementation of this SAMA would not be cost beneficial.

F.6.13 SAMA 66 – Install a New Feedwater Source

The goal of this SAMA is to improve the availability of secondary cooling by providing an additional source of makeup to the feedwater and AFW systems. This SAMA would add an additional makeup source to the secondary systems. This SAMA was modeled by setting to zero the failure probability for the hardware associated with water sources to the feedwater systems.

The results of the above modeling produced the following results:

STC Frequency = 7.544E-005 with the following contributions from each STC:

1	1.457E-006
2	0.000E+000
3	0.000E+000
4	3.670E-005
5	1.926E-007
6	4.717E-009
7	2.535E-008
8	2.497E-005
9	0.000E+000
10	0.000E+000
11	1.217E-007
12	1.546E-007
13	8.563E-006
14	3.252E-006

The frequency of each STC above is multiplied by the conditional dose from Table F-15 that is associated with each STC to obtain the expected dose for each STC. Then the expected dose values are summed to obtain the total expected dose after implementation of the SAMA, or 27.61 person-rem per year.

Similarly, the frequency of each STC above is multiplied by the conditional property damage value from Table F-16 that is associated with each STC to obtain the expected property damage value for each STC. Then the expected property damage values are summed to obtain the total expected damage after implementation of the SAMA, or $45,591 per year.

The benefit of implementing this SAMA is then calculated as shown in Section F.4. The results of each of these calculations as well as that of the total averted costs are shown in Table F-19 under the column labelled "SAMA 66." The present value of total averted costs for implementing this SAMA is $191,228. This amount is then doubled to account for the potential reduction in risk from external events resulting in a total potential benefit of $382,456.

As described above, implementation of this SAMA would improve the availability of secondary cooling. Implementation of this SAMA could be performed by using the fire water system to provide water to the heater drain tank or to the AFW system. Guidance to perform these actions is provided in SAG-01. This SAMA would incorporate these actions into the abnormal and emergency operating procedures.

Implementation of this SAMA would require a procedure change. Using the standard costs for a procedure change shown in Section 8.0, implementation of this alternative would cost a minimum of $50,000.

As quantified above, the total averted costs of this SAMA are $382,456. Implementation of this alternative would cost a minimum of $50,000. Therefore, the present worth can be calculated as:

$\text{NPV} \leq \$382{,}456 - \$50{,}000.$

$\text{NPV} \leq \$332{,}456.$

Since the present worth of this SAMA is positive, implementation of this SAMA could be cost beneficial.

F.6.14 SAMA 71 – Install A New Condensate Storage Tank

The goal of this SAMA is to improve the availability of secondary cooling by providing an additional source of makeup to the feedwater and AFW systems. This SAMA would add a new condensate storage tank (CST) thereby eliminating the need to cross-tie the existing CSTs with other sources. This SAMA was modeled by setting to zero the failure probability of events associated with providing a cross-tie of the CSTs to other sources. Therefore, an unlimited volume of water to the AFW system was modeled.

The results of the above modeling produced the following results:

STC Frequency = 6.513E-005 with the following contributions from each STC:

1	9.554E-007
2	0.000E+000
3	0.000E+000
4	3.923E-005
6	4.046E-009
7	2.174E-008
8	1.439E-005
9	0.000E+000
10	0.000E+000
11	1.217E-007
12	1.546E-007
13	6.924E-006
14	3.201E-006

The frequency of each STC above is multiplied by the conditional dose from Table F-15 that is associated with each STC to obtain the expected dose for each STC. Then the expected dose values are summed to obtain the total expected dose after implementation of the SAMA, or 24.74 person-rem per year.

Similarly, the frequency of each STC above is multiplied by the conditional property damage value from Table F-16 that is associated with each STC to obtain the expected property damage value for each STC. Then the expected property damage values are summed to obtain the total expected damage after implementation of the SAMA, or $38,536 per year.

The benefit of implementing this SAMA is then calculated as shown in Section F.4. The results of each of these calculations as well as that of the total averted costs are shown in Table F-19 under the column labelled "SAMA 71." The present value of total averted costs for implementing this

SAMA is $502,427. This amount is then doubled to account for the potential reduction in risk from external events resulting in a total potential benefit of $1,004,854.

As described above, implementation of this SAMA would provide a CST large enough that operator actions to ensure a long-term supply to AFW are not required. Costs to implement this SAMA are based on the costs to install two 350,000 gallon stainless steel fire tanks at Surry Power Station. A tank of about that size would be required for KPS to have 24 hours of CST inventory available. For the Surry station project, the cost of the tanks is $3.4 million and does not include any demolition of the old tanks. It could be assumed that the cost for one tank would be one half the costs of the two tanks, but that would underestimate the costs since the initial engineering costs would still apply. However, for this analysis, it will be assumed that the cost of one 350,000 gallon tank is half the cost of the two tanks planned for Surry. Since that cost, $1.7 million, is significantly greater than the benefit calculated above, no further evaluation is performed.

As quantified above, the total averted costs of this SAMA are $1,004,854. Implementation of this alternative would cost a minimum of $1,700,000. Therefore, the present worth can be calculated as:

NPV ≤ $1,004,854 – $1,700,000.

NPV ≤ -$695,146.

Since the present worth is negative, implementation of this SAMA would not be cost beneficial.

F.6.15 SAMA 76, SAMA 184 – Change Failure Position of Condenser Makeup Valve

The goal of these SAMAs is to improve the availability of secondary cooling eliminating a flow diversion path from the makeup to the feedwater and AFW systems. This SAMA would change the failure position of the CST makeup valve so that the valve fails closed on a loss of power or air. These SAMAs were modeled by removing any power dependencies from valve MU-3A.

The results of the above modeling produced the following results:

STC Frequency = 8.082E-005 with the following contributions from each STC:

1	1.495E-006
2	0.000E+000
3	0.000E+000
4	4.056E-005
5	1.968E-007
6	5.077E-009
7	2.728E-008
8	2.558E-005
9	0.000E+000
10	0.000E+000
11	1.217E-007
12	1.546E-007
13	9.392E-006
14	3.283E-006

The frequency of each STC above is multiplied by the conditional dose from Table F-15 that is associated with each STC to obtain the expected dose for each STC. Then the expected dose values are summed to obtain the total expected dose after implementation of the SAMAs, or 30.16 person-rem per year.

Similarly, the frequency of each STC above is multiplied by the conditional property damage value from Table F-16 that is associated with each STC to obtain the expected property damage value for each STC. Then the expected property damage values are summed to obtain the total expected damage after implementation of the SAMAs, or $49,654 per year.

The benefit of implementing these SAMAs is then calculated as shown in Section F.4. The results of each of these calculations as well as that of the total averted costs are shown in Table F-19 under the column labelled "SAMA 76." The present value of total averted costs for implementing these SAMAs is $2,183. This amount is then doubled to account for the potential reduction in risk from external events resulting in a total potential benefit of $4,366.

As described above, implementation of these SAMAs would eliminate a potential diversion path for AFW.

Implementation of this SAMA would require a plant modification. Using the standard costs for a modification shown in Section F.6, implementation of this alternative would cost a minimum of $100,000. Since the benefit for this SAMA, is much less than this value, no further evaluation of costs is performed.

As quantified above, the total averted costs of these SAMAs are $4,366. Implementation of this alternative would cost a minimum of $100,000. Therefore, the present worth can be calculated as:

$$\text{NPV} \leq \$4{,}366 - \$100{,}000.$$

$$\text{NPV} \leq -\$95{,}634$$

Since the present worth is negative, implementation of these SAMAs would not be cost beneficial.

F.6.16 SAMA 80 – Add Redundant Ventilation Systems

The goal of this SAMA is to improve the availability of components that are dependent on room cooling by providing an additional ventilation system. Since the SAMAs evaluated in Sections F.6.17 and F.6.18 address ventilation for systems located in the turbine building, this SAMA will consider ventilation systems needed for equipment located in the auxiliary building. This SAMA was modeled by removing any ventilation system dependencies for equipment located in the auxiliary building from the fault tree models.

The results of the above modeling produced the following results:

STC Frequency = 7.036E-005 with the following contributions from each STC:

1	1.079E-006
2	0.000E+000
3	0.000E+000
4	3.923E-005
5	1.498E-007
6	4.377E-009
7	2.352E-008
8	1.768E-005
9	0.000E+000
10	0.000E+000
11	1.217E-007
12	1.546E-007
13	8.670E-006
14	3.253E-006

The frequency of each STC above is multiplied by the conditional dose from Table F-15 that is associated with each STC to obtain the expected dose for each STC. Then the expected dose values are summed to obtain the total expected dose after implementation of the SAMA, or 28.37 person-rem per year.

Similarly, the frequency of each STC above is multiplied by the conditional property damage value from Table F-16 that is associated with each STC to obtain the expected property damage value for each STC. Then the expected property damage values are summed to obtain the total expected damage after implementation of the SAMA, or $46,303 per year.

The benefit of implementing this SAMA is then calculated as shown in Section F.4. The results of each of these calculations as well as that of the total averted costs are shown in Table F-19 under the column labelled "SAMA 80." The present value of total averted costs for implementing these SAMAs is $252,726. This amount is then doubled to account for the potential reduction in risk from external events resulting in a total potential benefit of $505,452.

As described above, this SAMA would provide additional ventilation capabilities for equipment located in the auxiliary building. While implementation of this SAMA could be accomplished by adding permanently-installed systems, another effective means would be to stage temporary equipment and provide necessary power and procedures needed to align and operate the temporary ventilation.

For this analysis, it will be assumed that adequate power sources, such as welding receptacles or spare MCC cubicles, are available where needed throughout the plant and that the power sources are supplied from a diesel-backed source. Therefore, no design changes will be required to provide power. Design changes, however, will be required to provide the new equipment, power cords, and ducting as well as to add staging areas for the equipment.

Because temporary equipment would be used to implement this SAMA, the costs of hardware are assumed to be minimal and will be ignored. Analyses will be required to determine the time available to provide the ventilation as well as the flow rates needed. These analyses are estimated to cost $100,000. The design change to procure and stage the temporary ventilation is estimated using the standard costs for a design change shown in Section F.6, or an additional $100,000. Also procedural changes for use of the temporary systems would also be required. Using the standard costs for a procedure change shown in Section F.6, an additional $50,000 would be required for procedures. Therefore, a total cost of $250,000 would be required to implement this SAMA.

As quantified above, the total averted costs of this SAMA are $505,452. Implementation of this alternative would cost a minimum of $250,000. Therefore, the present worth can be calculated as:

NPV ≤ $505,452 – $250,000.
NPV ≤ $255,452.

Since the present worth of this SAMA is positive, implementation of this SAMA could be cost beneficial.

F.6.17 SAMA 81, SAMA 160, SAMA 166, SAMA 167, SAMA 170, SAMA, 171 – Diesel Room Cooling Improvements

The goal of these SAMAs is to improve diagnosis and response to a loss of EDG room cooling. SAMA 81 and SAMA 171 would install a room high temperature alarm for the EDG rooms thereby improving the cues that initiate operator action to respond to a loss of cooling. SAMA 160 would install insulation on EDG exhaust ducting thereby mitigating any temperature rise that would occur on a loss of cooling. SAMA 166 and SAMA 167 would proceduralize compensatory actions in response to a loss of room cooling. SAMA 170 would provide equipment needed to implement the compensatory actions proceduralized by items 166 and 166. These SAMAs were modeled by assuming that diesel room ventilation was always successful.

The results of the above modeling produced the following results:

STC Frequency = 7.720E-005 with the following contributions from each STC:

1	1.478E-006
2	0.000E+000
3	0.000E+000
4	3.777E-005
5	1.881E-007
6	4.837E-009
7	2.599E-008
8	2.525E-005
9	0.000E+000
10	0.000E+000
11	1.217E-007
12	1.535E-007
13	8.954E-006
14	3.253E-006

The frequency of each STC above is multiplied by the conditional dose from Table F-15 that is associated with each STC to obtain the expected dose for each STC. Then the expected dose values are summed to obtain the total expected dose after implementation of the SAMAs, or 28.65 person-rem per year.

Similarly, the frequency of each STC above is multiplied by the conditional property damage value from Table F-16 that is associated with each STC to obtain the expected property damage value for each STC. Then the expected property damage values are summed to obtain the total expected damage after implementation of the SAMAs, or $47,415 per year.

The benefit of implementing these SAMAs is then calculated as shown in Section F.4. The results of each of these calculations as well as that of the total averted costs are shown in Table F-19 under the column labelled "SAMA 81." The present value of total averted costs for implementing these SAMAs is $119,809. This amount is then doubled to account for the potential reduction in risk from external events resulting in a total potential benefit of $239,618.

As described above, these SAMAs would improve the ability to detect and mitigate a loss of EDG room cooling. These SAMAs must, in general, be implemented together to have a benefit. Implementation of any one SAMA would likely have no impact. For example, staging of the temporary equipment for ventilation without adding a room high temperature alarm would likely not allow for adequate operator response time to prevent equipment failures.

The first step to implement these SAMAs would be to perform a room heat-up analysis to determine the temperature settings, operator response times, and ventilation flow requirements for the rooms. This analysis is estimated to cost $100,000.

Next, a modification would be required to install the room high temperature alarms. Adding room temperature alarms would be similar to adding the auxiliary building flooding indication circuits that were recently installed. Engineering and installation costs alone for the auxiliary building flooding alarms totaled $149,746.

Design changes, however, will be required to provide the new equipment, power cords, and ducting as well as to add staging areas for the equipment. Because temporary equipment will be used to implement this SAMA, the costs of hardware are assumed to be minimal and will be ignored. The design change to procure and stage the temporary ventilation is estimated using the standard costs for a design change shown in Section F.6, or an additional $100,000.

Additionally, procedure changes would be required to implement use of the new temporary ventilation equipment. Using the standard costs for a procedure change shown in Section F.6, an additional $50,000 would be required to implement that change. For this analysis, it will be assumed that adequate power supplies, such as welding receptacles or spare motor control center (MCC) cubicles, are available where needed to supply the temporary equipment and that the power supplies are supplied from a diesel-backed source. This analysis will also assume that the equipment costs associated with procuring the temporary equipment are small enough to be neglected.

Consideration of the above cost shows that implementation of these SAMAs would cost a minimum of $399,746 and neglects any costs associated with EDG exhaust insulation. Since this cost is greater than the potential benefit a detailed cost estimate is not performed.

As quantified above, the total averted costs of these SAMAs are $239,618. Implementation of this alternative would cost a minimum of $399,746. Therefore, the present worth can be calculated as:

$$NPV \leq \$239{,}618 - \$399{,}746.$$

$$NPV \leq -\$160{,}128.$$

Since the present worth is negative, implementation of these SAMAs would not be cost beneficial.

F.6.18 SAMA 82, SAMA 83, SAMA 170, SAMA 171 – Switchgear Room Ventilation Response

The goal of these SAMAs is to improve the diagnosis and response to a loss of switchgear room cooling. SAMA 82 and SAMA 170 would stage temporary equipment that can be used to compensate for a loss of normally-installed switchgear heating ventilation and air-conditioning system (HVAC). SAMA 83 and SAMA 171 would provide a room high temperature alarm. These SAMAs were modeled by adding an operator action to implement actions for temporary ventilation following any loss of switchgear room ventilation.

The results of the above modeling produced the following results:

STC Frequency = 7.375E-005 with the following contributions from each STC:

1	1.502E-006
2	0.000E+000
3	0.000E+000
4	3.411E-005
5	1.975E-007
6	4.606E-009
7	2.475E-008
8	2.569E-005
9	0.000E+000
10	0.000E+000
11	1.217E-007
12	1.544E-007
13	8.705E-006
14	3.246E-006

The frequency of each STC above is multiplied by the conditional dose from Table F-15 that is associated with each STC to obtain the expected dose for each STC. Then the expected dose values are summed to obtain the total expected dose after implementation of the SAMAs, or 27.35 person-rem per year.

Similarly, the frequency of each STC above is multiplied by the conditional property damage value from Table F-16 that is associated with each STC to obtain the expected property damage value for each STC. Then the expected property damage values are summed to obtain the total expected damage after implementation of the SAMAs, or $45,966 per year.

The benefit of implementing these SAMAs is then calculated as shown in Section F.4. The results of each of these calculations as well as that of the total averted costs are shown in Table F-19 under the column labelled "SAMA 83." The present value of total averted costs for implementing these SAMAs is $221,218. This amount is then doubled to account for the potential reduction in risk from external events resulting in a total potential benefit of $442,436.

As described above, these SAMAs would improve the ability to detect and mitigate a loss of 480 VAC switchgear room cooling. These SAMAs must, in general, be implemented together to have a benefit. Implementation of any one SAMA would likely have no impact. For example, staging of the temporary equipment for ventilation without adding a room high temperature alarm would likely not allow for adequate operator response time to prevent equipment failures.

The first step to implement these SAMAs would be to perform a room heat-up analysis to determine the temperature settings, operator response times, and ventilation flow requirements for the rooms. This analysis is estimated to cost $100,000.

Next a modification would be required to install the room high temperature alarms. Adding room temperature alarms would be similar to adding the auxiliary building flooding indication circuits that were recently installed. Engineering and installation costs alone for the auxiliary building flooding alarms totaled $149,746.

Design changes, however, will be required to provide the new equipment, power cords, and ducting as well as to add staging areas for the equipment. Because temporary equipment will be used to implement this SAMA, the costs of hardware are assumed to be minimal and will be ignored. The design change to procure and stage the temporary ventilation is estimated using the standard costs for a design change shown in Section F.6, or an additional $100,000.

Additionally, procedure changes would be required to implement use of the new temporary ventilation equipment. Using the standard costs for a procedure change shown in Section F.6, an additional $50,000 would be required to implement that change. For this analysis, it will be assumed that adequate power supplies, such as welding receptacles or spare MCC cubicles, are available where needed to supply the temporary equipment and that the power supplies are supplied from a diesel-backed source. Therefore, no design changes will be required to provide power.

Consideration of the above cost shows that implementation of these SAMAs would cost a minimum of $399,746.

As quantified above, the total averted costs of these SAMAs are $442,436. Implementation of this alternative would cost a minimum of $399,746. Therefore, the present worth can be calculated as:

$$\text{NPV} \leq \$442{,}436 - \$399{,}746.$$

$$\text{NPV} \leq \$42{,}690.$$

Since the present worth of this SAMA is positive, implementation of these SAMAs could be cost beneficial.

F.6.19 SAMA 86 – Proceduralize Backup Power to Air Compressors

The goal of this SAMA is to improve availability of instrument air following a loss of offsite power. This SAMA would develop procedures and stage equipment needed to provide a temporary, diesel-backed power source to the non-safety-related air compressors. This SAMA was modeled by assuming that power to air compressors F and G does not fail.

The results of the above modeling produced the following results:

STC Frequency = 8.071E-005 with the following contributions from each STC:

1	1.497E-006
2	0.000E+000
3	0.000E+000
4	4.044E-005
5	1.970E-007
6	5.071E-009
7	2.725E-008
8	2.561E-005
9	0.000E+000
10	0.000E+000
11	1.217E-007
12	1.518E-007
13	9.394E-006
14	3.268E-006

The frequency of each STC above is multiplied by the conditional dose from Table F-15 that is associated with each STC to obtain the expected dose for each STC. Then the expected dose values are summed to obtain the total expected dose after implementation of the SAMA, or 30.12 person-rem per year.

Similarly, the frequency of each STC above is multiplied by the conditional property damage value from Table F-16 that is associated with each STC to obtain the expected property damage value for each STC. Then the expected property damage values are summed to obtain the total expected damage after implementation of the SAMA, or $49,611 per year.

The benefit of implementing this SAMA is then calculated as shown in Section F.4. The results of each of these calculations as well as that of the total averted costs are shown in Table F-19 under the column labelled “SAMA 86.” The present value of total averted costs for implementing these SAMAs is $5,386. This amount is then doubled to account for the potential reduction in risk from external events resulting in a total potential benefit of $10,772.

As described above, implementation of this SAMA would reduce the probability of losing all instrument air. Implementation of this SAMA would require procedure changes. Using the standard costs for a procedure change shown in Section F.6, implementation of this alternative would cost a minimum of $50,000. Since the benefit for this SAMA is much less than this value, no further evaluation of costs is performed.

As quantified above, the total averted costs of this SAMA are $10,772. Implementation of this alternative would cost a minimum of $50,000. Therefore, the present worth can be calculated as:

NPV ≤ $10,772 – $50,000.

NPV ≤ -$39,228.

Since the present worth is negative, implementation of this SAMA would not be cost beneficial.

F.6.20 SAMA 87 – Replace Air Compressors With Self-Cooled Units

The goal of this SAMA is to eliminate air system dependence on service water cooling by replacing the water-cooled air-compressors with self-cooled units. This SAMA was modeled by removing the service water and plant equipment water dependency of air compressors from the system fault trees.

The results of the above modeling produced the following results:

STC Frequency = 8.032E-005 with the following contributions from each STC:

1	1.499E-006
2	0.000E+000
3	0.000E+000
4	4.000E-005
5	1.971E-007
6	5.044E-009
7	2.710E-008
8	2.563E-005
9	0.000E+000
10	0.000E+000
11	1.217E-007
12	1.546E-007
13	9.402E-006
14	3.284E-006

The frequency of each STC above is multiplied by the conditional dose from Table F-15 that is associated with each STC to obtain the expected dose for each STC. Then the expected dose values are summed to obtain the total expected dose after implementation of the SAMA, or 30.07 person-rem per year.

Similarly, the frequency of each STC above is multiplied by the conditional property damage value from Table F-16 that is associated with each STC to obtain the expected property damage value for each STC. Then the expected property damage values are summed to obtain the total expected damage after implementation of the SAMA, or $49,645 per year.

The benefit of implementing this SAMA is then calculated as shown in Section F.4. The results of each of these calculations as well as that of the total averted costs are shown in Table F-19 under the column labelled "SAMA 87." The present value of total averted costs for implementing these SAMAs is $12,805. This amount is then doubled to account for the potential reduction in risk from external events resulting in a total potential benefit of $25,610.

As described above, implementation of this SAMA would eliminate the dependence of the air system on service water. Implementation of this SAMA would require a design change. Using the standard costs for a design change shown in Section F.6, implementation of this alternative would cost a minimum of $100,000. Since the benefit for this SAMA is much less than this value, no further evaluation of costs is performed.

As quantified above, the total averted costs of this SAMA are $25,610. Implementation of this alternative would cost a minimum of $100,000. Therefore, the present worth can be calculated as:

$$NPV \leq \$25{,}610 - \$100{,}000.$$

$$NPV \leq -\$74{,}390$$

Since the present worth is negative, implementation of this SAMA would not be cost beneficial.

F.6.21 SAMA 111, SAMA 113 – Improve Prevention and Detection of ISLOCA

The goal of these SAMAs is to minimize the chance of an ISLOCA occurring, or if one does, then to improve the ability of operators to diagnose and detect the event. SAMA 111 would add pressure monitors that could provide indication of leakage past RCS pressure isolation valves thereby giving the operators time to prevent an ISLOCA from occurring. SAMA 113 would increase the frequency for testing pressure isolation valves thereby lowering the probability that an undetected failure of a pressure isolation valve would lead to an ISLOCA. These SAMAs were modeled by setting the ISLOCA frequency to zero.

The results of the above modeling produced the following results:

STC Frequency = 8.000E-005 with the following contributions from each STC:

1	1.483E-006
2	0.000E+000
3	0.000E+000
4	4.057E-005
5	1.952E-007
6	5.041E-009
7	2.708E-008
8	2.505E-005
9	0.000E+000
10	0.000E+000
11	0.000E+000
12	0.000E+000
13	9.380E-006
14	3.283E-006

The frequency of each STC above is multiplied by the conditional dose from Table F-15 that is associated with each STC to obtain the expected dose for each STC. Then the expected dose values are summed to obtain the total expected dose after implementation of these SAMAs, or 29.04 person-rem per year.

Similarly, the frequency of each STC above is multiplied by the conditional property damage value from Table F-16 that is associated with each STC to obtain the expected property damage value for each STC. Then the expected property damage values are summed to obtain the total expected damage after implementation of the SAMA, or $47,252 per year.

The benefit of implementing these SAMAs is then calculated as shown in Section F.4. The results of each of these calculations as well as that of the total averted costs are shown in Table F-19 under the column labelled "SAMA 111." The present value of total averted costs for implementing these SAMAs is $65,990. This amount is then doubled to account for the potential reduction in risk from external events resulting in a total potential benefit of $131,980.

As described above, implementation of these SAMAs would lower the expected frequency of an ISLOCA. Implementation of this SAMA would require a design change. Using the standard costs for a design change shown in Section F.6, implementation of this alternative would cost a minimum of $100,000. This minimum cost is only slightly less than the benefit calculated above.

Cost estimates to implement this SAMA range, depending on variables, from a low of over $190,000 provided in the Cook SAMA analysis (Reference F-19) through $2,300,000 in the V. C. Summer SAMA (Reference F-20), and over $10,000,000 in the Millstone 3 SAMA analysis (Reference F-16). This analysis will use the lowest of these three values, $190,000 as a lower-bound estimate for scoping.

As quantified above, the total averted costs of this SAMA are $131,980. Implementation of this alternative would cost a minimum of $190,000. Therefore, the present worth can be calculated as:

$$\text{NPV} \le \$131{,}980 - \$190{,}000.$$

$$\text{NPV} \le -\$58{,}020$$

Since the present worth is negative, implementation of these SAMAs would not be cost beneficial.

F.6.22 SAMA 112 – Enhance Containment Isolation Valve Indication

The goal of this SAMA is to reduce the frequency of containment isolation failure by installing an additional position indication switch for each containment isolation valve. This additional indication could improve detection of containment isolation failure or of an ISLOCA. This SAMA was modeled by setting the ISLOCA frequency to zero and containment isolation to success.

The results of the above modeling produced the following results:

STC Frequency = 8.000E-005 with the following contributions from each STC:

```
 1  1.484E-006
 2  0.000E+000
 3  0.000E+000
 4  4.059E-005
 5  1.953E-007
 6  0.000E+000
 7  0.000E+000
 8  2.506E-005
 9  0.000E+000
10  0.000E+000
11  0.000E+000
12  0.000E+000
13  9.383E-006
14  3.283E-006
```

The frequency of each STC above is multiplied by the conditional dose from Table F-15 that is associated with each STC to obtain the expected dose for each STC. Then the expected dose values are summed to obtain the total expected dose after implementation of this SAMA, or 29.03 person-rem per year.

Similarly, the frequency of each STC above is multiplied by the conditional property damage value from Table F-16 that is associated with each STC to obtain the expected property damage value for each STC. Then the expected property damage values are summed to obtain the total expected damage after implementation of the SAMA, or $47,215 per year.

The benefit of implementing these SAMAs is then calculated as shown in Section F.4. The results of each of these calculations as well as that of the total averted costs are shown in Table F-19 under the column labelled "SAMA 112." The present value of total averted costs for implementing these SAMAs is $66,702. This amount is then doubled to account for the potential reduction in risk from external events resulting in a total potential benefit of $133,404.

As described above, implementation of this SAMA would lower the probability of containment isolation failure by providing additional indication to the operators that a containment isolation valve is not closed. Adding additional indication of containment isolation valve position would be similar to adding the auxiliary building flooding indication circuits that were recently installed. However, many more circuits would be required for containment isolation valves so costs would be significantly higher. Engineering and installation costs alone for the auxiliary building flooding alarms totaled $149,746. Additional costs not considered would include procedures and training. Since the engineering and installation costs alone exceed the potential benefit, a detailed cost estimate is not performed.

As quantified above, the total averted costs of this SAMA are $133,404. Implementation of this alternative would cost a minimum of $149,746 but would be expected to cost significantly more if a detailed estimate was performed. Therefore, the present worth can be calculated as:

NPV $\leq$ $133,404 – $149,746.

NPV $\leq$ -$16,342.

Since the present worth is negative, implementation of this SAMA would not be cost beneficial.

F.6.23 SAMA 114 – Install Self-Actuating Containment Isolation Valves

The goal of this SAMA is to improve the reliability and effectiveness of containment isolation thus reducing the chance that radioactivity would be released to the atmosphere. The alternative proposed by the item is to make all containment isolation valves self-actuating thereby removing any support system dependencies. This SAMA was modeled by setting containment isolation to success in the Level 2 PRA models.

The results of the above modeling produced the following results:

STC Frequency = 8.089E-005 with the following contributions from each STC:

1 1.499E-006
2 0.000E+000

3	0.000E+000
4	4.059E-005
5	1.972E-007
6	0.000E+000
7	0.000E+000
8	2.564E-005
9	0.000E+000
10	0.000E+000
11	1.217E-007
12	1.546E-007
13	9.406E-006
14	3.284E-006

The frequency of each STC above is multiplied by the conditional dose from Table F-15 that is associated with each STC to obtain the expected dose for each STC. Then the expected dose values are summed to obtain the total expected dose after implementation of this SAMA, or 30.17 person-rem per year.

Similarly, the frequency of each STC above is multiplied by the conditional property damage value from Table F-16 that is associated with each STC to obtain the expected property damage value for each STC. Then the expected property damage values are summed to obtain the total expected damage after implementation of the SAMA, or $49,666 per year.

The benefit of implementing this SAMA is then calculated as shown in Section F.4. The results of each of these calculations as well as that of the total averted costs are shown in Table F-19 under the column labelled "SAMA 114." The present value of total averted costs for implementing this SAMA is $642. This amount is then doubled to account for the potential reduction in risk from external events resulting in a total potential benefit of $1284.

As described above, implementation of this SAMA would reduce the probability of containment isolation failure. Implementation of this SAMA would require a design change. Using the standard costs for a design change shown in Section F.6, implementation of this alternative would cost a minimum of $100,000 for the design change alone. Since the benefit for this SAMA is much less than this value, no further evaluation of costs is performed.

As quantified above, the total averted costs of this SAMA are $1284. Implementation of this alternative would cost a minimum of $100,000. Therefore, the present worth can be calculated as:

NPV ≤ $1284 – $100,000.

NPV ≤ -$98,716

Since the present worth is negative, implementation of this SAMA would not be cost beneficial.

F.6.24 SAMA 118 – Improve Training on ISLOCA

The goal of this SAMA is to reduce the consequences of ISLOCA events by improving operator response to mitigate such events. This SAMA would provide additional training on the response to ISLOCA events. This SAMA was modeled by setting the failure probability of all human action events associated with ISLOCAs to 1.0E-04.

The results of the above modeling produced the following results:

STC Frequency = 8.083E-005 with the following contributions from each STC:

1	1.499E-006
2	0.000E+000
3	0.000E+000
4	4.051E-005
5	1.971E-007
6	5.078E-009
7	2.728E-008
8	2.563E-005
9	0.000E+000
10	0.000E+000
11	1.217E-007
12	1.546E-007
13	9.391E-006
14	3.283E-006

The frequency of each STC above is multiplied by the conditional dose from Table F-15 that is associated with each STC to obtain the expected dose for each STC. Then the expected dose values are summed to obtain the total expected dose after implementation of this SAMA, or 30.15 person-rem per year.

Similarly, the frequency of each STC above is multiplied by the conditional property damage value from Table F-16 that is associated with each STC to obtain the expected property damage value for each STC. Then the expected property damage values are summed to obtain the total expected damage after implementation of the SAMA, or $49,645 per year.

The benefit of implementing this SAMA is then calculated as shown in Section F.4. The results of each of these calculations as well as that of the total averted costs are shown in Table F-19 under the column labelled "SAMA 118." The present value of total averted costs for implementing these SAMAs is $2,387. This amount is then doubled to account for the potential reduction in risk from external events resulting in a total potential benefit of $4774.

As described above, implementation of this SAMA would improve the operator response to an ISLOCA event. Although not specifically addressed in Section F.6, the costs of changing the training lesson plans and schedules along with conducting the training for five crews along with initial licensed operator costs would likely be similar to the costs for implementing a simple procedure change, or a minimum of $50,000. Since the benefit for this SAMA is much less than this value, no further evaluation of costs is performed.

As quantified above, the total averted costs of this SAMA are $4774. Implementation of this alternative would cost a minimum of $50,000. Therefore, the present worth can be calculated as:

$$\text{NPV} \leq \$4774 - \$50{,}000.$$

$$\text{NPV} \leq -\$45{,}226$$

Since the present worth is negative, implementation of this SAMA would not be cost beneficial.

F.6.25 SAMA 122 – Improve RCS Depressurization Capability

The goal of this SAMA is to improve the capability to cope with a steam generator tube rupture (SGTR). This SAMA would install a new system to depressurize the primary system. This SAMA was modeled by assuming that hardware associated with primary depressurization does not fail.

The results of the above modeling produced the following results:

STC Frequency = 8.079E-005 with the following contributions from each STC:

1	1.499E-006
2	0.000E+000
3	0.000E+000
4	4.049E-005
5	1.971E-007
6	5.077E-009
7	2.728E-008
8	2.563E-005
9	0.000E+000
10	0.000E+000
11	1.217E-007
12	1.546E-007
13	9.402E-006
14	3.268E-006

The frequency of each STC above is multiplied by the conditional dose from Table F-15 that is associated with each STC to obtain the expected dose for each STC. Then the expected dose values are summed to obtain the total expected dose after implementation of this SAMA, or 30.17 person-rem per year.

Similarly, the frequency of each STC above is multiplied by the conditional property damage value from Table F-16 that is associated with each STC to obtain the expected property damage value for each STC. Then the expected property damage values are summed to obtain the total expected damage after implementation of the SAMA, or $49,683 per year.

The benefit of implementing this SAMA is then calculated as shown in Section F.4. The results of each of these calculations as well as that of the total averted costs are shown in Table F-19 under the column labelled "SAMA 122." The present value of total averted costs for implementing this SAMA is $2336 This amount is then doubled to account for the potential reduction in risk from external events resulting in a total potential benefit of $4672.

As described above, implementation of this SAMA would improve the capability to cope with a SGTR. Implementation of this SAMA would require a design change. Using the standard costs for a design change shown in Section F.6, implementation of this alternative would cost a minimum of $100,000. Since the benefit for this SAMA than this value, no further evaluation of costs is performed.

As quantified above, the total averted costs of this SAMA are $4,672. Implementation of this alternative would cost a minimum of $100,000 for the design change alone. Therefore, the present worth can be calculated as:

NPV ≤ $4,672 – $100,000.

NPV ≤ -$95,328.

Since the present worth is negative, implementation of this SAMA would not be cost beneficial.

F.6.26 SAMA 124 – Improve Detection of SGTR

The goal of this SAMA is to improve the ability to detect steam generator tube failures and leaks, thereby improving the ability to diagnose and respond to a SGTR. This SAMA would install improved instrumentation to detect tube failures. This SAMA was modeled by assuming that probability of operator failure to detect and diagnose a SGTR is 1.0E-04.

The results of the above modeling produced the following results:

STC Frequency = 8.029E-005 with the following contributions from each STC:

1	1.499E-006
2	0.000E+000
3	0.000E+000
4	4.057E-005
5	1.971E-007
6	5.082E-009
7	2.731E-008
8	2.563E-005
9	0.000E+000
10	0.000E+000
11	1.217E-007
12	1.546E-007
13	8.797E-006
14	3.284E-006

The frequency of each STC above is multiplied by the conditional dose from Table F-15 that is associated with each STC to obtain the expected dose for each STC. Then the expected dose values are summed to obtain the total expected dose after implementation of this SAMA, or 28.93 person-rem per year.

Similarly, the frequency of each STC above is multiplied by the conditional property damage value from Table F-16 that is associated with each STC to obtain the expected property damage value for each STC. Then the expected property damage values are summed to obtain the total expected damage after implementation of the SAMA, or $47,019 per year.

The benefit of implementing this SAMA is then calculated as shown in Section F.4. The results of each of these calculations as well as that of the total averted costs are shown in Table F-19 under the column labelled "SAMA 124." The present value of total averted costs for implementing these

SAMAs is $65,905. This amount is then doubled to account for the potential reduction in risk from external events resulting in a total potential benefit of $131,810.

As described above, implementation of this SAMA would improve the probability of detecting and isolating a SGTR by providing additional indication to of a tube failure. Adding additional indication to the steam generators would be similar to adding the auxiliary building flooding indication circuits that were recently installed. However, it is expected that the steam generator detection instrumentation would be much more complex that the auxiliary building flooding circuits and, therefore, much costlier. Engineering and installation costs alone for the auxiliary building flooding alarms totaled $149,746. Additional costs not considered would include procedures and training. Since the engineering and installation costs alone exceed the potential benefit, a detailed cost estimate is not performed.

As quantified above, the total averted costs of this SAMA are $131,810. Implementation of this alternative would cost a minimum of $149,746. Therefore, the present worth can be calculated as:

NPV ≤ $131,810 – $149,746.

NPV ≤ -$17,936

Since the present worth is negative, implementation of this SAMA would not be cost beneficial.

F.6.27 SAMA 125, SAMA 129 – Prevent Release of SGTR From Steam Generators

The goal of these SAMAs is to reduce the consequences of a SGTR by preventing fission product release from a faulted steam generator. SAMA 125 would provide a system to route steam generator relief valve discharge lines through water to condense steam and fission products. SAMA 129 would route steam generator relief valve discharge lines inside containment. These SAMAs were modeled by changing the level 2 PRA model so that SGTR events do not lead to containment bypass.

The results of the above modeling produced the following results:

STC Frequency = 8.083E-005 with the following contributions from each STC:

1	1.694E-006
2	0.000E+000
3	0.000E+000
4	4.508E-005
5	2.263E-007
6	5.397E-009
7	2.900E-008
8	3.351E-005
9	0.000E+000
10	0.000E+000
11	1.217E-007
12	1.546E-007
13	0.000E+000
14	0.000E+000

The frequency of each STC above is multiplied by the conditional dose from Table F-15 that is associated with each STC to obtain the expected dose for each STC. Then the expected dose values are summed to obtain the total expected dose after implementation of these SAMAs, or 10.75 person-rem per year.

Similarly, the frequency of each STC above is multiplied by the conditional property damage value from Table F-16 that is associated with each STC to obtain the expected property damage value for each STC. Then the expected property damage values are summed to obtain the total expected damage after implementation of the SAMA, or $6,728 per year.

The benefit of implementing these SAMAs is then calculated as shown in Section F.4. The results of each of these calculations as well as that of the total averted costs are shown in Table F-19 under the column labelled "SAMA 125." The present value of total averted costs for implementing these SAMAs is $881,907. This amount is then doubled to account for the potential reduction in risk from external events resulting in a total potential benefit of $1,763,814.

As described above, implementation of these SAMAs would lower the expected offsite release expected following a SGTR event. Each of these SAMAs would require a significant plant modification.

Cost estimates to implement this SAMA range from a low of over $1,670,000 provided in the Farley SAMA analysis (Reference F-21) through over $2,700,000 in the Cook SAMA analysis (Reference F-19). This SAMA was deemed not feasible in the Millstone 3 SAMA analysis (Reference F-16). It is noted that neither Farley nor Cook performed a detailed estimate of the costs to implement this SAMA, but just noted that implementation costs would be well in excess of the maximum benefit. Since estimates performed for Millstone 3 deemed the SAMA infeasible, this analysis will use the middle cost estimate, $2,700,000 as the basis for scoping in this analysis.

As quantified above, the total averted costs of this SAMA are $1,763,814. Implementation of this alternative would cost a minimum of $2,700,000. Therefore, the present worth can be calculated as:

$$\text{NPV} \leq \$1{,}763{,}814 - \$2{,}700{,}000.$$

$$\text{NPV} \leq -\$936{,}186.$$

Since the present worth is negative, implementation of these SAMAs would not be cost beneficial.

F.6.28 SAMA 126 – Install Closed-Loop Steam Generator Cooling System

The goal of this SAMA is to reduce the consequences of a SGTR by installing a closed-loop secondary side steam generator cooling system. Installation of this system would allow cooling of a faulted steam generator without release of fission products from containment. This SAMA was modeled by assuming the hardware associated with cool down and depressurization would not fail following a SGTR.

The results of the above modeling produced the following results:

STC Frequency = 7.796E-005 with the following contributions from each STC:

1	1.499E-006
2	0.000E+000
3	0.000E+000
4	4.057E-005
5	1.971E-007
6	5.082E-009
7	2.731E-008
8	2.563E-005
9	0.000E+000
10	0.000E+000
11	1.217E-007
12	1.546E-007
13	9.402E-006
14	3.514E-007

The frequency of each STC above is multiplied by the conditional dose from Table F-15 that is associated with each STC to obtain the expected dose for each STC. Then the expected dose values are summed to obtain the total expected dose after implementation of this SAMA, or 29.35 person-rem per year.

Similarly, the frequency of each STC above is multiplied by the conditional property damage value from Table F-16 that is associated with each STC to obtain the expected property damage value for each STC. Then the expected property damage values are summed to obtain the total expected damage after implementation of the SAMA, or $48,131 per year.

The benefit of implementing this SAMA is then calculated as shown in Section F.4. The results of each of these calculations as well as that of the total averted costs are shown in Table F-19 under the column labelled "SAMA 126." The present value of total averted costs for implementing this SAMA is $84,213. This amount is then doubled to account for the potential reduction in risk from external events resulting in a total potential benefit of $168,426.

As described above, implementation of this SAMA would provide a closed-loop steam generator cooling system to reduce releases following SGTR events. Implementation of this SAMA would require a design change. Using the standard costs for a design change shown in Section F.6, implementation of this alternative would cost a minimum of $100,000. This minimum cost is only slightly less than the benefit calculated above.

Cost estimates to implement this SAMA range from a low of over $2,700,000 in the Cook SAMA analysis (Reference F-19) to not feasible in the Millstone 3 SAMA analysis (Reference F-16). This analysis will use the value from the Cook SAMA analysis, $2,700,000 as a lower-bound estimate for scoping.

As quantified above, the total averted costs of this SAMA are $168,426. Implementation of this alternative would cost a minimum of $2,700,000. Therefore, the present worth can be calculated as:

NPV ≤ $168,426 – $2,700,000.

NPV ≤ -$2,531,574.

Since the present worth is negative, implementation of this SAMA would not be cost beneficial.

F.6.29 SAMA 131 – Install Additional Primary System Relief Capacity to Mitigate ATWS

The goal of this SAMA is to reduce the consequences of an anticipated transient without scram (ATWS) event by installing additional primary system relief capacity capable of preventing RCS overpressure following an ATWS. This SAMA was modeled by setting the initiating event equation for ATWS events to zero.

The results of the above modeling produced the following results:

STC Frequency = 7.819E-005 with the following contributions from each STC:

1	1.484E-006
2	0.000E+000
3	0.000E+000
4	3.878E-005
5	1.952E-007
6	4.901E-009
7	2.633E-008
8	2.506E-005
9	0.000E+000
10	0.000E+000
11	1.217E-007
12	1.546E-007
13	9.083E-006
14	3.272E-006

The frequency of each STC above is multiplied by the conditional dose from Table F-15 that is associated with each STC to obtain the expected dose for each STC. Then the expected dose values are summed to obtain the total expected dose after implementation of this SAMA, or 29.14 person-rem per year.

Similarly, the frequency of each STC above is multiplied by the conditional property damage value from Table F-16 that is associated with each STC to obtain the expected property damage value for each STC. Then the expected property damage values are summed to obtain the total expected damage after implementation of the SAMA, or $48,107 per year.

The benefit of implementing this SAMA is then calculated as shown in Section F.4. The results of each of these calculations as well as that of the total averted costs are shown in Table F-19 under the column labelled "SAMA 131." The present value of total averted costs for implementing this SAMA is $85,068. This amount is then doubled to account for the potential reduction in risk from external events resulting in a total potential benefit of $170,136.

As described above, implementation of this SAMA would add relief capacity to prevent RPV overpressurization during any ATWS event. Implementation of this SAMA would require a design change. Using the standard costs for a design change shown in Section F.6, implementation of this alternative would cost a minimum of $100,000. This minimum cost is only slightly less than the benefit calculated..

A cost estimate to implement this SAMA was obtained from the Cook SAMA analysis (Reference F-19) which reported a minimum cost of over $700,000. This analysis will use the value from the Cook SAMA analysis, $700,000 as a lower-bound estimate for scoping.

As quantified above, the total averted costs of this SAMA are $170,136. Implementation of this alternative would cost a minimum of $700,000. Therefore, the present worth can be calculated as:

$$\text{NPV} \leq \$170{,}136 - \$700{,}000.$$

$$\text{NPV} \leq -\$529{,}864$$

Since the present worth is negative, implementation of this SAMA would not be cost beneficial.

F.6.30 SAMA 150 – Improve Maintenance Procedures

The goal of this SAMA is to increase the availability of important equipment thereby reducing CDF. This SAMA was modeled by maintenance unavailability for Maintenance Rule (a)(1) equipment to zero.

The results of the above modeling produced the following results:

STC Frequency = 7.972E-005 with the following contributions from each STC:

1	1.450E-006
2	0.000E+000
3	0.000E+000
4	4.048E-005
5	1.916E-007
6	5.003E-009
7	2.688E-008
8	2.468E-005
9	0.000E+000
10	0.000E+000
11	1.217E-007
12	1.546E-007
13	9.320E-006
14	3.280E-006

The frequency of each STC above is multiplied by the conditional dose from Table F-15 that is associated with each STC to obtain the expected dose for each STC. Then the expected dose values are summed to obtain the total expected dose after implementation of this SAMA, or 30.00 person-rem per year.

Similarly, the frequency of each STC above is multiplied by the conditional property damage value from Table F-16 that is associated with each STC to obtain the expected property damage value for each STC. Then the expected property damage values are summed to obtain the total expected damage after implementation of the SAMA, or $49,325 per year.

The benefit of implementing this SAMA is then calculated as shown in Section F.4. The results of each of these calculations as well as that of the total averted costs are shown in Table F-19 under the column labelled "SAMA 150." The present value of total averted costs for implementing this SAMA is $27,831. This amount is then doubled to account for the potential reduction in risk from external events resulting in a total potential benefit of $55,662.

As described above, implementation of this SAMA would reduce the failure probability of equipment needed to mitigate accident sequences. Implementation of this SAMA would require several procedure changes. Using the standard costs for a procedure change shown in Section F.6, implementation of this alternative would cost a minimum of $50,000 for each system. Assuming that, at a minimum, two or more systems would require procedure changes, implementation of this SAMA would cost a minimum of $100,000. Since the benefit for this SAMA is much less than this value, no further evaluation of costs is performed.

As quantified above, the total averted costs of this SAMA are $55,662. Implementation of this alternative would cost a minimum of $100,000. Therefore, the present worth can be calculated as:

$$\text{NPV} \leq \$55,662 - \$100,000.$$

$$\text{NPV} \leq -\$44,338.$$

Since the present worth is negative, implementation of this SAMA would not be cost beneficial.

F.6.31 SAMA 168 – Add Capability to Isolate Service Water Without Power

The goal of this SAMA is to reduce the risk from flooding events by providing the ability to isolate service water lines if power is lost. This SAMA was modeled by eliminating from the fault tree models the requirement for power to close service water valves SW-10A and SW-10B.

The results of the above modeling produced the following results:

STC Frequency = 7.995E-005 with the following contributions from each STC:

1	1.447E-006
2	0.000E+000
3	0.000E+000
4	4.046E-005
5	1.915E-007
6	5.019E-009
7	2.697E-008
8	2.486E-005
9	0.000E+000
10	0.000E+000
11	1.217E-007
12	1.546E-007
13	9.402E-006
14	3.284E-006

The frequency of each STC above is multiplied by the conditional dose from Table F-15 that is associated with each STC to obtain the expected dose for each STC. Then the expected dose values are summed to obtain the total expected dose after implementation of the SAMA, or 30.16 person-rem per year.

Similarly, the frequency of each STC above is multiplied by the conditional property damage value from Table F-16 that is associated with each STC to obtain the expected property damage value for each STC. Then the expected property damage values are summed to obtain the total expected damage after implementation of the SAMA, or $49,688 per year.

The benefit of implementing this SAMA is then calculated as shown in Section F.4. The results of each of these calculations as well as that of the total averted costs are shown in Table F-19 under the column labelled "SAMA 168." The present value of total averted costs for implementing these SAMAs is $16,462. This amount is then doubled to account for the potential reduction in risk from external events resulting in a total potential benefit of $32,924..

As described above, implementation of this SAMA would reduce the probability of containment isolation failure. Implementation of this SAMA would require a design change. Although SW-10A and SW-10B are equipped with handwheels and potentially could be operated locally, such operation may not be practical in the time period available for flooding scenarios. Therefore, this analysis assumes that a design change is required. Using the standard costs for a design change alone, without consideration of equipment purchase and installation, shown in Section F.6, implementation of this alternative would cost a minimum of $100,000. Since the benefit for this SAMA is much less than this value, no further evaluation of costs is performed.

As quantified above, the total averted costs of this SAMA are $32,924. Implementation of this alternative would cost a minimum of $100,000. Therefore, the present worth can be calculated as:

NPV ≤ $32,924 – $100,000.

NPV ≤ -$67,076

Since the present worth is negative, implementation of this SAMA would not be cost beneficial.

F.6.32 SAMA 169 – Provide Flood Protection for MCC-52E, -62E, and -62H

The goal of this SAMA is to increase availability of equipment needed to mitigate flooding events by preventing loss of these MCCs due to submergence in auxiliary building floods. These MCCs support ventilation and other equipment credited in the PRA. This SAMA was modeled by eliminating flood-induced failure of the three MCCs from the fault tree models.

The results of the above modeling produced the following results:

STC Frequency = 7.088E-005 with the following contributions from each STC:

1	1.188E-006
2	0.000E+000
3	0.000E+000
4	3.581E-005
5	1.632E-007
6	4.411E-009
7	2.370E-008
8	2.087E-005
9	0.000E+000
10	0.000E+000
11	1.217E-007
12	1.546E-007
13	9.264E-006
14	3.278E-006

The frequency of each STC above is multiplied by the conditional dose from Table F-15 that is associated with each STC to obtain the expected dose for each STC. Then the expected dose values are summed to obtain the total expected dose after implementation of the SAMA, or 28.88 person-rem per year.

Similarly, the frequency of each STC above is multiplied by the conditional property damage value from Table F-16 that is associated with each STC to obtain the expected property damage value for each STC. Then the expected property damage values are summed to obtain the total expected damage after implementation of the SAMA, or $48,621 per year.

The benefit of implementing this SAMA is then calculated as shown in Section F.4. The results of each of these calculations as well as that of the total averted costs are shown in Table F-19 under the column labelled "SAMA 169." The present value of total averted costs for implementing these SAMAs is $208,059. This amount is then doubled to account for the potential reduction in risk from external events resulting in a total potential benefit of $416,119.

As described above, implementation of this SAMA would install flood barriers, similar to other plant flood barriers, around MCC-52E, MCC-62E, and MCC-62H to prevent submergence-induced failure of these power sources. Recently, six flood barriers needed to protect the RHR pumps and equipment were installed in the auxiliary building. Total costs to install the RHR flood barriers were $284,000. Installation of the three barriers needed to protect these MCCs would be similar in scope to protecting the RHR pumps. Therefore, total costs of $284,000 will be used for this analysis.

As quantified above, the total averted costs of this SAMA are $416,119. Implementation of this alternative would cost a minimum of $284,000. Therefore, the present worth can be calculated as:

$$\text{NPV} \leq \$416{,}119 - \$284{,}000.$$

$$\text{NPV} \leq \$132{,}119.$$

Since the present worth of this SAMA is positive, implementation of this SAMA could be cost beneficial.

F.6.33 SAMA 172 – Provide Additional Alarm for Extremely Low CST Level

The goal of this SAMA is to reduce the probability of operator error leading to a loss of AFW cooling. This SAMA would provide an additional alarm on extremely low CST level that would indicate the immediate need to provide additional water sources to the AFW pumps. This additional alarm would provide an additional cue and, therefore, reduce the overall failure probability associated with this operator action. This SAMA was modeled by setting the failure probability for the associated basic event to 1.0E-04.

The results of the above modeling produced the following results:

STC Frequency = 6.919E-005 with the following contributions from each STC:

1	1.116E-006
2	0.000E+000
3	0.000E+000
4	3.968E-005
5	1.534E-007
6	4.315E-009
7	2.318E-008
8	1.718E-005
9	0.000E+000
10	0.000E+000
11	1.217E-007
12	1.546E-007
13	7.530E-006
14	3.223E-006

The frequency of each STC above is multiplied by the conditional dose from Table F-15 that is associated with each STC to obtain the expected dose for each STC. Then the expected dose values are summed to obtain the total expected dose after implementation of the SAMA, or 26.10 person-rem per year.

Similarly, the frequency of each STC above is multiplied by the conditional property damage value from Table F-16 that is associated with each STC to obtain the expected property damage value for each STC. Then the expected property damage values are summed to obtain the total expected damage after implementation of the SAMA, or $41,279 per year.

The benefit of implementing this SAMA is then calculated as shown in Section F.4. The results of each of these calculations as well as that of the total averted costs are shown in Table F-19 under the column labelled "SAMA 172." The present value of total averted costs for implementing this SAMA is $375,383. This amount is then doubled to account for the potential reduction in risk from external events resulting in a total potential benefit of $750,766.

As described above, implementation of this SAMA would lower the probability of losing the secondary heat sink by providing additional indication to the operators that loss of the CSTs as a water source was imminent. Adding an additional CST level alarm would be similar to adding the auxiliary building flooding indication circuits that were recently installed. It is assumed that the engineering and installation costs for the CST alarm would be similar to the costs for the auxiliary building flooding alarms. Engineering and installation costs for the auxiliary building flooding alarms totaled $149,746. In addition, procedural changes would be required to implement this change. This change would impact the emergency operating procedures and at least two procedure changes would be required. Using the standard costs for a procedure change shown in Section F.6, at least $100,000 would be required for the procedure changes to implement this SAMA. Therefore, total costs to implement this SAMA are estimated at $249,746.

As quantified above, the total averted costs of this SAMA are $750,766. Implementation of this alternative would cost a minimum of $249,676. Therefore, the present worth can be calculated as:

NPV $\leq$ \$750,766 – \$249,676.

NPV $\leq$ \$501,090.

Since the present worth of this SAMA is positive, implementation of this SAMA could be cost beneficial.

F.6.34 SAMA 173 – Protect Auxiliary Building Mezzanine Cooling Units From Spray

The goal of this SAMA is to increase the availability of equipment that is located in the auxiliary building and that requires room cooling. Flooding events that initiate on the mezzanine level of the auxiliary building can spray, thereby failing the mezzanine cooling units. Providing spray shields for the units could increase their survivability in flooding events. This SAMA would install shields on the cooling units to protect them from spray. This SAMA was modeled by removing flood-induced failures of the auxiliary building mezzanine cooling units from the fault tree models.

The results of the above modeling produced the following results:

STC Frequency = 7.799E-005 with the following contributions from each STC:

1	1.433E-006
2	0.000E+000
3	0.000E+000
4	4.052E-005
5	1.889E-007
6	4.888E-009
7	2.626E-008
8	2.328E-005
9	0.000E+000
10	0.000E+000
11	1.217E-007
12	1.546E-007
13	8.994E-006
14	3.268E-006

The frequency of each STC above is multiplied by the conditional dose from Table F-15 that is associated with each STC to obtain the expected dose for each STC. Then the expected dose values are summed to obtain the total expected dose after implementation of the SAMA, or 29.32 person-rem per year.

Similarly, the frequency of each STC above is multiplied by the conditional property damage value from Table F-16 that is associated with each STC to obtain the expected property damage value for each STC. Then the expected property damage values are summed to obtain the total expected damage after implementation of the SAMA, or $47,872 per year.

The benefit of implementing this SAMA is then calculated as shown in Section F.4. The results of each of these calculations as well as that of the total averted costs are shown in Table F-19 under the column labelled "SAMA 173." The present value of total averted costs for implementing this SAMA is $87,028. This amount is then doubled to account for the potential reduction in risk from external events resulting in a total potential benefit of $174,055.

Note that this benefit is likely much higher than would be expected because of conservatisms in the modeling of the fan coil units. Specifically, no credit is given for the non-safeguards auxiliary building ventilation systems, the normal cooling used. Credit for use of the normal ventilation systems would lower significantly the expected benefit.

As described above, implementation of this SAMA would install spray protection around the auxiliary building mezzanine cooling units. Implementation of this SAMA would be similar to similar work being planned elsewhere in the plant. Therefore, it is expected that the costs would be similar. It is estimated that $100,000 in engineering costs would be required to implement this SAMA. In addition, $25,000 would be required for material costs and $25,000 would be required for installation costs. Therefore, implementation of this SAMA is estimated to cost $150,000.

As quantified above, the total averted costs of this SAMA are $174,055. Implementation of this alternative would cost a minimum of $150,000. Therefore, the present worth can be calculated as:

$$NPV \leq \$174,055 - \$150,000.$$

$$NPV \leq \$24,055.$$

Since the present worth of this SAMA is positive, implementation of this SAMA could be cost beneficial.

F.6.35 SAMA 174 – Protect Boric Acid Transfer Pumps From Spray

The goal of this SAMA is to increase the availability of the boric acid transfer pumps. Flooding events that initiate on the mezzanine level of the auxiliary building can spray and thereby fail the boric acid transfer pumps. Providing spray shields for the pumps could increase their survivability in flooding events. This SAMA would install shields for the pumps to protect them from spray. This SAMA was modeled by removing flood-induced failures of the boric acid transfer pumps from the fault tree models.

The results of the above modeling produced the following results:

STC Frequency = 7.826E-005 with the following contributions from each STC:

1	1.439E-006
2	0.000E+000
3	0.000E+000
4	4.054E-005
5	1.896E-007
6	4.906E-009
7	2.636E-008
8	2.347E-005
9	0.000E+000
10	0.000E+000
11	1.217E-007
12	1.546E-007
13	9.040E-006
14	3.270E-006

The frequency of each STC above is multiplied by the conditional dose from Table F-15 that is associated with each STC to obtain the expected dose for each STC. Then the expected dose values are summed to obtain the total expected dose after implementation of the SAMA, or 29.43 person-rem per year.

Similarly, the frequency of each STC above is multiplied by the conditional property damage value from Table F-16 that is associated with each STC to obtain the expected property damage value for each STC. Then the expected property damage values are summed to obtain the total expected damage after implementation of the SAMA, or $48,083 per year.

The benefit of implementing this SAMA is then calculated as shown in Section F.4. The results of each of these calculations as well as that of the total averted costs are shown in Table F-19 under the column labelled "SAMA 174." The present value of total averted costs for implementing this SAMA is $78,011. This amount is then doubled to account for the potential reduction in risk from external events resulting in a total potential benefit of $156,023.

As described above, implementation of this SAMA would install spray protection around the boric acid transfer pumps. Implementation of this SAMA would be similar to similar work being planned elsewhere in the plant. Therefore, it is expected that the costs would be similar. It is estimated that $100,000 in engineering costs would be required to implement this SAMA. In addition, $25,000 would be required for material costs and $25,000 would be required for installation costs. Therefore, implementation of this SAMA is estimated to cost $150,000.

As quantified above, the total averted costs of this SAMA are $156,023. Implementation of this alternative would cost a minimum of $150,000. Therefore, the present worth can be calculated as:

$$\text{NPV} \leq \$156{,}023 - \$150{,}000.$$

$$\text{NPV} \leq \$6{,}023.$$

Since the calculated present worth of this SAMA is marginally positive, implementation of this SAMA could be cost beneficial.

F.6.36 SAMA 175 – Protect A-Train CCW Pump From Spray

The goal of this SAMA is to increase the availability of the CCW system. Flooding events that initiate on the mezzanine level of the auxiliary building can spray and thereby fail the A-train CCW pump that is located in the open area near the heat exchangers. The B-train CCW pump is enclosed in a separate room for fire protection purposes. Providing spray shields for the A-train pump could increase its survivability in flooding events. This SAMA would install shielding for the pump to protect it from spray. This SAMA was modeled by removing flood-induced failures of the A-train CCW pump from the fault tree models.

The results of the above modeling produced the following results:

STC Frequency = 7.769E-005 with the following contributions from each STC:

1 1.416E-006
2 0.000E+000
3 0.000E+000
4 4.050E-005
5 1.871E-007
6 4.867E-009
7 2.615E-008
8 2.302E-005
9 0.000E+000
10 0.000E+000
11 1.217E-007
12 1.546E-007
13 8.989E-006
14 3.268E-006

The frequency of each STC above is multiplied by the conditional dose from Table F-15 that is associated with each STC to obtain the expected dose for each STC. Then the expected dose values are summed to obtain the total expected dose after implementation of the SAMA, or 29.31 person-rem per year.

Similarly, the frequency of each STC above is multiplied by the conditional property damage value from Table F-16 that is associated with each STC to obtain the expected property damage value for each STC. Then the expected property damage values are summed to obtain the total expected damage after implementation of the SAMA, or $47,852 per year.

The benefit of implementing this SAMA is then calculated as shown in Section F.4. The results of each of these calculations as well as that of the total averted costs are shown in Table F-19 under the column labelled "SAMA 175." The present value of total averted costs for implementing this SAMA is $92,561. This amount is then doubled to account for the potential reduction in risk from external events resulting in a total potential benefit of $185,122.

As described above, implementation of this SAMA would install spray protection around the A-train CCW pump. Implementation of this SAMA would be similar to similar work being planned elsewhere in the plant. Therefore, it is expected that the costs would be similar. It is estimated that $100,000 in engineering costs would be required to implement this SAMA. In addition, $25,000 would be required for material costs and $25,000 would be required for installation costs. Therefore, implementation of this SAMA is estimated to cost $150,000.

As quantified above, the total averted costs of this SAMA are $185,122. Implementation of this alternative would cost a minimum of $150,000. Therefore, the present worth can be calculated as:

$$\text{NPV} \leq \$185{,}122 - \$150{,}000.$$

$$\text{NPV} \leq \$35{,}122$$

Since the present worth of this SAMA is marginally positive, implementation of this SAMA could be cost beneficial.

F.6.37 SAMA 176 – Install Larger Sump Pumps In Safeguards Alley

The goal of this SAMA is to prevent submergence-induced failure of electrical buses following flooding events. Flooding events that initiate in one room of safeguards alley can propagate to other rooms in the area through non-watertight doors and drain lines. If the water is not removed, level will eventually rise to a level that can fail the electrical buses. This SAMA would install larger sump pumps in safeguards alley. The pumps would be large enough to prevent inter-area propagation. This SAMA was modeled by eliminating submergence-induced failures of equipment from the fault tree models.

The results of the above modeling produced the following results:

STC Frequency = 7.386E-005 with the following contributions from each STC:

1	1.499E-006
2	0.000E+000
3	0.000E+000
4	3.383E-005
5	1.971E-007
6	4.611E-009
7	2.478E-008
8	2.563E-005
9	0.000E+000
10	0.000E+000
11	1.217E-007
12	1.546E-007
13	9.119E-006
14	3.273E-006

The frequency of each STC above is multiplied by the conditional dose from Table F-15 that is associated with each STC to obtain the expected dose for each STC. Then the expected dose values are summed to obtain the total expected dose after implementation of the SAMA, or 28.16 person-rem per year.

Similarly, the frequency of each STC above is multiplied by the conditional property damage value from Table F-16 that is associated with each STC to obtain the expected property damage value for each STC. Then the expected property damage values are summed to obtain the total expected damage after implementation of the SAMA, or $47,790 per year.

The benefit of implementing this SAMA is then calculated as shown in Section F.4. The results of each of these calculations as well as that of the total averted costs are shown in Table F-19 under the column labelled "SAMA 176." The present value of total averted costs for implementing this SAMA is $182,384. This amount is then doubled to account for the potential reduction in risk from external events resulting in a total potential benefit of $364,768.

As described above, implementation of this SAMA would eliminate, for low-flow rate flooding events, submergence–induced failures of equipment located in safeguards alley. Implementation of this SAMA would require a design change. Installation of larger sump pumps in the turbine building was evaluated along with other flooding-related modifications. In those evaluations, installation of new sump pumps was estimated to cost $269,000. It can be assumed that the costs to install larger sump pumps in safeguards alley would be similar to the costs to install larger sump pumps in the turbine building.

As quantified above, the total averted costs of this SAMA are $364,768. Implementation of this alternative would cost a minimum of $269,000. Therefore, the present worth can be calculated as:

$$\text{NPV} \leq \$364{,}768 - \$269{,}000.$$

$$\text{NPV} \leq \$95{,}768$$

Since the present worth of this SAMA is positive, implementation of this SAMA could be cost beneficial.

F.6.38 SAMA 177 – Install Watertight Barrier Between 480 VAC Switchgear Rooms

The goal of this SAMA is to improve availability of equipment needed for accident mitigation by preventing propagation of flooding events between electrical trains in safeguards alley. This SAMA would ensure that the currently-installed fire barrier between the two 480 VAC switchgear rooms would be capable of preventing flood propagation between the rooms. This SAMA was modeled by removing flood-propagation-induced failures of equipment in safeguards alley from the fault tree models for events that initiate on the opposite side of the wall.

The results of the above modeling produced the following results:

STC Frequency = 7.304E-005 with the following contributions from each STC:

1	1.501E-006
2	0.000E+000
3	0.000E+000
4	3.319E-005
5	1.974E-007
6	4.556E-009
7	2.448E-008
8	2.569E-005
9	0.000E+000
10	0.000E+000
11	1.217E-007
12	1.546E-007
13	8.897E-006
14	3.257E-006

The frequency of each STC above is multiplied by the conditional dose from Table F-15 that is associated with each STC to obtain the expected dose for each STC. Then the expected dose values are summed to obtain the total expected dose after implementation of the SAMA, or 27.56 person-rem per year.

Similarly, the frequency of each STC above is multiplied by the conditional property damage value from Table F-16 that is associated with each STC to obtain the expected property damage value for each STC. Then the expected property damage values are summed to obtain the total expected damage after implementation of the SAMA, or $46,736 per year.

The benefit of implementing this SAMA is then calculated as shown in Section F.4. The results of each of these calculations as well as that of the total averted costs are shown in Table F-19 under the column labelled "SAMA 177." The present value of total averted costs for implementing this SAMA is $220,442. This amount is then doubled to account for the potential reduction in risk from external events resulting in a total potential benefit of $440,885.

As described above, this SAMA would change the wall between the 480 VAC switchgear rooms in safeguards alley into a watertight barrier capable of preventing floods from propagating from one side to the other and causing flood-induced failure of equipment. Estimates to implement such a plant modification were performed along with evaluations of other modifications intended to reduce flood-related risk. These evaluations provide an estimate of $162,000 to perform this modification.

As quantified above, the total averted costs of this SAMA are $440,885. Implementation of this alternative would cost a minimum of $162,000. Therefore, the present worth can be calculated as:

NPV ≤ $440,885 – $162,000.

NPV ≤ $278,885.

Since the calculated present worth of this SAMA is positive, implementation of this SAMA could be cost beneficial.

F.6.39 SAMA 178 – Install Flood Detection In Battery Rooms

The goal of this SAMA is to improve the detection and diagnosis of flooding events that initiate in the battery rooms. Improved detection would reduce the chance of a flood event in one battery room from propagating to other areas and failing equipment needed to mitigate the event. This SAMA would install water detection and alarms in each battery room. This SAMA was modeled by setting to zero the probability of the basic event that represents operator failure to isolate battery room floods.

The results of the above modeling produced the following results:

STC Frequency = 7.931E-005 with the following contributions from each STC:

1	1.496E-006
2	0.000E+000
3	0.000E+000
4	3.926E-005
5	1.968E-007
6	4.976E-009
7	2.674E-008
8	2.559E-005
9	0.000E+000
10	0.000E+000
11	1.217E-007
12	1.546E-007
13	9.177E-006
14	3.275E-006

The frequency of each STC above is multiplied by the conditional dose from Table F-15 that is associated with each STC to obtain the expected dose for each STC. Then the expected dose values are summed to obtain the total expected dose after implementation of the SAMA, or 29.44 person-rem per year.

Similarly, the frequency of each STC above is multiplied by the conditional property damage value from Table F-16 that is associated with each STC to obtain the expected property damage value for each STC. Then the expected property damage values are summed to obtain the total expected damage after implementation of the SAMA, or $48,572 per year.

The benefit of implementing this SAMA is then calculated as shown in Section F.4. The results of each of these calculations as well as that of the total averted costs are shown in Table f-19 under the column labelled "SAMA 178." The present value of total averted costs for implementing this SAMA is $54,817. This amount is then doubled to account for the potential reduction in risk from external events resulting in a total potential benefit of $109,634.

As described above, this SAMA would add flood detection and alarm circuits for the battery rooms to improve the detection and diagnosis of flooding events. Adding additional flooding indication in the battery rooms would be similar to adding the auxiliary building flooding indication circuits that were recently installed. Engineering and installation costs alone for the auxiliary building flooding alarms totaled $149,746. Additional costs not considered would include procedures and training. Since the engineering and installation costs alone exceed the potential benefit a detailed cost estimate is not performed.

As quantified above, the total averted costs of this SAMA are $109,462. Implementation of this alternative would cost a minimum of $149,746. Therefore, the present worth can be calculated as:

NPV ≤ $109,634 – $149,746.

NPV ≤ -$40,112.

Since the present worth is negative, implementation of this SAMA would not be cost beneficial.

F.6.40 SAMA 179 – Add Diverse AFW Flow Indication

The goal of this SAMA is to reduce the chance that a mis-calibrated flow instrument would lead to a loss of secondary heat sink. If the flow instruments indicate flow to the steam generators when there is none, the operators would fail to initiate bleed and feed cooling because of the false belief that secondary cooling was available. This SAMA would install an additional diverse means of indicating AFW flow to the control room operators thereby reducing the potential for mis-calibration errors to lead to erroneous indication. This SAMA was modeled by setting to zero the probability of the AFW flow mis-calibration errors.

The results of the above modeling produced the following results:

STC Frequency = 7.828E-005 with the following contributions from each STC:

1	1.361E-006
2	0.000E+000
3	0.000E+000
4	4.056E-005
5	1.821E-007
6	4.907E-009
7	2.637E-008
8	2.357E-005
9	0.000E+000
10	0.000E+000
11	1.217E-007
12	1.545E-007
13	9.028E-006
14	3.269E-006

The frequency of each STC above is multiplied by the conditional dose from Table F-15 that is associated with each STC to obtain the expected dose for each STC. Then the expected dose values are summed to obtain the total expected dose after implementation of the SAMA, or 29.40 person-rem per year.

Similarly, the frequency of each STC above is multiplied by the conditional property damage value from Table F-16 that is associated with each STC to obtain the expected property damage value for each STC. Then the expected property damage values are summed to obtain the total expected damage after implementation of the SAMA, or $48,030 per year.

The benefit of implementing this SAMA is then calculated as shown in Section F.4. The results of each of these calculations as well as that of the total averted costs are shown in Table F-19 under the column labelled "SAMA 179." The present value of total averted costs for implementing this SAMA is $78,724. This amount is then doubled to account for the potential reduction in risk from external events resulting in a total potential benefit of $157,448.

As described above, this SAMA would add a diverse AFW flow instrument to reduce the chance that a mis-calibrated flow instrument would lead to a loss of secondary heat sink. Adding a diverse AFW flow indication circuit would be similar to adding the auxiliary building flooding indication circuits that were recently installed. However, this SAMA would require additional hardware for a flow detector and potentially an additional control room indicator so costs would be higher. Engineering and installation costs alone for the auxiliary building flooding alarms totaled $149,746. Additional costs not considered in the costs for the flood detectors would include procedures and training. Using the standard costs for a procedure change shown in Section F.6, implementation of procedures needed to implement this alternative would cost an additional $50,000. Therefore, this SAMA would cost at least $200,000. Since the engineering and installation costs along with the procedural costs exceed the potential benefit a detailed cost estimate is not performed.

As quantified above, the total averted costs of this SAMA are $157,448. Implementation of this alternative would cost a minimum of $200,000. Therefore, the present worth can be calculated as:

NPV ≤ $157,448 – $200,000.

NPV ≤ -$42,552.

Since the present worth is negative, implementation of this SAMA would not be cost beneficial.

F.6.41 SAMA 180 – Remove AFW Low Lube Oil Pressure Start Interlock

The goal of this SAMA is to improve the reliability of the AFW pumps by removing the low lube oil pressure start interlock from the AFW pump start circuitry. Eliminating the interlock removes several failure modes along with an electrical dependency that prevents success of the AFW pump. This SAMA would install a jumper across the interlock and implement procedures to ensure that each AFW pump is properly lubricated to support any start demand. This SAMA was modeled by removing the auxiliary lube oil pump failure logic from the fault tree models.

The results of the above modeling produced the following results:

STC Frequency = 7.886E-005 with the following contributions from each STC:

1	1.441E-006
2	0.000E+000
3	0.000E+000
4	3.980E-005
5	1.908E-007
6	4.945E-009
7	2.657E-008
8	2.742E-005
9	0.000E+000
10	0.000E+000
11	1.217E-007
12	1.545E-007
13	9.096E-007
14	3.273E-006

The frequency of each STC above is multiplied by the conditional dose from Table F-15 that is associated with each STC to obtain the expected dose for each STC. Then the expected dose values are summed to obtain the total expected dose after implementation of the SAMA, or 29.38 person-rem per year.

Similarly, the frequency of each STC above is multiplied by the conditional property damage value from Table F-16 that is associated with each STC to obtain the expected property damage value for each STC. Then the expected property damage values are summed to obtain the total expected damage after implementation of the SAMA, or $48,262 per year.

The benefit of implementing this SAMA is then calculated as shown in Section F.4. The results of each of these calculations as well as that of the total averted costs are shown in Table F-19 under the column labelled "SAMA 180." The present value of total averted costs for implementing this

SAMA is $67,396. This amount is then doubled to account for the potential reduction in risk from external events resulting in a total potential benefit of $134,792.

As described above, this SAMA would remove the low lube oil interlock from the AFW pump start circuitry. Only a minimal amount of material costs would be associated with this change because a jumper could be installed across the oil pressure switch. Therefore, material costs associated with this change are minimal and will be neglected. Implementation of this SAMA would require a design change. Using the standard costs for a design change shown in Section F.6, implementation of this alternative would cost a minimum of $100,000. In addition, procedure changes would be required to ensure that periodic operation of the lube oil pumps is performed to ensure proper lubrication. Using the standard costs for a procedure change shown in Section F.6, an additional $50,000 would be required. Therefore, this SAMA would cost at least $150,000. Since these costs exceed the potential benefit calculated above, the costs associated with implementing the periodic maintenance are neglected and no further cost estimamtes are performed.

As quantified above, the total averted costs of this SAMA are $134,792. Implementation of this alternative would cost a minimum of $150,000. Therefore, the present worth can be calculated as:

$$\text{NPV} \leq \$134{,}792 - \$150{,}000.$$

$$\text{NPV} \leq -\$15{,}208.$$

Since the present worth is negative, implementation of this SAMA would not be cost beneficial.

F.6.42 SAMA 181 – Install Break Away Mechanisms on EDG Room Doors

The goal of this SAMA is to prevent flooding events in one of the EDG rooms from causing a loss of offsite power by submerging the supply cables from the transformers to the safety buses. Flooding events that occur in the EDG rooms can exceed room drainage capacity. For these events, water level will rise in the rooms and, at 18-inches, submerge the power supply cables from the main, reserve, and tertiary auxiliary transformers. Because there are no circuit breakers outside the EDG rooms for these transformers, submergence results in a loss of offsite power. This SAMA would install a break away mechanism on the door from each room to the screenhouse tunnel. The mechanism would cause the door to fail open prior to water level reaching 18-inches thereby providing a pathway to drain water from the room and additional time for the operators to isolate the flood. This SAMA was modeled by removing flood-induced failures from the main, reserve, and tertiary auxiliary transformers.

The results of the above modeling produced the following results:

STC Frequency = 7.873E-005 with the following contributions from each STC:

1	1.499E-006
2	0.000E+000
3	0.000E+000
4	3.894E-005
5	1.971E-007
6	4.937E-009
7	2.653E-008
8	2.563E-005
9	0.000E+000
10	0.000E+000
11	1.217E-007
12	1.546E-007
13	8.903E-006
14	3.249E-006

The frequency of each STC above is multiplied by the conditional dose from Table F-15 that is associated with each STC to obtain the expected dose for each STC. Then the expected dose values are summed to obtain the total expected dose after implementation of the SAMA, or 28.80 person-rem per year.

Similarly, the frequency of each STC above is multiplied by the conditional property damage value from Table F-16 that is associated with each STC to obtain the expected property damage value for each STC. Then the expected property damage values are summed to obtain the total expected damage after implementation of the SAMA, or \$47,313 per year.

The benefit of implementing this SAMA is then calculated as shown in Section F.4. The results of each of these calculations as well as that of the total averted costs are shown in Table F-19 under the column labelled “SAMA 181.” The present value of total averted costs for implementing this SAMA is \$91,955. This amount is then doubled to account for the potential reduction in risk from external events resulting in a total potential benefit of \$183,910.

As described above, this SAMA would install breakaway mechanisms on the EDG room doors so that water level would not rise to a level that would cause a loss of offsite power. Only a minimal amount of material costs would be associated with this change because cane bolts are already in place on the doors and would require only that the existing cane bolts be replaced with new cane bolts. This analysis will neglect the hardware costs associated with procuring the replacement cane bolts. Implementation of this SAMA would require a design change. Using the standard costs for a design change shown in Section F.6, implementation of this alternative would cost a minimum of \$100,000.

As quantified above, the total averted costs of this SAMA are \$183,910. Implementation of this alternative would cost a minimum of \$100,000. Therefore, the present worth can be calculated as:

NPV ≤ \$183,910 – \$100,000.

NPV ≤ \$83,910.

Since the present worth of this SAMA is positive, implementation of this SAMA could be cost beneficial.

F.6.43 SAMA 182 – Install Flood Relief Path In Screenhouse

The goal of this SAMA is to prevent flooding events in the screenhouse from propagating to the switchgear rooms by providing a flow path from the screenhouse to the lake. This SAMA would install a large opening in the screenhouse floor so that water on the screenhouse floor can flow to the lake. This SAMA was modeled by removing flood propagation-induced equipment failures from accident sequences that begin with a screenhouse flood.

The results of the above modeling produced the following results:

STC Frequency = 7.974E-005 with the following contributions from each STC:

1	1.484E-006
2	0.000E+000
3	0.000E+000
4	3.980E-005
5	1.955E-007
6	5.005E-009
7	2.689E-008
8	2.540E-005
9	0.000E+000
10	0.000E+000
11	1.217E-007
12	1.546E-007
13	9.272E-006
14	3.275E-006

The frequency of each STC above is multiplied by the conditional dose from Table F-15 that is associated with each STC to obtain the expected dose for each STC. Then the expected dose values are summed to obtain the total expected dose after implementation of the SAMA, or 29.75 person-rem per year.

Similarly, the frequency of each STC above is multiplied by the conditional property damage value from Table F-16 that is associated with each STC to obtain the expected property damage value for each STC. Then the expected property damage values are summed to obtain the total expected damage after implementation of the SAMA, or $49,044 per year.

The benefit of implementing this SAMA is then calculated as shown in Section F.4. The results of each of these calculations as well as that of the total averted costs are shown in Table F-19 under the column labelled "SAMA 182." The present value of total averted costs for implementing this SAMA is $35,790. This amount is then doubled to account for the potential reduction in risk from external events resulting in a total potential benefit of $71,580.

As described above, implementation of this SAMA would prevent flooding events in the screenhouse from propagating to the switchgear rooms by providing an opening in the screenhouse to the outside. Implementation of this SAMA would require a design change. Using the standard costs for a design change shown in Section F.6, implementation of this alternative would cost a minimum of $100,000. Since the benefit for this SAMA is much less than this value, no further evaluation of costs is performed.

As quantified above, the total averted costs of this SAMA are $71,580. Implementation of this alternative would cost a minimum of $100,000. Therefore, the present worth can be calculated as:

$$\text{NPV} \leq \$71{,}580 - \$100{,}000.$$

$$\text{NPV} \leq -\$28{,}420.$$

Since the present worth is negative, implementation of this SAMA would not be cost beneficial.

F.6.44 SAMA 183 – Install Flood Detection in Control Room HVAC Room

The goal of this SAMA is to provide early indication of a pipe break in the control room HVAC room thereby increasing the chance of successfully isolating the break before propagation to other areas occurs. This SAMA would install flood detection switches and alarms to indicate in the control room that a pipe break occurred in the HVAC room. This SAMA was modeled by removing flood propagation-induced equipment failures from accident sequences that begin with a control room HVAC room flood.

The results of the above modeling produced the following results:

STC Frequency = 8.070E-005 with the following contributions from each STC:

1	1.499E-006
2	0.000E+000
3	0.000E+000
4	4.043E-005
5	1.971E-007
6	5.069E-009
7	2.724E-008
8	2.563E-005
9	0.000E+000
10	0.000E+000
11	1.217E-007
12	1.546E-007
13	9.354E-006
14	3.282E-006

The frequency of each STC above is multiplied by the conditional dose from Table F-15 that is associated with each STC to obtain the expected dose for each STC. Then the expected dose values are summed to obtain the total expected dose after implementation of the SAMA, or 30.06 person-rem per year.

Similarly, the frequency of each STC above is multiplied by the conditional property damage value from Table F-16 that is associated with each STC to obtain the expected property damage value for each STC. Then the expected property damage values are summed to obtain the total expected damage after implementation of the SAMA, or $49,472 per year.

The benefit of implementing this SAMA is then calculated as shown in Section F.4. The results of each of these calculations as well as that of the total averted costs are shown in Table F-19 under the column labelled "SAMA 183." The present value of total averted costs for implementing this SAMA is $8,448. This amount is then doubled to account for the potential reduction in risk from external events resulting in a total potential benefit of $16,896.

As described above, implementation of this SAMA would improve the probability of detection and isolation of flooding events in the control room HVAV room by adding flood detection circuits and alarms. Implementation of this SAMA would require a design change. Using the standard costs for a design change shown in Section F.6, implementation of this alternative would cost a minimum of $100,000. Since the benefit for this SAMA is much less than this value, no further evaluation of costs is performed.

As quantified above, the total averted costs of this SAMA are $16,896. Implementation of this alternative would cost a minimum of $100,000. Therefore, the present worth can be calculated as:

NPV ≤ $16,896 – $100,000.
NPV ≤ -$83,104.

Since the present worth is negative, implementation of this SAMA would not be cost beneficial.

F.6.45 SAMA 188 – Install Larger Capacity Sump Pumps In Turbine Building

The goal of this SAMA is to extend the time available to isolate turbine building flooding events before propagation would damage equipment needed to mitigate the accident sequence. This SAMA would install additional sump pumps capable of mitigating larger flooding events in the turbine building. This SAMA was modeled by setting to 1.0E-04 the HEP associated with isolating turbine building floods and assuming that small flooding events in safeguards alley cannot propagate.

The results of the above modeling produced the following results:

STC Frequency = 7.863E-005 with the following contributions from each STC:

1	1.499E-006
2	0.000E+000
3	0.000E+000
4	3.840E-005
5	1.971E-007
6	4.930E-009
7	2.649E-008
8	2.563E-005
9	0.000E+000
10	0.000E+000
11	1.217E-007
12	1.546E-007
13	9.311E-006
14	3.280E-006

The frequency of each STC above is multiplied by the conditional dose from Table F-15 that is associated with each STC to obtain the expected dose for each STC. Then the expected dose values are summed to obtain the total expected dose after implementation of the SAMA, or 29.53 person-rem per year.

Similarly, the frequency of each STC above is multiplied by the conditional property damage value from Table F-16 that is associated with each STC to obtain the expected property damage value for each STC. Then the expected property damage values are summed to obtain the total expected damage after implementation of the SAMA, or $49,085 per year.

The benefit of implementing this SAMA is then calculated as shown in Section F.4. The results of each of these calculations as well as that of the total averted costs are shown in Table F-19 under the column labelled “SAMA 188.” The present value of total averted costs for implementing this SAMA is $58,668. This amount is then doubled to account for the potential reduction in risk from external events resulting in a total potential benefit of $117,335.

As described above, implementation of this SAMA would install larger capacity sump pumps in the turbine building to prevent some flooding events from propagating between plant areas. Estimates to implement such a plant modification were performed along with evaluations of other modifications intended to reduce flood-related risk. These evaluations provide an estimate of $269,000 for installation of new turbine building sump pumps.

As quantified above, the total averted costs of this SAMA are $117,335. Implementation of this alternative would cost a minimum of $269,000. Therefore, the present worth can be calculated as:

NPV ≤ $117,335 – $269,000.

NPV ≤ -$151,665.

Since the present worth is negative, implementation of this SAMA would not be cost beneficial.

F.6.46 SAMA 189 – Install Diverse SI Flow Indication

The goal of this SAMA is to improve the reliability of operator actions to extend RWST inventory on a loss of ECCS recirculation capability. When reducing flow to conserve RWST inventory, a mis-calibrated instrument could cause flow to indicate when none exists. Addition of a diverse flow indication channel would minimize the potential for mis-calibration error. This SAMA would install a diverse SI flow indication channel. This SAMA was modeled by eliminating mis-calibration errors from the SI fault tree.

The results of the above modeling produced the following results:

STC Frequency = 8.055E-005 with the following contributions from each STC:

1	1.494E-006
2	0.000E+000
3	0.000E+000
4	4.057E-005
5	1.965E-007
6	5.067E-009
7	2.723E-008
8	2.544E-005
9	0.000E+000
10	0.000E+000
11	1.217E-007
12	1.546E-007
13	9.339E-006
14	3.193E-006

The frequency of each STC above is multiplied by the conditional dose from Table F-15 that is associated with each STC to obtain the expected dose for each STC. Then the expected dose values are summed to obtain the total expected dose after implementation of the SAMA, or 30.03 person-rem per year.

Similarly, the frequency of each STC above is multiplied by the conditional property damage value from Table F-16 that is associated with each STC to obtain the expected property damage value for each STC. Then the expected property damage values are summed to obtain the total expected damage after implementation of the SAMA, or $49,372 per year.

The benefit of implementing this SAMA is then calculated as shown in Section F.4. The results of each of these calculations as well as that of the total averted costs are shown in Table F-19 under the column labelled "SAMA 189." The present value of total averted costs for implementing this SAMA is $12,629. This amount is then doubled to account for the potential reduction in risk from external events resulting in a total potential benefit of $25,259.

As described above, implementation of this SAMA would add a diverse SI flow instrument to reduce the chance that a mis-calibrated flow instrument would lead to a loss of SI flow during attempts to conserve RWST inventory. Implementation of this SAMA would require a design change. Using the standard costs for a design change shown in Section F.6, implementation of this alternative would cost a minimum of $100,000. Since the benefit for this SAMA is much less than this value, no further evaluation of costs is performed.

As quantified above, the total averted costs of this SAMA are $25,259. Implementation of this alternative would cost a minimum of $100,000. Therefore, the present worth can be calculated as:

$$\text{NPV} \leq \$25{,}259 - \$100{,}000.$$

$$\text{NPV} \leq -\$74{,}741.$$

Since the present worth is negative, implementation of this SAMA would not be cost beneficial.

F.7 SENSITIVITY ANALYSIS

The parameters that influence the cost-benefit analyses of the SAMA evaluations were examined to determine if a change in value for one of the parameters would change the conclusions of the evaluation. Equations for each of the four types of averted costs (see Section F.4) each contain a term for the real discount rate and evaluation period. Therefore, a change in either of those terms would have a direct impact on the averted costs calculated.

Reference F-1 recommends using a 7% discount rate for cost-benefit analyses and suggests that a 5% discount rate should be used for sensitivity analyses on the maximum benefit and the unscreened SAMAs to indicate the sensitivity of the results to the choice of discount rate. In addition, Reference F-1 recommends performing a sensitivity using the years remaining in the facility life to determine if any SAMA items would show a positive benefit if implemented immediately. Since the KPS license expires on November 28, 2013, 26 years would remain in the facility life.

Additional sensitivities suggested in Reference F-1 include evaluation of evacuation speed, the impact of unresolved peer review findings, evaluation of benefits using a ratio of the base CDF to the upper 95th percentile CDF, and consideration of any plant modifications not included in the PRA models. Another sensitivity study performed was evaluation of the cost savings that could be obtained for implementing some SAMA items simultaneously.

Each of these sensitivity cases is discussed in the subsections that follow.

F.7.1 Three Percent Discount Rate Sensitivity Analysis

Using three percent as the discount rate, APE, AOC, and AOE are calculated as shown in Sections F.4.1 to F.4.3 respectively. Calculation of AOSC, however, requires a change in the equation used to calculate replacement power costs. Instead of using Equation 8 and 9 of Section F.4.4.2 to calculate U_{RP}, Reference F-23 recommends using a linear interpolation between \$1.9E+10 for a discount rate of one percent and 1.2E+10 for a discount rate of five percent. For a discount rate of three percent, the maximum benefit that could be achieved if all risk was eliminated would be \$4,048,149. This value is then doubled, as discussed in Section F.4.6, to give a maximum benefit of \$8,096,298.

Using this higher value for maximum benefit, all potential SAMAs in Table F-17 that are screened because of excessive implementation costs were reevaluated using the higher maximum benefit above. Of the SAMAs screened as having excessive implementation costs, four would not have screened as exceeding the maximum available benefit and would have had cost-benefit analysis performed. These four items, SAMA 2, 104, 116, and 119 are discussed below.

SAMA 2 proposed replacing the existing lead-acid batteries with fuel cells to improve the availability of DC power during a SBO. Other SAMA items, 1, 3, 5, 6, and 74 also had the goal of improving DC power availability. The benefit of these items was calculated to be \$1040 in the base case analysis and the benefit of SAMA 2 would be similar. Even if the benefit was greatly increased, it is unlikely that SAMA 2 would become cost beneficial. Therefore, this item would be screened.

SAMA 104 proposed increasing the frequency of piping surveillance to reduce the frequency of LOCAs. Costs for this item were estimated to be $8 million, only slightly less than the maximum available benefit. Since most of the risk at KPS is from flooding events, less than half the maximum benefit would be achieved. Therefore, it is expected that this item would be screened even if a three percent discount rate had been used.

SAMA 116 had costs of $4-6 million estimated by Reference 20. This item would reduce only the consequences of an ISLOCA and CDF would be constant. As shown in Section 4.0, about half of total baseline costs are onsite costs which vary with a change in CDF but are not impacted by any change in consequences. Since ISLOCAs contribute less than 0.4% to overall CDF, any change in onsite consequences would be very small. ISLOCA events are represented by STCs 11 and 12 and, as shown in Table F-13 are small contributors to overall offsite risk. Therefore, it is expected that the benefit from this SAMA would be much less than the estimated costs and that this item would be screened even if a three percent discount rate was used.

SAMA 119 proposed increasing the inspection of steam generator tubes to 100% to reduce the expected frequency of SGTRs. Costs for this item were estimated to be $8 million, only slightly less than the maximum available benefit. Since SGTRs contribute only slightly more than 6% to overall core damage frequency at KPS, it is expected that the benefits from this SAMA would be much less than the implementation costs. Therefore, it is expected that this item would be screened even if a three percent discount rate was used.

Next, the potential benefit for each potential SAMA that was not screened was determined using the three percent discount rate. The potential benefits were calculated as shown in Sections F.6.1 through F.6.46 except that a discount rate of three percent was used and the replacement power costs were calculated as described above. Initially, the conservatively low cost estimates shown in those sections were used to determine if any of the SAMA items would show a positive cost-benefit if a three percent discount rate was used.

The results of these analyses are shown in Table F-20 and show that twelve additional analyses representing five SAMA items would show a potentially positive cost-benefit if a discount rate of three percent was used. The first item, SAMA 26 proposed to install an additional high-pressure injection with an independent diesel. Using the estimated benefits calculated with a three percent discount rate, SAMA 26 is estimated to have a positive benefit of $740,275 and the benefits estimate assumed that RCP seals and safety injection would not fail. Clearly, these assumptions overstate the potential benefits to be obtained by the SAMA. As described in Section F.6.4, detailed cost estimates to implement SAMA 26 were not prepared. Rather, bounding estimates from the SAMA analyses for three other plants were examined and the lowest of the three estimates was used for the base case analysis. The lowest cost estimate, $2 million, was taken from the Cook SAMA submittal. The other plant SAMA analyses provided cost estimates significantly higher.

Previous studies for replacement of the existing service water pumps at KPS estimated the hardware costs for a service water pump and motor to be $735,000 alone. It can be expected that the costs for an additional high-pressure safety injection would be similar but likely higher because of the higher pressures required. Additional costs required would be for the diesel-generator, circuit breakers and associated switchgear, piping, valves, and instrumentation. The service water pump replacement study estimates miscellaneous electrical equipment for replacement of a service water pump to be $350,000. With $500,000 of engineering costs along with installation, training, procedures, and maintenance, the costs, it can reasonably be expected that the middle to higher cost estimates shown in Section F.6.4 would be more accurate than the boundingly low value used in the base case analysis for screening. Therefore, it is concluded that SAMA 26 would likely not be cost-beneficial even if a three percent discount was used to calculate potential benefits.

SAMA 55 and SAMA 56 proposed to install an additional RCP seal injection with an independent diesel and without an independent diesel respectively. Using a three percent discount rate, SAMA 55 is estimated to have a positive benefit of $75,975 and SAMA 56 is estimated to have a positive benefit of $185,645. The benefits for SAMA 55 assumed that RCP seals would never fail. For SAMA 56, the benefits assumed that RCP seals could only fail during a station blackout.

As with SAMA 26, bounding estimates from the SAMA analyses for three other plants were examined and the lowest of the three estimates was used for the base case analysis as the estimate of the costs for SAMAs 55 and 56. Since these modifications are very similar to SAMA 26, it is expected that the costs for these SAMAs would be much higher if detailed cost estimates were developed. Therefore, it is concluded that SAMAs 55 and 56 would likely not be cost-beneficial even if a three percent discount rate was were used.

SAMA 58, would replace the existing design of RCP seals with seals that would not require any seal cooling. The sensitivity analysis shows a net positive benefit of $652,975 using costs estimated at $1,423,000. That cost estimate was actual cost to replace the existing seals in October 2006. That cost did not include any engineering costs that would be required for a modification or any demolition or installation costs that would be associated with changing the seal cooling systems for the new seals. Based on the standard costs for a modification shown in Section F.6 and engineering judgment from review of other engineering costs reviewed as part of this analysis, additional costs of over $750,000 would be expected for such a modification. Therefore, it is concluded that this item would not show a positive cost-benefit using a three percent discount rate if more detailed and realistic cost estimates were used.

SAMA 59 proposed to install an additional CCW pump. Using the a three percent discount rate, SAMA 59 is estimated to have a positive benefit of $398,531 and the benefits estimate assumed that CCW pumps would not fail. Clearly, these assumptions overstate the potential benefits to be obtained by the SAMA. As described in Section F.6.12, detailed cost estimates to implement SAMA 59 were not prepared. Rather, costs for major pieces of equipment were estimated and these costs were shown to be much greater than the benefits estimated in the base case. Significant costs that would be required but that were omitted in the base case estimates include installation costs, circuit breakers, diesel loading calculations, room heatup calculations, procedures, training, maintenance, cabling, valves, and piping. It is reasonable to expect that these additional costs would cause total costs to exceed the potential benefit estimated using three percent discount rate.

SAMA 111 proposed a means to reduce the frequency of ISLOCA events. The potential benefits for implementing this SAMA were estimated by setting the ISLOCA frequency to zero. Clearly, this overstates the potential benefits. Using a three percent discount rate to calculate the potential benefits, this SAMA is estimated to have a positive benefit of $5,267. As described in Section F.6.21, detailed cost estimates to implement this SAMA was not prepared. Rather, bounding estimates from the SAMA analyses for three other plants were examined and the lowest of the three estimates was used for the base case analysis. The lowest cost estimate, $190,000, was taken from the Cook SAMA submittal and was an order of magnitude less than the other two estimates identified. Since the potential benefit for this SAMA is small and boundingly small cost estimates were used rather than plant specific cost estimates, it is concluded that this SAMA would likely not be cost-beneficial even if a three percent discount rate was used to calculate the potential benefits.

The next analysis to show a potentially positive cost-benefit using a three percent discount rate considered SAMA 112. This item would provide a redundant indication that containment isolation valves had not closed, thereby reducing the probability of containment isolation failure. The sensitivity analysis shows a net positive benefit of $47,510 using costs estimated at $149,746. That cost estimate was based on the costs to install flood indication circuitry in the auxiliary building. As discussed in Section F.6.22, the cost estimates above considered only the engineering and installation costs. Additional costs to consider include procedure development and training. Since the benefit for this SAMA using a 3-percent discount rate is small, it is concluded that this item would not show a positive cost-benefit using a three percent discount rate if more detailed and realistic cost estimates were used.

Another item to show a potentially positive cost-benefit is SAMA 124 with potential benefits estimated at $41,752. This item would install additional instrumentation to detect steam generator tube leaks and failures. As with SAMA 112, the cost estimates for this SAMA were based only on the engineering and installation costs for modifications to install the auxiliary building flooding indication and did not consider the costs for procedure development and training. Since the benefit for this SAMA using a 3-percent discount rate is small, it is concluded that this item would not show a positive cost-benefit using a three percent discount rate if more detailed and realistic cost estimates were used.

SAMA 178 proposed adding flood detection and alarms for the battery rooms. Using benefits calculated with a three percent discount rate, SAMA 178 is estimated to have a positive benefit of $22,695. As described in Section F.6.39, detailed cost estimates were not performed. Rather, the costs were estimated by comparing the costs to install additional flood alarms in the auxiliary building. Because the costs for engineering and installation alone exceeded the potential benefits for the base case, no further cost analysis was performed. However, it was noted that costs for procedure changes, training, and ongoing maintenance and calibration were not included. Clearly, these additional costs would exceed the potential benefit above. Therefore, it is concluded that SAMA 178 would likely not be cost-beneficial even if benefits were calculated using a three percent discount rate.

SAMA 179 proposed adding a diverse indication of AFW flow to reduce the chance that a miscalibrated instrument would lead to a loss of secondary heat sink. Using benefits calculated with a three percent discount rate, SAMA 179 is estimated to have a positive benefit of $51,795. As described in Section F.6.40, detailed cost estimates were not performed. Rather, the costs were estimated by comparing the costs to install additional flood alarms in the auxiliary building. The additional cost of a simple procedure change was included. Because these costs alone exceeded the potential benefits for the base case, no further cost analysis was performed. However, it should be noted that this modification would require changes to the EOPs as well as maintenance and testing procedures so the costs required for implementing procedures would likely be much higher. Also, costs for procedure changes, training, and ongoing maintenance and calibration were not included. Clearly, these additional costs would exceed the potential benefit above.

Therefore, it is concluded that SAMA 179 would likely not be cost-beneficial even if benefits calculated with a three percent discount rate were used.

SAMA 180 would remove the low-lube oil pressure start interlock from the AFW pump start circuitry. Using the 3-percent discount rate, this item shows a potentially positive benefit of $63.439. The cost estimates for this item did not consider costs associated with the periodic maintenance tasks that would occur over the 20-year period of license renewal. If the start interlock is removed, each of the three AFW pumps would require that the auxiliary lube oil pump be run weekly to ensure proper lubrication on a start. These costs would likely exceed the small positive benefit shown. Therefore, it is concluded that this item would not show a positive cost-benefit using a three percent discount rate if these additional costs were considered.

SAMA 182 proposed adding a flood relief path from the screen house to the outside to prevent flood propagation from the screenhouse to the diesel rooms. Using a three percent discount rate, SAMA 182 is estimated to have a positive benefit of $14,032. The cost estimates for this SAMA used the minimum base cost of $100,000 to implement a plant modification. This cost did not consider any installation costs or procedure changes that would be required. Since the minimum costs alone exceeded the potential benefits for the base case, no further cost analysis was performed. It is reasonable to expect that installation costs would exceed the potential benefit above. Therefore, it is concluded that SAMA 180 would likely not be cost-beneficial even if a 3-percent discount rate was used.

Based on the analyses summarized in the paragraphs above, it is concluded that no SAMA items with a negative cost-benefit would show a positive benefit if a 3-percent discount rate is used.

F.7.2 26-Year Evaluation Period Sensitivity Analysis

Using a 26-year evaluation period, the time period remaining from when this analysis was performed until the end of the extended license period, APE, AOC, AOE, and AOSC are calculated as shown in Sections F.4.1 to F.4.4 respectively. For an evaluation period of 26 years, the maximum benefit that could be achieved if all risk was eliminated would be $2,878,994. This value is then doubled, as discussed in Section F.4.6, to give a maximum benefit of $5,757,998.

Using this higher value for maximum benefit, all potential SAMAs in Table F-17 that are screened because of excessive implementation costs were reevaluated using the higher maximum benefit above. All of the SAMAs screened as having excessive implementation costs using the maximum benefit calculated with a 20-year evaluation period also would be screened as having excessive implementation costs using the 26-year evaluation period.

Next, the potential benefit for each potential SAMA that was not screened was determined using the 26-year evaluation period. The potential benefits were calculated as shown in Sections F.6.1 through F.6.46 except that a 26-year evaluation period was used. Initially, the conservatively low cost estimates shown in those sections were used to determine if any of the SAMA items would show a positive cost-benefit if a 26-year evaluation period was used.

The results of these analyses are shown in Table F.21 and show that three additional SAMA items would show a potentially positive cost-benefit if a 26-year evaluation period was used. The first item, SAMA 58, would replace the existing design of RCP seals with seals that would not require any seal cooling. The sensitivity analysis shows a net positive benefit of $78,053 using costs estimated at $1,423,000. That cost estimate was actual cost to replace the existing seals in October 2006. That cost did not include any engineering costs that would be required for a modification or any demolition or installation costs that would be associated with changing the seal cooling systems for the new seals. Based on the standard costs for a modification shown in Section F.6 and engineering judgment from review of other engineering costs reviewed as part of this analysis, additional costs of over $500,000 would be expected for such a modification. Therefore, it is concluded that this item would not show a positive cost-benefit using a 26-year evaluation period if more detailed and realistic cost estimates were used.

The second analysis to show a potentially positive cost-benefit using a 26-year evaluation period is SAMA 112. This item would provide a redundant indication that containment isolation valves had not closed, thereby reducing the probability of containment isolation failure. The sensitivity analysis shows a net positive benefit of $2224 using costs estimated at $149,746. That cost estimate was based on the costs to install flood indication circuitry in the auxiliary building. As discussed in Section F.6.22, the cost estimates above considered only the engineering and installation costs. Additional costs to consider include procedure development and training. Since the benefit for this SAMA using a 26-year evaluation period is small, it is concluded that this item would not show a positive cost-benefit using a 26-year evaluation period if more detailed and realistic cost estimates were used.

The third item to show a potentially positive cost-benefit is SAMA 180. This item would remove the low-lube oil pressure start interlock from the AFW pump start circuitry. Using the 26-year evaluation period, this item shows a potentially positive benefit of $8231. The cost estimates for this item did not consider costs associated with the periodic maintenance tasks that would occur over the 26-year period of license renewal. If the start interlock is removed, each of the three AFW pumps would require that the auxiliary lube oil pump be run weekly to ensure proper lubrication on a start. These costs would likely exceed the small positive benefit shown. Therefore, it is concluded that this item would not show a positive cost-benefit using a 26-year evaluation period if these additional costs were considered.

Based on the analyses summarized in the paragraphs above, it is concluded that no SAMA items with a negative cost-benefit would show a positive benefit if a 26-year evaluation period was used.

F.7.3 Evacuation Speed

The sensitivity of the overall offsite dose and property damage results to a change in the evacuation speed was performed as part of the Level 3 PRA. The baseline evacuation speed of 1.16 m/sec with an 80 minute time delay was reduced to one-half the base case speed. The sensitivity analysis, summarized in Table F-14 showed no change in the overall dose and offsite property damage costs to a change in the evacuation speed within the 10-mile emergency planning zone (EPZ) of KPS. Therefore, no specific evaluations of the SAMA items was performed since it is clear from the dose and cost results presented in Table F-14 that evacuation speed has a negligible impact on the overall results.

F.7.4 Unresolved Peer Review Findings

A Peer Review of the KPS PRA model was performed by the Westinghouse Owner's Group (WOG) in June 2002. That review used the 0101 Model completed in December 2001. In the final report for the Peer Review, five Level A and 49 Level B facts and observations (F&Os) were identified. Three of the Level B F&Os were related to maintenance and update of the model and do not have any impact on the model results. Since the Peer Review, all A and B Level F&Os except two have been resolved either through upgrading documentation, model changes, or both. The first remaining, unresolved, F&O relates to including loss of HVAC as a separate initiating event. Within that F&O, it is stated that evidence exists that loss of HVAC would not result in a reactor trip, but that a basis for the conclusion needs to be documented. The second unresolved F&O relates to not documenting the basis for room cooling requirements when HVAC was not modeled as a support system for components. In the current model, room cooling is modeled as a required support system for all components unless calculations show that HVAC is not needed. Several SAMA items related to HVAC have been evaluated with two showing a positive cost-benefit. Therefore, it is concluded that resolution of the two F&Os remaining unresolved from the Peer Review will not change the overall conclusions of this analysis.

F.7.5 95th Percentile Uncertainty

The results of the SAMA analysis can be impacted by implementing conservative values from the PRA's uncertainty distribution. If the best estimate failure probability values were consistently lower than the "actual" failure probabilities, the PRA model would underestimate plant risk and yield lower than "actual" averted cost-risk values for potential SAMAs. Re-assessing the cost benefit calculations using the high end of the failure probability distributions is a means of identifying the impact of having consistently underestimated failure probabilities for plant equipment and operator actions included in the PRA model. This sensitivity uses the 95^{th} percentile results to examine the impact of uncertainty in the PRA model.

For KPS, the WinNUPRA software code was used to perform the Level 1 internal events model uncertainty analysis. The results of the calculation are provided below:

Parameter	Value
Mean	7.75e-005
5 percent	4.25E-005
50 percent	6.79E-005
95 percent	1.38E-004
Standard Deviation	4.76e-005

Note that this analysis uses the frequency of the minimalized cutset equation for the analysis and not the sum of the accident sequence frequencies from the level 2 analysis. Therefore, the mean frequency is lower than that used for the SAMA analysis. The PRA uncertainty calculation identifies the 95th percentile CDF as 1.38E-04 per year. This is a factor of 1.8 greater than the mean CDF produced by the KPS PRA.

The uncertainty analyses available for the Level 1 models are not available for Level 2 and 3 PRA models. In order to simulate the use of the 95th percentile results for the Level 2 and 3 models, it will be assumed that the maximum benefit for the 95th percentile CDF will increase in the same ratio as the mean CDF to the 95th percentile CDF. That is the maximum benefit for KPS will increase from $5,089,322 to (1.8 * $5,089,322) or $9,160,780.

Using this higher value for maximum benefit, all potential SAMAs in Table 4 that are screened because of excessive implementation costs were reevaluated using the higher maximum benefit above. Of the SAMAs screened as having excessive implementation costs, four would not have screened as exceeding the maximum available benefit and would have had cost-benefit analysis performed. These four items, SAMA 2, 104, 116, and 119 are discussed below.

SAMA 2 proposed replacing the existing lead-acid batteries with fuel cells to improve the availability of DC power during a SBO. Other SAMA items, 1, 3, 5, 6, and 74 also had the goal of improving DC power availability. The benefit of these items was calculated to be $1040 in the base case analysis and the benefit of SAMA 2 would be similar. Even if the benefit was greatly increased, it is unlikely that SAMA 2 would become cost beneficial. Therefore, this item would be screened.

SAMA 104 proposed increasing the frequency of piping surveillance to reduce the frequency of LOCAs. Costs for this item were estimated to be $8 million, only slightly less than the maximum available benefit. Since most of the risk at KPS is from flooding events, less than half the maximum benefit would be achieved. Therefore, it is expected that this item would be screened even if the 95th percentile risk values were used.

SAMA 116 had costs of $4-6 million estimated by Reference 20. This item would reduce only the consequences of an ISLOCA and CDF would be constant. As shown in Section F.4, about half of total baseline costs are onsite costs which vary with a change in CDF but are not impacted by any change in consequences. Since ISLOCAs contribute less than 0.4% to overall CDF, any change in onsite consequences would be very small. ISLOCA events are represented by STCs 11 and 12 and, as shown in Table F-13 are small contributors to overall offsite risk. Therefore, it is expected that the benefit from this SAMA would be much less than the estimated costs and that this item would be screened even if the 95th percentile risk values were used.

SAMA 119 proposed increasing the inspection of steam generator tubes to 100% to reduce the expected frequency of SGTRs as initiating events, i.e., this SAMA would not impact the risk from induced SGTRs. Costs for this item were estimated to be $8 million, only slightly less than the maximum available benefit. As shown in Section F.4, about half of total baseline costs are onsite costs which vary with a change in CDF but are not impacted by any change in consequences. Since random SGTRs contribute only slightly more than 6% to overall core damage at KPS, any change in onsite consequences would be small. SGTR events are represented by STCs 13 and 14 and, as shown in Table F-13, are large contributors to offsite risk. However, since onsite costs would only experience a small reduction and costs to implement this SAMA are nearly equal to the maximum benefit estimated using the 95th percentile CDF, it is expected that the benefits from this SAMA would be much less than the implementation costs. Therefore, it is expected that this item would be screened even if the 95th percentile risk values were used.

Next, all SAMA items in Table F-19 that were screened as having a negative cost-benefit were reviewed. As mentioned above, the 95th percentile PRA results are not available for the Level 2 and 3 models. In order to estimate the impact of using the 95th percentile PRA results in the SAMA analysis, the same process used above for the initial screening was applied. That is, the averted cost-risk for each SAMA was increased by a factor of 1.8 over the base case. These analyses are presented below:

SAMA ID	Base Case Implementation Cost Estimates	Averted Cost-Risk (Base Case)	Net Value (Base Case)	Averted Cost-Risk (95th Percentile)	Net Value (95th Percentile)	Potential Change in Cost Effectiveness?
1	$50,000	$1,077	(-)$48,923	$1939	(-)$48,061	No
19	$50,000	(-)$22,978	(-)$72,978	(-)$41,360	(-)$91,360	No
21	$50,000	$8,622	(-)$41,378	$15,520	(-)$34,480	No
26	$2,000,000	$1,674,233	(-)$325,767	$3,013,619	$1,013,619	Yes
31	$50,000	$363	(-)$49,637	$653	(-)$49,347	No
32	$100,000	$51,215	(-)$48,785	$92,187	(-)$7,813	No
46	$2,700,000	$817,084	(-)$1,882,916	$1,470,751	(-)$1,229,249	No
50	$50,000	$15,433	(-)$34,567	$27,779	(-)$22,221	No
55	$2,000,000	$1,252,589	(-)$747,411	$2,254,660	$254,660	Yes
56	$1,500,000	$1,004,705	(-)$495,295	$1,808,469	$308,469	Yes
59	$1,215,000	$980,628	(-)$234,372	$1,765,130	$550,130	Yes
71	$1,700,000	$1,004,855	(-)$695,145	$1,808,739	$108,739	Yes
76	$100,000	$4,365	(-)$95,635	$7,857	(-)$92,143	No
81	$399,746	$239,617	(-)$160,129	$431,311	$31,565	Yes
86	$50,000	$10,772	(-)$39,228	$19,390	(-)$30,610	No
87	$100,000	$25,610	(-)$74,390	$46,098	(-)$53,902	No
111	$190,000	$131,980	(-)$58,020	$237,564	$47,564	Yes
112	$149,746	$133,403	(-)$16,343	$240,125	$90,379	Yes
114	$100,000	$1,284	(-)$98,716	$2,311	(-)$97,689	No
118	$50,000	$4,733	(-)$45,227	$8,591	(-)$41,409	No
122	$100,000	$4,671	(-)$95,329	$8,408	(-)$91,592	No
124	$149,746	$131,810	(-)$17,936	$237,258	$87,512	Yes
125	$2,700,000	$1,763,814	(-)$936,186	$3,174,865	$474,865	Yes
126	$2,700,000	$168,426	(-)$2,531,974	$303,167	(-)$2,396,833	No
131	$700,000	$170,136	(-)$529,864	$306,245	(-)$393,755	No
150	$100,000	$55,662	(-)$44,338	$100,192	$192	Yes
168	$100,000	$32,924	(-)$67,076	$59,263	(-)$40,737	No
178	$149,746	$109,633	(-)$40,113	$197,339	$47,593	Yes
179	$200,000	$157,448	(-)$42,552	$283,406	$83,406	Yes
180	$150,000	$134,791	(-)$15,209	$242,624	$92,624	Yes
182	$100,000	$71,580	(-)$28,420	$128,844	$28,844	Yes
183	$100,000	$16,896	(-)$83,104	$30,413	(-)$69,587	No
188	$269,000	$117,335	(-)$151,665	$211,203	(-)$57,797	No
189	$100,000	$23,259	(-)$74,741	$45,466	(-)$54,534	No

Of the SAMAs in Table F-19 with a negative cost-benefit, fifteen were found to be cost beneficial when the 95th percentile PRA results were applied. A discussion of each of these fifteen is provided below.

SAMA 26 proposed to install an additional high-pressure injection with an independent diesel. Using the estimated 95th percentile benefits, SAMA 26 is estimated to have a positive benefit of $1,013,619 and the benefits estimate assumed that RCP seals and safety injection would not fail. Clearly, these assumptions overstate the potential benefits to be obtained by the SAMA. As described in Section F.6.4, detailed cost estimates to implement SAMA 26 were not prepared. Rather, bounding estimates from the SAMA analyses for three other plants were examined and the lowest of the three estimates was used for the base case analysis. The lowest cost estimate, $2 million, was taken from the Cook SAMA submittal. The other plant SAMA analyses provided cost estimates significantly higher.

Previous studies for replacement of the existing service water pumps at KPS estimated the hardware costs for a service water pump and motor alone to be $735,000. It can be expected that the costs for an additional high-pressure safety injection pump would be similar but likely higher because of the higher pressures required. Additional costs required would be for the diesel-generator, circuit breakers and associated switchgear, piping, valves, and instrumentation. The service water pump replacement study estimates miscellaneous electrical equipment for replacement of a service water pump to be $350,000. With $500,000 of engineering costs along with installation, training, procedures, and maintenance, it can reasonably be expected that the middle to higher cost estimates shown in Section F.6.4 would be more accurate than the boundingly low value used in the base case analysis for screening. Therefore, it is concluded that SAMA 26 would not be cost-beneficial even if the 95th percentile risk benefit values were used.

SAMA 55 and SAMA 56 proposed to install an additional RCP seal injection with an independent diesel and without an independent diesel respectively. Using the estimated 95th percentile benefits, SAMA 55 is estimated to have a positive benefit of $254,660 and SAMA 56 is estimated to have a positive benefit of $308,469. The benefits for SAMA 55 assumed that RCP seals would never fail. For SAMA 56, the benefits assumed that RCP seals could only fail during a station blackout.

As with SAMA 26, bounding estimates from the SAMA analyses for three other plants were examined and the lowest of the three estimates was used for the base case analysis as the estimate of the costs for SAMAs 55 and 56. Since these modifications are very similar to SAMA 26, it is expected that the costs for these SAMAs would be much higher if detailed cost estimates were developed. Therefore, it is concluded that SAMAs 55 and 56 would likely not be cost-beneficial even if the 95th percentile risk benefit values were used.

SAMA 59 proposed to install an additional CCW pump. Using the estimated 95th percentile benefits, SAMA 59 is estimated to have a positive benefit of $550,130 and the benefits estimate assumed that CCW pumps would not fail. Clearly, these assumptions overstate the potential benefits to be obtained by the SAMA. As described in Section F.6.12, detailed cost estimates to implement SAMA 59 were not prepared. Rather, costs for major pieces of equipment were estimated and these costs were shown to be much greater than the benefits estimated in the base case. Significant costs that would be required but that were omitted in the base case estimates include installation costs, circuit breakers, diesel loading calculations, room heatup calculations, procedures, training, maintenance, cabling, valves, and piping. Because of space considerations, it is highly likely that a new Class I building would be required to house this new pump. It is reasonable to expect that these additional costs would cause total costs to far exceed the potential benefit estimated using the 95th percentile values.

SAMA 71 proposed to install a new, larger CST. Using the estimated 95th percentile benefits, SAMA 71 is estimated to have a positive benefit of $108,739 and the benefits estimate assumed that the CST could provide 24 hours of heat removal. As described in Section F.6.14, detailed cost estimates to implement SAMA 71 were not prepared. Rather, costs for a similar project at Surry were used. The estimates used for this analysis underestimated the total engineering costs that would be expected for the project and omitted any demolition costs, yet still far exceeded the positive benefit. Therefore, it is concluded that SAMA 71 would not be cost-beneficial even if the 95th percentile risk benefit values were used.

SAMA 81 along with SAMA 160, 166, 170, and 171 all proposed various means to reduce the potential impact of a loss of diesel room cooling. Using the estimated 95th percentile benefits, these SAMAs are estimated to have a positive benefit of $31,565 and the benefits estimate assumed that diesel room cooling was not required. The costs associated with implementing these SAMAs omitted costs associated with procedure development and training along with any equipment costs needed for the temporary equipment. Inclusion of these costs would clearly make the implementation costs associated with these SAMAs higher than the potential benefits. Therefore, it is concluded that these SAMAs would not be cost-beneficial even if the 95th percentile risk benefit values were used.

SAMA 111 along with SAMA 113 each proposed a means to reduce the frequency of ISLOCA events. The potential benefits for implementing these SAMAs were estimated by setting the ISLOCA frequency to zero. Clearly, this overstates the potential benefits. Using the estimated 95th percentile benefits, these SAMAs are estimated to have a positive benefit of $47,564. As described in Section F.6.21, detailed cost estimates to implement these SAMAs were not prepared. Rather, bounding estimates from the SAMA analyses for three other plants were examined and the lowest of the three estimates was used for the base case analysis. The lowest cost estimate, $190,000, was taken from the Cook SAMA submittal and was an order of magnitude less than the other two estimates identified. Since the potential benefit for these SAMAs is small and boundingly small cost estimates were used rather than plant specific cost estimates, it is concluded that these SAMAs would not be cost-beneficial even if the 95th percentile risk benefit values were used.

SAMA 112 proposed adding redundant indication for containment isolation valves to reduce the probability of containment isolation failure. Using the estimated 95th percentile benefits, SAMA 112 is estimated to have a positive benefit of $90,379 and the benefits estimate assumed that containment isolation was always successful. As described in Section F.6.22, detailed cost estimates were not performed. Rather, the costs were estimated by comparing the costs to install additional flood alarms in the auxiliary building. Because the costs for engineering and installation alone exceeded the potential benefits, no further cost analysis was performed. However, it was noted that costs for procedure changes, training, and ongoing maintenance and calibration were not included. Clearly, these additional costs would exceed the potential benefit above. Therefore, it is concluded that SAMA 112 would not be cost-beneficial even if the 95th percentile risk benefit values were used.

SAMA 124 proposed adding N-16 monitors to improve early detection of SGTRs. Using the estimated 95th percentile benefits, SAMA 124 is estimated to have a positive benefit of $87,512. As described in Section F.6.26, detailed cost estimates were not performed. Rather, the costs were estimated by comparing the costs to install additional flood alarms in the auxiliary building. Because the costs for engineering and installation alone exceeded the potential benefits, no further cost analysis was performed. However, it was noted that costs for procedure changes, training, and ongoing maintenance and calibration were not included. Clearly, these additional costs would exceed the potential benefit above. Therefore, it is concluded that SAMA 124 would not be cost-beneficial even if the 95th percentile risk benefit values were used.

SAMA 125 along with SAMA 129 each proposed a means to prevent release of reactor coolant through steam generator safety valves after a SGTR. Using the estimated 95th percentile benefits, these SAMAs are estimated to have a positive benefit of $474,865. As described in Section F.6.27, detailed cost estimates to implement these SAMAs were not prepared. Rather, bounding estimates from the SAMA analyses for three other plants were examined. Two of the estimates just indicated that the costs exceeded the maximum potential benefit for the associated plant. The third estimate was that implementation was clearly infeasible for an existing plant. Because the cost estimates greatly exceeded the base case potential benefits, no further cost estimates were performed. With respect to the large and uncertain estimated costs, the potential net benefit for these SAMAs is small, if not non-existent. Given the relatively small potential benefit calculated using the 95th percentile risk values and given the large scope of these SAMAs, it is concluded that these SAMAs would not be cost-beneficial even if the 95th percentile risk benefit values were used.

SAMA 150 proposed to improve maintenance procedures to improve reliability of equipment needed to respond to accidents. Using the estimated 95th percentile benefits, SAMA 150 is estimated to have a positive benefit of only $192. Since the costs assumed for this SAMA assumed that only two procedures would require change and the benefits assumed that the impacted components would have no maintenance unavailability, it is concluded that SAMA 150 would not be cost-beneficial even if the 95th percentile risk benefit values were used.

SAMA 178 proposed adding flood detection and alarms for the battery rooms. Using the estimated 95th percentile benefits, SAMA 178 is estimated to have a positive benefit of $47,593. As described in Section F.6.39, detailed cost estimates were not performed. Rather, the costs were estimated by comparing the costs to install additional flood alarms in the auxiliary building. Because the costs for engineering and installation alone exceeded the potential benefits for the base case, no further cost analysis was performed. However, it was noted that costs for procedure changes, training, and ongoing maintenance and calibration were not included. Clearly, these additional costs would exceed the potential benefit above. Therefore, it is concluded that SAMA 178 would not be cost-beneficial even if the 95th percentile risk benefit values were used.

SAMA 179 proposed adding a diverse indication of AFW flow to reduce the chance that a mis-calibrated instrument would lead to a loss of secondary heat sink. Using the estimated 95th percentile benefits, SAMA 179 is estimated to have a positive benefit of $83,406. As described in Section F.6.40, detailed cost estimates were not performed. Rather, the costs were estimated by comparing the costs to install additional flood alarms in the auxiliary building. The additional cost of a simple procedure change was included. Because these costs alone exceeded the potential benefits for the base case, no further cost analysis was performed. However, it should be noted that this modification would require changes to the EOPs as well as maintenance and testing procedures so the costs required for implementing procedures would likely be much higher. Also, costs for procedure changes, training, and ongoing maintenance and calibration were not included. Clearly, these additional costs would exceed the potential benefit above. Therefore, it is concluded that SAMA 179 would not be cost-beneficial even if the 95th percentile risk benefit values were used.

SAMA 180 proposed deleting the low lube-oil pressure interlock from the AFW pump start circuitry. Using the estimated 95th percentile benefits, SAMA 180 is estimated to have a positive benefit of $92,624. The cost estimates for this SAMA used the minimum base cost of $150,000 to implement a plant modification and a simple procedure change. This cost neglected hardware and installation costs as minimal. Also neglected were the ongoing costs associated with the periodic maintenance needed to operate weekly each of the three auxiliary lube oil pumps. This periodic task is needed to ensure proper lubrication of the AFW pumps on a start. If each of the three AFW pumps requires one hour of maintenance time per week, then over 3000 man-hours would be required over the period of life extension. Using a nominal labor rate of $75 per hour would show additional costs of over $200,000. Therefore, it is concluded that SAMA 180 would not be cost-beneficial even if the 95th percentile risk benefit values were used.

SAMA 182 proposed adding a flood relief path from the screenhouse to the outside to prevent flood propagation from the screenhouse to the diesel rooms. Using the estimated 95th percentile benefits, SAMA 182 is estimated to have a positive benefit of $28,884. The cost estimates for this SAMA used the minimum base cost of $100,000 to implement a plant modification. This cost did not consider any installation costs or procedure changes that would be required. Since the minimum costs alone exceeded the potential benefits for the base case, no further cost analysis was performed. It is reasonable to expect that installation costs would exceed the potential benefit above. Therefore, it is concluded that SAMA 180 would not be cost-beneficial even if the 95th percentile risk benefit values were used.

Based on the discussions above it is concluded that no additional SAMAs would show a positive cost-benefit if the 95th percentile risk benefit values were used provided that realistic cost estimates are also used.

F.7.6 Recent Plant Modifications

No major plant modifications that would impact the PRA models have been identified. One modification that would have a minor impact on the PRA models, however, has been completed. The PRA model used for this SAMA analysis assumed that circuit breaker 15206 would be raised to a higher level in bus 52 so that the potential of flood-induced loss of MCC-52E would be reduced. Later analyses have shown that the risk reduction of raising this circuit breaker would be minimal because flooding events that would cause failure of circuit breaker 15206 would also likely cause loss of bus 5, the power source for bus 52, because the rooms containing each bus are connected through drains. However, MCC-52E was modified to raise flood-susceptible components so that the chance of flood-induced failure of the MCC would occur only for high volume flooding events. The overall effect is that the results shown in this analysis are expected to be conservative and bound the risk reduction expected for the evaluated SAMA items.

F.7.7 Simultaneous SAMA Implementation

An evaluation of potential synergies between the SAMA items was performed to determine if a larger benefit could be obtained by implementing multiple SAMA items simultaneously. In general, SAMA items were distinctive enough that no synergies would be obtained. However, several of the items could be implemented simultaneously with a potential decrease in costs. These items are described below.

Potential synergies could be obtained by implementing SAMA items 173, 174, and 175, each of which installs spray shields to protect equipment in the auxiliary building mezzanine. Implementation of any one of these items was estimated to cost $150,000. However, because of the similarities in the modifications required and the close proximity of the equipment to be protected, it can be expected that some savings in engineering and installation costs could be obtained by implementing all three SAMA items together. Based on engineering judgment, it is expected that half of the additional engineering and installation costs for the second and third projects could be avoided with simultaneous implementation. Material costs would be the same. Therefore, total costs to implement the three SAMAs together would be:

$200,000	Engineering Costs
$50,000	Installation costs
<u>$75,000</u>	Material costs
$325,000	Total Costs

Although implementation of any of the items individually would achieve a portion of the benefits of the other items, it will be assumed for this analysis that the benefits are unique to each. Therefore, the total benefit for concurrent implementation will be the sum of the individual benefits, or:

$174,055	SAMA 173
$156,023	SAMA 174
<u>$185,123</u>	SAMA 175
$515,201	Total Benefits

These costs and potential benefits would result in a positive NPV of $190,201 for concurrent implementation of these three items.

Potential synergies could be obtained by implementing SAMA items 80, 81, 82, 83, 166, 167, 170, and 171, each of which proposes a means to reduce the likelihood or consequences of a loss of ventilation. However, SAMA 80 evaluated the benefits of improved ventilation in the auxiliary building while the other items addressed ventilation to equipment located in safeguards alley. Given the physical separation between the auxiliary building and safeguards alley, it is expected that any potential synergies with the other areas would be small if any. However, analysis of ventilation for the diesel and switchgear rooms could result in synergies between the heatup analyses, procedure development and equipment needed.

To provide a lower bound for the costs associated with implementing these SAMAs simultaneously, it will be assumed that SAMAs 81, 82, 83, 166, 167, 170, and 171 can be implemented simultaneously for the same costs as implementing them for just a single area, or $399,746.

Further, it will be assumed that the benefits for implementing the SAMAs can be added. That is, it will be assumed that there is no overlap in the benefits for the SAMAs. This is a conservative assumption because implementation of any single SAMA will improve the availability of AC power so implementing all the items would be expected to have a benefit less than the sum of the costs for the second and third projects. The combined, maximum benefit would then be:

$239,617	SAMA 81
<u>$442,437</u>	SAMAs 82, 83, 166, 167, 170, and 171
$682,054	Total Benefit

Assuming that implementation costs for all the above items are no greater than for either of the two options, the net cost-benefit would be $282,308 for concurrent implementation of these items. Therefore, simultaneous implementation of these items should be considered.

No other SAMAs were evaluated as having potential synergies.

F.8 CONCLUSIONS

The analyses described in the previous sections analyzed 189 conceptual alternatives for mitigating KPS severe accident impacts. Preliminary screening eliminated 127 SAMA candidates from further consideration, based on inapplicability to KPS site-specific design features, design features that have already been incorporated into the current KPS site-specific design, procedures and programs that already implement the intent of the SAMA candidates, or extremely high cost of the alternatives considered. During the final disposition, 48 remaining SAMA candidates were eliminated because the cost was expected to exceed their benefit. The remaining 14 SAMA candidates can be grouped together into three potential areas for risk improvement. Each of the three areas is described below followed by an evaluation of the SAMAs in the context of license renewal.

F.8.1 Improve Availability of AFW Sources

SAMA Numbers 66 and 172 are related to improving availability of secondary cooling. SAMA 66 would incorporate actions to provide alternate means of secondary cooling sources into abnormal and emergency operating procedures. These actions are already included in the SAMGs, but those procedures are not entered until after core damage is imminent. Incorporating the actions into the EOPs would reduce the chance of core damage due to a loss of secondary cooling. SAMA 172 would provide an additional alarm to indicate that CST level had decreased to the point that AFW pump suction loss was imminent. This additional alarm would provide an immediate cue to the operators to provide an additional water source or to prepare for a switch to bleed and feed cooling.

F.8.2 Improve Availability of HVAC

SAMA items 80, 82, 83, 170, and 171 are related to improvements that would improve the reliability and availability of ventilation to risk-significant equipment. SAMA 80 would provide temporary ventilation equipment and procedures to be used following a loss of installed ventilation equipment serving the auxiliary building.

The goal of SAMA items 82, 83, 170, and 171 is to mitigate the chance of losing cooling to the 480 VAC switchgear rooms and, if a loss of HVAC occurs, to improve the ability to detect and mitigate such a loss. These SAMAs would install alarms to detect high temperatures in the switchgear rooms and provide temporary ventilation equipment and procedures to be used following a loss of installed ventilation equipment serving the rooms. As discussed in Section F.7.7, synergies may be possible if these items are implemented concurrently with SAMA items 81, 160, 166, and 167, which would provide similar capabilities for the EDG rooms.

F.8.3 Internal Flooding-Related Improvements

Seven of the SAMA items are directly related to minimizing the consequences of internal flooding events. SAMA item 169 would install flood barriers around MCC-52E, MCC-62E, and MCC-62H so that flood waters accumulating in the auxiliary building will not cause failure of these key power sources.

SAMA items 173, 174, and 175 would install spray protection for equipment located on the auxiliary building mezzanine level. Item 173 would protect the auxiliary building mezzanine coolers, item 174 would protect the boric acid transfer pumps, and item 175 would protect the A-train CCW pump. As discussed in Section F.7.7, synergies may be possible if these items are implemented concurrently. One potential conservatism in the PRA model is that normal auxiliary building ventilation is not included. Use of normal auxiliary building ventilation may obviate the need for these SAMAs and may be included in a future model update.

SAMA 176 would install higher capacity sump pumps in safeguards alley. These pumps would be large enough to prevent propagation from one room to another for floods with a flow rate of less than about 500 gpm. By preventing propagation, the likelihood of failing multiple trains of equipment in the area would be reduced.

SAMA 177 would ensure that the fire barrier separating the two 480 VAC switchgear rooms was capable of withstanding flooding events and preventing water from propagating from one side to the other. This modification, as with item 176, would help prevent flood-induced failures of multiple equipment trains.

SAMA 181 would install break-away latching mechanisms that would ensure that the doors from the EDG rooms to the screenhouse tunnel would open before water level in the EDG rooms would reach a level that would cause a loss of offsite power.

F.8.4 Consideration of SAMAs With Respect To License Renewal

Fourteen SAMA candidates discussed in Sections F.8.1 through F.8.3, above, were determined to be potentially cost beneficial for mitigating the consequences of a severe accident. These determinations were made using the 7 percent real discount rate recommended in Reference F-1. Using a very conservative discount rate of 3 percent, results in an increase in the calculated benefit of these SAMA candidates. However, no new SAMA candidates would be considered cost beneficial even using the 3 percent discount rate. In actuality, a 7 percent discount rate is actually conservative and a more realistic discount rate of about 14 percent is appropriate, which would result in benefits that are much lower than those on which this analysis is based.

Another sensitivity study used a 26-year benefit period, roughly the time from the expected submittal of the license renewal application to the end of the extended license. Although the extended period raised the benefit of SAMA items already determined to have a potentially positive cost-benefit, it was concluded that no new SAMA items would show a positive cost-benefit.

Two unresolved F&Os from the WOG peer review remains open. An assessment of those items, which both relate to loss of HVAC, determined that it would not impact the overall PRA model or SAMA results. All other A and B-level F&Os from the peer review were resolved.

An evaluation of risk levels at the 95th percentile was performed. The results, shown in Section F.7.5, show that no new SAMA items would show a positive cost-benefit provided that more detailed and realistic cost estimates than are used for the base case analysis are used.

Potential synergies from concurrent implementation of multiple items were examined in Section F.7.7. Items that would show improved benefit or reduced costs are discussed in Sections F.8.2 and F.8.3 in conjunction with other potentially cost-beneficial SAMA items.

In summary, Dominion identified 14 potentially cost beneficial SAMA candidates, although the 14 are grouped into three areas because of their impacts on accident mitigation. These SAMAs do not relate to the management of aging during the period of extended operation, and are therefore unrelated to any of the technical matters that must be addressed pursuant to 10 C.F.R. Part 54. Accordingly, these potential SAMAs will be further reviewed for implementation as part of Dominion's ongoing performance improvement programs.

F.9 References

F-1 NEI 05-01, "Severe Accident Mitigation Alternatives (SAMA) Analysis Guidance Document," Revision A.

F-2 Chanin, D. and Young, M., Code Manual for MACCS2: Volume 1, User's-Guide, SAND 97-0594, 1997

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Table F-1. Contribution to Core Damage Frequency by Initiating Event

Initiating Event ID	Initiating Event Description	Percent Contribution to CDF
IE-SA-8B--U	Moderate Flood from Train A Service Water in Auxiliary Building Basement (CS/SI Pump Area)	8.58%
IE-TRA	Transient with Main Feedwater Available	8.46%
IE-TCC	Loss of Component Cooling Water	7.75%
IE-SB-8B--U	Moderate Flood from Train B Service Water in Auxiliary Building Basement (CS/SI Pump Area)	7.63%
IE-SGTR	Steam Generator Tube Rupture	6.14%
IE-LOSP	Loss of Offsite Power	5.01%
IE-SB-156-S	Small Flood from Train B Service Water in Auxiliary Building Mezzanine	4.40%
IE-SB-5B--U	Train B Service Water Flood Beyond Drain Capacity in A-Train 480 VAC Switchgear Room	2.58%
IE-SOPORV	Stuck Open Pressurizer PORV	2.56%
IE-TSW	Loss of Service Water	2.52%
IE-SB-403-U	Train B Service Water Flood on Upper Elevation of Auxiliary Building	2.38%
IE-W--14B-U	Flood from AFW Pipe Break in Auxiliary Building Basement (CVCS Tank Area)	2.19%
IE-TMF	Loss of Main Feedwater	2.01%
IE-W-5B24-U	AFW Pipe Break Greater than Drain Capacity in Safeguards Alley	1.77%
IE-SLO	Small LOCA	1.59%
IE-S-5B14-M	Major Flood from Service Water Header in Safeguards Alley	1.36%
IE-VEF	Vessel Failure	1.23%
IE-SB-14B-S	Flood from AFW Pipe Break in Auxiliary Building Basement (CVCS Tank Area)	1.23%
IE-SB-3B--M	Major Flood from Service Water Train B in B-train EDG Room	1.21%
IE-W-5B24-S	Small AFW Pipe Break (within Drain Capacity) in Safeguards Alley	1.17%
IE-SB-5B1-S	Small Flood (within Drain Capacity) From Train B Service Water in B-Train 480 VAC Switchgear Room	1.11%
IE-SA-129-U	Train A Service Water Flood (Greater than Drain Capacity) in A-Train Battery Room	1.11%
IE-SB-22B2U	Moderate Service Water Flood from B-train Service Water in B-Train Service Water Pump Area.	1.05%
IE-TIA	Loss of Instrument Air	1.04%
IE-SB-130-U	Train B Service Water Flood (Greater than Drain Capacity) in B-Train Battery Room	1.03%
	All Other Initiating Events	<1% each

Table F-2. Contribution to Large Early Release Frequency by Initiating Event

Initiating Event ID	Initiating Event Description	Percent Contribution to LERF
IE-SGTR	Steam Generator Tube Rupture	19.3%
IE-TCC	Loss of Component Cooling Water	9.08%
IE-TRA	Transient with Main Feedwater Available	7.75%
IE-LOSP	Loss of Offsite Power	6.41%
IE-SB-8B--U	Moderate Flood from Train B Service Water in Auxiliary Building Basement (CS/SI Pump Area)	5.50%
IE-SB-156-S	Small Flood from Train B Service Water in Auxiliary Building Mezzanine	4.21%
IE-W-5B24-U	AFW Pipe Break Greater than Drain Capacity in Safeguards Alley	2.72%
IE-S-5B14-M	Major Flood from Service Water Header in Safeguards Alley	2.60%
IE-W--14B-U	Flood from AFW Pipe Break in Auxiliary Building Basement (CVCS Tank Area)	2.54%
IE-SB-3B--M	Major Flood from Service Water Train B in B-train EDG Room	2.31%
IE-TMF	Loss of Main Feedwater	2.14%
IE-SOPORV	Stuck Open Pressurizer PORV	2.00%
IE-SB-3B--U	Moderate Flood from Service Water Train B in B-train EDG Room	1.86%
IE-TSW	Loss of Service Water	1.76%
IE-ISL	Interfacing Systems LOCA	1.62%
IE-F--2B--M	Major Flood from Fire Protection Water A-train EDG Room	1.60%
IE-SA-2B--M	Major Flood from Service Water Train A in A-train EDG Room	1.55%
IE-SA-8B--U	Moderate Flood from Train A Service Water in Auxiliary Building Basement (CS/SI Pump Area)	1.49%
IE-W-5B24-S	Small AFW Pipe Break (within Drain Capacity) in Safeguards Alley	1.36%
IE-SA-129-U	Train A Service Water Flood (Greater than Drain Capacity) in A-Train Battery Room	1.31%
IE-SB-130-U	Train B Service Water Flood (Greater than Drain Capacity) in B-Train Battery Room	1.21%
IE-SB-3B--S	Small Flood from Service Water Train B in B-train EDG Room	1.10%
IE-F--4B--M	Major Flood from Fire Protection Water CO2 Tank Room	1.05%
	All Other Initiating Events	<1% each

Table F-3. Basic Event Importance with Respect to Core Damage Frequency

Item No.	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
1	LERF-59	1.000e+000	2.360e-001	LARGE EARLY RELEASE FREQUENCY FOR PLANT DAMAGE STATE 59	This basic event is a flag-type of event used to facilitate the overall quantification and represents no physical failures. No SAMA items are generated as a result of this basic event.
2	LOSP-24	5.287e-003	1.793e-001	LOSS OF ALL POWER FROM GRID DURING 24 HOURS	This basic event represents a loss of offsite power that occurs within the first 24 hours following the initiating event. This event is important to the KPS results for several reasons. First, flooding events generally result in a loss of one train of service water and, therefore, the associated EDG. Thus loss of the other EDG results in a station blackout. Second, because power is needed to operate the valves that are used to isolate many of the internal flooding initiating events. Failure of offsite power causes the inability to isolate some flooding events. In actuality, however, flooding isolation must occur early in the event, typically in less than one hour. The ability to isolate flooding events without requiring power would greatly lower the importance of this event. Refer to SAMA item 168.
3	05B-CST-DIAG-HE	8.656e-004	1.602e-001	OPERATOR FAILS TO DIAGNOSE NEED FOR ALTERNATE AFW SRC	This item is important because it applies to accident sequences from nearly all initiating events. Additional alarms to indicate CST depletion, an automatic switchover to an alternate water source, or larger CSTs would lower the importance of this event. Refer to SAMA items 172, 71, and 66.
4	LERF-16	1.000e+000	1.235e-001	LARGE EARLY RELEASE FREQUENCY FOR PLANT DAMAGE STATE 16	This basic event is a flag-type of event used to facilitate the overall quantification and represents no physical failures. No SAMA items are generated as a result of this basic event.
5	LERF-60	1.000e+000	1.204e-001	LARGE EARLY RELEASE FREQUENCY FOR PLANT DAMAGE STATE 60	This basic event is a flag-type of event used to facilitate the overall quantification and represents no physical failures. No SAMA items are generated as a result of this basic event.
6	LERF-42	1.000e+000	1.101e-001	LARGE EARLY RELEASE FREQUENCY FOR PLANT DAMAGE STATE 42	This basic event is a flag-type of event used to facilitate the overall quantification and represents no physical failures. No SAMA items are generated as a result of this basic event.
7	LERF-46	1.000e+000	9.389e-002	LARGE EARLY RELEASE FREQUENCY FOR PLANT DAMAGE STATE 46	This basic event is a flag-type of event used to facilitate the overall quantification and represents no physical failures. No SAMA items are generated as a result of this basic event.

Table F-3. Basic Event Importance with Respect to Core Damage Frequency (Continued)

Item No.	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
8	IE-SA-8B--U	2.170e-003	8.575e-002	MODERATE TRAIN A SW PIPE BREAKS IN ROOM 8B (Aux Building Basement)	This initiating event leads to core damage due to flood-induced failure of equipment needed to maintain RCP seal cooling, specifically, failure of MCCs 52E, 62E, and 62H. Loss of these MCCs leads to a loss of charging pumps and a loss of ventilation needed to ensure continued functioning of CCW pumps. Refer to SAMA item 169.
9	IE-TRA	9.994e-001	8.462e-002	TRANSIENT WITH MAIN FEEDWATER AVAILABLE OCCURS	The importance of this initiating event is driven by sequences where failure of room cooling causes a loss of AFW pumps and other equipment located in safeguards alley. The ability to provide alternate room cooling for safeguards alley would lower the importance of this initiating event to overall core damage. Refer to SAMA items 170 and 171.
10	IE-TCC	3.650e+002	7.752e-002	LOSS OF COMPONENT COOLING WATER INITIATING EVENT	This basic event is a tag event that is attached to all cutsets representing a loss of component cooling water initiating event. The basic event itself represents no physical failures. The importance of this initiating event is driven by sequences where failure of room cooling causes a loss of AFW pumps and other equipment located in safeguards alley and subsequences where a long-term source of water to AFW pump suction is not available. The ability to provide alternate room cooling for safeguards alley would lower the importance of this initiating event to overall core damage. Refer to SAMA items 170 and 171. Additional alarms to indicate CST depletion, an automatic switchover to an alternate water source, or larger CSTs would lower the importance of this event. Refer to SAMA items 172, 71, and 66.
11	IE-SB-8B--U	3.300e-003	7.629e-002	MODERATE TRAIN B SW PIPE BREAKS IN ROOM 8B (Aux Building Basement)	This initiating event leads to core damage due to flood-induced failure of equipment needed to maintain RCP seal cooling, specifically, failure of MCCs 52E, 62E, and 62H. Loss of these MCCs leads to a loss of charging pumps and a loss of ventilation needed to ensure continued functioning of CCW pumps. Refer to SAMA item 169.
12	LERF-47	1.000e+000	6.560e-002	LARGE EARLY RELEASE FREQUENCY FOR PLANT DAMAGE STATE 47	This basic event is a flag-type of event used to facilitate the overall quantification and represents no physical failures. No SAMA items are generated as a result of this basic event.

Table F-3. Basic Event Importance with Respect to Core Damage Frequency (Continued)

Item No.	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
13	IE-SGTR	3.800e-003	6.143e-002	STEAM GENERATOR TUBE RUPTURE INITIATING EVENT	This initiating event is important to core damage because of failure of the operator actions required to mitigate the event. The actions modeled are from emergency operating procedures developed from standard Westinghouse Owners Group guidance. No weaknesses in the procedures have been identified in these procedures. Therefore, hardware modifications would be required to reduce the importance of this event further. SAMA items 122, 124, 125, 126, and 129 have been identified to address SGTRs.
14	05B-DOOR-AFW-HE	6.090e-003	5.911e-002	OPERATOR FAILS TO OPEN DOORS TO AFW ROOM B FOR VNTLTN	This event represents failure to open doors to the AFW pump rooms on a loss of ventilation. This event then results in failure of the AFW pumps. Provision of room temperature alarms or the ability to provide alternate room cooling for safeguards alley would lower the importance of this initiating event to overall core damage. Refer to SAMA items 170 and 171.
15	LERF-24	1.000e+000	5.812e-002	LARGE EARLY RELEASE FREQUENCY FOR PLANT DAMAGE STATE 24	This basic event is a flag-type of event used to facilitate the overall quantification and represents no physical failures. No SAMA items are generated as a result of this basic event.
16	10-GE-DG1A---PR	1.883e-002	5.568e-002	INDEPENDENT FAILURE DIESEL GENERATOR A FAILS TO RUN	A large part of the importance of this basic event is driven by the need to isolate flooding events (refer to item 2 above). This event is important to the KPS results because power is needed to operate the valves that are used to isolate many of the internal flooding initiating events. Failure of offsite power coupled with failure of the diesel-generator to operate causes the inability to isolate some flooding events. In actuality, however, flooding isolation must occur early in the event, typically in less than one hour. The ability to isolate flooding events without requiring power would greatly lower the importance of this event. Refer to SAMA item 168. Station blackout contributes 4.3% to overall core damage. Preventing failure of the diesel-generator would eliminate station blackout as a concern. Other means are available to mitigate station blackouts. Refer to SAMA items 55, 56, 58, 21, and 22.
17	LERF-50	1.000e+000	5.315e-002	LARGE EARLY RELEASE FREQUENCY FOR PLANT DAMAGE STATE 50	This basic event is a flag-type of event used to facilitate the overall quantification and represents no physical failures. No SAMA items are generated as a result of this basic event.

Table F-3. Basic Event Importance with Respect to Core Damage Frequency (Continued)

Item No.	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
18	16-FNAKPRCCF123	3.700e-005	5.033e-002	COMMON CAUSE FAILURE OF AFW PUMP AND TURBINE BUILDING BASEMENT FAN COOLING UNITS	This event represents common cause failure of all cooling units in safeguards alley. This event then results in failure of the AFW pumps and safety-related 480 VAC equipment. Provision of room temperature alarms or the ability to provide alternate room cooling for safeguards alley would lower the importance of this initiating event to overall core damage. Refer to SAMA items 170 and 171.
19	IE-LOSP	2.980e-002	5.010e-002	LOSS OF OFFSITE POWER INITIATING EVENT	This initiating event leads to core damage predominantly through station blackout sequences. Items designed to mitigate station blackout or RCP seal failures would reduce the importance of this event. . Refer to SAMA items 55, 56, 58, 21, and 22.
20	02-SWHDRISOXHHE	2.529e-001	5.001e-002	OPERATOR FAILS TO ISOLATE A MOD. SW BRK BEFORE 3" IN AUXILIARY BUILDING BASEMENT	This initiating event leads to core damage due to flood-induced failure of equipment needed to maintain RCP seal cooling, specifically, failure of MCCs 52E, 62E, and 62H. Loss of these MCCs leads to a loss of charging pumps and a loss of ventilation needed to ensure continued functioning of CCW pumps. Refer to SAMA item 169.
21	05BPT—AFW1C-PS	2.013e-002	4.920e-002	INDEPENDENT FAILURE TD AFW PUMP FAILS TO START	The importance of the turbine-driven AFW pump is caused mainly by loss of room cooling inducing failure of the motor-driven AFW pumps. The loss of room cooling could be caused directly by a loss of the coolers or by flood-induced failure of the power supplies. Instituting measures to ensure adequate room cooling to safeguards alley after a loss of room cooling would lower the importance of the turbine-driven AFW pump. The ability to provide alternate room cooling for safeguards alley would lower the importance of this initiating event to overall core damage. Refer to SAMA items 170 and 171.
22	27A-OR2----RDHE	1.414e-001	4.487e-002	OPERATOR FAILS TO LIMIT SI FLOW AND REFILL RWST – SGTR	This basic event represents failure of operator action to refill the RWST to continue ECCS injection following a steam generator tube rupture. This event represents a dependent operator action given failure of operator actions to cooldown and depressurize the RCS. Because this event is a dependent operator action, steps to reduce the events on which it is dependent must be taken. Refer to item 25 below. No SAMA items identified as a result of this event.

Table F-3. Basic Event Importance with Respect to Core Damage Frequency (Continued)

Item No.	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
23	27A-ORR------HE	9.212e-002	4.413e-002	OPERATOR FAILS TO LIMIT SI FLOW AND REFILL RWST – NO CD	This basic event represents execution failures of the actions to provide RWST makeup to ensure continued ECCS injection. These actions occur after a successful diagnosis of the need for the actions. These actions are important primarily because failure of secondary cooling via AFW or MFW has necessitated the need for bleed and feed cooling and high-pressure recirculation. Two approaches can be taken to minimize the importance of this operator action. The first is to lower the overall failure probability of the AFW system. The second is to provide a simple method to align makeup water to the RWST. Failure of the AFW system is primarily caused by failure of the room cooling systems needed to support operation of the motor-driven AFW pumps. The ability to provide alternate room cooling for safeguards alley would lower the importance of this initiating event to overall core damage. Refer to SAMA items 170 and 171. Potential improvements related to switchover to ECCS recirculation are addressed by items 31 and 32. Successful ECCS recirculation obviates the need to provide RWST makeup. Provision of an additional means to refill the RWST would likely be of little value to reducing the importance of this basic event because the event represents failure in the execution phase of the action, after a successful diagnosis.
24	IE-SB-156-S	2.520e-003	4.400e-002	SMALL TRAIN B SW PIPE BREAKS IN ROOM 156 (Aux Building Mezzanine)	This initiating event leads to core damage due to flood-induced failure of equipment needed to maintain RCP seal cooling, specifically, failure of MCCs 52E, 62E, and 62H. Loss of these MCCs leads to a loss of charging pumps and a loss of ventilation needed to ensure continued functioning of CCW pumps. Refer to SAMA item 169.
25	06--OC4------HE	1.850e-001	4.288e-002	OPERATOR FAILS TO CD AND DEPRES RCS IN ECA-3.1/3.2	This basic event represents failure operator action to cooldown and depressurize the steam generators following a steam generator tube rupture. The actions modeled are from emergency operating procedures developed from standard Westinghouse Owners Group guidance. No weaknesses in the procedures have been identified. Therefore, hardware modifications would be required to reduce the importance of this event further. SAMA items 122, 124, 125, 126, and 129 have been identified to address SGTRs.

Table F-3. Basic Event Importance with Respect to Core Damage Frequency (Continued)

Item No.	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
26	31-PM-KPRCCF12	7.140e-005	4.166e-002	DOUBLE COMMON CAUSE FAILURE (CCF) CCW-1A/-1B FAIL TO RUN	This basic event causes the loss of CCW initiating event and the importance of the event is almost entirely related to loss of CCW accident sequences. The importance of this event is driven by sequences where failure of room cooling causes a loss of AFW pumps and other equipment located in safeguards alley and subsequences where a long-term source of water to AFW pump suction is not available. The ability to provide alternate room cooling for safeguards alley would lower the importance of this initiating event to overall core damage. Refer to SAMA items 170 and 171. Additional alarms to indicate CST depletion, an automatic switchover to an alternate water source, or larger CSTs would lower the importance of this event. Refer to SAMA items 172, 71, and 66.
27	36--OBF------HE	2.451e-002	3.806e-002	OPERATOR FAILS TO ESTABLISH BLEED AND FEED	This basic event represents execution failures of the actions to initiate bleed and feed cooling. These actions occur after a successful diagnosis of the need for the actions. These actions are important primarily because failure of secondary cooling via AFW or MFW has necessitated the need for bleed and feed cooling. Two approaches can be taken to minimize the importance of this operator action. The first is to lower the overall failure probability of the AFW system. The second is to provide a simple method to initiate bleed and feed cooling. Failure of the AFW system is primarily caused by failure of the room cooling systems needed to support operation of the motor-driven AFW pumps. The ability to provide alternate room cooling for safeguards alley would lower the importance of this initiating event to overall core damage. Refer to SAMA items 170 and 171. Initiation of bleed and feed cooling is directed by the integrated plant emergency operating procedures (IPEOPs), which are written per the WOG standard, and the actions taken are quite simple. It is unlikely that any changes that would improve this action could be implemented.
28	LERF-64	1.000e+000	3.783e-002	LARGE EARLY RELEASE FREQUENCY FOR PLANT DAMAGE STATE 64	This basic event is a flag-type of event used to facilitate the overall quantification and represents no physical failures. No SAMA items are generated as a result of this basic event.

Table F-3. Basic Event Importance with Respect to Core Damage Frequency (Continued)

Item No.	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
29	10-GE-DG1A---TM	1.303e-002	3.574e-002	DIESEL GENERATOR A UNAVAILABLE DUE TO TEST OR MAINTENANCE	A large part of the importance of this basic event is driven by the need to isolate flooding events (refer to item 2 above). This event is important to the KPS results because power is needed to operate the valves that are used to isolate many of the internal flooding initiating events. Failure of offsite power coupled with failure of the diesel-generator to operate causes the inability to isolate some flooding events. In actuality, however, flooding isolation must occur early in the event, typically in less than one hour. The ability to isolate flooding events without requiring power would greatly lower the importance of this event. Refer to SAMA item 168. Station blackout contributes 4.3% to overall core damage. Preventing failure of the diesel-generator would eliminate station blackout as a concern. Other means are available to mitigate station blackouts. Refer to SAMA items 55, 56, 58, 21, and 22.
30	06--OC3------HE	2.330e-002	3.488e-002	OPERATOR FAILS TO CD AND DEPRES RCS TO STOP TUBE LEAK	This basic event represents failure of operator action to cooldown and depressurize the steam generators following a steam generator tube rupture. The actions modeled are from emergency operating procedures developed from standard Westinghouse Owners Group guidance. No weaknesses in the procedures have been identified in these procedures. Therefore, hardware modifications would be required to reduce the importance of this event further. SAMA items 122, 124, 125, 126, and 129 have been identified to address SGTRs.
31	02-SWHDRISOXMHE	2.459e-002	3.363e-002	OPERATOR FAILS TO ISOLATE A MOD. SW BRK BEFORE 8.5" IN AUXILIARY BUILDING BASEMENT	This initiating event leads to core damage due to flood-induced failure of equipment needed to maintain RCP seal cooling, specifically, failure of MCCs 52E, 62E, and 62H. Loss of these MCCs leads to a loss of charging pumps and a loss of ventilation needed to ensure continued functioning of CCW pumps. Refer to SAMA item 169.

Table F-3. Basic Event Importance with Respect to Core Damage Frequency (Continued)

Item No.	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
32	36--LHS-DIAG-HE	1.730e-003	3.072e-002	OPERATOR FAILS TO DIAGNOSE LOSS OF HEAT SINK	This basic event represents cognitive failure to recognize a loss of the secondary heat sink and the need to initiate bleed and feed cooling. These actions are important primarily because failure of secondary cooling via AFW or MFW has necessitated the need for bleed and feed cooling. Two approaches can be taken to minimize the importance of this operator action. The first is to lower the overall failure probability of the AFW system. The second is to provide more and clear cues for the loss of heat sink. Failure of the AFW system is primarily caused by failure of the room cooling systems needed to support operation of the motor-driven AFW pumps. The ability to provide alternate room cooling for safeguards alley would lower the importance of this initiating event to overall core damage. Refer to SAMA items 170 and 171. Initiation of bleed and feed cooling is directed by the IPEOPs, which are written per the WOG standard, and the cues given in the procedures are redundant and clear. It is unlikely that any changes that would improve this action could be implemented.
33	STBY-CCWPA	5.000e-001	3.012e-002	COMPONENT COOLING PUMP A IS IN STANDBY	This basic event is a flag-type of event used to facilitate the overall quantification and represents no physical failures. No SAMA items are generated as a result of this basic event.
34	10-GE-DG1B---PR	1.883e-002	2.968e-002	INDEPENDENT FAILURE DIESEL GENERATOR B FAILS TO RUN	A large part of the importance of this basic event is driven by the need to isolate flooding events (refer to item 2 above). This event is important to the KPS results because power is needed to operate the valves that are used to isolate many of the internal flooding initiating events. Failure of offsite power coupled with failure of the diesel-generator to operate causes the inability to isolate some flooding events. In actuality, however, flooding isolation must occur early in the event, typically in less than one hour. The ability to isolate flooding events without requiring power would greatly lower the importance of this event. Refer to SAMA item 168. Station blackout contributes 4.3% to overall core damage. Preventing failure of the diesel-generator would eliminate station blackout as a concern. Other means are available to mitigate station blackouts. Refer to SAMA items 55, 56, 58, 21, and 22.

Table F-3. Basic Event Importance with Respect to Core Damage Frequency (Continued)

Item No.	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
35	XEQN-R1B156S	1.000e+000	2.952e-002	N/A ─ Automatically generated as part of the quantification process	This basic event is automatically generated as part of the quantification process and postulates that the event tree top event to refill the RWST fails as a result of the conditions represented in the event tree. Equipment needed to refill the RWST, specifically the boric acid transfer pumps and auxiliary building mezzanine cooling units, is failed by the flooding event. Refill of the RWST is important primarily because failure of secondary cooling via AFW or MFW has necessitated the need for bleed and feed cooling and high-pressure recirculation. Two approaches can be taken to minimize the importance of this operator action. The first is to lower the overall failure probability of the AFW system. The second is to protect equipment needed to refill the RWST from the effects of spray. Failure of the AFW system is primarily caused by failure of the room cooling systems needed to support operation of the motor-driven AFW pumps. The ability to provide alternate room cooling for safeguards alley would lower the importance of this initiating event to overall core damage. Refer to SAMA items 169, 170, and 171. Potential improvements related to protecting auxiliary building equipment are addressed by items 173 and 174.

Table F-3. Basic Event Importance with Respect to Core Damage Frequency (Continued)

Item No.	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
36	XEQN-LRB156S	1.000e+000	2.952e-002	N/A – Automatically generated as part of the quantification process	This basic event is automatically generated as part of the quantification process and postulates that the event tree top event to switch to low-pressure recirculation fails as a result of the conditions represented in the event tree. Equipment needed for low-pressure recirculation, specifically the CCW pumps and auxiliary building mezzanine cooling units, is failed by the flooding event. Low pressure recirculation is important primarily because failure of secondary cooling via AFW or MFW has necessitated the need for bleed and feed cooling and ECCS recirculation. Two approaches can be taken to minimize the importance of this operator action. The first is to lower the overall failure probability of the AFW system. The second is to protect equipment needed for ECCS recirculation from the effects of spray. Failure of the AFW system is primarily caused by failure of the room cooling systems needed to support operation of the motor-driven AFW pumps. The ability to provide alternate room cooling for safeguards alley would lower the importance of this initiating event to overall core damage. Refer to SAMA items 169, 170, and 171. Potential improvements related to protecting auxiliary building equipment are addressed by items 173 and 175.

Table F-3. Basic Event Importance with Respect to Core Damage Frequency (Continued)

Item No.	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
37	XEQN-HRB156S	1.000e+000	2.952e-002	N/A – Automatically generated as part of the quantification process	This basic event is automatically generated as part of the quantification process and postulates that the event tree top event to switch to high-pressure recirculation fails as a result of the conditions represented in the event tree. Equipment needed for low-pressure recirculation, specifically the CCW pumps and auxiliary building mezzanine cooling units, is failed by the flooding event. High pressure recirculation is important primarily because failure of secondary cooling via AFW or MFW has necessitated the need for bleed and feed cooling and ECCS recirculation. Two approaches can be taken to minimize the importance of this operator action. The first is to lower the overall failure probability of the AFW system. The second is to protect equipment needed for ECCS recirculation from the effects of spray. Failure of the AFW system is primarily caused by failure of the room cooling systems needed to support operation of the motor-driven AFW pumps. The ability to provide alternate room cooling for safeguards alley would lower the importance of this initiating event to overall core damage. Refer to SAMA items 169, 170 and 171. Potential improvements related to protecting auxiliary building equipment are addressed by items 173 and 175.
38	31--DOOR-CCW-HE	1.000e-002	2.899e-002	OPERATOR FAILS TO OPEN DOORS FOR ROOM COOLING TO CCW PUMP A	This basic event represents operator actions to open doors to ensure adequate room cooling to the A-train CCW pump if the auxiliary building mezzanine cooling units fail. A major contributor to loss of the mezzanine cooling units is flood-induced failure of MCCs 52E and 62E. Protection of these MCCs from flooding would reduce the need for this actioin. Refer to SAMA item 169. The reliability of the action could also be improved by providing an alarm to indicate that room temperatures are about to exceed desired values. This alarm would also require procedural guidance to take actions to lower temperatures.

Table F-3. Basic Event Importance with Respect to Core Damage Frequency (Continued)

Item No.	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
39	02-SWHDRISOX6HE	3.681e-002	2.730e-002	OPERATOR FAILS TO ISOLATE A MOD. SW BRK IN A-TRAIN SWITCHGEAR ROOMS BEFORE FAIL 480 VAC BUSES	While plant modifications to protect the electrical buses from spray are being implemented, a large break could still cause failure of the buses by submergence. For breaks that exceed the drainage capacity of the room, submergence-induced loss of the buses could occur. This basic event represents failure operator actions to isolate a break exceeding drainage capacity before flow from the break fails the electrical buses. Installation of sump pumps in safeguards alley could lessen the importance of this event. Installation of a flood barrier between the A and B-train 480 VAC switchgear rooms would prevent a loss of both buses if this event fails. Refer to SAMA items 176 and 177.
40	IE-SB-5B—U	5.190e-005	2.580e-002	MODERATE TRAIN B SW PIPE BREAKS IN ROOM 5B (A-train 480 VAC room)	This initiating event leads to core damage due to flood-induced failure of equipment to mitigate the event. Predominantly, accident sequences that lead to core damage are caused by a failure to isolate the break before the volume of water released would cause a loss of both trains of 480 VAC. Installation of sump pumps in safeguards alley could lessen the importance of this event. Installation of a flood barrier between the A and B-train 480 VAC switchgear rooms would prevent a loss of both buses if this event fails. Refer to SAMA items 176 and 177.
41	31-PM--CCW1A-PR	2.004e-003	2.576e-002	INDEPENDENT FAILURE COMPONENT COOLING PUMP A FTR	This basic event represents failure of the A-train CCW pump to run. SAMA items 58 and 59 would reduce the importance of this item.
42	IE-SOPORV	4.175e-002	2.556e-002	STUCK OPEN PORV INITIATING EVENT	The importance of this event is due to conservatism in modeling. The conservatism assumes that if offsite power is lost at any time within 24 hours following the initial stuck open PORV, then the diesel generator is needed to close the associated PORV lock valve. In actuality, however, PORV isolation must occur early in the event, typically in less than one hour. Unlike flooding events, a stuck open power operated relief valve (PORV) does not impair the electrical systems needed to close the block valve. Since more detailed modeling would remove this event from the importance, no SAMA items are generated from this basic event.

Table F-3. Basic Event Importance with Respect to Core Damage Frequency (Continued)

Item No.	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
43	IE-TSW	3.650e+002	2.525e-002	LOSS OF SERVICE WATER INITIATING EVENT	This basic event is a tag event that is attached to all cutsets representing a loss of service water initiating event. The basic event itself represents no physical failures. The importance of this initiating event is dominated by two failures; common cause failure of all service water pumps and low forebay level. Loss of all service water pumps is addressed by SAMA items 46 and 62. Low forebay level is a natural phenomenon. To compensate for low forebay level would require structural changes to the intake structure and engineering judgment indicates that the cost of such changes would greatly exceed the maximum benefit available.
44	10-GE-KPRCCF12	1.450e-003	2.442e-002	DOUBLE COMMON CAUSE FAILURE (CCF) EDGS FAIL TO RUN	A large part of the importance of this basic event is driven by the need to isolate flooding events (refer to item 2 above). This event is important to the KPS results because power is needed to operate the valves that are used to isolate many of the internal flooding initiating events. Failure of offsite power coupled with failure of the diesel-generator to operate causes the inability to isolate some flooding events. In actuality, however, flooding isolation must occur early in the event, typically in less than one hour. The ability to isolate flooding events without requiring power would greatly lower the importance of this event. Refer to SAMA item 168. Station blackout contributes 4.3% to overall core damage. Preventing failure of the diesel-generator would eliminate station blackout as a concern. Other means are available to mitigate station blackouts. Refer to SAMA items 55, 56, 58, 21, and 22.
45	IE-SB-403-U	4.470e-003	2.381e-002	MODERATE TRAIN B SW PIPE BREAKS IN ROOM 403 (Auxiliary building HVAC area)	This initiating event leads to core damage due to flood-induced failure of equipment needed to maintain RCP seal cooling, specifically, failure of MCCs 52E, 62E, and 62H. Loss of these MCCs leads to a loss of charging pumps and a loss of ventilation needed to ensure continued functioning of CCW pumps. Refer to SAMA item 169.
46	LERF-63	1.000e+000	2.359e-002	LARGE EARLY RELEASE FREQUENCY FOR PLANT DAMAGE STATE 63	This basic event is a flag-type of event used to facilitate the overall quantification and represents no physical failures. No SAMA items are generated as a result of this basic event.

Table F-3. Basic Event Importance with Respect to Core Damage Frequency (Continued)

Item No.	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
47	16-FNAKPRCCF23	1.730e-005	2.342e-002	DOUBLE COMMON CAUSE FAILURE (CCF) TBB A, B FCU FTR	This event represents common cause failure of the two fan cooling units for the switchgear rooms in safeguards alley. This event then results in failure of the AFW pumps and safety-related 480 VAC equipment. Provision of room temperature alarms or the ability to provide alternate room cooling for safeguards alley would lower the importance of this initiating event to overall core damage. Refer to SAMA items 170 and 171.
48	49-CB-KFOCCF12	3.730e-005	2.211e-002	DOUBLE COMMON CAUSE FAILURE (CCF) 49-C-KFOCCF12 (Reactor Trip Breakers)	This basic event occurs in ATWS sequences. KPS has implemented the WOG IPEOPs that direct mitigation of ATWS events. Since the failure probability for this basic event is based on generic data, hardware modifications related to reactor trip breakers would not result in a change to the failure probability. No issues specific to the KPS reactor trip breakers exist. Therefore, no SAMA items are generated as a result of this basic event.
49	IE-W--14B-U	1.510e-004	2.187e-002	MODERATE BREAK FROM AFW PIPE IN ROOM 14B (Auxiliary Building Basement)	This initiating event leads to core damage due to flood-induced failure of equipment needed to maintain RCP seal cooling and switch to ECCS recirculation, specifically, failure of MCCs 52E, 62E, and 62H. Loss of these MCCs leads to a loss of charging pumps, loss of the ability to switch to ECCS recirculation, and a loss of ventilation needed to ensure continued functioning of CCW pumps. Refer to SAMA item 169.
50	XEQN-AFWU14B	1.000e+000	2.173e-002	N/A – Automatically generated as part of the quantification process	This basic event is automatically generated as part of the quantification process and postulates that auxiliary feedwater fails as a result of the conditions represented in the event tree. Because the initiating event itself renders the AFW system nonfunctional, no SAMA items are generated.
51	LERF-45	1.000e+000	2.114e-002	LARGE EARLY RELEASE FREQUENCY FOR PLANT DAMAGE STATE 45	This basic event is a flag-type of event used to facilitate the overall quantification and represents no physical failures. No SAMA items are generated as a result of this basic event.
52	02-PMRKPRCCF1-4	3.220e-007	2.103e-002	GLOBAL COMMON CAUSE FAILURE OF SW PUMPS TO RUN	Loss of all service water pumps is addressed by SAMA items 46 and 62.

Table F-3. Basic Event Importance with Respect to Core Damage Frequency (Continued)

Item No.	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
53	02-SWHDRISOXPHE	1.707e-002	2.066e-002	OPERATOR FAILS TO ISOLATE MODERATE SW BREAK IN BATTERY RM	This basic event postulates failure of the operator actions to isolate a moderate service water break in a one battery room before the break propagates to the opposite battery room and causes failure of the 480 VAC MCC located there. These failures then result in a loss of all DC power. Installation of flood detection in the room could improve the cues available to the operators that a flood was occurring. See SAMA item 178.
54	05BPMSKPSCCF123	1.380e-004	2.064e-002	TRIPLE COMMON CAUSE FAILURE (CCF) AFW-1A/1B/TD PUMP START	Reducing the importance of this basic event requires either a reduction in the base failure rate of the pumps, a reduction in the common cause factors, or the addition of a redundant or diverse AFW pump. The failure data for KPS AFW pumps failing to start is about the same as generic industry data so it is unlikely that any efforts to reduce the base failure rate would result in a meaningful reduction. The common cause factors used are generic values taken from a standard industry source. No vulnerabilities related to common cause failure of the KPS AFW pumps have been identified so no actions to address the common cause factors would be applicable. The cost of adding a redundant or diverse AFW pump is judged to exceed the maximum available benefit. Therefore, no SAMA items are added as a result of this basic event.
55	IE-TMF	9.717e-002	2.014e-002	TRANSIENT INITIATING EVENT WITH A LOSS OF MAIN FEEDWATER	Accident sequences following a loss of main feedwater include failures of the AFW system and a subsequent failure to initiate bleed and feed cooling. Failures of the AFW system that contribute to TMF core damage sequences include loss of room cooling and common cause failure of the AFW pumps to start. These issues are addressed in items 18 and 54 above. Issues related to bleed and feed cooling are identified in item 27 above. No new SAMA items are identified to address the importance of this basic event.

Table F-3. Basic Event Importance with Respect to Core Damage Frequency (Continued)

Item No.	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
56	10-GE-DG1A---PS	6.724e-003	1.929e-002	DIESEL GENERATOR A INDEPENDENT FAILURE TO START	A large part of the importance of this basic event is driven by the need to isolate flooding events (refer to item 2 above). This event is important to the KPS results because power is needed to operate the valves that are used to isolate many of the internal flooding initiating events. Failure of offsite power coupled with failure of the diesel-generator to operate causes the inability to isolate some flooding events. In actuality, however, flooding isolation must occur early in the event, typically in less than one hour. The ability to isolate flooding events without requiring power would greatly lower the importance of this event. Refer to SAMA item 168. Station blackout contributes 4.3% to overall core damage. Preventing failure of the diesel-generator would eliminate station blackout as a concern. Other means are available to mitigate station blackouts. Refer to SAMA items 55, 56, 58, 21, and 22.
57	31-PM--CCW1B-PR	2.004e-003	1.926e-002	INDEPENDENT FAILURE COMPONENT COOLING PUMP B FTR	This basic event represents failure of the B-train CCW pump to run. SAMA items 58 and 59 would reduce the importance of this item.
58	STBY-CCWPB	5.000e-001	1.923e-002	COMPONENT COOLING PUMP B IS IN STANDBY	This basic event is a flag-type of event used to facilitate the overall quantification and represents no physical failures. No SAMA items are generated as a result of this basic event.
59	36--LHS-DEP--HE	1.000e-006	1.864e-002	OPERATOR ERRORS LEAD TO LOSS OFHEAT SINK	This basic event models operator errors that lead to a loss of secondary heat sink. It is assumed that any such errors will result in a loss of all secondary cooling and a loss of bleed and feed cooling with no chance of recovery. These assumptions are conservative. The already low value for this basic event and conservative nature of the assumptions used in its development indicate that removal of conservatisms from the analysis would likely reduce the importance of the event. Therefore, no SAMA items are developed to address the importance of this event.

Table F-3. Basic Event Importance with Respect to Core Damage Frequency (Continued)

Item No.	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
60	35--CH2------HE	1.162e-001	1.840e-002	OPERATOR FAILS TO ESTABLISH CHARGING FLOW DURING SBO	This event represents failure of the operator actions to establish charging flow using the TSC diesel as the power source during a station blackout. The importance of this event is because of the high failure probability. The high probability is because of the large number of actions needed to implement the charging with the TSC diesel. Reducing the number of actions required would require hardware changes. SAMA items 1 through 24 address improving the reliability of AC power. SAMA items 55 through 58 address reducing RCP seal LOCAs. No additional SAMA items identified as a result of this basic event.
61	IE-W-5B24-U	1.290e-004	1.766e-002	MODERATE BREAK FROM AFW PIPE IN ROOM AFW PUMP ROOMS	This initiating event leads to core damage when operator actions to isolate the AFW piping fail. Failure to isolate the pipe break causes a loss of the bottom row of circuit breakers on 480 VAC buses and a loss of bus 5. The probability of the operators failing to isolate the break is currently low so it is unlikely that any SAMAs could reduce them further. Because the event fails the AFW pumps, loss of secondary cooling dominates the event accident sequences and secondary cooling relies on main feedwater. Adding sump pumps to safeguards alley could eliminate the need to isolate AFW breaks prior to failing the 480 VAC breakers. Refer to SAMA item 176.
62	XEQN-AFAU-SA	1.000e+000	1.755e-002	N/A – Automatically generated as part of the quantification process	This basic event is automatically generated as part of the quantification process and indicates that auxiliary feedwater is a guaranteed failure as a result of the conditions represented in the event tree. Because the initiating event itself renders the AFW system nonfunctional, no SAMA items are generated.
63	SL76	8.000e-001	1.690e-002	SMALL REACTOR COOLANT PUMP SEAL LOCA (21,57,76 GPM)	The importance of RCP seal LOCAs is addressed by preventing the loss of seal cooling. SAMA item 58 addresses improved RCP seals.
64	05BFAFWB-CAL-AE	8.158e-004	1.686e-002	TECHNICIAN MISCALIBRATES AFW TRAIN A FLOW	Miscalibration of the AFW flow indication could lead the operators to mis-diagnose a loss of secondary heat sink and, in turn, fail to switch to bleed and feed cooling. Calibration procedures currently incorporate appropriate checks into the process. It is not likely that this failure probability could be reduced further by procedural changes. Hardware changes that add a diverse indicating circuit could reduce the importance of this event. Refer to SAMA item 179.

Table F-3. Basic Event Importance with Respect to Core Damage Frequency (Continued)

Item No.	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
65	05BFAFWA-CAL-AE	8.158e-004	1.686e-002	TECHNICIAN MISCALIBRATES AFW TRAIN B FLOW	Miscalibration of the AFW flow indication could lead the operators to mis-diagnose a loss of secondary heat sink and, in turn, fail to switch to bleed and feed cooling. Calibration procedures currently incorporate appropriate checks into the process. It is not likely that this failure probability could be reduced further by procedural changes. Hardware changes that add a diverse indicating circuit could reduce the importance of this event. Refer to SAMA item 179.
66	10-GE-DG1B---TM	1.184e-002	1.607e-002	DIESEL GENERATOR B UNAVAILABLE DUE TO TEST OR MAINTENANCE	A large part of the importance of this basic event is driven by the need to isolate flooding events (refer to item 2 above). This event is important to the KPS results because power is needed to operate the valves that are used to isolate many of the internal flooding initiating events. Failure of offsite power coupled with failure of the diesel-generator to operate causes the inability to isolate some flooding events. In actuality, however, flooding isolation must occur early in the event, typically in less than one hour. The ability to isolate flooding events without requiring power would greatly lower the importance of this event. Refer to SAMA item 168. Station blackout contributes 4.3% to overall core damage. Preventing failure of the diesel-generator would eliminate station blackout as a concern. Other means are available to mitigate station blackouts. Refer to SAMA items 55, 56, 58, 21, and 22.
67	IE-SLO	3.001e-003	1.589e-002	SMALL LOCA INITIATING EVENT	The frequency for this initiating event is taken from generic industry data. Any specific actions taken to lower this frequency would not make a statistically meaningful change in the overall frequency. Therefore, no SAMA items are identified to address the importance of this initiating event.
68	05BPMOKPSCCF123	1.050e-004	1.567e-002	TRIPLE COMMON CAUSE FAILURE (CCF) ALOP-1A/1B/1C PS (AFW pump auxiliary lube oil pumps)	Currently, the KPS AFW pumps will not start without adequate lube oil pressure that is provided by the auxiliary lube oil pumps. Removal of the interlock from the start circuitry would eliminate the need for the auxiliary lube oil pumps (ALOPs). Refer to SAMA item 180.
69	XCOM-CHSBO	8.139e-001	1.550e-002	N/A — Automatically generated as part of the quantification process	This item represents success of the charging top event in the SBO event trees and is generated as part of the quantification process. No SAMA items generated to address this basic event.

Table F-3. Basic Event Importance with Respect to Core Damage Frequency (Continued)

Item No.	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
70	33--2TRN-REC-HE	2.133e-002	1.531e-002	OPERATOR FAILS TO ESTABLISH RECIRC (1 OF 2 TRAINS)	Eliminating the operator actions required to switch to ECCS recirculation is addressed by SAMA item 32.
71	PORV-A	5.000e-001	1.471e-002	FRACTION OF STUCK OPEN PORVS ON PR-2A	This event is a scalar. No SAMA items identified to address the importance of this basic event.
72	LERF-10	1.000e+000	1.462e-002	LARGE EARLY RELEASE FREQUENCY FOR PLANT DAMAGE STATE 10	This basic event is a flag-type of event used to facilitate the overall quantification and represents no physical failures. No SAMA items are generated as a result of this basic event.
73	AC-0221	2.676e-001	1.462e-002	OFFSITE POWER NOT RECOVERED WITHIN 2 HOURS, 21 MINUTES	Items that address mitigating or recovering from a loss of offsite power are addressed by SAMA items 1 through 24, 55, and 58.
74	XEQN-LRWU14B	1.000e+000	1.433e-002	N/A — Automatically generated as part of the quantification process	This basic event is automatically generated as part of the quantification process and postultes that the event tree top event to switch to low-pressure recirculation fails as a result of the conditions represented in the event tree, failure of AFW piping in the auxiliary building basement. Equipment needed for low-pressure recirculation, specifically the CCW pumps and auxiliary building mezzanine cooling units, is failed by the flooding event. Low pressure recirculation is important primarily because failure of secondary cooling via AFW or MFW has necessitated the need for bleed and feed cooling and ECCS recirculation. Two approaches can be taken to minimize the importance of this operator action. The first is to lower the overall failure probability of the AFW system. The second is to protect equipment needed for ECCS recirculation from the effects of spray. Failure of the AFW system is caused by the initiating event which is a failure of the AFW piping. The analyis conservatively assumes that failure of the suction piping precludes use of the service water supply to the AFW pumps. Therefore, no items are identified to address improving AFW cooling for this initiating event. Potential improvements related to protecting auxiliary building equipment are addressed by items 173 and 175.

Table F-3. Basic Event Importance with Respect to Core Damage Frequency (Continued)

Item No.	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
75	XEQN-HRWU14B	1.000e+000	1.433e-002	N/A – Automatically generated as part of the quantification process	This basic event is automatically generated as part of the quantification process and indicates that the event tree top event to switch to high-pressure recirculation is a guaranteed failure as a result of the conditions represented in the event tree, failure of AFW piping in the auxiliary building basement. Equipment needed for low-pressure recirculation, specifically the CCW pumps and auxiliary building mezzanine cooling units, is failed by the flooding event. High pressure recirculation is important primarily because failure of secondary cooling via AFW or MFW has necessitated the need for bleed and feed cooling and ECCS recirculation. Two approaches can be taken to minimize the importance of this operator action. The first is to lower the overall failure probability of the AFW system. The second is to protect equipment needed for ECCS recirculation from the effects of spray. Failure of the AFW system is caused by the initiating event which is a failure of the AFW piping. The analysis conservatively assumes that failure of the suction piping precludes use of the service water supply to the AFW pumps. Therefore, no items are identified to address improving AFW cooling for this initiating event. Potential improvements related to protecting auxiliary building equipment are addressed by items 173 and 175.
76	02-SWHDRISOXTHE	5.802e-003	1.391e-002	OPERATOR FAILS TO ISOLATE A MODERATE. SW BREAK IN SAFEGUARDS ALLEY BEFORE BUS FAILURE	Adding larger sump pumps to safeguards alley could eliminate the need to isolate some pipe breaks. Refer to SAMA item 176.
77	IE-S-5B14-M	1.050e-006	1.358e-002	MAJOR SERVICE WATER BREAK IN SAFEGUARDS ALLEY	This initiating event is assumed to fail all equipment located in safeguards alley, thereby leading directly to core damage. Installation a sturdy watertight barrier between the two 480 VAC switchgear rooms could allow one train of equipment to remain available. Refer to SAMA item 177.

Table F-3. Basic Event Importance with Respect to Core Damage Frequency (Continued)

Item No.	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
78	34--RHR------HE	8.235e-002	1.350e-002	OPERATOR FAILS TO ESTABLISH RHR	Operator action to establish RHR cooling can be used to compensate for a loss of secondary cooling due to depletion of CST inventory. Establishing RHR cooling requires a cooldown of the RCS and then placing the RHR system in service. Given the time required for cooldown and the actions required to place RHR in service, it is unlikely that any actions to reduce the failure probability of this event would be meaningful. Providing a larger CST is addressed in SAMA item 71.
79	LERF-26	1.000e+000	1.230e-002	LARGE EARLY RELEASE FREQUENCY FOR PLANT DAMAGE STATE 26	This basic event is a flag-type of event used to facilitate the overall quantification and represents no physical failures. No SAMA items are generated as a result of this basic event.
80	IE-VEF	9.511e-007	1.230e-002	VESSEL FAILURE INITIATING EVENT	This event leads directly to core damage and the initiating event frequency is taken from generic industry data. No SAMA items generated to address the importance of this item.
81	IE-SB-14B-S	1.550e-003	1.228e-002	SMALL BREAK FROM SERVICE WATER TRAIN B PIPE IN ROOM 14B (Auxiliary Building Basement)	This initiating event leads to core damage due to flood-induced failure of equipment needed to maintain RCP seal cooling and switch to ECCS recirculation, specifically, failure of MCCs 52E, 62E, and 62H. Loss of these MCCs leads to a loss of charging pumps, loss of the ability to switch to ECCS recirculation, and a loss of ventilation needed to ensure continued functioning of CCW pumps. Refer to SAMA item 169.
82	IE-SB-3B--M	1.510e-005	1.207e-002	MAJOR BREAK FROM TRAIN B SERVICE WATER PIPE IN ROOM 3B (Train B diesel and switchgear room)	A major rupture of the B-train service water pipe in the B-train switchgear room causes a loss of the B-train switchgear and leads to a loss of offsite power. The dominant contributors to accident sequences following this event are failures of the A-train diesel. Providing a path for water to leave the room before level reaches 18-inches would preclude a loss of offsite power and minimize the need for the A-train diesel-generator. Refer to SAMA item 181.

Table F-3. Basic Event Importance with Respect to Core Damage Frequency (Continued)

Item No.	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
83	02-SWHDRISOXAHE	1.000e+000	1.199e-002	OPERATOR FAILS TO ISOLATE MAJOR SW REAK IN DG B ROOM	This event is assumed failed because of the short time available to perform it. A major rupture of the B-train service water pipe in the B-train switchgear room causes a loss of the B-train switchgear and leads to a loss of offsite power. The dominant contributors to accident sequences following this event are failures of the A-train diesel. Providing a path for water to leave the room before level reaches 18-inches would preclude a loss of offsite power and minimize the need for the A-train diesel-generator. Refer to SAMA item 181.
84	IE-W-5B24-S	2.340e-004	1.171e-002	SMALL BREAK FROM AFW PIPE IN ROOM AFW PUMP ROOMS	This initiating event leads to core damage when operator actions to isolate the AFW piping fail. Failure to isolate the pipe break causes a loss of the bottom row of circuit breakers on 480 VAC buses. The probability of the operators failing to isolate the break is currently low so it is unlikely that any SAMAs could reduce them further. Because the event fails the AFW pumps, loss of secondary cooling dominates the event accident sequences and secondary cooling relies on main feedwater. Adding sump pumps to safeguards alley could eliminate the need to isolate AFW breaks prior to failing the 480 VAC breakers. Refer to SAMA item 176.
85	XEQN-AFAS-SA	1.000e+000	1.150e-002	N/A – Automatically generated as part of the quantification process	This basic event is automatically generated as part of the quantification process and indicates that auxiliary feedwater is a guaranteed failure as a result of the conditions represented in the event tree. Because the initiating event itself renders the AFW system nonfunctional, no SAMA items are generated.
86	SL182	1.975e-001	1.146e-002	MEDIUM REACTOR COOLANT PUMP SEAL LOCA (182 GPM)	The importance of RCP seal LOCAs is addressed by preventing the loss of seal cooling. SAMA item 58 addresses improved RCP seals.
87	05B-AFW-ISO-7-HE	6.499e-003	1.115e-002	FAIL TO ISOLATE MOD AFW BREAK BEFORE BUS FAILURE	Failure to isolate the pipe break causes a loss of the bottom row of circuit breakers on 480 VAC buses and a loss of bus 5. The probability of the operators failing to isolate the break is currently low so it is unlikely that any SAMAs could reduce them further. Adding sump pumps to safeguards alley could eliminate the need to isolate AFW breaks prior to failing the 480 VAC breakers. Refer to SAMA item 176.

Table F-3. Basic Event Importance with Respect to Core Damage Frequency (Continued)

Item No.	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
88	IE-SB-5B1-S	1.000e-003	1.113e-002	TRAIN B SW FLOOD IN ROOM 5B-1 WITHIN DRAIN CAPACITY (B-train 480 VAC switchgear room)	This initiating event leads to core damage due to flood-induced failure of equipment mitigate the event. Predominantly, accident sequences that lead to core damage are caused by a failure to isolate the break before the volume of water released would cause a loss of both trains of 480 VAC. Installation of sump pumps in safeguards alley could lessen the importance of this event. Installation of a flood barrier between the A and B-train 480 VAC switchgear rooms would prevent a loss of both buses if this event fails. Refer to SAMA items 176 and 177.
89	IE-SA-129-U	4.610e-005	1.112e-002	TRAIN A SW FLOOD IN ROOM 129 EXCEEDS DRAIN CAPACITY (A-train battery room)	This initiating event results in core damage when operator actions to isolate the break before propagation to the opposite battery room fail. Then propagation causes failure of the 480 VAC MCC located there. These failures then result in a loss of all DC power. Installation of flood detection in the room could improve the cues available to the operators that a flood was occurring. See SAMA item 178.
90	16-FN-DGAF---PS	3.940e-003	1.107e-002	INDEPENDENT FAILURE DIESEL ROOM A SUPPLY FAN FTS	A large part of the importance of this basic event is driven by the need to isolate flooding events (refer to item 2 above). This event is important to the KPS results because power is needed to operate the valves that are used to isolate many of the internal flooding initiating events. Failure of offsite power coupled with failure of the diesel-generator to operate causes the inability to isolate some flooding events. In actuality, however, flooding isolation must occur early in the event, typically in less than one hour. The ability to isolate flooding events without requiring power would greatly lower the importance of this event. Refer to SAMA item 168. Station blackout contributes 4.3% to overall core damage. Preventing failure of the diesel-generator would eliminate station blackout as a concern. Other means are available to mitigate station blackouts. Refer to SAMA items 55, 56, 58, 21, and 22.
91	36--RXCPSTOP-HE	6.659e-003	1.094e-002	OPERATOR FAILS TO STOP RXCPS	Failure to stop RCPs on a loss of seal cooling is assumed to result in a large seal LOCA. Actions to trip the RCPs occur early in the abnormal procedures. The importance of RCP seal LOCAs is addressed by preventing the loss of seal cooling. SAMA item 58 addresses improved RCP seals.

Table F-3. Basic Event Importance with Respect to Core Damage Frequency (Continued)

Item No.	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
92	XEQN-MFSUA129	1.000e+000	1.087e-002	N/A – Automatically generated as part of the quantification process	This basic event is automatically generated as part of the quantification process and postulates that main feedwater fails as a result of the conditions represented in the event tree. Because the initiating event itself renders the MFW system nonfunctional, no SAMA items are generated.
93	PORV-B	5.000e-001	1.086e-002	FRACTION OF STUCK OPEN PORVS ON PR-2B	This event is a scalar. No SAMA items identified to address the importance of this basic event.
94	XEQN-CCB156S	1.000e+000	1.081e-002	N/A – Automatically generated as part of the quantification process	This basic event is automatically generated as part of the quantification process and postulates that component cooling water fails as a result of the conditions represented in the event tree. Equipment needed for CCW operation, specifically the CCW pumps and auxiliary building mezzanine cooling units, is failed by the flooding event. CCW operation is important primarily because the charging pumps are failed due to propagation of the flood to the auxiliary building basement. Potential improvements related to protecting auxiliary building equipment are addressed by items 173 and 175.
95	IE-SB-22B2U	7.940e-004	1.054e-002	MODERATE BREAK FROM TRAIN B SERVICE WATER PIPE IN SCREENHOUSE	This event is important because failure to isolate the break in a timely manner leads to flooding the switchgear rooms. Installation of a drainage path from the screenhouse to the lake would eliminate the need for isolation. See SAMA item 182.
96	IE-TIA	3.650e+002	1.037e-002	LOSS OF INSTRUMENT AIR INITIATING EVENT	This basic event is a tag event that is attached to all cutsets representing a loss of instrument air initiating event. The basic event itself represents no physical failures. The importance of this initiating event is driven by sequences where failure of room cooling causes a loss of AFW pumps. The ability to provide alternate room cooling for safeguards alley would lower the importance of this initiating event to overall core damage. Refer to SAMA items 170 and 171. Improving the reliability of the air compressors could improve the reliability of the air system. Refer to SAMA items 86 and 87.

Table F-3. Basic Event Importance with Respect to Core Damage Frequency (Continued)

Item No.	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
97	IE-SB-130-U	4.390e-005	1.033e-002	TRAIN B SW FLOOD IN ROOM 130 EXCEEDS RAIN CAPACITY (B-train battery room)	This initiating event results in core damage when operator actions to isolate the break before propagation to the opposite battery room fail. Then propagation causes failure of the 480 VAC MCC located there. These failures then result in a loss of all DC power. Installation of flood detection in the room could improve the cues available to the operators that a flood was occurring. See SAMA item 178.
98	10-GE-DG1B---PS	6.724e-003	1.002e-002	DIESEL GENERATOR B INDEPENDENT FAILURE TO START	A large part of the importance of this basic event is driven by the need to isolate flooding events (refer to item 2 above). This event is important to the KPS results because power is needed to operate the valves that are used to isolate many of the internal flooding initiating events. Failure of offsite power coupled with failure of the diesel-generator to operate causes the inability to isolate some flooding events. In actuality, however, flooding isolation must occur early in the event, typically in less than one hour. The ability to isolate flooding events without requiring power would greatly lower the importance of this event. Refer to SAMA item 168. Station blackout contributes 4.3% to overall core damage. Preventing failure of the diesel-generator would eliminate station blackout as a concern. Other means are available to mitigate station blackouts. Refer to SAMA items 55, 56, 58, 21, and 22.
99	IE-SB-3B--U	1.230e-004	9.770e-003	MODERATE BREAK FROM TRAIN B SERVICE WATER PIPE IN ROOM 3B (Train B diesel and switchgear room)	A moderate rupture of the B-train service water pipe in the B-train switchgear room causes a loss of the B-train switchgear and leads to a loss of offsite power if the break is not isolated before water level in the room reaches 18-inches. The dominant contributors to accident sequences following this event are failures of the A-train diesel. Providing a path for water to leave the room before level reaches 18-inches would preclude a loss of offsite power and minimize the need for the A-train diesel-generator. Refer to SAMA item 181.

Table F-3. Basic Event Importance with Respect to Core Damage Frequency (Continued)

Item No.	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
100	02-SWHDRISOX1HE	3.827e-004	9.614e-003	OPERATOR FAILS TO ISOLATE A SMALL SERVICE WATER BREAK IN SAFEGUARDS ALLEY	This operator action initiating event leads to core damage due to flood-induced failure of equipment needed to mitigate the event, specifically, failure to isolate the break before the volume of water released would cause a loss of both trains of 480 VAC. Installation of sump pumps in safeguards alley could lessen the importance of this event. Installation of a flood barrier between the A and B-train 480 VAC switchgear rooms would prevent a loss of both buses if this event fails. Refer to SAMA items 176 and 177.
101	31-PM--CCW1A-TM	4.820e-003	9.404e-003	COMPONENT COOLING PUMP A UNAVAILABLE DUE TO TEST OR MAINTENANCE	SAMA items 58 and 59 would reduce the importance of this item.
102	10-GE-DG1A---FL	3.363e-003	9.366e-003	INDEPENDENT FAILURE DIESEL GENERATOR A FAILS TO LOAD	A large part of the importance of this basic event is driven by the need to isolate flooding events (refer to item 2 above). This event is important to the KPS results because power is needed to operate the valves that are used to isolate many of the internal flooding initiating events. Failure of offsite power coupled with failure of the diesel-generator to operate causes the inability to isolate some flooding events. In actuality, however, flooding isolation must occur early in the event, typically in less than one hour. The ability to isolate flooding events without requiring power would greatly lower the importance of this event. Refer to SAMA item 168. Station blackout contributes 4.3% to overall core damage. Preventing failure of the diesel-generator would eliminate station blackout as a concern. Other means are available to mitigate station blackouts. Refer to SAMA items 55, 56, 58, 21, and 22.
103	27A-RMST-CST-HE	1.237e-003	9.264e-003	OPERATOR FAILS TO CROSS-TIE CSTS AND RMSTS	Operator action to cross-tie the reactor makeup storage tanks (RMSTs) to the CSTs is used to prevent a loss of secondary cooling due to depletion of CST inventory. Providing a larger CST is addressed in SAMA item 71.
104	02-SWHDRISOXEHE	1.156e-002	9.188e-003	OPERATOR FAILS TO ISOLATE MAJOR SW BREAK IN SCREENHOUSE	This event is important because failure to isolate the break in a timely manner leads to flooding the switchgear rooms. Installation of a drainage path from the screenhouse to the lake would eliminate the need for isolation. See SAMA item 182.

Table F-3. Basic Event Importance with Respect to Core Damage Frequency (Continued)

Item No.	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
105	05BPT--AFW1C-TM	3.930e-003	9.185e-003	TD AFW PUMP UNAVAILABLE DUE TO TEST OR MAINTENANCE	The importance of the turbine-driven AFW pump is caused mainly by loss of room cooling inducing failure of the motor-driven AFW pumps. The loss of room cooling could be caused directly by a loss of the coolers or by flood-induced failure of the power supplies. Instituting measures to ensure adequate room cooling to safeguards alley after a loss of room cooling would lower the importance of the turbine-driven AFW pump. The ability to provide alternate room cooling for safeguards alley would lower the importance of this initiating event to overall core damage. Refer to SAMA items 170 and 171.
106	IE-SB-5B3-U	1.100e-004	9.085e-003	MODERATE TRAIN B SW PIPE BREAKS IN ROOM 5B-3 (B-train AFW pump room)	This initiating event leads to core damage due to flood-induced failure of equipment mitigate the event. Predominantly, accident sequences that lead to core damage are caused by a failure to isolate the break before the volume of water released would cause a loss of both trains of 480 VAC. Installation of sump pumps in safeguards alley could lessen the importance of this event. Installation of a flood barrier between the A and B-train 480 VAC switchgear rooms would prevent a loss of both buses if this event fails. Refer to SAMA items 176 and 177.
107	02-SWHDRISOX0HE	9.152e-002	8.930e-003	OPERATOR FAILS TO ISOLATE A MOD. SW BREAK IN DG B ROOM	A moderate rupture of the B-train service water pipe in the B-train switchgear room causes a loss of the B-train switchgear and leads to a loss of offsite power if the break is not isolated before water level in the room reaches 18-inches. The dominant contributors to accident sequences following this event are failures of the A-train diesel. Providing a path for water to leave the room before level reaches 18-inches would preclude a loss of offsite power and minimize the need for the A-train diesel-generator. Refer to SAMA item 181.
108	IE-SB-5B--S	8.650e-004	8.904e-003	SMALL TRAIN B SW PIPE BREAKS IN ROOM 5B (A-train 480 VAC room)	This initiating event leads to core damage due to flood-induced failure of equipment mitigate the event. Predominantly, accident sequences that lead to core damage are caused by a failure to isolate the break before the volume of water released would cause failure of other equipment needed to mitigate the event. Installation of sump pumps in safeguards alley could lessen the importance of this event. Refer to SAMA item 176.

Table F-3. Basic Event Importance with Respect to Core Damage Frequency (Continued)

Item No.	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
109	49-ROD-MECH--FA	1.800e-006	8.590e-003	CONTROL RODS FAIL TO DROP INTO THE CORE	The reason that this basic event is important to core damage is a modeling assumption that any failure to scram following an internal flooding event will lead to core damage. More detailed modeling would result in decreased importance. Therefore, no SAMA items were identified as a result of this event.
110	36--SGTRDIAG-HE	1.123e-003	8.582e-003	OPERATOR FAILS TO DIAGNOSE SGTR	This event is important to core damage because of failure of the operator actions required to mitigate the event. The actions modeled are from emergency operating procedures developed from standard Westinghouse Owners Group guidance. No weaknesses in the procedures have been identified in these procedures. Therefore, hardware modifications would be required to reduce the importance of this event further. SAMA items 122, 124, 125, 126, and 129 have been identified to address SGTRs.
111	IE-F--2B--M	1.120e-005	8.439e-003	MAJOR BREAK FROM FIRE PROTECTION WATER PIPE IN ROOM 2B (Train A diesel and switchgear room)	A major rupture of the fire protection water pipe in the A-train switchgear room causes a loss of the A-train switchgear and leads to a loss of offsite power. The dominant contributors to accident sequences following this event are failures of the B-train diesel. Providing a path for water to leave the room before level reaches 18-inches would preclude a loss of offsite power and minimize the need for the B-train diesel-generator. Refer to SAMA item 181.
112	16-FNDKPSCCF12	5.120e-004	8.436e-003	DOUBLE COMMON CAUSE FAILURE (CCF) DG1A/1B FF	Items to address ventilation are addressed by SAMA items 80 through 83.
113	IE-SB-5B3-S	8.050e-004	8.420e-003	SMALL TRAIN B SW PIPE BREAKS IN ROOM 5B-3 (B-train AFW pump room)	This initiating event leads to core damage due to flood-induced failure of equipment to mitigate the event. Predominantly, accident sequences that lead to core damage are caused by a failure to isolate the break before the volume of water released would cause a loss of both trains of 480 VAC. Installation of sump pumps in safeguards alley could lessen the importance of this event. Refer to SAMA item 176.
114	04--LO-LEVEL-FB	5.140e-004	8.407e-003	LOW FOREBAY LEVEL	Low forebay level is a natural phenomenon. To compensate for low forebay level would require structural changes to the intake structure and engineering judgment indicates that the cost of such changes would greatly exceed the maximum benefit available.

Table F-3. Basic Event Importance with Respect to Core Damage Frequency (Continued)

Item No.	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
115	16-DM-TAV63A-FO	3.000e-003	8.322e-003	DAMPER TAV-63A FAILS TO OPEN	Items to address ventilation are addressed by SAMA items 80 through 83.
116	16-DM-TAV60A-FO	3.000e-003	8.322e-003	DAMPER TAV-60A FAILS TO OPEN	Items to address ventilation are addressed by SAMA items 80 through 83.
117	AC-1632	2.743e-002	8.312e-003	OFFSITE POWER NOT RECOVERED WITHIN 16 HOURS, 32 MINUTES	Items that address mitigating or recovering from a loss of offsite power are addressed by SAMA items 1 through 24, 55, and 58.
118	IE-SA-2B--M	1.080e-005	8.169e-003	MAJOR BREAK FROM A-TRAIN SERVICE WATER PIPE IN ROOM 2B (Train A diesel and switchgear room)	A major rupture of the A-train service water pipe in the A-train switchgear room causes a loss of the A-train switchgear and leads to a loss of offsite power. The dominant contributors to accident sequences following this event are failures of the B-train diesel. Providing a path for water to leave the room before level reaches 18-inches would preclude a loss of offsite power and minimize the need for the B-train diesel-generator. Refer to SAMA item 181.
119	06--OC2------HE	4.722e-002	8.092e-003	OPERATOR FAILS TO COOLDOWN AND DEPRESSURIZE RCS FOR CHARGING	Success of this operator action obviates the need for ECCS recirculation after a small LOCA. The importance of this event is caused by two things. The first is placing the cooldown event prior to the ECCS recirculation node on the small LOCA event tree. The second factor is the number of procedure steps that take place prior to initiating cooldown. The procedure steps are based on standard WOG guidance. Items that improve the reliability of ECCS recirculation could reduce the importance of this event. Refer to SAMA item 32.
120	02-SWHDRISOX7HE	1.000e+000	8.052e-003	OPERATOR FAILS TO ISOLATE A MAJOR SERVICE WATER BREAK IN DG A ROOM	A major rupture of the A-train service water pipe in the A-train switchgear room causes a loss of the A-train switchgear and leads to a loss of offsite power. The dominant contributors to accident sequences following this event are failures of the B-train diesel. Providing a path for water to leave the room before level reaches 18-inches would preclude a loss of offsite power and minimize the need for the B-train diesel-generator. Refer to SAMA item 181.
121	LERF-32	1.000e+000	7.631e-003	LARGE EARLY RELEASE FREQUENCY FOR PLANT DAMAGE STATE 32	This basic event is a flag-type of event used to facilitate the overall quantification and represents no physical failures. No SAMA items are generated as a result of this basic event.

Table F-3. Basic Event Importance with Respect to Core Damage Frequency (Continued)

Item No.	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
122	07-MV-KFCCCF1-4	4.930e-005	7.262e-003	GLOBAL COMMON CAUSE FAILURE OF BLOWDOWN ISOLATION VALVES	Failure of these valves causes a depletion of water needed to maintain secondary cooling. Providing a larger CST is addressed in SAMA item 71.
123	IE-SA-14B-S	1.450e-003	7.243e-003	SMALL BREAK FROM SERVICE WATER TRAIN A PIPE IN ROOM 14B (Auxiliary Building Basement)	This initiating event leads to core damage due to flood-induced failure of equipment needed to maintain RCP seal cooling and switch to ECCS recirculation, specifically, failure of MCCs 52E, 62E, and 62H. Loss of these MCCs leads to a loss of charging pumps, loss of the ability to switch to ECCS recirculation, and a loss of ventilation needed to ensure continued functioning of CCW pumps. Refer to SAMA item 169.
124	IE-SB-156-U	4.030e-004	7.039e-003	MODERATE TRAIN B SW PIPE BREAKS IN ROOM 156 (Aux Building Mezzanine)	This initiating event leads to core damage due to flood-induced failure of equipment needed to maintain RCP seal cooling, specifically, failure of MCCs 52E, 62E, and 62H. Loss of these MCCs leads to a loss of charging pumps and a loss of ventilation needed to ensure continued functioning of CCW pumps. Refer to SAMA item 169.
125	27A-OR2----LDHE	1.511e-001	6.951e-003	OPERATOR FAILS TO LIMIT SI FLOW AND REFILL RWST – SLO	This basic event represents execution failures of the actions to provide RWST makeup to ensure continued ECCS injection. These actions occur after a successful diagnosis of the need for the actions. Potential improvements related to switchover to ECCS recirculation are addressed by items 31 and 32. Successful ECCS recirculation obviates the need to provide RWST makeup. Provision of an additional means to refill the RWST would likely be of little value to reducing the importance of this basic event because the event represents failure in the execution phase of the action, after a successful diagnosis.

Table F-3. Basic Event Importance with Respect to Core Damage Frequency (Continued)

Item No.	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
126	10-GE-KPSCCF12	4.070e-004	6.656e-003	DOUBLE COMMON CAUSE FAILURE (CCF) EDGS FAIL TO START	A large part of the importance of this basic event is driven by the need to isolate flooding events (refer to item 2 above). This event is important to the KPS results because power is needed to operate the valves that are used to isolate many of the internal flooding initiating events. Failure of offsite power coupled with failure of the diesel-generator to operate causes the inability to isolate some flooding events. In actuality, however, flooding isolation must occur early in the event, typically in less than one hour. The ability to isolate flooding events without requiring power would greatly lower the importance of this event. Refer to SAMA item 168. Station blackout contributes 4.3% to overall core damage. Preventing failure of the diesel-generator would eliminate station blackout as a concern. Other means are available to mitigate station blackouts. Refer to SAMA items 55, 56, 58, 21, and 22.
127	STBY-ABBFD	5.000e-001	6.602e-003	AUX BLDG BASEMENT FAN COIL UNIT D IS IN STANDBY	This basic event is a flag-type of event used to facilitate the overall quantification and represents no physical failures. No SAMA items are generated as a result of this basic event.
128	IE-SA-301-U	2.110e-003	6.456e-003	MODERATE TRAIN A SW PIPE BREAKS IN ROOM 301 (Control Room HVAC)	This initiating event causes a loss of main feedwater because there is no means to detect pipe failures in the room before water would rise to a level that would fail the door. Installation of flood detection instruments in the room could provide a means to detect and isolate a pipe break before MFW would be lost. Refer to SAMA item 183.
129	06--IS2------HE	4.280e-003	6.379e-003	OPERATOR FAILS TO ISOLATE 1 OF 2 STEAM GENERATORS	This basic event represents failure of operator action to isolate the steam generators after a steam generator tube rupture. The actions modeled are from emergency operating procedures developed from standard Westinghouse Owners Group guidance. No weaknesses in the procedures have been identified in these procedures. Therefore, hardware modifications would be required to reduce the importance of this event further. SAMA items 122, 124, 125, 126, and 129 have been identified to address SGTRs.

Table F-3. Basic Event Importance with Respect to Core Damage Frequency (Continued)

Item No.	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
130	IE-SB-3B--S	8.440e-004	6.204e-003	SMALL BREAK FROM TRAIN B SERVICE WATER PIPE IN ROOM 3B (Train B diesel and switchgear room)	A small rupture of the B-train service water pipe in the B-train switchgear room causes a loss of the B-train switchgear and leads to a loss of offsite power if the break is not isolated before water level in the room reaches 18-inches. The dominant contributors to accident sequences following this event are failures of the A-train diesel. Providing a path for water to leave the room before level reaches 18-inches would preclude a loss of offsite power and minimize the need for the A-train diesel-generator. Refer to SAMA item 181.
131	IE-SB-22B2M	1.340e-005	6.192e-003	MAJOR BREAK FROM TRAIN B SERVICE WATER PIPE IN SCREENHOUSE	This event is important because failure to isolate the break in a timely manner leads to flooding the switchgear rooms. Installation of a drainage path from the screenhouse to the lake would eliminate the need for isolation. See SAMA item 182.
132	27A-OR2------HE	9.625e-002	6.080e-003	OPERATOR FAILS TO LIMIT SI FLOW AND REFILL RWST	This basic event represents execution failures of the actions to provide RWST makeup to ensure continued ECCS injection. These actions occur after a successful diagnosis of the need for the actions. Potential improvements related to switchover to ECCS recirculation are addressed by SAMA items 31 and 32. Successful ECCS recirculation obviates the need to provide RWST makeup. Provision of an additional means to refill the RWST would likely be of little value to reducing the importance of this basic event because the event represents failure in the execution phase of the action, after a successful diagnosis.
133	IE-TDA	3.650e+002	6.077e-003	LOSS OF TRAIN A DC POWER INITIATING EVENT	This basic event is a tag event that is attached to all cutsets representing a loss of train A DC power initiating event. The basic event itself represents no physical failures. The importance of this initiating event is driven by sequences where failure of room cooling causes a loss of AFW pumps and other equipment located in safeguards alley and subsequences where a long-term source of water to AFW pump suction is not available. The ability to provide alternate room cooling for safeguards alley would lower the importance of this initiating event to overall core damage. Refer to SAMA items 170 and 171. Additional alarms to indicate CST depletion, an automatic switchover to an alternate water source, or larger CSTs would lower the importance of this event. Refer to SAMA items 172, 71, and 66.

Table F-3. Basic Event Importance with Respect to Core Damage Frequency (Continued)

Item No.	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
134	LERF-11	1.000e+000	5.959e-003	LARGE EARLY RELEASE FREQUENCY FOR PLANT DAMAGE STATE 11	This basic event is a flag-type of event used to facilitate the overall quantification and represents no physical failures. No SAMA items are generated as a result of this basic event.
135	IE-SLB	9.000e-003	5.738e-003	STEAM OR FEEDWATER LINE BREAK INITIATING EVENT	This basic event is important because of the PRA models conservatively assume that all breaks are large enough to require immediate isolation to prevent core steam blowdown. However, many of the breaks included in the data used to develop this initiating event frequency would not result in steam generator blowdown for many minutes. Therefore, a more realistic modeling of this event would result in a lower importance for this event. Therefore, no SAMA items are developed from this basic event.
136	LERF-41	1.000e+000	5.666e-003	LARGE EARLY RELEASE FREQUENCY FOR PLANT DAMAGE STATE 41	This basic event is a flag-type of event used to facilitate the overall quantification and represents no physical failures. No SAMA items are generated as a result of this basic event.
137	16-FN-DGBF---PS	3.940e-003	5.648e-003	INDEPENDENT FAILURE DIESEL ROOM B SUPPLY FAN FTS	A large part of the importance of this basic event is driven by the need to isolate flooding events (refer to item 2 above). This event is important to the KPS results because power is needed to operate the valves that are used to isolate many of the internal flooding initiating events. Failure of offsite power coupled with failure of the diesel-generator to operate causes the inability to isolate some flooding events. In actuality, however, flooding isolation must occur early in the event, typically in less than one hour. The ability to isolate flooding events without requiring power would greatly lower the importance of this event. Refer to SAMA item 168. Items related to ventilation are identified in SAMA items 80 through 83.
138	08-FPHDRISOX9HE	4.088e-004	5.609e-003	OPERATOR FAILS TO ISOLATE A MAJOR FIRE PROTECTION BREAK IN SCREENHOUSE	This event is important because failure to isolate the break in a timely manner leads to flooding the switchgear rooms. Installation of a drainage path from the screenhouse to the lake would eliminate the need for isolation. See SAMA item 182.
139	AC-0715	7.643e-002	5.557e-003	OFFSITE POWER NOT RECOVERED WITHIN 7 HOURS, 15 MINUTES	Items that address mitigating or recovering from a loss of offsite power are addressed by SAMA items 1 through 24, 55, and 58.

Table F-3. Basic Event Importance with Respect to Core Damage Frequency (Continued)

Item No.	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
140	33--ORI------HE	1.499e-002	5.528e-003	OPERATOR FAILS TO RESTORE RCS INVENTORY AFTER SBO	The need to restore RCS inventory after a station blackout is due to the loss of inventory through the RCP seals. The importance of RCP seal LOCAs is addressed by preventing the loss of seal cooling. SAMA item 58 addresses improved RCP seals.
141	02-AVSW301A--FO	2.168e-003	5.512e-003	INDEPENDENT FAILURE AOV SW-301A FAILS TO OPEN (DG A cooling water)	A large part of the importance of this basic event is driven by the need to isolate flooding events (refer to item 2 above). This event is important to the KPS results because power is needed to operate the valves that are used to isolate many of the internal flooding initiating events. Failure of offsite power coupled with failure of the diesel-generator to operate causes the inability to isolate some flooding events. In actuality, however, flooding isolation must occur early in the event, typically in less than one hour. The ability to isolate flooding events without requiring power would greatly lower the importance of this event. Refer to SAMA item 168. Station blackout contributes 4.3% to overall core damage. Preventing failure of the diesel-generator would eliminate station blackout as a concern. Other means are available to mitigate station blackouts. Refer to SAMA items 55, 56, 58, 21, and 22.
142	IE-F--4B--M	6.930e-006	5.502e-003	MAJOR FIRE PROTECTION PIPE BREAK IN ROOM 4B (CarDox room)	A major fire protection pipe break in the CarDox room rapidly propagates to the B-train switchgear room and causes a loss of offsite power. The dominant accident sequences for this event involve failure of the A-train diesel-generator thereby resulting in a station blackout. The KPS PRA models assume that any internal flooding event that results in a station blackout results in core damage. However, detailed evaluation of station blackout events would likely show that some mitigation of flood-induced station blackouts could occur, thereby decreasing the importance of this event. Since this event is of low importance and more detailed modeling of existing procedures and equipment would lessen the importance, no SAMA items are developed from this event.

Table F-3. Basic Event Importance with Respect to Core Damage Frequency (Continued)

Item No.	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
143	08-FPHDRISOX8HE	1.000e+000	5.499e-003	OPERATOR FAILS TO ISOLATE A MAJOR FIRE PROTECTION BREAK IN ROOM 4B (CarDox room)	A major fire protection pipe break in the CarDox room rapidly propagates to the B-train switchgear room and causes a loss of offsite power. The dominant accident sequences for this event involve failure of the A-train diesel-generator thereby resulting in a station blackout. The KPS PRA models assume that any internal flooding event that results in a station blackout results in core damage. However, detailed evaluation of station blackout events would likely show that some mitigation of flood-induced station blackouts could occur, thereby decreasing the importance of this event. Since this event is of low importance and more detailed modeling of existing procedures and equipment would lessen the importance, no SAMA items are developed from this event.
144	IE-F--22B2M	1.850e-004	5.474e-003	MAJOR BREAK FROM FIRE PROTECTION WATER PIPE IN SCREENHOUSE	This event is important because failure to isolate the break in a timely manner leads to flooding the switchgear rooms. Installation of a drainage path from the screenhouse to the lake would eliminate the need for isolation. See SAMA item 182.
145	05BMVI-MS102-FO	2.375e-003	5.415e-003	MOV MS-102 FAILS TO OPEN (Steam supply to TDAFWP)	The importance of the turbine-driven AFW pump is caused mainly by loss of room cooling inducing failure of the motor-driven AFW pumps. The loss of room cooling could be caused directly by a loss of the coolers or by flood-induced failure of the power supplies. Instituting measures to ensure adequate room cooling to safeguards alley after a loss of room cooling would lower the importance of the turbine-driven AFW pump. The ability to provide alternate room cooling for safeguards alley would lower the importance of this initiating event to overall core damage. Refer to SAMA items 170 and 171.
146	02-MV-SW10A--FC	1.905e-003	5.191e-003	MOV SW-10A FAILS TO CLOSE (Auxiliary Building A-train Header Isolation Valve)	This event is important to core damage because of the need to isolate internal flooding events before flood-induced failure of equipment needed to maintain RCP seal cooling, specifically, failure of MCCs 52E, 62E, and 62H. Loss of these MCCs leads to a loss of charging pumps and a loss of ventilation needed to ensure continued functioning of CCW pumps. Refer to SAMA item 169.

Table F-3. Basic Event Importance with Respect to Core Damage Frequency (Continued)

Item No.	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
147	UET-2PORVS	1.620e-001	5.177e-003	UNFAVORABLE EXPOSURE TIME FOR 2 PORVS AVAILABLE	The numerical value of this event is the fraction of core life during which inadequate relief capacity exists to prevent overpressure of the RCS following an ATWS event. In the KPS models, all ATWS events are modeled as the worst case loss of feedwater event. However, most of the contribution to ATWS-induced core damage is from events other than loss of feedwater events. Therefore, the PRA analysis overstates the importance of this event and a more detailed analysis of ATWS events would result in reduced importance of this event. Therefore, no SAMA items are developed for this event.
148	10-GE-TSC-DG-PR	3.587e-002	5.099e-003	TSC DIESEL GENERATOR FAILS TO RUN	This event is important because of station blackout accident sequences. Items that address mitigating or recovering from a loss of offsite power are addressed by SAMA items 1 through 24, 55, and 58.
149	IE-SA-403-U	4.650e-003	5.051e-003	MODERATE SERVICE WATER TRAIN A FLOOD IN ROOM 403 (Auxiliary Building 657-foot elevation)	This initiating event leads to core damage due to flood-induced failure of equipment needed to maintain RCP seal cooling, specifically, failure of MCCs 52E, 62E, and 62H. Loss of these MCCs leads to a loss of charging pumps and a loss of ventilation needed to ensure continued functioning of CCW pumps. Refer to SAMA item 169.

Table F-4. WOG PEER PRA SUMMARY REPORT

OVERALL ASSESSMENT			
	GRADE BASED ON SUB-ELEMENTS		
PRA ELEMENT	Minimum [(a)]	Average [(b))]	Assigned [(c)]
Initiating Events	2*	2.7	3c
Accident Sequence Evaluation	2*	2.7	3c
Thermal Hydraulic Analysis	2*	2.2	3c
System Analysis	2	2.5	3c
Data Analysis	2*	2.8	3c
Human Reliability Analysis	1**	2.2	3c
Dependencies	1**	2.6	3c
Structural Response	2*	2.7	3c
Quantification	2	2.6	2
Containment Performance	2*	2.8	3c
Maintenance & Update	1**	2.3	3c
Overall Assessment: The Kewaunee PRA can be effectively used to support risk significance applications, subject to addressing the items identified as significant in the technical element summaries and in the Fact & Observations sheets as appropriate for specific applications. The recommendations for improvement included in the element summaries and Fact & Observation sheets, or suitable alternatives, should be addressed for support risk significance evaluations with deterministic input applications to be supported by the PRA.			

a) Minimum grade assigned, regardless of whether or not the grade was a contingent grade, and not counting "NA" grades.

b) Average reflects an arbitrarily conservative reduction in any individual sub-element grade assigned as "contingent" by one grade level. Averages were not considered by the reviewers during the consensus discussions. Sub-elements graded as "NA" not included in the average.

c) These are the grades as recommended by consensus of the reviewers. A "(C)" designation indicates that the grade is contingent upon implementation of recommended improvements or equivalent actions.

* Denotes minimum grade was contingent 3, which appears here as 2.

** Denotes lowest grade was an "NA", with an implied grade 1.

Table F-5. Status of WOG Peer Review F&O Resolution

Item	Level	Observation	Resolution
IE-1	B	Loss of ventilation system as a reactor trip initiator (e.g., loss of control room / relay room HVAC) is not discussed in detail. Loss of auxiliary building ventilation is subsumed in the reactor trip with main feedwater initiating event. The initiating Event Notebook indicates that a manual trip may be required for loss of certain ventilation systems. No detailed discussion (e.g., the basis) is provided for the effects of the loss of auxiliary building ventilation or other ventilation systems in the plant.	Determined to be documentation issue only. Not Yet Resolved
IE-2	B	Transients involving PORV opening are included in the calculation of the small LOCA initiating event frequency. Section 2.4.C provides a calculation of PORV LOCAs taking credit for the closure of the block valve for LOCA isolation. The block valve dependency on AC power appears to be missing from the analysis. In addition, the operator action required to close the valve is not included in the calculation. Limited plant specific data was utilized in the determination of PORV challenges following a plant trip (as part of the small LOCA frequency calculation). PORV challenge probability was not calculated as a function of the initiating event.	Now explicitly modeled
IE-3	B	Interfacing system LOCA frequency does not fully consider the guidance provided in the most recent NUREG/CRs. For example, NUREG/CR-5102 and NUREG/CR-5744 provide guidance on modeling of ISLOCA initiating event failures and plant response. Two items were noted: It was not clear to the reviewers what assumptions were applied regarding how the time-dependent nature of certain failure modes are captured (e.g., first valve in a series exposed for some portion of the year, second valve exposed thereafter). It appears that common cause failures of series valves has been modeled in the ISLOCA initiating event frequency fault tree. This is not common practice, does not really reflect the actual valve exposures, and is not supported by available common cause data.	New ISLOCA model uses latest NUREGs
IE-9	B	Section 2 of the PRA, Initiating Events Analysis, cites frequencies of steamline breaks inside containment, steamline breaks outside containment, and feedwater line breaks from NUREG/CR-5750. These three initiators were subsumed into a single initiator (large steamline/feedline breaks) in the Kewaunee PRA. The current treatment may be conservative, but the actual impact of this grouping, and the initiator frequency calculation is difficult to determine based on the limited documentation provided.	In the new model, steam line breaks are modeled differently depending on their location (e.g., steam or feed line, upstream of downstream of isolation valves).

Table F-5. Status of WOG Peer Review F&O Resolution (Continued)

Item	Level	Observation	Resolution
IE-11	B	In quantification of the V-sequence frequency and any other cutsets whose frequency is proportional to X^N where X is a failure rate and N is a number of independent events in the cutset having the same failure rate, the mean frequency is not equal to the Nth power of the mean failure rate. For N=2 and the case where X is lognormally-distributed, $X^2 = M^2 + V$, where M is the mean failure rate and V is the variance of the lognormal distribution. The problem is more complicated with N>2. When dealing with the V-sequence the failure rates are very low and the variance is very high such that the variance term dominates. When this is taken into account the Mean V-sequence frequency can easily be an order of magnitude greater than the result obtained using a mean point estimate (M^2). It is not clear that this has been taken into account in the V-sequence quantification.	New model explicitly accounts for variance terms by making them separate basic events.
IE-12	B	The support system initiating events are developed using the system fault trees. The fault trees are developed to calculate the 24 hour unavailability of the system post trip. These models were converted to initiating event models by simply multiplying the result by 365. This appears to be reasonable for most of these initiators, but perhaps not for the loss of service water event, where the "top event" definition may be different for the initiator versus the post trip system response. The loss of service water is calculated using the system fault tree in Appendix F.4 (Service water system notebook). The fault tree is developed to calculate the post trip availability of the SW system, and is converted to an initiating event model by "and"-ing the top gate with an event to multiply the 24 hour mission time by a factor of 365. The model allows success of a train of service water if one of two pumps in the train operate given the turbine building loads have isolated. Using this model for the initiating event model may be missing some trip scenarios. Cutsets with insufficient flow to the turbine building loads may cause a trip, and although SW to the emergency loads would not be failed, it would be in a degraded state. The basis for this approach should be documented in more detail. Another impact of this approach is that for cutsets involving failure of multiple components, the repair time for the "1st" failure is implicitly assumed to be 24 hours. This may be conservative for some cutsets, and non-conservative for others.	Revised SW tree to explicitly account for repair time.
IE-14	B	Spurious ESF Actuation may cause MFW isolation; this may have a different MFW failure probability than a general reactor trip. Table 2.2-4 indicates that spurious ESF actuation (7.3.15) is grouped under 7.3 Reactor Trip. Since SI signal would isolate MFW, an operator action is required to make MFW available, so this is different from a general reactor trip.	Spurious SI now explicitly modeled.
AS-1	A	The transient event trees (non-LOCA) do not recognize that following AFW success, a long term cooling source will be required. The success criteria for the system is defined as inventory sufficient to cool down to decay heat removal (DHR) conditions. However, the event trees do not model this requirement on the AFW success branch. An alternate success path would be a long term suction supply for AFW. However, this is also not modeled.	CST inventory explicitly modeled by modeling crossover to makeup water tanks.

Table F-5. Status of WOG Peer Review F&O Resolution (Continued)

Item	Level	Observation	Resolution
AS-2	B	RCP Seal LOCA model for non loss of offsite power (LOSP) initiators does not address RCP Seal failure due to vibration effects caused by loss of CCW cooling to RCP bearings coupled with failure to trip RCPs within short period of time. Operator action to trip RCP pumps on loss of CCW has been omitted from the model.	This was resolved with a calculation. No model change was needed.
AS-3	A	Two issues were identified with the treatment of LOSP/SBO modeling and AC power recovery. First, it may be possible to further refine the LOSP frequency and recovery curve, to reduce conservatisms, by separating LOSP into three categories: weather related, plant centered and grid related events, each with a different probability of recovery. It may also be possible to exclude the Turkey Point LOSP as not applicable to Kewaunee. Second, although some time phasing has been included in the Loss of Offsite Power Recovery model, the model could be made more realistic by including the time dependent offsite power non-recovery and EDG failure to run probability. Currently, a single mission time of 4 hours is assumed to calculate the EDG failure probability, and then applied as a SBO initiating event. Ignoring the time phasing of the EDG failures may be a conservative treatment, and the basis for the current diesel generator mission time of 4 hours is not provided.	Current model is conservative and consistent with MSPI.
AS-4	B	The ISLOCA event tree assumes success for some sequences without establishing a clear stable end condition. The RHR pump seal LOCA paths (sequences 19, 20, 21 on Figure 3.2-7 of the Accident Sequence Notebook), which are assumed to be equivalent in size to smaller medium LOCAs, are examples. For these, RWST refill and ECCS flow minimization are modeled as leading to avoidance of core damage, even though there is no evaluation of how much coolant would be lost through the break, where it would end up, what additional impacts there might be in the Auxiliary Building as a result of the ISLOCA-induced flooding there, and so forth. Further, the mission time for modeled equipment (e.g., HPSI, for the sequences noted above) is 24 hours, and establishing a stable end state in this case might require modeling of a longer time. RWST refill is modeled elsewhere in the PRA, e.g., for transients with consequential RCP seal LOCA and subsequent inability to perform ECCS recirculation cooling. Although RWST refill is a proceduralized action, its inclusion in the PRA leads to end states requiring accident management for establishment of clear success. This uncertainty in the outcome of such sequences is inconsistent with the philosophy of establishing a clearly stable end condition.	RWST refill model removed from ISLOCA.
AS-5	B	The reviewers identified two issues with the ATWS model. 1. The ATWS event tree includes only loss of MFW initiating events. 2. The sequence involving successfully removing power from MG set (ORP) is assumed to have the same effect as manually tripping the reactor and initiating the turbine trip in the ATWS event tree. This may be true from the subcriticality standpoint, but may be underestimating the adverse impact of turbine not tripping.	All initiators except LLO can now lead to ATWS. The event tree was changed to require AFW if ORP is successful.

Table F-5. Status of WOG Peer Review F&O Resolution (Continued)

Item	Level	Observation	Resolution
AS-8	B	For this review, the host utility provided a new Station Blackout (SBO) event tree write-up. This write-up was provided because it includes the implementation of the going-forward Reactor Coolant Pump Seal LOCA model (e.g., WOG2000) in the SBO plant response representation. The write-up cites Reference 1 when it describes the seal LOCA model, however, the Reference 1 listed is the old model reference. In addition, there are numerous other instances of incorrect references, reference numbers that were missing from the Reference list, and lack of references for citations that support key technical conclusions.	Documentation issue resolved.
TH-1	B	In Appendix B (Bases for Top Event Success Criteria) of the Accident Sequence notebook, for event ACC (accumulator injection), a discussion is provided justifying success for small LOCA with only one accumulator injecting following cooldown and depressurization in response to an inadequate core cooling (ICC) condition. The basis for the justification starts with an analysis performed for the 4-loop Wolf Creek plant using the TREAT code, in support of a Westinghouse Owners Group training program for Loss of Reactor or Secondary Coolant Training Program. Various plant parameters are used to "scale" the results to Kewaunee to reach the conclusion that success would also be achieved for Kewaunee. The primary area of concern with this assessment is that it is not clear that a TREAT code prediction of plant response for Wolf Creek is directly scalable to Kewaunee, and the basis for this conclusion is not discussed. In addition, the steps in question are sufficiently far into the procedure that they would likely not be addressed for a relatively long time. There is no information provided to determine whether the referenced analysis accounts for this, and how it would apply to Kewaunee. Reference is also made in Appendix B (in the discussion of low pressure injection (LPI)) to this same source to support elimination of the need for SI pump injection following Large LOCA. The LPI discussion in Appendix B also notes that, for small LOCA and medium LOCA, the time to switchover to low pressure recirculation "is considerably longer" than the 1-hour estimated by the generic reference for large LOCA. However, the statement is made that "for simplicity, the LPI mission time assumed for both medium and small LOCA is one hour." It is not clear that this is a valid assumption. Kewaunee PRA personnel noted that they are in the process of revising Appendix B based on new analyses that are being performed (e.g., with MAAP). In doing this, items such as those noted above should be replaced with plant-specific (or at least applicable generic) evaluations.	Documentation issue resolved by referencing Kewaunee design basis analysis, rather than generic.

Table F-5. Status of WOG Peer Review F&O Resolution (Continued)

Item	Level	Observation	Resolution
TH-2	B	There is insufficient guidance and documentation in the PRA to allow a thorough review of the bases for success criteria, and a lack of information regarding how decisions were made to select the type of analytical basis (e.g., Kewaunee FSAR, Kewaunee-specific calc other than FSAR, generic 2-loop plant analysis, other plant analysis) to be used to support the various success criteria. The documentation of accident sequence success criteria in the Event Tree Notebook (PRA Section 3.0) does not adequately demonstrate the reasonableness of the success criteria or provide sufficient traceability to supporting analyses. It is recognized that Kewaunee PRA staff are in the process of updating the PRA success criteria analyses, including performing and documenting a relatively extensive set of MAAP analyses, and assumed that once the documentation of these analyses is integrated into the appropriate PRA sections (e.g., Accident Sequences, HRA) the general philosophy for success criteria will be clearer. It is suggested that additional discussion be provided to enhance the success criteria documentation, e.g., consider addressing the following: • Document more clearly how each of the success criteria are supported by the various engineering analyses, references, and assumptions. • Identify where conservative, optimistic, or simplifying assumptions or conditions have been retained in the model, and why. • Provide the rationale for the success criteria development process and the supporting engineering calculations. • Document calculations (generic and plant-specific) or other references used to establish success criteria, and identification of cases for which they are used. • Identify computer codes or other methods used to establish plant-specific success criteria. • Document any limitations (e.g., potential conservatisms or limitations that could challenge the applicability of computer models in certain cases) of the calculations or codes. • Identify important assumptions used in establishing success criteria.	Documentation issue resolved.

Table F-5. Status of WOG Peer Review F&O Resolution (Continued)

Item	Level	Observation	Resolution
TH-4	B	Examination of sample room heatup calcs that were performed in support of the PRA (e.g., Kewaunee Nuclear Plant calcs C10730, C10731, C10723, C10724, for the AFW pump rooms) indicates that a number of conservative (i.e., pessimistic) assumptions regarding initial and ambient temperatures, and equipment loads, have been made. These may affect the modeling decisions that have been made regarding room cooling failure impacts for these rooms. For example, Section 2 of C10730 notes that adjacent room temperature has been assumed to be 105 degF, outdoor air temperature has been assumed to be constant at 95 degF, no air in- or ex-filtration has been credited, etc. Resulting steady state temperatures were calculated to be 229 degF in pump room A and 173 degF in pump room B, and opening doors resulted in an approximately 50 degF reduction in room A temperature and a 25 degF reduction in room B temperature. This indicates that a more realistic calc might show that crediting opening of room doors, if allowed by procedure, could allow for success. Similar comments apply to other room heatup calcs that were available for review. One notable exception to the above is the recently revised Loss of HVAC Chiller Room Temperature Transient calc for the Control Room, Relay Room, and HVAC Equipment Room. This calc evaluates heatup for these rooms under both bounding initial conditions and more realistic initial conditions, and then compares these to results of an actual short-term test that was performed in 2001, showing good agreement. In addition to the above, the reviewers did not find information regarding what would constitute acceptable equipment survivability temperatures. Without this information, it is not possible to realistically assess the need for room cooling.	HVAC is conservatively addressed. If no calcs exist, room cooling is assumed to be required. Even though this issue has been addressed in a conservative basis, complete resolution of this issue is pending.
TH-5	A	The HRA does not provide references to analyses providing the basis for time available to perform human actions modeled in the PRA. The HRA notebook includes values for the time windows available to complete actions for success and the time required by the operator to implement those actions, but these are not tied to bases.	HEPs recalculated with explicit timing based on thermal hydraulic codes and simulator observations.
TH-6	B	Success criteria mission times are the same for high pressure injection (HPI), high pressure recirculation (HPR) and low pressure recirculation (LPR) for a wide variety of initiating events (e.g., MLOCA, SLOCA, SGTR, transients with main feedwater available). Since the timing for these sequences varies, and the mission times chosen are long, this assumption results in unnecessary conservatism in some failure probabilities.	Mission times were adjusted based on sequence.

Table F-5. Status of WOG Peer Review F&O Resolution (Continued)

Item	Level	Observation	Resolution
TH-8	B	The new Appendix D (Level 1 MAAP Run) write-up that was provided to the review team identifies assumptions applicable to all of the MAAP runs. Included in the list is an assumption identifying a MAAP4 code limitation regarding the early stages of a LOCA with diameter greater than 10" ID due to inadequate reverse core flow modeling. For these cases the appendix states that conclusions are backed up by information from design basis calculations. However, no reference is provided for the basis for this MAAP4 code shortcoming, nor for the design basis calculations that were used. In addition, there have been other known issues with the use of MAAP for success criteria that were identified in a past EPRI study. There is no documented review of these past issues and why they might not still be applicable or how they are resolved with respect to MAAP usage here.	Documentation issue resolved.
TH-11	B	There is currently no process for controlling the use of the MAAP code or a software control process under which MAAP is implemented, although there are plans for such processes.	Code control procedures developed.

Table F-5. Status of WOG Peer Review F&O Resolution (Continued)

Item	Level	Observation	Resolution
SY-1	B	The AFW system analysis notebook (PRA Section 4.9) provides the following information related to AFW success criteria: • Condensate system provides the normal suction supply to the AFW pumps for 90 minutes from the condensate storage tanks • Service Water provides the backup, manually actuated suction supply • The CSTs contain a minimum volume of 39,000 gallons [assumed to be total of both CSTs] for use by the AFW system • The minimum volume is based on having sufficient water for 90 minutes at hot shutdown with a suitable margin to prevent loss of net positive suction head prior to switching AFW pump suction to the SW system • The success of the AFW system is based on its ability to cool the reactor coolant system via the steam generators (SGs) to approximately 300-350 degF. Thereafter, the RHR system is capable of providing the necessary heat sink • The AFW success criterion is stated as 1 of 3 AFW pumps providing 176 gpm flow to 1 of 2 steam generators. A statement of the mission time modeled for AFW was not noted in the Notebook, but was stated to be 24 hours by Kewaunee PRA personnel. A review of the fault tree logic for AFW (e.g., fault tree sheet AFW, 8, gate GAFW800) indicates that loss of water supplies to the AFW pump requires failure of both the CST supply and the service water system (SWS) supply. That is, "AND" failure logic is used such that the logic assumes that the CST inventory is adequate for a 24-hour AFW mission time. However, at 176 gpm, the minimum CST volume would be good for less than 4 hours; at the maximum useful volume (i.e., 96% total volume) this source would be good for about 14 hours. (Kewaunee PRA personnel provided results of an undocumented MAAP analysis that indicated that if both CSTs started at max. useful volume and if AFW flow were continuously throttled to match decreasing decay heat levels, the CST could provide a source of AFW for about 23 hours.) Thus, the CST inventory is not sufficient by itself to demonstrate a stable end state without operator action and operation of other equipment. As a result, the success logic for loss of water supplies for AFW is incorrect.	CST inventory explicitly modeled by modeling crossover to makeup water tanks.

Table F-5. Status of WOG Peer Review F&O Resolution (Continued)

Item	Level	Observation	Resolution
SY-3	B	The Low Pressure Safety Injection Notebook (PRA Section 4.7) includes the following assumption #9 for LPI: “It is assumed that CCW flow to the RHR pumps during LPI is not required. Procedure A-CC-31A, allows the RHR pumps to be run indefinitely without CCW if the process fluid temperature remains less than 160degF. If the process fluid is between 160degF and 200degF, then the pumps can be operated for 24 hours in this mode. It is assumed that the injection of the cool RWST water keeps the process fluid temperature below these limits and allows the use of the RHR pumps during LPI without CCW to the pumps.” This assumption is valid for events in which LPI actuates and quickly begins to inject RWST water. However, there are some sequences (e.g., MLOCA sequences 8 and 21 on Figure 3.2 3) in which LPI would receive a start signal early in the event but would not be able to inject until RCS pressure decreased to below the shutoff head of the LPI pumps. Depending on the break size, this time may not be insignificant. During this time the LPI pumps would be operating in miniflow recirculation mode, and, if CCW were unavailable for pump cooling, the temperature rise of the miniflow recirculation fluid could be substantial. Thus, this assumption does not appear to be justified for all scenarios, and the noted MLOCA sequences appear to be missing an LPI dependency on CCW. Further, plant procedures provide the following instructions: (a) EOPs (E-1, step 14) instruct the operators to stop the low head pumps if there is no low head injection flow. (b) The RHR System Operating Procedure (N-RHR-34) states that, without CCW to the RHR pump water jacket, if the pumped water temperature is 160 – 200 deg F the pumps can be run for 24 hours, but no guidance is provided for conditions where pumped water temperature exceeds 200 deg F. Since the volume control tank (VCT) is not a pressurized system, it seems unlikely the operators would allow water temperature to exceed 200 deg F and keep the pumps running. (CVCS Operating Procedures were not reviewed.) In the types of sequences noted above, then, the pumps, if started on an SI signal, would very likely be stopped and re-started when needed. So the correct fault tree logic for LPI should probably reflect failure of LPI if there is no CCW cooling AND the operators fail to stop (and re-start) the pumps.	This was resolved with a calculation. No model change was needed.
SY-5	B	The Aux. Feedwater Model does not contain a common cause failure mode associated with two possible mechanisms: 1) bio-fouling which would apply when the Service Water System is used as the suction supply. Debris such as zebra mussels could be drawn into the Aux. Feedwater system causing failure of the system. 2) Steam binding of pumps (The procedures implemented to detect and recover from this issue are addressed in a response to an NRC RAI on the IPE. However, neither the procedure nor the residual risk significance of this issue are discussed in the AFW system model)	Documentation issue resolved.

Table F-5. Status of WOG Peer Review F&O Resolution (Continued)

Item	Level	Observation	Resolution
SY-8	B	Main feedwater is modeled as a redundant means of providing SG cooling in the event of AFW failure. However, this model does not address adequacy of condensate suction source. Since hotwells contain about 50,000 gpm of usable condensate water, make up from the CST will be required. This could bring in CST and SW dependencies with AFW.	CST now explicitly modeled as long-term source for MFW.
SY-9	B	The Section 4.13 "Miscellaneous System" notebook does not contain sufficient detail for some relatively important system models. For example the Charging System is contained in Section 4.13.2. This section does not meet the requirements of the Kewaunee system modeling guidelines, nor does it provide sufficient detail such that the evaluation could be reproduced. The following deficiencies were observed in the Charging System section: • The simplified diagram does not contain many of the components that are actually in the fault tree model and system boundaries are not sufficiently defined. • Omitted equipment failure modes of are not discussed or justified. • There is no evidence of a search of the operating history for plant specific failure modes. • There are no references to plant documents such as design basis documents (DBDs) or procedures used to develop the model • Not all support system dependencies are discussed	This notebook was rewritten with more detail.
SY-10	B	Fault tree guidance proposes elimination of mechanically locked open manual valves and normally open manual, air, solenoid and motor operated valves that are not required to change state and are tested frequently. This approach is not consistent with current industry practice and could lead to non conservative results. This practice can also create problems during applications where intended closure/ spurious closure may be an issue (e.g., fire analysis).	All fluid systems were examined and valves added if they couldn't be screened out using ASME Standard.
DA-2	B	The documentation in Section 4.2.4 clearly identifies CCF parameters that are not standard with respect to the calculation of the CCF basic event probabilities. Several asymmetric component groups are identified, e.g., AFW pumps where there are 2 motor driven pumps (MDPs) and 1 turbine driven pump (TDP), and charging pumps where two pumps are AC powered and the third is DC powered. In these cases, the total failure rate is not the same for all the components in the group. For any basic event involving components with different failure rates, the Kewaunee PRA uses the highest failure rate in the calculation of the CCF basic event. Based on the availability of data, this is a reasonable, although somewhat conservative result.	These basic events were changed to more realistic values.
DA-7	B	The compilation of plant specific test and maintenance unavailabilities is presented in Appendix A of the Data Analysis Notebook. The introduction paragraph to this appendix states that the collection period for the T&M data came from the Maintenance Rule Data, but the time periods listed for specific component groups vary from group to group without explanation. The documentation should include the reason for these variable data collection time periods.	Documentation issue resolved.

Table F-5. Status of WOG Peer Review F&O Resolution (Continued)

Item	Level	Observation	Resolution
DA-10	B	Losses of offsite power following transients due to induced grid instabilities are not included in the model.	This is now explicitly modeled.
HR-1	B	The EPRI Cause Based Decision Tree Methodology (EPRI 100259) is used for evaluating the post initiator (type C) cognitive events and THERP is used for type C execution errors. The ASEP approach (NUREG/CR4772) was generally used for Type A events. These methods are state of the art. However, the guidance provided does not discuss the need for extensive involvement of operator/ training personnel or incorporation of simulator experience to gain a full understanding of the EOP implementation, competing priorities and resource requirements and stress levels under given accident conditions. The omission of the need for such involvement in the methodology description is not consistent with the current state of the art and may have led to errors in the HRA implementation	HEPs recalculated using operator input.
HR-2	B	No separate guidance document for HRA is provided. However the methodology description provided in Section 4.15 generally provides sufficient information for an experienced HRA PSA analyst to understand and reproduce the results. However, guidance in the following areas is lacking. 1. While a systematic screening process for test and maintenance activities leading to valve misalignments is provided in — 4.1.15 no similar guidance is provided for screening of potential miscalibration errors. As a result only 2 miscalibration errors have been included in the model (associated with RWST level and Auxiliary Building Radiation monitoring). Other miscalibrations typically included in PSAs, such as SG level, Pressurizer Level and VCT level, have been omitted. 2. No guidance is provided for identifying key post-initiator operator actions to be included in the model.	Miscalibration errors were modeled.
HR-5	B	In reviewing P_C worksheets for evaluating cognitive error probabilities, an error was identified in applying a decision event tree branch probability associated with 36-SGTR-DIAG-HE (Diagnose SGTR tube rupture); P_{ce} branch c should be 0.003, whereas .001 has been used. This results in a factor of 3 increase in the HEP	This was corrected in HRA update.
HR-6	B	Pre-initiator human actions to close the accumulator refill valves are the dominant contributor with respect to LERF as these events are presumed to lead to a high pressure injection flow diversion path. This event is quantified using THERP (rather than screened using ASEP). However, the analysis did not credit independent verification which was confirmed by PSA staff to be required by procedure and noted in the calc. In addition the valve position is also indicated on the control board and may be rectified following an initiating event. As a result the operator action HEPs are overestimated.	This was corrected. A justification for removing the accumulator refill line from the model was prepared.

Table F-5. Status of WOG Peer Review F&O Resolution (Continued)

Item	Level	Observation	Resolution
HR-7	B	Although HEP worksheets provide a time window for the action being evaluated, the plant condition at the start and end of the window is not described. It is therefore often difficult to trace and understand the impact of the timing information being provided on the HEP.	HEPs recalculated with explicit timing based on thermal hydraulic codes and simulator observations.
DE-2	B	The Loss of Service Water Event and Loss of CCW Event requires charging pump flow to maintain RCP seal cooling to prevent RCP seal LOCA. The Charging system model does not recognize that for these initiators, there will be a loss of letdown heat exchanger cooling requiring the operators to divert letdown flow from the VCT. This will require auto swap from the VCT to the BWST to maintain a suction supply for the charging pumps.	Loss of CCW now explicitly included in letdown model.
DE-3	B	Plant specific walkdown was performed in 1991. The analysis relies heavily on the flooding analysis performed by Sargent and Lundy in response to INPO SOER 85-05. Assumptions and practices for such design-basis analyses differ from those required for internal flooding risk analysis, and the different treatments may change the risk profile of flooding scenarios significantly.	The new flooding assessment included a new flooding walkdown.
DE-6	B	There was no evidence of any structural calculations to support the assumption that doors that open in the direction of the flooding event would not fail.	The new flooding assessment included new door structural calculations.
DE-7	A	The flooding analysis done for the IPE has not been updated and is not consistent with the current methods for analyzing flooding risk. The following issues were identified with the flooding analysis: • Pipe failures resulting in rupture were excluded from the analysis. Only leaks were considered credible. • Propagation though doors with gaps less than 1/8" was ignored without regard to the ability to stop continued leakage. • Backflow through drains was considered but was stopped once the flooding source was isolated. It is not clear how continued backflow would be stopped until water levels equalize between connected rooms. • Operator action to terminate the flooding was assumed to occur at an estimated time with essentially 100% success. • Human action dependencies between the flooding and mitigation action were not addressed. • The potential to cause flooding through maintenance and testing or special system configuration was not considered. • There was no evidence of a search of plant-specific initiating events that might be relevant to flooding. • Flood frequencies are based on very old generic data.	The entire Kewaunee flooding analysis was re-done to the requirements of the ASME standard.

Table F-5. Status of WOG Peer Review F&O Resolution (Continued)

Item	Level	Observation	Resolution
DE-8	B	There is no evidence of including the availability of flood alarms, dikes, curbs, drains, sumps, shields, water-tight doors, and operator actions in the model. No explicit human reliability analyses were performed to include performance shaping factors (PSFs) for:(a)Additional workload,(b)Uncertainties for event progression, and(c)Effect of flooding on mitigation, required response, and flooding-specific job aids and training.	Flooding initiating events now include human-induced events.
DE-9	B	For included flood-induced initiating events, no review of operating experience was performed to address the impact of plant-specific initiating event precursors and system alignments, and alignments of supporting systems.	The new flooding assessment examined operating experience for impact on inititaing frequencies.
DE-10	B	There is very little discussion of the potential for total loss of Service Water due to intake anomalies, such as bio-fouling or frazil ice. The Service Water System notebook does state that “the design of the auxiliary intakes are such that they will not be damaged by frazil ice”, but no basis for this statement is provided, and there is no discussion the potential loss due to bio-fouling.	It really is modeled. Documentation was corrected to reflect this.
DE-11	B	Susceptibility of each SSC in the flood area to flood-induced failure mechanisms was identified. However, spray was assumed to be bounded by the flooding. NRC's Kewaunee IPE SER/TER page 6 indicated that effects of sprays were not completely assessed.	The new flooding assessment examined operating experience for impact on initiating frequencies.

Table F-5. Status of WOG Peer Review F&O Resolution (Continued)

Item	Level	Observation	Resolution
ST-1	B	In the interfacing systems LOCA analysis, there are several instances where credit is taken for closing of valves to isolate the LOCA. It appears that the analysis assumed that if there is a valve in the line, it will be capable of closing, and, if the operator action to close it is successful, it will close and hold RCS pressure. There is no evidence that an evaluation has been performed to determine that such valves would in fact be capable of closing against and holding RCS pressure. Further, the reviewers did not find evaluations of either accessibility of the valves given that there may also be a pipe break (due to overpressure of the low pressure piping) in the vicinity of the valve to be isolated, or of the potential that the pipe break might defeat valve controls on remote-operated valves. For example: • in screening RCP thermal barrier pathways, it was noted that ".. . there are multiple valves that could be used to isolate a leak from the RCS to the component cooling system through the RCP thermal barrier ", but there is no check that these valves are capable of holding RCS pressure. • Similarly, credit is taken for relief valves operating perfectly and relieving fully to prevent failure of downstream low pressure piping. For example: • the Calculation of ISLOCA Frequency discussion in PRA Notebook Section 2 notes that "If the valve configuration communicated with a system outside of containment and there were no pressure relieving devices on the low pressure piping or the pressure relieving devices were not capable of retrieving flow rates associated with ruptured valves, it was assumed that this represented a possible configuration for an interfacing systems LOCA." This implies that as long as a relief device capable of relieving flow was present, it was always credited as functioning. • in the discussion of screening RCP seal return line pathways, it was noted that "…the seal water return line has a safety valve located inside containment that would prevent over pressurization of the piping." This is true IF the safety valve is sized for this occurrence AND IF the safety valve does not fail to operate. There also appear to be inconsistencies in the quantification of ISLOCA human error probabilities. The HEP for event 34--OCV------HE (action to isolate the ISLOCA) as quantified in the HRA notebook assumes a time window of 50 minutes. But it appears from the event tree for ISLOCA that there could have been a rupture of low pressure piping in some scenarios in which this action is credited. Thus, there would be 50 minutes of RCS flow from a potentially large rupture of pipe in the Aux. Building, making it unlikely that a local operator action could be performed successfully and likely that a remote action would fail due to high energy line break type effects. A more probabilistic treatment of the mitigating capability of equipment and human actions credited for eliminating ISLOCA pathways should be included in the analysis.	This is now explicitly addressed.

Table F-5. Status of WOG Peer Review F&O Resolution (Continued)

Item	Level	Observation	Resolution
QU-1	A	A review of the dominant cutsets for CDF and LERF identified a pre-initiator human error (33-AV-SI101A-AE, 33-AV-SI101B-AE) which was modeled as failing both trains of safety injection due to a flow diversion through the accumulator. It appears that this is an overly conservative treatment for several reasons. First, the probability for the human error was calculated conservatively (HR_06). Second, no credit for post event recovery was modeled even though there would have been control room indication of the flow diversion path. Third, it is very likely that realistic T/H analyses would show that adequate flow to prevent core damage would be provided even if some flow was diverted through this open path.	This was corrected. A justification for removing the accumulator refill line from the model was prepared.
QU-2	B	A description of the quantification process is provided in Section 5 of the PRA, but this is a very general, top level description and would not be sufficient guidance to reproduce the results. Due to complexities generally associated with large PRA models, (i.e., the size and complexity of fault trees and support files), detailed guidance is very important to support the quantification process.	Documentation issue corrected.
QU-3	B	The summary of results for the most recent PRA update contained in Section 5 was mostly created by the software output reports, and is weak in the qualitative development and discussion of insights about the risk contributions and importance, what they mean, and how they should be interpreted by those outside the PRA group. There was no detailed discussion of the top ranking sequences, or comparison of results to other similar plant PRAs. In addition the detailed nature of the information contained in the calculation file (primarily cutsets and basic event importance lists), while meaningful to the PRA team, is not particularly useful to those outside the team to develop appropriate risk insights for managing the plant. Therefore it is highly recommended that the PRA team develop a summary report that exhibits and promotes a deep understanding of the risk contributions (i.e., to CDF and LERF) from sequences, sequence classes, and important contributors, and provides specific insights that can be used for day to day risk management activities. In developing this summary, it is recommended that development of functional sequence groups be considered to provide insights about important classes of accident sequences such as high pressure core melts, ATWS, RCP seal LOCAs, transient induced LOCAs, etc. Such grouping helps organize the detailed sequence information contained in the PRA. A detailed summary of results and development of insights is also critical to identifying conservatisms or errors in the model. A number of these types of problems have been identified during the course of this peer review (for example, see F&Os QU-01, AS-01, HR-04, ST-01). This highlights the importance a detailed review, evaluation, and summary to ensuring the validity of the results.	Documentation issue corrected.
QU-5	B	The need to break circular logic loops in the fault tree model, and strategies available to accomplish this are discussed in Section 5 of the PRA. But no details are provided as to specifically where in the model these logic loops existed and how the were resolved.	Documentation issue corrected.

Table F-5. Status of WOG Peer Review F&O Resolution (Continued)

Item	Level	Observation	Resolution
QU-7	B	The results presentation in Section 5 of the PRA had a discussion regarding the benefits of reviewing model inputs, assumptions, success criteria, etc. and performing sensitivity analysis to investigate the impact of these inputs on the quantitative results. No such search was documented, and no sensitivity results were presented (with the exception of global changes to HEPs, CCF values and truncation values).	Documentation issue corrected.
QU-10	B	No parametric uncertainty analysis was performed, but WinNUPRA will support this analysis and most of the inputs are in place in terms of the underlying basic event probability distributions.	Documentation issue corrected.
L2-2	B	The Westinghouse Owners' Group LERF definition, which is used in the Level 2 analysis, assigns an evacuation time from the onset of core damage. This is an analytically convenient definition which does not require the EAL bases to be considered.	EALs are now explicitly accounted for in LERF assessment.
L2-6	B	The Level 2/LERF quantification process is not adequately documented. The LERF discussion does not include any description of: the steps involved in quantifying the Level 2/LERF analysis, dominant LERF contributors, comparison to similar plant results and any unusual plant-specific results, or other significant influences on the LERF result.	Documentation issue corrected.
MU-3	B	The PRA control procedures do not discuss physical control of the PRA Living Model or Model of Record files or sensitivity cases that have been performed to support an application. The current practice is to physically store these files on a stand-alone computer with a backup copy on a Zip disk. The Zip disk is stored in an individual's office space. Kewaunee PRA personnel noted that control of PRA software is transitioning to the site software procedures.	Dominion procedures reflect software control requirements.
MU-4	B	Kewaunee does not appear to have a single list of "Living PRA Applications" or logs for tracking those calculations that may be affected by PSA updates. Some past PRA Applications that may be affected by the latest information and update were re-performed. Due to the timing of the PSA update and demand to support other plant requests, not all affected PSA applications have been addressed.	Dominion procedures provide list of PRA Products.
MU-6	B	Kewaunee has a requirement for analysis signoff by the preparer, an independent reviewer and the PRA supervisor. The reviewers noted that while some of the PRA update calculations that were reviewed had all the required signatures, not all did. Further, there were no review notes or discussion of the disposition of review comments in the various calcs examined by the peer reviewers. More importantly, the peer reviewers found examples of inconsistencies in the PRA results that it appeared may have been carried through several PRA Update Calc revisions (e.g., top CDF and LERF cutsets that included single failures in Safety Injection System which should have required multiple failures).	Dominion procedures provide tight controls on review process.

Table F-6. Kewaunee Release Category Frequency and Release Fractions

STC	1	4	5	6	7	8	9	10	11	12	13	14
Frequency	1.50E-06	4.05E-05	1.97E-07	5.08E-09	2.73E-08	2.56E-05	0.00E+00	0.00E+00	1.22E-07	1.55E-07	9.39E-06	3.28E-06
MAAP ID	KE2LSP01	KE2FLD02	KE2TRA01	KE2TSW02	KE2SLB01	KE2LSP01	KE2SLB01	KE2TSW02	KE2ISL01	KE2ISL01	KE2SGR01	KE2SGR02
Run Time	48	168	120	48	48	48	48	48	48	48	72	72
GE Time (time from scram)	14.0	29.9	2.4	2.4	2.5	14.0	2.5	2.4	5.3	5.3	32.1	36.1
Noble Start	N/R	85.0	86.9	3.6	3.0	N/R	3.0	3.6	5.4	5.4	32.1	37.4
Noble End	N/R	87.8	97.3	48.0	48.0	N/R	48.0	48.0	9.5	9.5	34.0	39.9
Noble Frac	0.0E+00	1.0E+00	9.8E-01	7.9E-02	3.2E-01	0.0E+00	3.2E-01	7.9E-02	1.0E+00	1.0E+00	9.6E-01	7.5E-01
CsI Start	N/R	85.1	86.9	2.9	3.0	N/R	3.0	2.9	5.4	5.4	32.5	37.4
CsI End	N/R	155.2	95.2	18.6	11.3	N/R	11.3	18.6	23.3	23.3	47.0	39.9
CsI Frac	0.0E+00	7.9E-03	8.8E-04	7.5E-04	6.9E-02	0.0E+00	6.9E-02	7.5E-04	1.3E-01	7.0E-01	2.4E-01	2.0E-02
TeO2 Start	N/R	85.0	86.9	2.9	3.0	N/R	3.0	2.9	5.1	5.1	32.7	37.9
TeO2 End	N/R	151.8	95.2	16.7	13.0	N/R	13.0	16.7	48.0	48.0	36.5	39.7
TeO2 Frac	0.0E+00	3.0E-04	4.0E-04	1.0E-03	5.2E-02	0.0E+00	5.2E-02	1.0E-03	7.2E-02	4.0E-01	3.0E-01	1.9E-02
SrO Start	N/R	85.0	86.9	3.0	3.2	N/R	3.2	3.0	5.5	5.5	32.5	37.7
SrO End	N/R	87.3	95.4	14.5	13.0	N/R	13.0	14.5	10.9	10.9	37.4	39.9
SrO Frac	0.0E+00	1.7E-07	1.1E-04	1.8E-06	3.1E-03	0.0E+00	3.1E-03	1.8E-06	5.7E-03	3.2E-02	3.0E-03	4.4E-05
MoO2 Start	N/R	85.0	86.9	2.9	3.0	N/R	3.0	2.9	6.1	6.1	32.8	38.5
MoO2 End	N/R	87.3	107.3	14.5	10.1	N/R	10.1	14.5	7.0	7.0	34.0	39.9
MoO2 Frac	0.0E+00	5.6E-07	6.7E-06	1.4E-05	2.4E-03	0.0E+00	2.4E-03	1.4E-05	8.8E-03	4.9E-02	3.8E-03	5.5E-03
CsOH Start	N/R	85.2	86.9	3.0	3.0	N/R	3.0	3.0	5.4	5.4	32.4	37.3
CsOH End	N/R	168.0	95.2	29.4	13.1	N/R	13.1	29.4	48.0	48.0	34.5	39.8
CsOH Frac	0.0E+00	2.7E-03	5.1E-04	9.8E-04	4.8E-02	0.0E+00	4.8E-02	9.8E-04	1.2E-01	6.5E-01	2.2E-01	4.7E-03
BaO Start	N/R	85.0	86.9	2.9	3.0	N/R	3.0	2.9	5.4	5.4	32.5	38.2

Table F-6. Kewaunee Release Category Frequency and Release Fractions (Continued)

STC	1	4	5	6	7	8	9	10	11	12	13	14
BaO End	N/R	87.3	106.8	14.6	12.7	N/R	12.7	14.6	10.2	10.2	34.5	39.9
BaO Frac	0.0E+00	3.3E-07	6.1E-05	1.2E-05	3.5E-03	0.0E+00	3.5E-03	1.2E-05	5.8E-03	3.2E-02	6.2E-03	9.0E-04
La2O3 Start	N/R	85.0	86.9	2.9	3.0	N/R	3.0	2.9	5.5	5.5	32.5	37.8
La2O3 End	N/R	87.3	95.3	14.5	12.9	N/R	12.9	14.5	29.8	29.8	38.0	39.6
La2O3 Frac	0.0E+00	1.3E-07	2.7E-05	1.2E-07	4.4E-05	0.0E+00	4.4E-05	1.2E-07	3.2E-04	1.8E-03	1.1E-04	2.7E-06
CsO2 Start	N/R	85.0	86.9	2.9	3.1	N/R	3.1	2.9	5.6	5.6	32.5	37.8
CsO2 End	N/R	87.3	95.2	14.5	13.0	N/R	13.0	14.5	30.1	30.1	40.2	39.7
CsO2 Frac	0.0E+00	1.4E-07	6.1E-04	2.2E-07	4.0E-04	0.0E+00	4.0E-04	2.2E-07	5.9E-03	3.3E-02	1.2E-03	1.2E-05
Sb Start	N/R	85.6	86.9	3.0	3.0	N/R	3.0	3.0	1.2	1.2	32.6	37.6
Sb End	N/R	168.0	95.2	14.6	12.0	N/R	12.0	14.6	13.9	13.9	37.2	40.0
Sb Frac	0.0E+00	6.9E-04	9.1E-04	3.0E-04	2.2E-02	0.0E+00	2.2E-02	3.0E-04	6.1E-02	3.4E-01	1.0E-01	1.4E-02
Te2 Start	N/R	85.0	86.9	N/R	N/R	N/R	N/R	N/R	8.4	8.4	36.6	N/R
Te2 End	N/R	101.2	95.6	N/R	N/R	N/R	N/R	N/R	25.7	25.7	72.0	N/R
Te2 Frac	0.0E+00	1.6E-06	7.1E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	8.3E-04	4.6E-03	3.1E-05	0.0E+00
UO2 Start	N/R	N/R	86.9	N/R	N/R	N/R	N/R	N/R	8.5	8.5	36.6	N/R
UO2 End	N/R	N/R	98.6	N/R	N/R	N/R	N/R	N/R	32.1	32.1	47.2	N/R
UO2 Frac	0.0E+00	0.0E+00	5.2E-06	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.1E-05	1.8E-04	1.1E-06	0.0E+00

Table F-7. Kewaunee Unranked STC Frequencies

STC	Description	Frequency	Percent of Total
1	Containment Intact	1.50E-06	1.85%
2	Late cont. failure; sprays operate continuously	0.00E+00	0.00%
3	Late cont. failure; sprays operate early	0.00E+00	0.00%
4	Late cont. failure; sprays never operate	4.05E-05	50.12%
5	Basemat meltthrough	1.97E-07	0.24%
6	Small cont. isolation failure	5.08E-09	0.01%
7	Large cont. isolation failure	2.73E-08	0.03%
8	Containment Intact, no vessel failure	2.56E-05	31.71%
9	Large cont. isolation failure; no vessel failure (note 1)	0.00E+00	0.00%
10	Small cont. isolation failure; no vessel failure (note 2)	0.00E+00	0.00%
11	Scrubbed ISLOCA	1.22E-07	0.15%
12	Unscrubbed ISLOCA	1.55E-07	0.19%
13	SGTR with SG isolation failure	9.39E-06	11.62%
14	SGTR with SG isolation successful	3.28E-06	4.06%
Total		8.089E-05	100.00%

Notes:
Conservatively treated the same as Release Category 7 for release fractions
Conservatively treated the same as Release Category 6 for release fractions

Table F-8. Basic Event Importance with Respect to LERF

Item No.	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
1	05B-CST-DIAG-HE	8.66E-04	2.21E-01	OPERATOR FAILS TO DIAGNOSE NEED FOR ALTERNATE AFW SRC	This item is important because it applies to accident sequences from nearly all initiating events. Additional alarms to indicate CST depletion, an automatic switchover to an alternate water source, or larger CSTs would lower the importance of this event. Refer to SAMA items 172, 71, and 66.
2	LERF-42	2.35E-01	2.12E-01	LARGE EARLY RELEASE FREQUENCY FOR PLANT DAMAGE STATE 42	This basic event is a flag-type of event used to facilitate the overall quantification and represents no physical failures. No SAMA items are generated as a result of this basic event.
3	IE-SGTR	3.80E-03	1.93E-01	STEAM GENERATOR TUBE RUPTURE INITIATING EVENT	This initiating event is important to LERF because of failure of the operator actions required to mitigate the event. The actions modeled are from emergency operating procedures developed from standard Westinghouse Owners Group guidance. No weaknesses in the procedures have been identified in these procedures. Therefore, hardware modifications would be required to reduce the importance of this event further. SAMA items 122, 124, 125, 126, and 129 have been identified to address SGTRs.
4	LERF-63	1.00E+00	1.93E-01	LARGE EARLY RELEASE FREQUENCY FOR PLANT DAMAGE STATE 63	This basic event is a flag-type of event used to facilitate the overall quantification and represents no physical failures. No SAMA items are generated as a result of this basic event.
5	LERF-60	1.42E-01	1.52E-01	LARGE EARLY RELEASE FREQUENCY FOR PLANT DAMAGE STATE 60	This basic event is a flag-type of event used to facilitate the overall quantification and represents no physical failures. No SAMA items are generated as a result of this basic event.
6	LERF-16	1.42E-01	1.43E-01	LARGE EARLY RELEASE FREQUENCY FOR PLANT DAMAGE STATE 16	This basic event is a flag-type of event used to facilitate the overall quantification and represents no physical failures. No SAMA items are generated as a result of this basic event.

Table F-8. Basic Event Importance with Respect to LERF (Continued)

Item No.	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
7	LOSP-24	5.29E-03	1.22E-01	LOSS OF ALL POWER FROM GRID DURING 24 HOURS	This basic event represents a loss of offsite power that occurs within the first 24 hours following the initiating event. This event is important to the KPS results for several reasons. First, flooding events generally result in a loss of one train of service water and, therefore, the associated EDG. Thus loss of the other EDG results in a station blackout. Second, because power is needed to operate the valves that are used to isolate many of the internal flooding initiating events. Failure of offsite power causes the inability to isolate some flooding events. In actuality, however, flooding isolation must occur early in the event, typically in less than one hour. The ability to isolate flooding events without requiring power would greatly lower the importance of this event. Refer to SAMA item 168.
8	LERF-46	1.42E-01	1.13E-01	LARGE EARLY RELEASE FREQUENCY FOR PLANT DAMAGE STATE 46	This basic event is a flag-type of event used to facilitate the overall quantification and represents no physical failures. No SAMA items are generated as a result of this basic event.
9	27A-OR2----RDHE	1.41E-01	1.11E-01	OPERATOR FAILS TO LIMIT SI FLOW AND REFILL RWST – SGTR	This basic event represents failure operator action to refill the RWST to continue ECCS injection following a steam generator tube rupture. This event represents a dependent operator action given failure of operator actions to cooldown and depressurize the RCS. Because this event is a dependent operator action, steps to reduce the events on which it is dependent must be taken. Refer to item 25 below. No SAMA items identified as a result of this event.
10	IE-TCC	3.65E+02	9.08E-02	LOSS OF COMPONENT COOLING WATER INITIATING EVENT	This basic event is a tag event that is attached to all cutsets representing a loss of component cooling water initiating event. The basic event itself represents no physical failures. The importance of this initiating event is driven by sequences where failure of room cooling causes a loss of AFW pumps and other equipment located in safeguards alley and subsequences where a long-term source of water to AFW pump suction is not available. The ability to provide alternate room cooling for safeguards alley would lower the importance of this initiating event to overall core damage. Refer to SAMA items 170 and 171. Additional alarms to indicate CST depletion, an automatic switchover to an alternate water source, or larger CSTs would lower the importance of this event. Refer to SAMA items 172, 71, and 66.

Table F-8. Basic Event Importance with Respect to LERF (Continued)

Item No.	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
11	IE-TRA	9.99E-01	7.75E-02	TRANSIENT WITH MAIN FEEDWATER AVAILABLE OCCURS	The importance of this initiating event is driven by sequences where failure of room cooling causes a loss of AFW pumps and other equipment located in safeguards alley. The ability to provide alternate room cooling for safeguards alley would lower the importance of this initiating event to overall core damage. Refer to SAMA items 170 and 171.
12	36--SGTRDIAG-HE	1.12E-03	7.00E-02	OPERATOR FAILS TO DIAGNOSE SGTR	This event is important to LERF because of failure of the operator actions required to mitigate the event. The actions modeled are from emergency operating procedures developed from standard Westinghouse Owners Group guidance. No weaknesses in the procedures have been identified in these procedures. Therefore, hardware modifications would be required to reduce the importance of this event further. SAMA items 122, 124, 125, 126, and 129 have been identified to address SGTRs.
13	LERF-24	1.42E-01	6.76E-02	LARGE EARLY RELEASE FREQUENCY FOR PLANT DAMAGE STATE 24	This basic event is a flag-type of event used to facilitate the overall quantification and represents no physical failures. No SAMA items are generated as a result of this basic event.
14	LERF-50	1.42E-01	6.56E-02	LARGE EARLY RELEASE FREQUENCY FOR PLANT DAMAGE STATE 50	This basic event is a flag-type of event used to facilitate the overall quantification and represents no physical failures. No SAMA items are generated as a result of this basic event.
15	06--OC4------HE	1.85E-01	6.52E-02	OPERATOR FAILS TO CD AND DEPRES RCS IN ECA-3.1/3.2	This basic event represents failure operator action to cooldown and depressurize the steam generators following a steam generator tube rupture. The actions modeled are from emergency operating procedures developed from standard Westinghouse Owners Group guidance. No weaknesses in the procedures have been identified. Therefore, hardware modifications would be required to reduce the importance of this event further. SAMA items 122, 124, 125, 126, and 129 have been identified to address SGTRs.

Table F-8. Basic Event Importance with Respect to LERF (Continued)

Item No.	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
16	05BPT--AFW1C-PS	2.01E-02	6.48E-02	TD AFW PUMP INDEPENDENT FAILURE TO START	The importance of the turbine-driven AFW pump is caused mainly by loss of room cooling inducing failure of the motor-driven AFW pumps. The loss of room cooling could be caused directly by a loss of the coolers or by flood-induced failure of the power supplies. Instituting measures to ensure adequate room cooling to safeguards alley after a loss of room cooling would lower the importance of the turbine-driven AFW pump. The ability to provide alternate room cooling for safeguards alley would lower the importance of this initiating event to overall core damage. Refer to SAMA items 170 and 171.
17	IE-LOSP	2.98E-02	6.41E-02	LOSS OF OFFSITE POWER INITIATING EVENT	This initiating event leads to core damage predominantly through station blackout sequences. Items designed to mitigate station blackout or RCP seal failures would reduce the importance of this event. . Refer to SAMA items 55, 56, 58, 21, and 22.
18	IE-SB-8B--U	3.30E-03	5.50E-02	MODERATE TRAIN B SW PIPE BREAKS IN ROOM 8B (Aux Building Basement)	This initiating event leads to core damage due to flood-induced failure of equipment needed to maintain RCP seal cooling, specifically, failure of MCCs 52E, 62E, and 62H. Loss of these MCCs leads to a loss of charging pumps and a loss of ventilation needed to ensure continued functioning of CCW pumps. Refer to SAMA item 169.
19	06--IS2------HE	4.28E-03	5.21E-02	OPERATOR FAILS TO ISOLATE 1 OF 2 STEAM GENERATORS	This basic event represents failure operator action to isolate the steam generators after a steam generator tube rupture. The actions modeled are from emergency operating procedures developed from standard Westinghouse Owners Group guidance. No weaknesses in the procedures have been identified in these procedures. Therefore, hardware modifications would be required to reduce the importance of this event further. SAMA items 122, 124, 125, 126, and 129 have been identified to address SGTRs.

Table F-8. Basic Event Importance with Respect to LERF (Continued)

Item No.	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
20	27A-ORR------HE	9.21E-02	4.93E-02	OPERATOR FAILS TO LIMIT SI FLOW AND REFILL RWST – NO CD	This basic event represents execution failures of the actions to provide RWST makeup to ensure continued ECCS injection. These actions occur after a successful diagnosis of the need for the actions. These actions are important primarily because failure of secondary cooling via AFW or MFW has necessitated the need for bleed and feed cooling and high-pressure recirculation. Two approaches can be taken to minimize the importance of this operator action. The first is to lower the overall failure probability of the AFW system. The second is to provide a simple method to align makeup water to the RWST. Failure of the AFW system is primarily caused by failure of the room cooling systems needed to support operation of the motor-driven AFW pumps. The ability to provide alternate room cooling for safeguards alley would lower the importance of this initiating event to overall core damage. Refer to SAMA items 170 and 171. Potential improvements related to switchover to ECCS recirculation are addressed by items 31 and 32. Successful ECCS recirculation obviates the need to provide RWST makeup. Provision of an additional means to refill the RWST would likely be of little value to reducing the importance of this basic event because the event represents failure in the execution phase of the action, after a successful diagnosis.
21	34--RHR------HE	8.24E-02	4.88E-02	OPERATOR FAILS TO ESTABLISH RHR	Operator action to establish RHR cooling can be used to compensate for a loss of secondary cooling due to depletion of CST inventory. Establishing RHR cooling requires a cooldown of the RCS and then placing the RHR system in service. Given the time required for cooldown and the actions required to place RHR in service, it is unlikely that any actions to reduce the failure probability of this event would be meaningful. Providing a larger CST is addressed in SAMA item 71.
22	16-FNAKPRCCF123	3.70E-05	4.81E-02	COMMON CAUSE FAILURE OF AFW PUMP AND TURBINE BUILDING BASEMENT FAN COOLING UNITS	This event represents common cause failure of all cooling units in safeguards alley. This event then results in failure of the AFW pumps and safety-related 480 VAC equipment. Provision of room temperature alarms or the ability to provide alternate room cooling for safeguards alley would lower the importance of this initiating event to overall core damage. Refer to SAMA items 170 and 171.

Table F-8. Basic Event Importance with Respect to LERF (Continued)

Item No.	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
23	31-PM-KPRCCF12	7.14E-05	4.79E-02	DOUBLE COMMON CAUSE FAILURE (CCF) CCW-1A/-1B FAIL TO RUN	This basic event causes the loss of CCW initiating event and the importance of the event is almost entirely related to loss of CCW accident sequences. The importance of this event is driven by sequences where failure of room cooling causes a loss of AFW pumps and other equipment located in safeguards alley and subsequences where a long-term source of water to AFW pump suction is not available. The ability to provide alternate room cooling for safeguards alley would lower the importance of this initiating event to overall core damage. Refer to SAMA items 170 and 171. Additional alarms to indicate CST depletion, an automatic switchover to an alternate water source, or larger CSTs would lower the importance of this event. Refer to SAMA items 172, 71, and 66.
24	36--OBF------HE	2.45E-02	4.44E-02	OPERATOR FAILS TO ESTABLISH BLEED AND FEED	This basic event represents execution failures of the actions to initiate bleed and feed cooling. These actions occur after a successful diagnosis of the need for the actions. These actions are important primarily because failure of secondary cooling via AFW or MFW has necessitated the need for bleed and feed cooling. Two approaches can be taken to minimize the importance of this operator action. The first is to lower the overall failure probability of the AFW system. The second is to provide a simple method to initiate bleed and feed cooling. Failure of the AFW system is primarily caused by failure of the room cooling systems needed to support operation of the motor-driven AFW pumps. The ability to provide alternate room cooling for safeguards alley would lower the importance of this initiating event to overall core damage. Refer to SAMA items 170 and 171. Initiation of bleed and feed cooling is directed by the IPEOPs, which are written per the WOG standard, and the actions taken are quite simple. It is unlikely that any changes that would improve this action could be implemented.

Table F-8. Basic Event Importance with Respect to LERF (Continued)

Item No.	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
25	10-GE-DG1A---PR	1.88E-02	4.39E-02	INDEPENDENT FAILURE DIESEL GENERATOR A FAILS TO RUN	A large part of the importance of this basic event is driven by the need to isolate flooding events (refer to item 2 above). This event is important to the KPS results because power is needed to operate the valves that are used to isolate many of the internal flooding initiating events. Failure of offsite power coupled with failure of the diesel-generator to operate causes the inability to isolate some flooding events. In actuality, however, flooding isolation must occur early in the event, typically in less than one hour. The ability to isolate flooding events without requiring power would greatly lower the importance of this event. Refer to SAMA item 168. Station blackout contributes 4.3% to overall core damage. Preventing failure of the diesel-generator would eliminate station blackout as a concern. Other means are available to mitigate station blackouts. Refer to SAMA items 55, 56, 58, 21, and 22.
26	IE-SB-156-S	2.52E-03	4.21E-02	SMALL TRAIN B SW PIPE BREAKS IN ROOM 156 (Aux Building Mezzanine)	This initiating event leads to core damage due to flood-induced failure of equipment needed to maintain RCP seal cooling, specifically, failure of MCCs 52E, 62E, and 62H. Loss of these MCCs leads to a loss of charging pumps and a loss of ventilation needed to ensure continued functioning of CCW pumps. Refer to SAMA item 169.
27	10-GE-DG1B---PR	1.88E-02	3.97E-02	INDEPENDENT FAILURE DIESEL GENERATOR B FAILS TO RUN	A large part of the importance of this basic event is driven by the need to isolate flooding events (refer to item 2 above). This event is important to the KPS results because power is needed to operate the valves that are used to isolate many of the internal flooding initiating events. Failure of offsite power coupled with failure of the diesel-generator to operate causes the inability to isolate some flooding events. In actuality, however, flooding isolation must occur early in the event, typically in less than one hour. The ability to isolate flooding events without requiring power would greatly lower the importance of this event. Refer to SAMA item 168. Station blackout contributes 4.3% to overall core damage. Preventing failure of the diesel-generator would eliminate station blackout as a concern. Other means are available to mitigate station blackouts. Refer to SAMA items 55, 56, 58, 21, and 22.

Table F-8. Basic Event Importance with Respect to LERF (Continued)

Item No.	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
28	XEQN-R1B156S	1.00E+00	3.71E-02	N/A – Automatically generated as part of the quantification process	This basic event is automatically generated as part of the quantification process and indicates that the event tree top event to refill the RWST is a guaranteed failure as a result of the conditions represented in the event tree. Equipment needed to refill the RWST, specifically the boric acid transfer pumps and auxiliary building mezzanine cooling units, is failed by the flooding event. Refill of the RWST is important primarily because failure of secondary cooling via AFW or MFW has necessitated the need for bleed and feed cooling and high-pressure recirculation. Two approaches can be taken to minimize the importance of this operator action. The first is to lower the overall failure probability of the AFW system. The second is to protect equipment needed to refill the RWST from the effects of spray. Failure of the AFW system is primarily caused by failure of the room cooling systems needed to support operation of the motor-driven AFW pumps. The ability to provide alternate room cooling for safeguards alley would lower the importance of this initiating event to overall core damage. Refer to SAMA items 169, 170, and 171. Potential improvements related to protecting auxiliary building equipment are addressed by items 173 and 174.

Table F-8. Basic Event Importance with Respect to LERF (Continued)

Item No.	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
29	XEQN-LRB156S	1.00E+00	3.71E-02	N/A – Automatically generated as part of the quantification process	This basic event is automatically generated as part of the quantification process and indicates that the event tree top event to switch to low-pressure recirculation is a guaranteed failure as a result of the conditions represented in the event tree. Equipment needed for low-pressure recirculation, specifically the CCW pumps and auxiliary building mezzanine cooling units, is failed by the flooding event. Low pressure recirculation is important primarily because failure of secondary cooling via AFW or MFW has necessitated the need for bleed and feed cooling and ECCS recirculation. Two approaches can be taken to minimize the importance of this operator action. The first is to lower the overall failure probability of the AFW system. The second is to protect equipment needed for ECCS recirculation from the effects of spray. Failure of the AFW system is primarily caused by failure of the room cooling systems needed to support operation of the motor-driven AFW pumps. The ability to provide alternate room cooling for safeguards alley would lower the importance of this initiating event to overall core damage. Refer to SAMA items 169, 170, and 171. Potential improvements related to protecting auxiliary building equipment are addressed by items 173 and 175.

Table F-8. Basic Event Importance with Respect to LERF (Continued)

Item No.	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
30	XEQN-HRB156S	1.00E+00	3.71E-02	N/A – Automatically generated as part of the quantification process	This basic event is automatically generated as part of the quantification process and indicates that the event tree top event to switch to high-pressure recirculation is a guaranteed failure as a result of the conditions represented in the event tree. Equipment needed for low-pressure recirculation, specifically the CCW pumps and auxiliary building mezzanine cooling units, is failed by the flooding event. High pressure recirculation is important primarily because failure of secondary cooling via AFW or MFW has necessitated the need for bleed and feed cooling and ECCS recirculation. Two approaches can be taken to minimize the importance of this operator action. The first is to lower the overall failure probability of the AFW system. The second is to protect equipment needed for ECCS recirculation from the effects of spray. Failure of the AFW system is primarily caused by failure of the room cooling systems needed to support operation of the motor-driven AFW pumps. The ability to provide alternate room cooling for safeguards alley would lower the importance of this initiating event to overall core damage. Refer to SAMA items 169, 170 and 171. Potential improvements related to protecting auxiliary building equipment are addressed by items 173 and 175.
31	36--LHS-DIAG-HE	1.73E-03	3.61E-02	OPERATOR FAILS TO DIAGNOSE LOSS OF HEAT SINK	This basic event represents cognitive failure to recognize a loss of the secondary heat sink and the need to initiate bleed and feed cooling. These actions are important primarily because failure of secondary cooling via AFW or MFW has necessitated the need for bleed and feed cooling. Two approaches can be taken to minimize the importance of this operator action. The first is to lower the overall failure probability of the AFW system. The second is to provide more and clear cues for the loss of heat sink. Failure of the AFW system is primarily caused by failure of the room cooling systems needed to support operation of the motor-driven AFW pumps. The ability to provide alternate room cooling for safeguards alley would lower the importance of this initiating event to overall core damage. Refer to SAMA items 170 and 171. Initiation of bleed and feed cooling is directed by the IPEOPs, which are written per the WOG standard, and the cues given in the procedures are redundant and clear. It is unlikely that any changes that would improve this action could be implemented.

Table F-8. Basic Event Importance with Respect to LERF (Continued)

Item No.	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
32	10-GE-KPRCCF12	1.45E-03	3.32E-02	DOUBLE COMMON CAUSE FAILURE (CCF) EDGS FAIL TO RUN	A large part of the importance of this basic event is driven by the need to isolate flooding events (refer to item 2 above). This event is important to the KPS results because power is needed to operate the valves that are used to isolate many of the internal flooding initiating events. Failure of offsite power coupled with failure of the diesel-generator to operate causes the inability to isolate some flooding events. In actuality, however, flooding isolation must occur early in the event, typically in less than one hour. The ability to isolate flooding events without requiring power would greatly lower the importance of this event. Refer to SAMA item 168. Station blackout contributes 4.3% to overall core damage. Preventing failure of the diesel-generator would eliminate station blackout as a concern. Other means are available to mitigate station blackouts. Refer to SAMA items 55, 56, 58, 21, and 22.
33	SL76	8.00E-01	3.26E-02	SMALL REACTOR COOLANT PUMP SEAL LOCA (21,57,76 GPM)	The importance of RCP seal LOCAs is addressed by preventing the loss of seal cooling. SAMA item 58 addresses improved RCP seals.
34	IE-W-5B24-U	1.29E-04	2.72E-02	MODERATE BREAK FROM AFW PIPE IN ROOM AFW PUMP ROOMS	This initiating event leads to core damage when operator actions to isolate the AFW piping fail. Failure to isolate the pipe break causes a loss of the bottom row of circuit breakers on 480 VAC buses and a loss of bus 5. The probability of the operators failing to isolate the break is currently low so it is unlikely that any SAMAs could reduce them further. Because the event fails the AFW pumps, loss of secondary cooling dominates the event accident sequences and secondary cooling relies on main feedwater. Adding sump pumps to safeguards alley could eliminate the need to isolate AFW breaks prior to failing the 480 VAC breakers. Refer to SAMA item 176.
35	XEQN-AFAU-SA	1.00E+00	2.71E-02	N/A – Automatically generated as part of the quantification process	This basic event is automatically generated as part of the quantification process and indicates that auxiliary feedwater is a guaranteed failure as a result of the conditions represented in the event tree. Because the initiating event itself renders the AFW system nonfunctional, no SAMA items are generated.

Table F-8. Basic Event Importance with Respect to LERF (Continued)

Item No.	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
36	10-GE-DG1A---TM	1.30E-02	2.68E-02	DIESEL GENERATOR A UNAVAILABLE DUE TO TEST OR MAINTENANCE	A large part of the importance of this basic event is driven by the need to isolate flooding events (refer to item 2 above). This event is important to the KPS results because power is needed to operate the valves that are used to isolate many of the internal flooding initiating events. Failure of offsite power coupled with failure of the diesel-generator to operate causes the inability to isolate some flooding events. In actuality, however, flooding isolation must occur early in the event, typically in less than one hour. The ability to isolate flooding events without requiring power would greatly lower the importance of this event. Refer to SAMA item 168. Station blackout contributes 4.3% to overall core damage. Preventing failure of the diesel-generator would eliminate station blackout as a concern. Other means are available to mitigate station blackouts. Refer to SAMA items 55, 56, 58, 21, and 22.
37	IE-S-5B14-M	1.05E-06	2.60E-02	MAJOR SERVICE WATER BREAK IN SAFEGUARDS ALLEY	This initiating event is assumed to fail all equipment located in safeguards alley, thereby leading directly to core damage. Installation a sturdy watertight barrier between the two t80 VAC switchgear rooms could allow one train of equipment to remain available. Refer to SAMA item 177.
38	35--CH2------HE	1.16E-01	2.60E-02	OPERATOR FAILS TO ESTABLISH CHARGING FLOW DURING SBO	This event represents failure of the operator actions to establish charging flow using the technical support center (TSC) diesel as the power source during a station blackout. The importance of this event is because of the high failure probability. The high probability is because of the large number of actions needed to implement the charging with the TSC diesel. Reducing the number of actions required would require hardware changes. SAMA items 1 through 24 address improving the reliability of AC power. SAMA items 55 through 58 address reducing RCP seal LOCAs. No additional SAMA items identified as a result of this basic event.
39	49-CB-KFOCCF12	3.73E-05	2.56E-02	DOUBLE COMMON CAUSE FAILURE (CCF) 49-C-KFOCCF12 (Reactor Trip Breakers)	This basic event occurs in ATWS sequences. KPS has implemented the WOG IPEOPs that direct mitigation of ATWS events. Since the failure probability for this basic event is based on generic data, hardware modifications related to reactor trip breakers would not result in a change to the failure probability. No issues specific to the KPS reactor trip breakers exist. Therefore, no SAMA items are generated as a result of this basic event.

Table F-8. Basic Event Importance with Respect to LERF (Continued)

Item No.	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
40	IE-W--14B-U	1.51E-04	2.54E-02	MODERATE BREAK FROM AFW PIPE IN ROOM 14B (Auxiliary Building Basement)	This initiating event leads to core damage due to flood-induced failure of equipment needed to maintain RCP seal cooling and switch to ECCS recirculation, specifically, failure of MCCs 52E, 62E, and 62H. Loss of these MCCs leads to a loss of charging pumps, loss of the ability to switch to ECCS recirculation, and a loss of ventilation needed to ensure continued functioning of CCW pumps. Refer to SAMA item 169.
41	XEQN-AFWU14B	1.00E+00	2.52E-02	N/A – Automatically generated as part of the quantification process	This basic event is automatically generated as part of the quantification process and indicates that auxiliary feedwater is a guaranteed failure as a result of the conditions represented in the event tree. Because the initiating event itself renders the AFW system nonfunctional, no SAMA items are generated.
42	05BPMSKPSCCF123	1.38E-04	2.52E-02	TRIPLE COMMON CAUSE FAILURE (CCF) AFW-1A/ 1B/TD PUMP START	Reducing the importance of this basic event requires either a reduction in the base failure rate of the pumps, a reduction in the common cause factors, or the addition of a redundant or diverse AFW pump. The failure data for KPS AFW pumps failing to start is about the same as generic industry data so it is unlikely that any efforts to reduce the base failure rate would result in a meaningful reduction. The common cause factors used are generic values taken from a standard industry source. No vulnerabilities related to common cause failure of the KPS AFW pumps have been identified so no actions to address the common cause factors would be applicable. The cost of adding a redundant or diverse AFW pump is judged to exceed the maximum available benefit. Therefore, no SAMA items are added as a result of this basic event.
43	02-SWHDRISOXPHE	1.71E-02	2.40E-02	OPERATOR FAILS TO ISOLATE MODERATE SW BREAK IN BATTERY RM	This basic event represents failure of the operator actions to isolate a moderate service water break in a one battery room before the break propagates to the opposite battery room and causes failure of the 480 VAC MCC located there. These failures then result in a loss of all DC power. Installation of flood detection in the room could improve the cues available to the operators that a flood was occurring. See SAMA item 178.
44	31-PM--CCW1A-PR	2.00E-03	2.38E-02	INDEPENDENT FAILURE COMPONENT COOLING PUMP A FTR	This basic event represents failure of the A-train CCW pump to run. SAMA items 58 and 59 would reduce the importance of this item.

Table F-8. Basic Event Importance with Respect to LERF (Continued)

Item No.	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
45	IE-SB-3B--M	1.51E-05	2.31E-02	MAJOR BREAK FROM TRAIN B SERVICE WATER PIPE IN ROOM 3B (Train B diesel and switchgear room)	A major rupture of the B-train service water pipe in the B-train switchgear room causes a loss of the B-train switchgear and leads to a loss of offsite power. The dominant contributors to accident sequences following this event are failures of the A-train diesel. Providing a path for water to leave the room before level reaches 18-inches would preclude a loss of offsite power and minimize the need for the A-train diesel-generator. Refer to SAMA item 181.
46	02-SWHDRISOXAHE	1.00E+00	2.30E-02	OPERATOR FAILS TO ISOLATE MAJOR SW BREAK IN DG B ROOM	This event is assumed failed because of the short time available to perform it. A major rupture of the B-train service water pipe in the B-train switchgear room causes a loss of the B-train switchgear and leads to a loss of offsite power. The dominant contributors to accident sequences following this event are failures of the A-train diesel. Providing a path for water to leave the room before level reaches 18-inches would preclude a loss of offsite power and minimize the need for the A-train diesel-generator. Refer to SAMA item 181.
47	STBY-CCWPA	5.00E-01	2.29E-02	COMPONENT COOLING PUMP A IS IN STANDBY	This basic event is a flag-type of event used to facilitate the overall quantification and represents no physical failures. No SAMA items are generated as a result of this basic event.
48	16-FNAKPRCCF23	1.73E-05	2.21E-02	DOUBLE COMMON CAUSE FAILURE (CCF) TBB A, B FCU FTR	This event represents common cause failure of the two fan cooling units for the switchgear rooms in safeguards alley. This event then results in failure of the AFW pumps and safety-related 480 VAC equipment. Provision of room temperature alarms or the ability to provide alternate room cooling for safeguards alley would lower the importance of this initiating event to overall core damage. Refer to SAMA items 170 and 171.
49	31-PM--CCW1B-PR	2.00E-03	2.20E-02	INDEPENDENT FAILURE COMPONENT COOLING PUMP B FTR	This basic event represents failure of the B-train CCW pump to run. SAMA items 58 and 59 would reduce the importance of this item.

Table F-8. Basic Event Importance with Respect to LERF (Continued)

Item No.	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
50	36--LHS-DEP--HE	1.00E-06	2.19E-02	OPERATOR ERRORS LEAD TO LOSS OFHEAT SINK	This basic event models operator errors that lead to a loss of secondary heat sink. It is assumed that any such errors will result in a loss of all secondary cooling and a loss of bleed and feed cooling with no chance of recovery. These assumptions are conservative. The already low value for this basic event and conservative nature of the assumptions used in its development indicate that removal of conservatisms from the analysis would likely reduce the importance of the event. Therefore, no SAMA items are developed to address the importance of this event.
51	STBY-CCWPB	5.00E-01	2.14E-02	COMPONENT COOLING PUMP B IS IN STANDBY	This basic event is a flag-type of event used to facilitate the overall quantification and represents no physical failures. No SAMA items are generated as a result of this basic event.
52	10-GE-DG1B---TM	1.18E-02	2.14E-02	DIESEL GENERATOR B UNAVAILABLE DUE TO TEST OR MAINTENANCE	A large part of the importance of this basic event is driven by the need to isolate flooding events (refer to item 2 above). This event is important to the KPS results because power is needed to operate the valves that are used to isolate many of the internal flooding initiating events. Failure of offsite power coupled with failure of the diesel-generator to operate causes the inability to isolate some flooding events. In actuality, however, flooding isolation must occur early in the event, typically in less than one hour. The ability to isolate flooding events without requiring power would greatly lower the importance of this event. Refer to SAMA item 168. Station blackout contributes 4.3% to overall core damage. Preventing failure of the diesel-generator would eliminate station blackout as a concern. Other means are available to mitigate station blackouts. Refer to SAMA items 55, 56, 58, 21, and 22.
53	IE-TMF	9.72E-02	2.14E-02	TRANSIENT INITIATING EVENT WITH A LOSS OF MAIN FEEDWATER	Accident sequences following a loss of main feedwater include failures of the AFW system and a subsequent failure to initiate bleed and feed cooling. Failures of the AFW system that contribute to TMF core damage sequences include loss of room cooling and common cause failure of the AFW pumps to start. These issues are addressed in items 18 and 54 above. Issues related to bleed and feed cooling are identified in item 27 above. No new SAMA items are identified to address the importance of this basic event.

Table F-8. Basic Event Importance with Respect to LERF (Continued)

Item No.	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
54	FAULT-B	5.00E-01	2.08E-02	STEAM GENERATOR B IS FAULTED	This basic event is a flag-type of event used to facilitate the overall quantification and represents no physical failures. No SAMA items are generated as a result of this basic event.
55	FAULT-A	5.00E-01	2.07E-02	STEAM GENERATOR A IS FAULTED	This basic event is a flag-type of event used to facilitate the overall quantification and represents no physical failures. No SAMA items are generated as a result of this basic event.
56	IE-SOPORV	4.18E-02	2.00E-02	STUCK OPEN PORV INITIATING EVENT	The importance of this event is due to conservatism in modeling. The conservatism assumes that if offsite power is lost at any time within 24 hours following the initial stuck open PORV, then the diesel generator is needed to close the associated PORV lock valve. In actuality, however, PORV isolation must occur early in the event, typically in less than one hour. Unlike flooding events, a stuck open PORV does not impair the electrical systems needed to close the block valve. Since more detailed modeling would remove this event from the importance, no SAMA items are generated from this basic event.
57	05BFAFWA-CAL-AE	8.16E-04	1.98E-02	TECHNICIAN MISCALIBRATES AFW TRAIN B FLOW	Miscalibration of the AFW flow indication could lead the operators to mis-diagnose a loss of secondary heat sink and, in turn, fail to switch to bleed and feed cooling. Calibration procedures currently incorporate appropriate checks into the process. It is not likely that this failure probability could be reduced further by procedural changes. Hardware changes that add a diverse indicating circuit could reduce the importance of this event. Refer to SAMA item 179.
58	05BFAFWB-CAL-AE	8.16E-04	1.98E-02	TECHNICIAN MISCALIBRATES AFW TRAIN A FLOW	Miscalibration of the AFW flow indication could lead the operators to mis-diagnose a loss of secondary heat sink and, in turn, fail to switch to bleed and feed cooling. Calibration procedures currently incorporate appropriate checks into the process. It is not likely that this failure probability could be reduced further by procedural changes. Hardware changes that add a diverse indicating circuit could reduce the importance of this event. Refer to SAMA item 179.

Table F-8. Basic Event Importance with Respect to LERF (Continued)

Item No.	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
59	05B-AFW-ISO-7-HE	6.50E-03	1.97E-02	FAIL TO ISOLATE MOD AFW BREAK BEFORE BUS FAILURE	Failure to isolate the pipe break causes a loss of the bottom row of circuit breakers on 480 VAC buses and a loss of bus 5. The probability of the operators failing to isolate the break is currently low so it is unlikely that any SAMAs could reduce them further. Adding sump pumps to safeguards alley could eliminate the need to isolate AFW breaks prior to failing the 480 VAC breakers. Refer to SAMA item 176.
60	05BPMOKPSCCF123	1.05E-04	1.91E-02	TRIPLE COMMON CAUSE FAILURE (CCF) ALOP-1A/ 1B/1C PS (AFW pump auxiliary lube oil pumps)	Currently, the KPS AFW pumps will not start without adequate lube oil pressure that is provided by the auxiliary lube oil pumps. Removal of the interlock from the start circuitry would eliminate the need for the ALOPs. Refer to SAMA item 180.
61	IE-SB-3B--U	1.23E-04	1.86E-02	MODERATE BREAK FROM TRAIN B SERVICE WATER PIPE IN ROOM 3B (Train B diesel and switchgear room)	A moderate rupture of the B-train service water pipe in the B-train switchgear room causes a loss of the B-train switchgear and leads to a loss of offsite power if the break is not isolated before water level in the room reaches 18-inches. The dominant contributors to accident sequences following this event are failures of the A-train diesel. Providing a path for water to leave the room before level reaches 18-inches would preclude a loss of offsite power and minimize the need for the A-train diesel-generator. Refer to SAMA item 181.
62	XCOM-CHSBO	8.14E-01	1.80E-02	N/A — Automatically generated as part of the quantification process	This item represents success of the charging top event in the SBO event trees and is generated as part of the quantification process. No SAMA items generated to address this basic event.
63	IE-TSW	3.65E+02	1.76E-02	LOSS OF SERVICE WATER INITIATING EVENT	This basic event is a tag event that is attached to all cutsets representing a loss of service water initiating event. The basic event itself represents no physical failures. The importance of this initiating event is dominated by two failures; common cause failure of all service water pumps and low forebay level. Loss of all service water pumps is addressed by SAMA items 46 and 62. Low forebay level is a natural phenomenon. To compensate for low forebay level would require structural changes to the intake structure and engineering judgment indicates that the cost of such changes would greatly exceed the maximum benefit available.

Table F-8. Basic Event Importance with Respect to LERF (Continued)

Item No.	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
64	02-SWHDRISOX0HE	9.15E-02	1.71E-02	OPERATOR FAILS TO ISOLATE A MOD. SW BREAK IN DG B ROOM	A moderate rupture of the B-train service water pipe in the B-train switchgear room causes a loss of the B-train switchgear and leads to a loss of offsite power if the break is not isolated before water level in the room reaches 18-inches. The dominant contributors to accident sequences following this event are failures of the A-train diesel. Providing a path for water to leave the room before level reaches 18-inches would preclude a loss of offsite power and minimize the need for the A-train diesel-generator. Refer to SAMA item 181.
65	AC-0221	2.68E-01	1.69E-02	OFFSITE POWER NOT RECOVERED WITHIN 2 HOURS, 21 MINUTES	Items that address mitigating or recovering from a loss of offsite power are addressed by SAMA items 1 through 24, 55, and 58.
66	LERF-10	1.42E-01	1.69E-02	LARGE EARLY RELEASE FREQUENCY FOR PLANT DAMAGE STATE 10	This basic event is a flag-type of event used to facilitate the overall quantification and represents no physical failures. No SAMA items are generated as a result of this basic event.
67	XEQN-HRWU14B	1.00E+00	1.66E-02	N/A – Automatically generated as part of the quantification process	This basic event is automatically generated as part of the quantification process and indicates that the event tree top event to switch to low-pressure recirculation is a guaranteed failure as a result of the conditions represented in the event tree, failure of AFW piping in the auxiliary building basement. Equipment needed for low-pressure recirculation, specifically the CCW pumps and auxiliary building mezzanine cooling units, is failed by the flooding event. Low pressure recirculation is important primarily because failure of secondary cooling via AFW or MFW has necessitated the need for bleed and feed cooling and ECCS recirculation. Two approaches can be taken to minimize the importance of this operator action. The first is to lower the overall failure probability of the AFW system. The second is to protect equipment needed for ECCS recirculation from the effects of spray. Failure of the AFW system is caused by the initiating evene which is a failure of the AFW piping. The analyis conservatively assumes that failure of the suction piping precludes use of the service water supply to the AFW pumps. Therefore, no items are identified to address improving AFW cooling for this initiating event. Potential improvements related to protecting auxiliary building equipment are addressed by items 173 and 175.

Table F-8. Basic Event Importance with Respect to LERF (Continued)

Item No.	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
68	XEQN-LRWU14B	1.00E+00	1.66E-02	N/A – Automatically generated as part of the quantification process	This basic event is automatically generated as part of the quantification process and indicates that the event tree top event to switch to high-pressure recirculation is a guaranteed failure as a result of the conditions represented in the event tree, failure of AFW piping in the auxiliary building basement. Equipment needed for low-pressure recirculation, specifically the CCW pumps and auxiliary building mezzanine cooling units, is failed by the flooding event. High pressure recirculation is important primarily because failure of secondary cooling via AFW or MFW has necessitated the need for bleed and feed cooling and ECCS recirculation. Two approaches can be taken to minimize the importance of this operator action. The first is to lower the overall failure probability of the AFW system. The second is to protect equipment needed for ECCS recirculation from the effects of spray. Failure of the AFW system is caused by the initiating event which is a failure of the AFW piping. The analysis conservatively assumes that failure of the suction piping precludes use of the service water supply to the AFW pumps. Therefore, no items are identified to address improving AFW cooling for this initiating event. Potential improvements related to protecting auxiliary building equipment are addressed by items 173 and 175.
69	IE-ISL	1.00E+00	1.62E-02	INTERFACING SYSTEM LOSS OF COOLANT ACCIDENT OCCURS	This basic event is a tag event that is attached to all cutsets representing an interfacing systems LOCA initiating event. This event causes an interfacing system LOCA initiating event. Given the low importance of this event, very little benefit would be obtained from efforts to reduce the importance further. Therefore, no SAMA items are added.
70	IE-F--2B--M	1.12E-05	1.60E-02	MAJOR BREAK FROM FIRE PROTECTION WATER PIPE IN ROOM 2B (Train A diesel and switchgear room)	A major rupture of the fire protection water pipe in the A-train switchgear room causes a loss of the A-train switchgear and leads to a loss of offsite power. The dominant contributors to accident sequences following this event are failures of the B-train diesel. Providing a path for water to leave the room before level reaches 18-inches would preclude a loss of offsite power and minimize the need for the B-train diesel-generator. Refer to SAMA item 181.

Table F-8. Basic Event Importance with Respect to LERF (Continued)

Item No.	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
71	AC-1632	2.74E-02	1.59E-02	OFFSITE POWER NOT RECOVERED WITHIN 16 HOURS, 32 MINUTES	Items that address mitigating or recovering from a loss of offsite power are addressed by SAMA items 1 through 24, 55, and 58.
72	IE-SA-2B--M	1.08E-05	1.55E-02	MAJOR BREAK FROM A-TRAIN SERVICE WATER PIPE IN ROOM 2B (Train A diesel and switchgear room)	A major rupture of the A-train service water pipe in the A-train switchgear room causes a loss of the A-train switchgear and leads to a loss of offsite power. The dominant contributors to accident sequences following this event are failures of the B-train diesel. Providing a path for water to leave the room before level reaches 18-inches would preclude a loss of offsite power and minimize the need for the B-train diesel-generator. Refer to SAMA item 181.
73	02-SWHDRISOX7HE	1.00E+00	1.53E-02	OPERATOR FAILS TO ISOLATE A MAJOR SERVICE WATER BREAK IN DG A ROOM	A major rupture of the A-train service water pipe in the A-train switchgear room causes a loss of the A-train switchgear and leads to a loss of offsite power. The dominant contributors to accident sequences following this event are failures of the B-train diesel. Providing a path for water to leave the room before level reaches 18-inches would preclude a loss of offsite power and minimize the need for the B-train diesel-generator. Refer to SAMA item 181.
74	IE-SA-8B--U	2.17E-03	1.49E-02	MODERATE TRAIN A SW PIPE BREAKS IN ROOM 8B (Aux Building Basement)	This initiating event leads to core damage due to flood-induced failure of equipment needed to maintain RCP seal cooling, specifically, failure of MCCs 52E, 62E, and 62H. Loss of these MCCs leads to a loss of charging pumps and a loss of ventilation needed to ensure continued functioning of CCW pumps. Refer to SAMA item 169.

Table F-8. Basic Event Importance with Respect to LERF (Continued)

Item No.	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
75	10-GE-DG1A---PS	6.72E-03	1.49E-02	DIESEL GENERATOR A INDEPENDENT FAILURE TO START	A large part of the importance of this basic event is driven by the need to isolate flooding events (refer to item 2 above). This event is important to the KPS results because power is needed to operate the valves that are used to isolate many of the internal flooding initiating events. Failure of offsite power coupled with failure of the diesel-generator to operate causes the inability to isolate some flooding events. In actuality, however, flooding isolation must occur early in the event, typically in less than one hour. The ability to isolate flooding events without requiring power would greatly lower the importance of this event. Refer to SAMA item 168. Station blackout contributes 4.3% to overall core damage. Preventing failure of the diesel-generator would eliminate station blackout as a concern. Other means are available to mitigate station blackouts. Refer to SAMA items 55, 56, 58, 21, and 22.
76	LERF-32	2.35E-01	1.48E-02	LARGE EARLY RELEASE FREQUENCY FOR PLANT DAMAGE STATE 32	This basic event is a flag-type of event used to facilitate the overall quantification and represents no physical failures. No SAMA items are generated as a result of this basic event.
77	IE-W-5B24-S	2.34E-04	1.36E-02	SMALL BREAK FROM AFW PIPE IN ROOM AFW PUMP ROOMS	This initiating event leads to core damage when operator actions to isolate the AFW piping fail. Failure to isolate the pipe break causes a loss of the bottom row of circuit breakers on 480 VAC buses. The probability of the operators failing to isolate the break is currently low so it is unlikely that any SAMAs could reduce them further. Because the event fails the AFW pumps, loss of secondary cooling dominates the event accident sequences and secondary cooling relies on main feedwater. Adding sump pumps to safeguards alley could eliminate the need to isolate AFW breaks prior to failing the 480 VAC breakers. Refer to SAMA item 176.

Table F-8. Basic Event Importance with Respect to LERF (Continued)

Item No.	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
78	10-GE-DG1B---PS	6.72E-03	1.34E-02	DIESEL GENERATOR A INDEPENDENT FAILURE TO START	A large part of the importance of this basic event is driven by the need to isolate flooding events (refer to item 2 above). This event is important to the KPS results because power is needed to operate the valves that are used to isolate many of the internal flooding initiating events. Failure of offsite power coupled with failure of the diesel-generator to operate causes the inability to isolate some flooding events. In actuality, however, flooding isolation must occur early in the event, typically in less than one hour. The ability to isolate flooding events without requiring power would greatly lower the importance of this event. Refer to SAMA item 168. Station blackout contributes 4.3% to overall core damage. Preventing failure of the diesel-generator would eliminate station blackout as a concern. Other means are available to mitigate station blackouts. Refer to SAMA items 55, 56, 58, 21, and 22.
79	XEQN-AFAS-SA	1.00E+00	1.33E-02	N/A – Automatically generated as part of the quantification process	This basic event is automatically generated as part of the quantification process and indicates that auxiliary feedwater is a guaranteed failure as a result of the conditions represented in the event tree. Because the initiating event itself renders the AFW system nonfunctional, no SAMA items are generated.
80	IE-SA-129-U	4.61E-05	1.31E-02	TRAIN A SW FLOOD IN ROOM 129 EXCEEDS DRAIN CAPACITY (A-train battery room)	This initiating event results in core damage when operator actions to isolate the break before propagation to the opposite battery room fail. Then propagation causes failure of the 480 VAC MCC located there. These failures then result in a loss of all DC power. Installation of flood detection in the room could improve the cues available to the operators that a flood was occurring. See SAMA item 178.
81	LERF-61	5.00E-01	1.28E-02	LARGE EARLY RELEASE FREQUENCY FOR PLANT DAMAGE STATE 61	This basic event is a flag-type of event used to facilitate the overall quantification and represents no physical failures. No SAMA items are generated as a result of this basic event.
82	XEQN-MFSUA129	1.00E+00	1.26E-02	N/A – Automatically generated as part of the quantification process	This basic event is automatically generated as part of the quantification process and indicates that main feedwater is a guaranteed failure as a result of the conditions represented in the event tree. Because the initiating event itself renders the MFW system nonfunctional, no SAMA items are generated.

Table F-8. Basic Event Importance with Respect to LERF (Continued)

Item No.	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
83	IE-SB-130-U	4.39E-05	1.21E-02	TRAIN B SW FLOOD IN ROOM 130 EXCEEDS DRAIN CAPACITY (B-train battery room)	This initiating event results in core damage when operator actions to isolate the break before propagation to the opposite battery room fail. Then propagation causes failure of the 480 VAC MCC located there. These failures then result in a loss of all DC power. Installation of flood detection in the room could improve the cues available to the operators that a flood was occurring. See SAMA item 178.
84	05BPT--AFW1C-TM	3.93E-03	1.18E-02	TD AFW PUMP UNAVAILABLE DUE TO TEST OR MAINTENANCE	The importance of the turbine-driven AFW pump is caused mainly by loss of room cooling inducing failure of the motor-driven AFW pumps. The loss of room cooling could be caused directly by a loss of the coolers or by flood-induced failure of the power supplies. Instituting measures to ensure adequate room cooling to safeguards alley after a loss of room cooling would lower the importance of the turbine-driven AFW pump. The ability to provide alternate room cooling for safeguards alley would lower the importance of this initiating event to overall core damage. Refer to SAMA items 170 and 171.
85	16-FNDKPSCCF12	5.12E-04	1.15E-02	DOUBLE COMMON CAUSE FAILURE (CCF) DG1A/1B FF	Items to address ventilation are addressed by SAMA items 80 through 83.
86	27A-RMST-CST-HE	1.24E-03	1.12E-02	OPERATOR FAILS TO CROSS-TIE CSTS AND RMSTS	Operator action to cross-tie the RMSTs to the CSTs is used to prevent a loss of secondary cooling due to depletion of CST inventory. Providing a larger CST is addressed in SAMA item 71.
87	IE-SB-3B--S	8.44E-04	1.10E-02	SMALL BREAK FROM TRAIN B SERVICE WATER PIPE IN ROOM 3B (Train B diesel and switchgear room)	A small rupture of the B-train service water pipe in the B-train switchgear room causes a loss of the B-train switchgear and leads to a loss of offsite power if the break is not isolated before water level in the room reaches 18-inches. The dominant contributors to accident sequences following this event are failures of the A-train diesel. Providing a path for water to leave the room before level reaches 18-inches would preclude a loss of offsite power and minimize the need for the A-train diesel-generator. Refer to SAMA item 181.
88	33-PM-KPSCCF12	1.10E-04	1.07E-02	DOUBLE COMMON CAUSE FAILURE (CCF) 33-PMKPSCCF12	Given the low importance of this event, very little benefit would be obtained from efforts to reduce the importance further. Therefore, no SAMA items are added.

Table F-8. Basic Event Importance with Respect to LERF (Continued)

Item No.	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
89	IE-F--4B--M	6.93E-06	1.05E-02	MAJOR FIRE PROTECTION PIPE BREAK IN ROOM 4B (CarDox room)	A major fire protection pipe break in the CarDox room rapidly propagates to the B-train switchgear room and causes a loss of offsite power. The dominant accident sequences for this event involve failure of the A-train diesel-generator thereby resulting in a station blackout. The KPS PRA models assume that any internal flooding event that results in a station blackout results in core damage. However, detailed evaluation of station blackout events would likely show that some mitigation of flood-induced station blackouts could occur, thereby decreasing the importance of this event. Since this event is of low importance and more detailed modeling of existing procedures and equipment would lessen the importance, no SAMA items are developed from this event.
90	08-FPHDRISOX8HE	1.00E+00	1.05E-02	OPERATOR FAILS TO ISOLATE A MAJOR FIRE PROTECTION BREAK IN ROOM 4B (CarDox room)	A major fire protection pipe break in the CarDox room rapidly propagates to the B-train switchgear room and causes a loss of offsite power. The dominant accident sequences for this event involve failure of the A-train diesel-generator thereby resulting in a station blackout. The KPS PRA models assume that any internal flooding event that results in a station blackout results in core damage. However, detailed evaluation of station blackout events would likely show that some mitigation of flood-induced station blackouts could occur, thereby decreasing the importance of this event. Since this event is of low importance and more detailed modeling of existing procedures and equipment would lessen the importance, no SAMA items are developed from this event.
91	PORV-A	5.00E-01	1.00E-02	FRACTION OF STUCK OPEN PORVS ON PR-2A	This event is a scalar. No SAMA items identified to address the importance of this basic event.
92	PORV-B	5.00E-01	9.99E-03	FRACTION OF STUCK OPEN PORVS ON PR-2B	This event is a scalar. No SAMA items identified to address the importance of this basic event.
93	02-SWHDRISOXEHE	1.16E-02	9.18E-03	OPERATOR FAILS TO ISOLATE MAJOR SW BREAK IN SCREENHOUSE	This event is important because failure to isolate the break in a timely manner leads to flooding the switchgear rooms. Installation of a drainage path from the screenhouse to the lake would eliminate the need for isolation. See SAMA item 182.

Table F-8. Basic Event Importance with Respect to LERF (Continued)

Item No.	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
94	10-GE-KPSCCF12	4.07E-04	9.07E-03	DOUBLE COMMON CAUSE FAILURE (CCF) EDGS FAIL TO START	A large part of the importance of this basic event is driven by the need to isolate flooding events (refer to item 2 above). This event is important to the KPS results because power is needed to operate the valves that are used to isolate many of the internal flooding initiating events. Failure of offsite power coupled with failure of the diesel-generator to operate causes the inability to isolate some flooding events. In actuality, however, flooding isolation must occur early in the event, typically in less than one hour. The ability to isolate flooding events without requiring power would greatly lower the importance of this event. Refer to SAMA item 168. Station blackout contributes 4.3% to overall core damage. Preventing failure of the diesel-generator would eliminate station blackout as a concern. Other means are available to mitigate station blackouts. Refer to SAMA items 55, 56, 58, 21, and 22.
95	07-MV-KFCCCF1-4	4.93E-05	8.82E-03	GLOBAL COMMON CAUSE FAILURE OF BLOWDOWN ISOLATION VALVES	Failure of these valves causes a depletion of water needed to maintain secondary cooling. Providing a larger CST is addressed in SAMA item 71.
96	04--LO-LEVEL-FB	5.14E-04	8.79E-03	LOW FOREBAY LEVEL	Low forebay level is a natural phenomenon. To compensate for low forebay level would require structural changes to the intake structure and engineering judgment indicates that the cost of such changes would greatly exceed the maximum benefit available.
97	33--ORI------HE	1.50E-02	8.79E-03	OPERATOR FAILS TO RESTORE RCS INVENTORY AFTER SBO	The need to restore RCS inventory after a station blackout is due to the loss of inventory through the RCP seals. The importance of RCP seal LOCAs is addressed by preventing the loss of seal cooling. SAMA item 58 addresses improved RCP seals.
98	02-PMRKPRCCF1-4	3.22E-07	8.43E-03	GLOBAL COMMON CAUSE FAILURE OF SW PUMPS TO RUN	Loss of all service water pumps is addressed by SAMA items 46 and 62.

Table F-8. Basic Event Importance with Respect to LERF (Continued)

Item No.	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
99	16-FN-DGAF---PS	3.94E-03	8.38E-03	INDEPENDENT FAILURE DIESEL ROOM A SUPPLY FAN FTS	A large part of the importance of this basic event is driven by the need to isolate flooding events (refer to item 2 above). This event is important to the KPS results because power is needed to operate the valves that are used to isolate many of the internal flooding initiating events. Failure of offsite power coupled with failure of the diesel-generator to operate causes the inability to isolate some flooding events. In actuality, however, flooding isolation must occur early in the event, typically in less than one hour. The ability to isolate flooding events without requiring power would greatly lower the importance of this event. Refer to SAMA item 168. Station blackout contributes 4.3% to overall core damage. Preventing failure of the diesel-generator would eliminate station blackout as a concern. Other means are available to mitigate station blackouts. Refer to SAMA items 55, 56, 58, 21, and 22.
100	IE-TIA	3.65E+02	8.27E-03	LOSS OF INSTRUMENT AIR INITIATING EVENT	This basic event is a tag event that is attached to all cutsets representing a loss of instrument air initiating event. The basic event itself represents no physical failures. The importance of this initiating event is driven by sequences where failure of room cooling causes a loss of AFW pumps. The ability to provide alternate room cooling for safeguards alley would lower the importance of this initiating event to overall core damage. Refer to SAMA items 170 and 171. Improving the reliability of the air compressors could improve the reliability of the air system. Refer to SAMA items 86 and 87.
101	02-SWHDRISOXHHE	2.53E-01	7.92E-03	OPERATOR FAILS TO ISOLATE A MOD. SW BRK BEFORE 3" IN AUXILIARY BUILDING BASEMENT	This initiating event leads to core damage due to flood-induced failure of equipment needed to maintain RCP seal cooling, specifically, failure of MCCs 52E, 62E, and 62H. Loss of these MCCs leads to a loss of charging pumps and a loss of ventilation needed to ensure continued functioning of CCW pumps. Refer to SAMA item 169.
102	IE-SA-301-U	2.11E-03	7.54E-03	MODERATE TRAIN A SW PIPE BREAKS IN ROOM 301 (Control Room HVAC)	This initiating event causes a loss of main feedwater because there is no means to detect pipe failures in the room before water would rise to a level that would fail the door. Installation of flood detection instruments in the room could provide a means to detect and isolate a pipe break before MFW would be lost. Refer to SAMA item 183.

Table F-8. Basic Event Importance with Respect to LERF (Continued)

Item No.	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
103	16-FN-DGBF---PS	3.94E-03	7.50E-03	INDEPENDENT FAILURE DIESEL ROOM B SUPPLY FAN FTS	A large part of the importance of this basic event is driven by the need to isolate flooding events (refer to item 2 above). This event is important to the KPS results because power is needed to operate the valves that are used to isolate many of the internal flooding initiating events. Failure of offsite power coupled with failure of the diesel-generator to operate causes the inability to isolate some flooding events. In actuality, however, flooding isolation must occur early in the event, typically in less than one hour. The ability to isolate flooding events without requiring power would greatly lower the importance of this event. Refer to SAMA item 168. Station blackout contributes 4.3% to overall core damage. Preventing failure of the diesel-generator would eliminate station blackout as a concern. Other means are available to mitigate station blackouts. Refer to SAMA items 55, 56, 58, 21, and 22.
104	IE-SB-22B2U	7.94E-04	7.34E-03	MODERATE BREAK FROM TRAIN B SERVICE WATER PIPE IN SCREENHOUSE	This event is important because failure to isolate the break in a timely manner leads to flooding the switchgear rooms. Installation of a drainage path from the screenhouse to the lake would eliminate the need for isolation. See SAMA item 182.
105	IE-SB-403-U	4.47E-03	7.26E-03	MODERATE TRAIN B SW PIPE BREAKS IN ROOM 403 (Auxiliary building HVAC area)	This initiating event leads to core damage due to flood-induced failure of equipment needed to maintain RCP seal cooling, specifically, failure of MCCs 52E, 62E, and 62H. Loss of these MCCs leads to a loss of charging pumps and a loss of ventilation needed to ensure continued functioning of CCW pumps. Refer to SAMA item 169.
106	IE-SA-403-U	4.65E-03	7.24E-03	MODERATE SERVICE WATER TRAIN A FLOOD IN ROOM 403 (Auxiliary Building 657-foot elevation)	This initiating event leads to core damage due to flood-induced failure of equipment needed to maintain RCP seal cooling, specifically, failure of MCCs 52E, 62E, and 62H. Loss of these MCCs leads to a loss of charging pumps and a loss of ventilation needed to ensure continued functioning of CCW pumps. Refer to SAMA item 169.

Table F-8. Basic Event Importance with Respect to LERF (Continued)

Item No.	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
107	IE-SA-2B--S	7.22E-04	7.21E-03	TRAIN A SW FLOOD IN ROOM 2B WITHIN DRAIN CAPACITY (A-train DG room)	A large part of the importance of this basic event is driven by the need to isolate flooding events (refer to item 2 above). This event is important to the KPS results because power is needed to operate the valves that are used to isolate many of the internal flooding initiating events. Failure of offsite power coupled with failure of the diesel-generator to operate causes the inability to isolate some flooding events. In actuality, however, flooding isolation must occur early in the event, typically in less than one hour. The ability to isolate flooding events without requiring power would greatly lower the importance of this event. Refer to SAMA item 168.
108	10-GE-TSC-DG-PR	3.59E-02	7.20E-03	TSC DIESEL GENERATOR FAILS TO RUN	This event is important because of station blackout accident sequences. Items that address mitigating or recovering from a loss of offsite power are addressed by SAMA items 1 through 24, 55, and 58.
109	10-GE-DG1A---FL	3.36E-03	7.05E-03	INDEPENDENT FAILURE DIESEL GENERATOR A FAILS TO LOAD	A large part of the importance of this basic event is driven by the need to isolate flooding events (refer to item 2 above). This event is important to the KPS results because power is needed to operate the valves that are used to isolate many of the internal flooding initiating events. Failure of offsite power coupled with failure of the diesel-generator to operate causes the inability to isolate some flooding events. In actuality, however, flooding isolation must occur early in the event, typically in less than one hour. The ability to isolate flooding events without requiring power would greatly lower the importance of this event. Refer to SAMA item 168. Station blackout contributes 4.3% to overall core damage. Preventing failure of the diesel-generator would eliminate station blackout as a concern. Other means are available to mitigate station blackouts. Refer to SAMA items 55, 56, 58, 21, and 22.

Table F-8. Basic Event Importance with Respect to LERF (Continued)

Item No.	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
110	IE-TDA	3.65E+02	7.04E-03	LOSS OF TRAIN A DC POWER INITIATING EVENT	This basic event is a tag event that is attached to all cutsets representing a loss of train A DC power initiating event. The basic event itself represents no physical failures. The importance of this initiating event is driven by sequences where failure of room cooling causes a loss of AFW pumps and other equipment located in safeguards alley and subsequences where a long-term source of water to AFW pump suction is not available. The ability to provide alternate room cooling for safeguards alley would lower the importance of this initiating event to overall core damage. Refer to SAMA items 170 and 171. Additional alarms to indicate CST depletion, an automatic switchover to an alternate water source, or larger CSTs would lower the importance of this event. Refer to SAMA items 172, 71, and 66.
111	STBY-ABBFD	5.00E-01	7.00E-03	AUX BLDG BASEMENT FAN COIL UNIT D IS IN STANDBY	This basic event is a flag-type of event used to facilitate the overall quantification and represents no physical failures. No SAMA items are generated as a result of this basic event.
112	05BMVI-MS102-FO	2.38E-03	6.84E-03	MOV MS-102 FAILS TO OPEN (Steam supply to TDAFWP)	The importance of the turbine-driven AFW pump is caused mainly by loss of room cooling inducing failure of the motor-driven AFW pumps. The loss of room cooling could be caused directly by a loss of the coolers or by flood-induced failure of the power supplies. Instituting measures to ensure adequate room cooling to safeguards alley after a loss of room cooling would lower the importance of the turbine-driven AFW pump. The ability to provide alternate room cooling for safeguards alley would lower the importance of this initiating event to overall core damage. Refer to SAMA items 170 and 171.
113	IE-SA-22B1U	7.89E-04	6.73E-03	SW TRAIN A FLOOD <2000 GPM IN ROOM 22B-1 (A-train service water pump area)	This event is important because failure to isolate the break in a timely manner leads to flooding the switchgear rooms. Installation of a drainage path from the screenhouse to the lake would eliminate the need for isolation. See SAMA item 182.
114	33-F925--CAL-AE	4.84E-03	6.72E-03	TECHNICIAN MISCALIBRATES SI FLOW CHANNEL F925	This basic event represents a pre-initiator (type A) operator action failure that results in an inaccurate reading of safety injection flow. The addition of a second instrument to indicate SI flow would eliminate the importance of this event. Refer to SAMA item 189.

Table F-8. Basic Event Importance with Respect to LERF (Continued)

Item No.	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
115	06-AV-KFCCCF12	4.90E-04	6.68E-03	DOUBLE COMMON CAUSE FAILURE (CCF) AVMS-1A/1B FC	This event is common cause failure of both MDSIVs to close. Given the low importance of this event, very little benefit would be obtained from efforts to reduce the importance further. Therefore, no SAMA items are added.
116	IE-SLB	9.00E-03	6.64E-03	STEAM OR FEEDWATER LINE BREAK INITIATING EVENT	This basic event is important because of the PRA models conservatively assume that all breaks are large enough to require immediate isolation to prevent core steam blowdown. However, many of the breaks included in the data used to develop this initiating event frequency would not result in steam generator blowdown for many minutes. Therefore, a more realistic modeling of this event would result in a lower importance for this event. Therefore, no SAMA items are developed from this basic event.
117	IE-SB-156-U	4.03E-04	6.64E-03	MODERATE TRAIN B SW PIPE BREAKS IN ROOM 156 (Aux Building Mezzanine)	This initiating event leads to core damage due to flood-induced failure of equipment needed to maintain RCP seal cooling, specifically, failure of MCCs 52E, 62E, and 62H. Loss of these MCCs leads to a loss of charging pumps and a loss of ventilation needed to ensure continued functioning of CCW pumps. Refer to SAMA item 169.
118	10-GE-DG1B---FL	3.36E-03	6.29E-03	INDEPENDENT FAILURE DIESEL GENERATOR B FAILS TO LOAD	A large part of the importance of this basic event is driven by the need to isolate flooding events (refer to item 2 above). This event is important to the KPS results because power is needed to operate the valves that are used to isolate many of the internal flooding initiating events. Failure of offsite power coupled with failure of the diesel-generator to operate causes the inability to isolate some flooding events. In actuality, however, flooding isolation must occur early in the event, typically in less than one hour. The ability to isolate flooding events without requiring power would greatly lower the importance of this event. Refer to SAMA item 168. Station blackout contributes 4.3% to overall core damage. Preventing failure of the diesel-generator would eliminate station blackout as a concern. Other means are available to mitigate station blackouts. Refer to SAMA items 55, 56, 58, 21, and 22.
119	16-DM-TAV60A-FO	3.00E-03	6.25E-03	DAMPER TAV-60A FAILS TO OPEN	Items to address ventilation are addressed by SAMA items 80 through 83.

Table F-8. Basic Event Importance with Respect to LERF (Continued)

Item No.	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
120	16-DM-TAV63A-FO	3.00E-03	6.25E-03	DAMPER TAV-63A FAILS TO OPEN	Items to address ventilation are addressed by SAMA items 80 through 83.
121	05BPT--AFW1C-PR	2.64E-03	6.18E-03	TD AFW PUMP INDEPENDENT FAILURE TO RUN	The importance of the turbine-driven AFW pump is caused mainly by loss of room cooling inducing failure of the motor-driven AFW pumps. The loss of room cooling could be caused directly by a loss of the coolers or by flood-induced failure of the power supplies. Instituting measures to ensure adequate room cooling to safeguards alley after a loss of room cooling would lower the importance of the turbine-driven AFW pump. The ability to provide alternate room cooling for safeguards alley would lower the importance of this initiating event to overall core damage. Refer to SAMA items 170 and 171.
122	IE-SB-14B-S	1.55E-03	5.94E-03	SMALL BREAK FROM SERVICE WATER TRAIN B PIPE IN ROOM 14B (Auxiliary Building Basement)	This initiating event leads to core damage due to flood-induced failure of equipment needed to maintain RCP seal cooling and switch to ECCS recirculation, specifically, failure of MCCs 52E, 62E, and 62H. Loss of these MCCs leads to a loss of charging pumps, loss of the ability to switch to ECCS recirculation, and a loss of ventilation needed to ensure continued functioning of CCW pumps. Refer to SAMA item 169.

Table F-8. Basic Event Importance with Respect to LERF (Continued)

Item No.	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
123	XEQN-R1SBU156	1.00E+00	5.90E-03	N/A – Automatically generated as part of the quantification process	This basic event is automatically generated as part of the quantification process and indicates that the event tree top event to refill the RWST is a guaranteed failure as a result of the conditions represented in the event tree. Equipment needed to refill the RWST, specifically the boric acid transfer pumps and auxiliary building mezzanine cooling units, is failed by the flooding event. Refill of the RWST is important primarily because failure of secondary cooling via AFW or MFW has necessitated the need for bleed and feed cooling and high-pressure recirculation. Two approaches can be taken to minimize the importance of this operator action. The first is to lower the overall failure probability of the AFW system. The second is to protect equipment needed to refill the RWST from the effects of spray. Failure of the AFW system is primarily caused by failure of the room cooling systems needed to support operation of the motor-driven AFW pumps. The ability to provide alternate room cooling for safeguards alley would lower the importance of this initiating event to overall core damage. Refer to SAMA items 169, 170, and 171. Potential improvements related to protecting auxiliary building equipment are addressed by items 173 and 174.

Table F-8. Basic Event Importance with Respect to LERF (Continued)

Item No.	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
124	XEQN-HRSBU156	1.00E+00	5.90E-03	N/A – Automatically generated as part of the quantification process	This basic event is automatically generated as part of the quantification process and indicates that the event tree top event to switch to high-pressure recirculation is a guaranteed failure as a result of the conditions represented in the event tree. Equipment needed for low-pressure recirculation, specifically the CCW pumps and auxiliary building mezzanine cooling units, is failed by the flooding event. High pressure recirculation is important primarily because failure of secondary cooling via AFW or MFW has necessitated the need for bleed and feed cooling and ECCS recirculation. Two approaches can be taken to minimize the importance of this operator action. The first is to lower the overall failure probability of the AFW system. The second is to protect equipment needed for ECCS recirculation from the effects of spray. Failure of the AFW system is primarily caused by failure of the room cooling systems needed to support operation of the motor-driven AFW pumps. The ability to provide alternate room cooling for safeguards alley would lower the importance of this initiating event to overall core damage. Refer to SAMA items 169, 170 and 171. Potential improvements related to protecting auxiliary building equipment are addressed by items 173 and 175.

Table F-8. Basic Event Importance with Respect to LERF (Continued)

Item No.	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
125	XEQN-LRSBU156	1.00E+00	5.90E-03	N/A – Automatically generated as part of the quantification process	This basic event is automatically generated as part of the quantification process and indicates that the event tree top event to switch to low-pressure recirculation is a guaranteed failure as a result of the conditions represented in the event tree. Equipment needed for low-pressure recirculation, specifically the CCW pumps and auxiliary building mezzanine cooling units, is failed by the flooding event. Low pressure recirculation is important primarily because failure of secondary cooling via AFW or MFW has necessitated the need for bleed and feed cooling and ECCS recirculation. Two approaches can be taken to minimize the importance of this operator action. The first is to lower the overall failure probability of the AFW system. The second is to protect equipment needed for ECCS recirculation from the effects of spray. Failure of the AFW system is primarily caused by failure of the room cooling systems needed to support operation of the motor-driven AFW pumps. The ability to provide alternate room cooling for safeguards alley would lower the importance of this initiating event to overall core damage. Refer to SAMA items 169, 170, and 171. Potential improvements related to protecting auxiliary building equipment are addressed by items 173 and 175.
126	AC-0159	3.21E-01	5.82E-03	OFFSITE POWER NOT RECOVERED WITHIN 1 HOUR, 59 MINUTES	Items that address mitigating or recovering from a loss of offsite power are addressed by SAMA items 1 through 24, 55, and 58.
127	IE-SB-301-U	6.15E-04	5.59E-03	TRAIN B SW FLOOD IN ROOM 301 (Control room HVAC area)	This initiating event causes a loss of main feedwater because there is no means to detect pipe failures in the room before water would rise to a level that would fail the door. Installation of flood detection instruments in the room could provide a means to detect and isolate a pipe break before MFW would be lost. Refer to SAMA item 183.
128	16-DM-TAV60B-FO	3.00E-03	5.55E-03	DAMPER TAV-60B FAILS TO OPEN	Items to address ventilation are addressed by SAMA items 80 through 83.
129	34-CVSI3034AVCO	1.01E-07	5.32E-03	CHECK VALVES RHR-5A SI-303A AND SI304A TRANS OPEN VAR TERM	This event causes an interfacing system LOCA initiating event. Given the low importance of this event, very little benefit would be obtained from efforts to reduce the importance further. Therefore, no SAMA items are added.

Table F-8. Basic Event Importance with Respect to LERF (Continued)

Item No.	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
130	34-CVSI3034BVCO	1.01E-07	5.32E-03	CHECK VALVES RHR-5A SI-303B AND SI304B TRANS OPEN VAR TERM	This event causes an interfacing system LOCA initiating event. Given the low importance of this event, very little benefit would be obtained from efforts to reduce the importance further. Therefore, no SAMA items are added.
132	38-CBA102-04-CO	7.51E-06	5.04E-03	BKR FROM BUS BRA-102 TO BUS BRA-104 TRANS OPEN	This basic event is important because it causes a loss of A-train DC power initiating event. The importance of this initiating event is driven by sequences where failure of room cooling causes a loss of AFW pumps and other equipment located in safeguards alley and subsequences where a long-term source of water to AFW pump suction is not available. The ability to provide alternate room cooling for safeguards alley would lower the importance of this initiating event to overall core damage. Refer to SAMA items 170 and 171. Additional alarms to indicate CST depletion, an automatic switchover to an alternate water source, or larger CSTs would lower the importance of this event. Refer to SAMA items 172, 71, and 66.

Table F-9. Estimated KPS Core Inventory

Nuclide	Core Inventory (Curies)	Nuclide	Core Inventory (Curies)
Co-58	4.55E+05	I-131	4.76E+07
Co-60	3.48E+05	I-132	6.91E+07
Kr-85	5.39E+05	I-133	9.83E+07
Kr-85m	1.31E+07	I-134	1.08E+08
Kr-87	2.53E+07	I-135	9.18E+07
Kr-88	3.56E+07	Xe-133	9.42E+07
Rb-86	1.05E+05	Xe-135	2.61E+07
Sr-89	4.82E+07	Cs-134	9.26E+06
Sr-90	4.26E+06	Cs-136	2.64E+06
Sr-91	5.97E+07	Cs-137	5.75E+06
Sr-92	6.44E+07	Ba-139	8.81E+07
Y-90	4.42E+06	Ba-140	8.48E+07
Y-91	6.18E+07	La-140	9.21E+07
Y-92	6.47E+07	La-141	8.05E+07
Y-93	7.42E+07	La-142	7.80E+07
Zr-95	8.22E+07	Ce-141	8.06E+07
Zr-97	8.13E+07	Ce-143	7.52E+07
Nb-95	8.27E+07	Ce-144	6.17E+07
Mo-99	9.08E+07	Pr-143	7.27E+07
Tc-99m	7.96E+07	Nd-147	3.21E+07
Ru-103	7.16E+07	Np-239	9.50E+08
Ru-105	4.81E+07	Pu-238	1.79E+05
Ru-106	2.38E+07	Pu-239	1.82E+04
Rh-105	4.45E+07	Pu-240	2.52E+04
Sb-127	5.05E+06	Pu-241	5.89E+06
Sb-129	1.53E+07	Am-241	7.13E+03
Te-127	5.01E+06	Cm-242	1.53E+06
Te-127m	6.51E+05	Cm-244	1.57E+05
Te-129	1.50E+07	Xe-131m	5.32E+05
Te-129m	2.22E+06	Xe-133m	2.88E+06
Te-131m	6.90E+06	Xe-135m	1.91E+07
Te-132	6.80E+07	Xe-138	8.16E+07

Source: Reference F-10 except cobalt inventories based on the PWR inventory in MACCS2 sample problem A multiplied by 1782.6/3412. The ratio is the KPS SAMA power level divided by the sample problem A power level.

Table F-10. Accident Sequence Nuclide Release Frequencies

Source Term Category	1	4[a]	5	6	7	8	9	10	11	12	13	14
Frequency	1.50E-06	4.05E-05	1.97E-07	5.08E-09	2.73E-08	2.56E-05	0.00E+00	0.00E+00	1.22E-07	1.55E-07	9.39E-06	3.28E-06
Release Fraction by Release Category												
Xe/Kr	0.00E+00	1.00E+00	9.80E-01	7.90E-02	3.20E-01	0.00E+00	3.20E-01	7.90E-02	1.00E+00	1.00E+00	9.60E-01	7.50E-01
I	0.00E+00	7.90E-03	8.80E-04	7.50E-04	6.90E-02	0.00E+00	6.90E-02	7.50E-04	7.00E-01	1.30E-01	2.40E-01	2.00E-02
Cs	0.00E+00	3.11E-03	5.39E-04	9.61E-04	4.96E-02	0.00E+00	4.96E-02	9.61E-04	6.54E-01	1.21E-01	2.22E-01	5.91E-03
Te	0.00E+00	1.60E-06	7.10E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.60E-03	8.30E-04	3.10E-05	0.00E+00
Sr	0.00E+00	1.70E-07	1.10E-04	1.80E-06	3.10E-03	0.00E+00	3.10E-03	1.80E-06	3.20E-02	5.70E-03	3.00E-03	4.40E-05
Ru	0.00E+00	5.60E-07	6.70E-06	1.40E-05	2.40E-03	0.00E+00	2.40E-03	1.40E-05	4.90E-02	8.80E-03	3.80E-03	5.50E-03
La	0.00E+00	1.30E-07	2.70E-05	1.20E-07	4.40E-05	0.00E+00	4.40E-05	1.20E-07	1.80E-03	3.20E-04	1.10E-04	2.70E-06
Ce	0.00E+00	1.40E-07	6.10E-04	2.20E-07	4.00E-04	0.00E+00	4.00E-04	2.20E-07	3.30E-02	5.90E-03	1.20E-03	1.20E-05
Ba	0.00E+00	3.30E-07	6.09E-05	1.20E-05	3.50E-03	0.00E+00	3.50E-03	1.20E-05	3.20E-02	5.80E-03	6.20E-03	9.00E-04
Sb	0.00E+00	6.90E-04	9.10E-04	3.00E-04	2.20E-02	0.00E+00	2.20E-02	3.00E-04	3.40E-01	6.10E-02	1.00E-01	1.40E-02
Release time (hr from scram) of noble gas / Cs release	0 / 0	85-87.8 / 85.2-168.0	86.9-97.3 / 86.9-95.2	3.6-48.0 / 3.0-29.4	3.0-48.0 / 3.0-13.1	0 / 0	3.0-48.0 / 3.0-13.1	3.6-48.0 / 3.0-29.4	5.4-9.5 / 5.4-48.0	5.4-9.5 / 5.4-48.0	32.1-34.0 / 32.4-34.5	37.4-39.9 / 37.3-39.8

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[a] Source Term Categories 02 and 03 are zero frequency categories that were not analyzed further.

Table F-11. MACCS Release Categories vs. KPS MAAP Release Categories

MACCS Release Categories	KPS MAAP Release Categories
Xe/Kr	1 – noble gases
I	2 – CsI
Cs	2 & 6 – CsI and CsOH
Te	3 & 11- TeO_2 & Te_2
Sr	4 – SrO
Ru	5 – MoO_2 (Mo is in Ru MACCS category)
La	8 – La_2O_3
Ce	9 – CeO_2 & UO_2
Ba	7 – BaO
Sb (supplemental category)	10 – Sb

Table F-12. General Emergency Declaration Times

Source Term Category	1	4	5	6	7	8	9	10	11	12	13	14
G.E. Time (Hours from Reactor Trip)	14.0	20.0	2.4	2.4	2.5	14.0	2.5	2.4	5.3	5.3	32.1	36.1

Table F-13. Results of KPS Level 3 PRA Analysis (Annual Risk)

Source Term Category	1	4	5	6	7	8	9	10	11	12	13	14	Total
Population dose risk (person-rem)													
0-50 miles	0[a]	8.64	0.0188	3.88E-4	0.0247	0[a]	0[b]	0[b]	0.231	0.869	19.5	0.938	30.2
Total economic cost risk ($)													
0-50 miles	0	3,883	7.67	0.24	52.2	0	0	0	580.8	1778	41,650	1755	49,700

[a] Zero release for source term categories 01 and 08
[b] Zero frequency of release for source term categories 09 and 10

Table F-14. Sensitivity of KPS Baseline Risk (Dose/Economic) to Parameter Changes

Parameter	Input Discussion	Ratio to 50-Mile Baseline Population Dose/Cost Risk	Output Discussion
Annual Met Data Set	Each year 2002-2004	Dose = 96% (2003 and 2004) Cost = 96% (2003) to 100% (2004)	2002, maximum dose risk year and within 0.2% of maximum cost risk year, chosen as baseline.
Wind Speed Height at Top of Containment	Baseline wind speeds modified from top of containment to 10-meters. Sensitivity considers wind speed data at top of containment with input wind release height specified at ground level to avoid further data modification by MACCS2.	Dose = 100% Cost = 99%	Explicitly using top of containment wind speeds or specifying 10-meter wind speeds and letting MACCS2 modify the wind speed for release height result in risks within 1.4% of each other. The latter is chosen as more representative of the physical situation (release at top of containment, receptors at ground level).
2000 Evacuation Speed	Baseline updated 2000 study with 2033 population, assumed EPZ roads at saturation in former.	No change[a]	Faster 2000 evacuation speed does not significantly change risk. 0-10 mile risk is minor contributor to 50-mile risk.
One-half Evacuation Speed	One-half of baseline evacuation speed	No change	Decrease in evacuation speed does not significantly change risk. 0-10 mile risk is minor contributor to 50-mile risk.
General emergency declaration at time of core uncovery	Baseline assumed declaration at later time of core damage	Dose = 99% Cost = No change	Sooner start of evacuation does not significantly change risk. 0-10 mile risk is minor contributor to 50-mile risk.
95% of population evacuating as indicator of period from emergency declaration until evacuation begins	Baseline considered 50% of population evacuating as indicator.	No change	0-10 mile risk is minor contributor to 50-mile risk.
Release Height (ground level)	Baseline assumed release from top of containment vessel.	Dose = 94% Cost = 94%	Decrease in release height increases close-in deposition. Larger downwind population affected by relatively depleted plume.
Release Heat (1 MW per segment)	Baseline assumed no heat. Up to 4 segments released per scenario.	Dose= 101% Cost = 101%	Effect of buoyant plume rise is similar to increase in release height.

Table F-14. Sensitivity of KPS Baseline Risk (Dose/Economic) to Parameter Changes (Continued)

Parameter	Input Discussion	Ratio to 50-Mile Baseline Population Dose/Cost Risk	Output Discussion
Release Heat (10 MW per segment)	Baseline assumed no heat. Large value to bound effects.	Dose= 104% Cost = 105%	Increase in buoyancy increases downwind pop-dose. See release height notes above.
Wake Effects, SIGYINIT, SIGZINIT	Baseline determined from containment vessel. Uncertainty due to both neglecting containment shell building and proximity of other buildings.	One-half baseline: Dose = No change Cost = 101%	Minor changes very near release.
		Two times baseline: Dose = No change Cost = No change	
Meteorology specification in last spatial segment, LIMSPA	Rainfall imposed at all times from 40 to 50 miles from release to force conservative population exposure.	Dose = 61% Cost = 66%	Entire decrease is due to removing perpetual rainfall (wet deposition) and specifying measured meteorology in ring from 40 to 50 miles from site.

[a] "No change" indicates <0.5% change in risk.

Table F-15. Offsite Exposure By Source Term Category

STC	Description	STC Frequency (per year)	Conditional Person-Sv Offsite	Conditional Person-REM Offsite	Expected Person-REM/yr Offsite
1	No Containment Failure	1.499E-06	0.000E+00	0.000E+00	0.000E+00
2	Late Containment Overpressure With Containment Sprays Operating (Continuous Or Early)	0.00E+00	0.000E+00	0.000E+00	0.000E+00
3	Late Containment Overpressure With Containment Sprays Operating (Continuous Or Early)	0.00E+00	0.000E+00	0.000E+00	0.000E+00
4	Late Containment Overpressure, No Containment Sprays	4.057E-05	2.130E+03	2.130E+05	8.641E+00
5	Late-Late Containment Failure – Basemat Meltthrough	1.971E-07	9.520E+02	9.520E+04	1.876E-02
6	Small Containment Isolation Failure – Reactor Vessel Failure	5.082E-09	7.630E+02	7.630E+04	3.878E-04
7	Large Containment Isolation Failure – Reactor Vessel Failure	2.731E-08	9.050E+03	9.050E+05	2.472E-02
8	No Containment Failure	2.563E-05	0.000E+00	0.000E+00	0.000E+00
9	Large Containment Isolation Failure – Reactor Vessel Remains Intact	0.00E+00	9.050E+03	9.050E+05	0.00E+00
10	Small Containment Isolation Failure – Reactor Vessel Remains Intact	0.00E+00	7.630E+02	7.630E+04	0.00E+00
11	ISLOCA With Effective Scrubbing Of Releases	1.217E-07	1.900E+04	1.900E+06	2.312E-01
12	ISLOCA Without Effective Scrubbing Of Releases	1.546E-07	5.620E+04	5.620E+06	8.689E-01
13	SGTR With Failure Of Secondary Side Isolation	9.402E-06	2.070E+04	2.070E+06	1.946E+01
14	SGTR With Successful Secondary Side Isolation	3.284E-06	2.860E+03	2.860E+05	9.392E-01
		8.089E-05			**30.19**

Table F-16. Offsite Property Damage Costs By Source Term Category

STC	Description	STC Frequency (per year)	Conditional Property Costs ($)	Expected Property Costs ($)
1	No Containment Failure	1.499E-06	0.000E+00	0.000E+00
2	Late Containment Overpressure With Containment Sprays Operating (Continuous Or Early)	0.00E+00	0.000E+00	0.000E+00
3	Late Containment Overpressure With Containment Sprays Operating (Continuous Or Early)	0.00E+00	0.000E+00	0.000E+00
4	Late Containment Overpressure, No Containment Sprays	4.057E-05	9.57E+07	3.883E+03
5	Late-Late Containment Failure – Basemat Meltthrough	1.971E-07	3.89E+07	7.667E+00
6	Small Containment Isolation Failure – Reactor Vessel Failure	5.082E-09	4.82E+07	2.450E-01
7	Large Containment Isolation Failure – Reactor Vessel Failure	2.731E-08	1.93E+09	5.217E+01
8	No Containment Failure	2.563E-05	0.000E+00	0.000E+00
9	Large Containment Isolation Failure – Reactor Vessel Remains Intact	0.00E+00	1.93E+09	0.000E+00
10	Small Containment Isolation Failure – Reactor Vessel Remains Intact	0.00E+00	4.82E+07	0.000E+00
11	ISLOCA With Effective Scrubbing Of Releases	1.217E-07	4.69E+09	5.708E+02
12	ISLOCA Without Effective Scrubbing Of Releases	1.546E-07	1.15E+10	1.778E+03
13	SGTR With Failure Of Secondary Side Isolation	9.402E-06	4.43E+09	4.165E+04
14	SGTR With Successful Secondary Side Isolation	3.284E-06	5.38E+08	1.757E+03
		8.089E-05		**$49,700**

Table F-17. Phase 1 SAMA List

SAMA ID	Potential Enhancement (SAMA Title)	Result of Potential Enhancement	Source Reference	Qualitative Screening
Improvements Related to AC and DC Power				
001	Provide additional DC battery capacity.	Extended DC power availability during an SBO. *Items 1, 3, 5, 6, and 74 are analyzed together.*	F-1	Needs Further Eval
002	Replace lead-acid batteries with fuel cells	Extended DC Power availability during an SBO *Cost estimated to be >>$5 million based on previous SAMA submittals and engineering judgement.*	F-1	Excessive Imp. Cost
003	Add additional battery charger or portable diesel-driven battery charger to existing DC system	Improved availability of DC power system *Items 1, 3, 5, 6, and 74 are analyzed together.*	F-1	Needs Further Eval
004	Improve DC bus load shedding.	Extended DC power availability during an SBO. *The only loads on the safety-related DC buses are breaker control power and instrument inverters. Other loads are on the non-safety batteries.*	F-1	Already Implemented
005	Provide DC bus cross-ties.	Improved availability of DC power system. *Items 1, 3, 5, 6, and 74 are analyzed together.*	F-1	Needs Further Eval
006	Provide additional DC power to the 120/240V vital AC system.	Increased availability of the 120 V vital AC bus. *Items 1, 3, 5, 6, and 74 are analyzed together.*	F-1	Needs Further Eval
007	Add an automatic feature to transfer the 120V vital AC bus from normal to standby power.	Increased availability of the 120 V vital AC bus.	F-1	Already Implemented
008	Increase training on response to loss of two 120V AC buses which causes inadvertent actuation signals.	Improved chances of successful response to loss of two 120V AC buses. *Training on loss of 120 VAC is scheduled and conducted per Licensed Operator Requalification Long-Range Training Plan Revision D using LRC-05-SE404.*	F-1	Already Implemented
009	Provide an additional diesel generator.	Increased availability of on-site emergency AC power.	F-1	Excessive Imp. Cost

Table F-17. Phase 1 SAMA List (Continued)

SAMA ID	Potential Enhancement (SAMA Title)	Result of Potential Enhancement	Source Reference	Qualitative Screening
Improvements Related to AC and DC Power (Continued)				
010	Revise procedure to allow bypass of diesel generator trips.	Extended diesel generator operation. *Review of the maintenance rule functional failures from January 2001 through August 2001 show no diesel generator failures that involve the trip circuitry and would have prevented operation of the diesel generators.*	F-1	Very Low Benefit
011	Improve 4.16-kV bus cross-tie ability.	Increased availability of on-site AC power. *Implemented in E-HV-39, Revision 35.*	F-1	Already Implemented
012	Create AC power cross-tie capability with other unit (multi-unit site)	Increased availability of on-site AC power.	F-1	Not Applicable
013	Install an additional, buried off-site power source.	Reduced probability of loss of off-site power.	F-1	Excessive Imp. Cost
014	Install a gas turbine generator.	Increased availability of on-site AC power.	F-1	Excessive Imp. Cost
015	Install tornado protection on gas turbine generator.	Increased availability of on-site AC power.	F-1	Not Applicable
016	Improve uninterruptible power supplies.	Increased availability of power supplies supporting front-line equipment. *The importance analysis for core damage cutsets gives a Fussell-Vesely importance of 2.04E-04 for inverters.*	F-1	Very Low Benefit
017	Create a cross-tie for diesel fuel oil (multiunit site).	Increased diesel generator availability.	F-1	Not Applicable
018	Develop procedures for replenishing diesel fuel oil.	Increased diesel generator availability. *Each EDG has an 850 gallon day tank which provides an 8-hour supply. In addition, there are two 35,000 gallon storage tanks which supply the day tanks and each tank provides a one-week supply of fuel oil.*	F-1	Already Implemented
019	Use fire water system as a backup source for diesel cooling.	Increased diesel generator availability. *Items 19 and 20 are analyzed together.*	F-1	Needs Further Eval
020	Add a new backup source of diesel cooling.	Increased diesel generator availability. *Items 19 and 20 are analyzed together.*	F-1	Needs Further Eval

Table F-17. Phase 1 SAMA List (Continued)

SAMA ID	Potential Enhancement (SAMA Title)	Result of Potential Enhancement	Source Reference	Qualitative Screening
Improvements Related to AC and DC Power (Continued)				
021	Develop procedures to repair or replace failed 4 KV breakers.	Increased probability of recovery from failure of breakers that transfer 4.16 kV nonemergency buses from unit station service transformers.	F-1	Needs Further Eval
022	In training, emphasize steps in recovery of off-site power after an SBO.	Reduced human error probability during off-site power recovery. *Training on recovery of offsite power is covered in the following lesson plans: LRC-HI-SEG08, rev. C, AOC-07-LPH01 HO-1, rev. 2, AOC-07-LPH03, and AOI-47-LPEOP.*	F-1	Already Implemented
023	Develop a severe weather conditions procedure.	Improved off-site power recovery following external weather-related events. *Procedure E-0-05, Revision X, "Response to Natural Events."*	F-1	Already Implemented
024	Bury off-site power lines.	Improved off-site power reliability during severe weather.	F-1	Excessive Imp. Cost
Improvements Related to Core Cooling Systems				
025	Install an independent active or passive high pressure injection system.	Improved prevention of core melt sequences. *Engineering judgment is used to determine that the cost of such a modification would exceed the maximum benefit.*	F-1	Excessive Imp. Cost
026	Provide an additional high pressure injection pump with independent diesel.	Reduced frequency of core melt from small LOCA and SBO sequences.	F-1	Needs Further Eval
027	Revise procedure to allow operators to inhibit automatic vessel depressurization in non-ATWS scenarios.	Extended high pressure coolant injection (HPCI) and reactor core isolation cooling (RCIC) operation.	F-1	Not Applicable
028	Add a diverse low pressure injection system.	Improved injection capability. *Engineering judgment is used to determine that the cost of such a modification would exceed the maximum benefit.*	F-1	Excessive Imp. Cost
029	Provide capability for alternate injection via diesel-driven fire pump.	Improved injection capability. *KPS does not have a diesel-driven fire pump.*	F-1	Not Applicable

Table F-17. Phase 1 SAMA List (Continued)

SAMA ID	Potential Enhancement (SAMA Title)	Result of Potential Enhancement	Source Reference	Qualitative Screening
Improvements Related to Core Cooling Systems (Continued)				
030	Improve ECCS suction strainers.	Enhanced reliability of ECCS suction.	F-1	Already Implemented
031	Add the ability to manually align emergency core cooling system recirculation.	Enhanced reliability of ECCS suction.	F-1	Needs Further Eval
032	Add the ability to automatically align emergency core cooling system to recirculation mode upon refueling water storage tank depletion.	Enhanced reliability of ECCS suction.	F-1	Needs Further Eval
033	Provide hardware and procedure to refill the reactor water storage tank once it reaches a specified low level.	Extended reactor water storage tank capacity in the event of a steam generator tube rupture. *Refer to procedures ECA-1.1 and N-CVC-35A*	F-1	Already Implemented
034	Provide an in-containment reactor water storage tank.	Continuous source of water to the safety injection pumps during a LOCA event, since water released from a breach of the primary system collects in the in-containment reactor water storage tank, and thereby eliminates the need to realign the safety injection pumps for long-term post-LOCA recirculation. *Engineering judgment is used to determine that the cost of such a modification would exceed the maximum benefit.*	F-1	Excessive Imp. Cost
035	Throttle low pressure injection pumps earlier in medium or large-break LOCAs to maintain reactor water storage tank inventory.	Extended reactor water storage tank capacity. *The importance analysis for core damage cutsets gives a Fussell-Vesely importance of 2.17E-03 for MLO. The basic event for operator action to switch to recirculation following a large LOCA does not appear in the core damage cutsets.*	F-1	Very Low Benefit
036	Emphasize timely recirculation alignment in operator training.	Reduced human error probability associated with recirculation failure. *Training on ECCS recirculation is conducted per LRC-05-SE204.*	F-1	Already Implemented

Table F-17. Phase 1 SAMA List (Continued)

SAMA ID	Potential Enhancement (SAMA Title)	Result of Potential Enhancement	Source Reference	Qualitative Screening
Improvements Related to Core Cooling Systems (Continued)				
037	Upgrade the chemical and volume control system to mitigate small LOCAs.	For a plant like the Westinghouse AP600, where the chemical and volume control system cannot mitigate a small LOCA, an upgrade would decrease the frequency of core damage.	F-1	Excessive Imp. Cost
038	Change the in-containment reactor water storage tank suction from four check valves to two check and two air-operated valves.	Reduced common mode failure of injection paths.	F-1	Not Applicable
039	Replace two of the four electric safety injection pumps with diesel-powered pumps.	Reduced common cause failure of the safety injection system. This SAMA was originally intended for the Westinghouse-CE System 80+, which has four trains of safety injection. However, the intent of this SAMA is to provide diversity within the high- and low-pressure safety injection systems.	F-1	Not Applicable
040	Provide capability for remote, manual operation of secondary side pilot-operated relief valves in a station blackout.	Improved chance of successful operation during station blackout events in which high area temperatures may be encountered (no ventilation to main steam areas). *For example, refer to FR-C.1 and FR-C.2*	F-1	Already Implemented
041	Create a reactor coolant depressurization system.	Allows low pressure emergency core cooling system injection in the event of small LOCA and high-pressure safety injection failure. *Refer to FR-C.1 and FR-C.2*	F-1	Already Implemented
042	Make procedure changes for reactor coolant system depressurization.	Allows low pressure emergency core cooling system injection in the event of small LOCA and high-pressure safety injection failure. *Refer to FR-C.1 and FR-C.2*	F-1	Already Implemented

Table F-17. Phase 1 SAMA List (Continued)

SAMA ID	Potential Enhancement (SAMA Title)	Result of Potential Enhancement	Source Reference	Qualitative Screening
Improvements Related to Cooling Water				
043	Add redundant DC control power for SW pumps.	Increased availability of SW. *The importance analysis for core damage cutsets gives a Fussell-Vesely importance of 2.24E-05 for the breaker supplying control power to the A-train SW pumps and 1.32E-05 for the breaker supplying control power to the B-train SW pumps.*	F-1	Very Low Benefit
044	Replace ECCS pump motors with air-cooled motors.	Elimination of ECCS dependency on component cooling system. RHR pump motors are air-cooled. SI pump motors are air-cooled. The ICS pump motors are air-cooled.	F-1	Already Implemented
045	Enhance procedural guidance for use of cross-tied component cooling or service water pumps.	Reduced frequency of loss of component cooling water and service water. *Operation of the service water system is normally in a cross-tied configuration and directed by procedures N-SW-02 and A-SW-02. The design of the CCW system is such that cross-tied operation is normal. Operation of the CCW system is directed by N-CC-31 and A-CC-31.*	F-1	Already Implemented
046	Add a service water pump.	Increased availability of cooling water.	F-1	Needs Further Eval
047	Enhance the screen wash system.	Reduced potential for loss of SW due to clogging of screens. *The importance analysis for core damage cutsets gives a Fussell-Vesely importance of 3.08E-04 for failure of the traveling water screens.*	F-1	Very Low Benefit
048	Cap downstream piping of normally closed component cooling water drain and vent valves.	Reduced frequency of loss of component cooling water initiating events, some of which can be attributed to catastrophic failure of one of the many single isolation valves. *Drawings OPERK-100-19 and OPERK-100-20 show vent and drain valves as being capped.*	F-1	Already Implemented
049	Enhance loss of component cooling water (or loss of service water) procedures to facilitate stopping the reactor coolant pumps.	Reduced potential for reactor coolant pump seal damage due to pump bearing failure. *Included in RNO for Step 1 of A-CC-31.*	F-1	Already Implemented

Table F-17. Phase 1 SAMA List (Continued)

SAMA ID	Potential Enhancement (SAMA Title)	Result of Potential Enhancement	Source Reference	Qualitative Screening
Improvements Related to Cooling Water (Continued)				
050	Enhance loss of component cooling water procedure to underscore the desirability of cooling down the reactor coolant system prior to seal LOCA.	Reduced probability of reactor coolant pump seal failure. *Items 50, 162, and163 are analyzed together.*	F-1	Needs Further Eval
051	Additional training on loss of component cooling water.	Improved success of operator actions after a loss of component cooling water. *Training on these events is scheduled for cycle 07-05.*	F-1	Already Implemented
052	Provide hardware connections to allow another essential raw cooling water system to cool charging pump seals.	Reduced effect of loss of component cooling water by providing a means to maintain the charging pump seal injection following a loss of normal cooling water. *The charging pumps at KPS are positive-displacement and require no external cooling.*	F-1	Not Applicable
053	On loss of essential raw cooling water, proceduralize shedding component cooling water loads to extend the component cooling water heat-up time.	Increased time before loss of component cooling water (and reactor coolant pump seal failure) during loss of essential raw cooling water sequences. *See step 14 of A-SW-02, revision Z.*	F-1	Already Implemented
054	Increase charging pump lube oil capacity.	Increased time before charging pump failure due to lube oil overheating in loss of cooling water sequences. *The charging pumps at KPS are positive-displacement and require no external cooling.*	F-1	Not Applicable
055	Install an independent reactor coolant pump seal injection system, with dedicated diesel.	Reduced frequency of core damage from loss of component cooling water, service water, or station blackout.	F-1	Needs Further Eval
056	Install an independent reactor coolant pump seal injection system, without dedicated diesel.	Reduced frequency of core damage from loss of component cooling water or service water, but not a station blackout.	F-1	Needs Further Eval
057	Use existing hydro test pump for reactor coolant pump seal injection.	Reduced frequency of core damage from loss of component cooling water or service water, but not a station blackout.	F-1	Not Applicable
058	Install improved reactor coolant pump seals.	Reduced likelihood of reactor coolant pump seal LOCA.	F-1	Needs Further Eval
059	Install an additional component cooling water pump.	Reduced likelihood of loss of component cooling water leading to a reactor coolant pump seal LOCA.	F-1	Needs Further Eval

Table F-17. Phase 1 SAMA List (Continued)

SAMA ID	Potential Enhancement (SAMA Title)	Result of Potential Enhancement	Source Reference	Qualitative Screening
Improvements Related to Cooling Water (Continued)				
060	Prevent makeup pump flow diversion through the relief valves.	Reduced frequency of loss of reactor coolant pump seal cooling if spurious high pressure injection relief valve opening creates a flow diversion large enough to prevent reactor coolant pump seal injection. *DCR 748 installed a suction stabilizer in the charging line. This greatly reduced the problem of relief valves opening.*	F-1	Already Implemented
061	Change procedures to isolate reactor coolant pump seal return flow on loss of component cooling water, and provide (or enhance) guidance on loss of injection during seal LOCA.	Reduced frequency of core damage due to loss of seal cooling. RCP seal injection would still be available from charging pumps on a loss of CCW.	F-1	Not Applicable
062	Implement procedures to stagger high pressure safety injection pump use after a loss of service water.	Extended high pressure injection prior to overheating following a loss of service water. *The SI pumps require service water for lube oil cooling so staggering use of the pumps will provide only a slight delay in the overall failure time.*	F-1	Very Low Benefit
063	Use fire prevention system pumps as a backup seal injection and high pressure makeup source.	Reduced frequency of reactor coolant pump seal LOCA. *Fire protection pumps do not produce adequate head to inject to the RCS.*	F-1	Not Applicable
064	Implement procedure and hardware modifications to allow manual alignment of the fire water system to the component cooling water system, or install a component cooling water header cross-tie.	Improved ability to cool residual heat removal heat exchangers. The KPS CCW system design is a normally-cross-tied system.	F-1	Already Implemented
Improvements Related to Feedwater and Condensate				
065	Install a digital feed water upgrade.	Reduced chance of loss of main feed water following a plant trip. The feedwater system components have very low importance to the overall CDF results.	F-1	Very Low Benefit
066	Create ability for emergency connection of existing or new water sources to feedwater and condensate systems.	Increased availability of feedwater.	F-1	Needs Further Eval

Table F-17. Phase 1 SAMA List (Continued)

SAMA ID	Potential Enhancement (SAMA Title)	Result of Potential Enhancement	Source Reference	Qualitative Screening
Improvements Related to Feedwater and Condensate (Continued)				
067	Install an independent diesel for the condensate storage tank makeup pumps.	Extended inventory in CST during an SBO. *The RMSTs can be aligned to the CSTs using only manual valves thereby ensuring a 24 hour availability for steam generator decay heat removal without requiring power.*	F-1	Already Implemented
068	Add a motor-driven feedwater pump.	Increased availability of feedwater. *KPS design has two motor-driven and one turbine-driven AFW pumps.*	F-1	Already Implemented
069	Install manual isolation valves around auxiliary feedwater turbine-driven steam admission valves.	Reduced dual turbine-driven pump maintenance unavailability. *TDAFP maintenance has a total Fussell-Vesely importance of 9.19E-03. This SAMA would improve only a portion of the total unavailability.*	F-1	Very Low Benefit
070	Install accumulators for turbine-driven auxiliary feedwater pump flow control valves.	Eliminates the need for local manual action to align nitrogen bottles for control air following a loss of off-site power. The flow control valves at KPS are motor-operated.	F-1	Not Applicable
071	Install a new condensate storage tank (auxiliary feedwater storage tank).	Increased availability of the auxiliary feedwater system.	F-1	Needs Further Eval
072	Modify the turbine-driven auxiliary feedwater pump to be self-cooled.	Improved success probability during a station blackout. *Room cooling is not required for the TDAFP and oil coolers are supplied by process flow.*	F-1	Already Implemented
073	Proceduralize local manual operation of auxiliary feedwater system when control power is lost.	Extended auxiliary feedwater availability during a station blackout. Also provides a success path should auxiliary feedwater control power be lost in non-station blackout sequences. *ECA-0.0, Rev AI, step 4, provides directions to operate the TDAFW pump manually. Implementation of SAMA item 1, 3, or 5 would ensure that indication is available.*	F-1	Already Implemented
074	Provide hookup for portable generators to power the turbine-driven auxiliary feedwater pump after station batteries are depleted.	Extended auxiliary feedwater availability. *Items 1, 3, 5, 6, and 74 are analyzed together.*	F-1	Needs Further Eval

Table F-17. Phase 1 SAMA List (Continued)

SAMA ID	Potential Enhancement (SAMA Title)	Result of Potential Enhancement	Source Reference	Qualitative Screening
Improvements Related to Feedwater and Condensate (Continued)				
075	Use fire water system as a backup for steam generator inventory.	Increased availability of steam generator water supply. *The fire water pumps at KPS are motor-driven and powered through the same electrical buses as the service water pumps. Therefore, if electrical power is available to the fire water pumps, power would be available to the service water pumps which are the emergency supply to the AFW suction.*	F-1	Very Low Benefit
076	Change failure position of condenser makeup valve if the condenser makeup valve fails open on loss of air or power.	Allows greater inventory for the auxiliary feedwater pumps by preventing condensate storage tank flow diversion to the condenser. *Items 76 and184 are analyzed together.*	F-1	Needs Further Eval
077	Provide a passive, secondary-side heat rejection loop consisting of a condenser and heat sink.	Reduced potential for core damage due to loss-of-feedwater events.	F-1	Excessive Imp. Cost
078	Modify the startup feedwater pump so that it can be used as a backup to the emergency feedwater system, including during a station blackout scenario.	Increased reliability of decay heat removal. *KPS does not have a startup feedwater pump.*	F-1	Not Applicable
079	Replace existing pilot-operated relief valves with larger ones, such that only one is required for successful feed and bleed.	Increased probability of successful feed and bleed. *KPS PRA models show success of bleed and feed cooling with only one PORV open.*	F-1	Already Implemented
Improvements Related to Heating, Ventilation, and Air Conditioning				
080	Provide a redundant train or means of ventilation.	Increased availability of components dependent on room cooling. *480 VAC rooms and battery rooms have been evaluated by calculation C11748 and require no fans, only opening doors.* *Other areas such as auxiliary building and EDG rooms need to be evaluated.*	F-1	Needs Further Eval
081	Add a diesel building high temperature alarm or redundant louver and thermostat.	Improved diagnosis of a loss of diesel building HVAC. . *Items 81, 160, 166, 167, 170, and 171 are analyzed together.*	F-1	Needs Further Eval

Table F-17. Phase 1 SAMA List (Continued)

SAMA ID	Potential Enhancement (SAMA Title)	Result of Potential Enhancement	Source Reference	Qualitative Screening
Improvements Related to Heating, Ventilation, and Air Conditioning (Continued)				
082	Stage backup fans in switchgear rooms.	Increased availability of ventilation in the event of a loss of switchgear ventilation. *480 VAC rooms and battery rooms have been evaluated by calculation C11748 and require no fans only opening doors.* *DG rooms need to be evaluated.* *Items 82, 83, 170, and 171 are analyzed together.*	F-1	Needs Further Eval
083	Add a switchgear room high temperature alarm.	Improved diagnosis of a loss of switchgear HVAC. *Items 82, 83, 170, and 171 are analyzed together.*	F-1	Needs Further Eval
084	Create ability to switch emergency feedwater room fan power supply to station batteries in a station blackout.	Continued fan operation in a station blackout. *Room cooling is not required for the TDAFP and oil coolers are supplied by process flow.*	F-1	Already Implemented
Improvements Related to Instrument Air and Nitrogen Supply				
085	Provide cross-unit connection of uninterruptible compressed air supply.	Increased ability to vent containment using the hardened vent.	F-1	Not Applicable
086	Modify procedure to provide ability to align diesel power to more air compressors.	Increased availability of instrument air after a LOOP.	F-1	Needs Further Eval
087	Replace service and instrument air compressors with more reliable compressors which have self-contained air cooling by shaft driven fans.	Elimination of instrument air system dependence on service water cooling.	F-1	Needs Further Eval
088	Install nitrogen bottles as backup gas supply for safety relief valves.	Extended SRV operation time. *Accumulators are installed on the air supply lines to the pressurizer PORVs. KPS PRA models show successful operation of the PORVs if the accumulators are available.*	F-1	Already Implemented
089	Improve SRV and main steam isolation valve (MSIV) pneumatic components.	Improved availability of SRVs and MSIVs. *The importance analysis for core damage cutsets shows that pneumatic components related to MSIVs and pressurizer PORVs have very low Fussell-Vesely importance measures.*	F-1	Very Low Benefit

Table F-17. Phase 1 SAMA List (Continued)

SAMA ID	Potential Enhancement (SAMA Title)	Result of Potential Enhancement	Source Reference	Qualitative Screening
Improvements Related to Containment Phenomena				
090	Create a reactor cavity flooding system.	Enhanced debris cool ability, reduced core concrete interaction, and increased fission product scrubbing. *As described in the revised Level 2 PRA analysis, two submarine-type doors are left open during normal operations and provide a path for water to flow from the annular compartment to the cavity if the RWST is injected.*	F-1	Already Implemented
091	Install a passive containment spray system.	Improved containment spray capability. *The importance analysis for core damage cutsets gives a Fussell-Vesely importance of 1.204E-03 for the basic event that represents failure of represents operator action to switch to low-pressure recirculation. The importance values for containment spray hardware are much less than the operator action.*	F-1	Very Low Benefit
092	Use the fire water system as a backup source for the containment spray system.	Improved containment spray capability. *The importance analysis for core damage cutsets gives a Fussell-Vesely importance of 1.204E-03 for the basic event that represents failure of represents operator action to switch to low-pressure recirculation. The importance values for containment spray hardware are much less than the operator action.*	F-1	Very Low Benefit
093	Install an unfiltered, hardened containment vent.	Increased decay heat removal capability for non-ATWS events, without scrubbing released fission products.	F-1	Excessive Imp. Cost
094	Install a filtered containment vent to remove decay heat Option 1: Gravel Bed Filter Option 2: Multiple Venturi Scrubber	Increased decay heat removal capability for non-ATWS events, with scrubbing of released fission products.	F-1	Excessive Imp. Cost
095	Enhance fire protection system and standby gas treatment system hardware and procedures.	Improved fission product scrubbing in severe accidents.	F-1	Not Applicable
096	Provide post-accident containment inerting capability.	Reduced likelihood of hydrogen and carbon monoxide gas combustion.	F-1	Excessive Imp. Cost

Table F-17. Phase 1 SAMA List (Continued)

SAMA ID	Potential Enhancement (SAMA Title)	Result of Potential Enhancement	Source Reference	Qualitative Screening
Improvements Related to Instrument Air and Nitrogen Supply				
097	Create a large concrete crucible with heat removal potential to contain molten core debris.	Increased cooling and containment of molten core debris. Molten core debris escaping from the vessel is contained within the crucible and a water cooling mechanism cools the molten core in the crucible, preventing melt-through of the base mat.	F-1	Excessive Imp. Cost
098	Create a core melt source reduction system.	Increased cooling and containment of molten core debris. Refractory material would be placed underneath the reactor vessel such that a molten core falling on the material would melt and combine with the material. Subsequent spreading and heat removal from the vitrified compound would be facilitated, and concrete attack would not occur.	F-1	Excessive Imp. Cost
099	Strengthen primary/secondary containment (e.g., add ribbing to containment shell).	Reduced probability of containment over-pressurization.	F-1	Excessive Imp. Cost
100	Increase depth of the concrete base mat or use an alternate concrete material to ensure melt-through does not occur.	Reduced probability of base mat melt-through.	F-1	Excessive Imp. Cost
101	Provide a reactor vessel exterior cooling system.	Increased potential to cool a molten core before it causes vessel failure, by submerging the lower head in water.	F-1	Excessive Imp. Cost
102	Construct a building to be connected to primary/secondary containment and maintained at a vacuum.	Reduced probability of containment over-pressurization.	F-1	Excessive Imp. Cost
103	Institute simulator training for severe accident scenarios.	Improved arrest of core melt progress and prevention of containment failure. *Training on SAMGs is conducted per LRC-05-LP0508.*	F-1	Already Implemented
104	Improve leak detection procedures.	Increased piping surveillance to identify leaks prior to complete failure. Improved leak detection would reduce LOCA frequency. *The cost of implementing this item is assumed to be similar to implementing item 119.*	F-1	Excessive Imp. Cost

Table F-17. Phase 1 SAMA List (Continued)

SAMA ID	Potential Enhancement (SAMA Title)	Result of Potential Enhancement	Source Reference	Qualitative Screening
Improvements Related to Instrument Air and Nitrogen Supply (Continued)				
105	Delay containment spray actuation after a large LOCA.	Extended reactor water storage tank availability. *The importance analysis for core damage cutsets gives a Fussell-Vesely importance of 1.204E-03 for the basic event that represents failure of represents operator action to switch to low-pressure recirculation. Implementation of this SAMA would reduce, not eliminate, the need for the action.*	F-1	Very Low Benefit
106	Install automatic containment spray pump header throttle valves.	Extended time over which water remains in the reactor water storage tank, when full containment spray flow is not needed. *The importance analysis for core damage cutsets gives a Fussell-Vesely importance of 1.204E-03 for the basic event that represents failure of represents operator action to switch to low-pressure recirculation. Implementation of this SAMA would reduce, not eliminate, the need for the action.*	F-1	Very Low Benefit
107	Install a redundant containment spray system.	Increased containment heat removal ability. *The importance analysis for core damage cutsets gives a Fussell-Vesely importance of 1.204E-03 for the basic event that represents failure of represents operator action to switch to low-pressure recirculation. The importance values for containment spray hardware are much less than the operator action.*	F-1	Very Low Benefit
108	Install an independent power supply to the hydrogen control system using either new batteries, a non-safety grade portable generator, existing station batteries, or existing AC/DC independent power supplies, such as the security system diesel.	Reduced hydrogen detonation potential. *The revised Level 2 PRA model shows that hydrogen burns are not dominant contributors to the overall containment failure probability.*	F-1	Very Low Benefit
109	Install a passive hydrogen control system.	Reduced hydrogen detonation potential. *The revised Level 2 PRA model shows that hydrogen burns are not dominant contributors to the overall containment failure probability.*	F-1	Very Low Benefit

Table F-17. Phase 1 SAMA List (Continued)

SAMA ID	Potential Enhancement (SAMA Title)	Result of Potential Enhancement	Source Reference	Qualitative Screening
Improvements Related to Instrument Air and Nitrogen Supply (Continued)				
110	Erect a barrier that would provide enhanced protection of the containment walls (shell) from ejected core debris following a core melt scenario at high pressure.	Reduced probability of containment failure. *The revised Level 2 PRA model shows that ejected core debris causing failure of containment is not of concern for large, dry containments in general and Kewaunee specifically.*	F-1	Very Low Benefit
Improvements Related to Containment Bypass				
111	Install additional pressure or leak monitoring instruments for detection of ISLOCAs.	Reduced ISLOCA frequency. *Items 111 and 113 are analyzed together.*	F-1	Needs Further Eval
112	Add redundant and diverse limit switches to each containment isolation valve.	Reduced frequency of containment isolation failure and ISLOCAs.	F-1	Needs Further Eval
113	Increase leak testing of valves in ISLOCA paths.	Reduced ISLOCA frequency. *Items 111 and 113 are analyzed together.*	F-1	Needs Further Eval
114	Install self-actuating containment isolation valves.	Reduced frequency of isolation failure.	F-1	Needs Further Eval
115	Locate residual heat removal (RHR) inside containment	Reduced frequency of ISLOCA outside containment.	F-1	Excessive Imp. Cost
116	Ensure ISLOCA releases are scrubbed. One method is to plug drains in potential break areas so that break point will be covered with water.	Scrubbed ISLOCA releases.	F-1	Excessive Imp. Cost
117	Revise EOPs to improve ISLOCA identification.	Increased likelihood that LOCAs outside containment are identified as such. A plant had a scenario in which an RHR ISLOCA could direct initial leakage back to the pressurizer relief tank, giving indication that the LOCA was inside containment. *ECA-1.2 provides guidance to locate the failed line. If the failure results in break flow being directed to containment, then the fluid is available for recirculati*on and the concerns of an ISLOCA are not applicable.	F-1	Already Implemented
118	Improve operator training on ISLOCA coping.	Decreased ISLOCA consequences.	F-1	Needs Further Eval

Table F-17. Phase 1 SAMA List (Continued)

SAMA ID	Potential Enhancement (SAMA Title)	Result of Potential Enhancement	Source Reference	Qualitative Screening
Improvements Related to Containment Bypass (Continued)				
119	Institute a maintenance practice to perform a 100% inspection of steam generator tubes during each refueling outage.	Reduced frequency of steam generator tube ruptures. *CCNP estimated the cost of this SAMA at $8M per year.*	F-1	Excessive Imp. Cost
120	Replace steam generators with a new design.	Reduced frequency of steam generator tube ruptures.	F-1	Excessive Imp. Cost
121	Increase the pressure capacity of the secondary side so that a steam generator tube rupture would not cause the relief valves to lift.	Eliminates release pathway to the environment following a steam generator tube rupture.	F-1	Excessive Imp. Cost
122	Install a spray system to depressurize the primary system during a steam generator tube rupture	Enhanced depressurization capabilities during steam generator tube rupture.	F-1	Needs Further Eval
123	Proceduralize use of pressurizer vent valves during steam generator tube rupture sequences.	Backup method to using pressurizer sprays to reduce primary system pressure following a steam generator tube rupture. *Refer to SAG-02, Rev. C, step 5.1.3.*	F-1	Already Implemented
124	Provide improved instrumentation to detect steam generator tube ruptures, such as Nitrogen-16 monitors.	Improved mitigation of steam generator tube ruptures.	F-1	Needs Further Eval
125	Route the discharge from the main steam safety valves through a structure where a water spray would condense the steam and remove most of the fission products.	Reduced consequences of a steam generator tube rupture. *Items 125 and 129 are analyzed together.*	F-1	Needs Further Eval
126	Install a highly reliable (closed loop) steam generator shell-side heat removal system that relies on natural circulation and stored water sources	Reduced consequences of a steam generator tube rupture.	F-1	Needs Further Eval
127	Revise emergency operating procedures to direct isolation of a faulted steam generator.	Reduced consequences of a steam generator tube rupture. *E-3, step 4 directs that the faulted steam generator be isolated.*	F-1	Already Implemented
128	Direct steam generator flooding after a steam generator tube rupture, prior to core damage.	Improved scrubbing of steam generator tube rupture releases. *Refer to SAG-01, Rev. F, — 5.5.*	F-1	Already Implemented

Table F-17. Phase 1 SAMA List (Continued)

SAMA ID	Potential Enhancement (SAMA Title)	Result of Potential Enhancement	Source Reference	Qualitative Screening
Improvements Related to Containment Bypass (Continued)				
129	Vent main steam safety valves in containment.	Reduced consequences of a steam generator tube rupture. *Items 125 and 129 are analyzed together.*	F-1	Needs Further Eval
Improvements Related to ATWS				
130	Add an independent boron injection system.	Improved availability of boron injection during ATWS.	F-1	Not Applicable
131	Add a system of relief valves to prevent equipment damage from pressure spikes during an ATWS.	Improved equipment availability after an ATWS.	F-1	Needs Further Eval
132	Provide an additional control system for rod insertion (e.g., AMSAC).	Improved redundancy and reduced ATWS frequency. *KPS has AMSAC installed.*	F-1	Already Implemented
133	Install an ATWS sized filtered containment vent to remove decay heat.	Increased ability to remove reactor heat from ATWS events.	F-1	Excessive Imp. Cost
134	Revise procedure to bypass MSIV isolation in turbine trip ATWS scenarios.	Affords operators more time to perform actions. Discharge of a substantial fraction of steam to the main condenser (i.e., as opposed to into the primary containment) affords the operator more time to perform actions (e.g., SLC injection, lower water level, depressurize RPV) than if the main condenser was unavailable, resulting in lower human error probabilities.	F-1	Not Applicable
135	Revise procedure to allow override of low pressure core injection during an ATWS event.	Allows immediate control of low pressure core injection. On failure of high pressure core injection and condensate, some plants direct reactor depressurization followed by five minutes of automatic low pressure core injection.	F-1	Not Applicable
136	Install motor generator set trip breakers in control room.	Reduced frequency of core damage due to an ATWS. *Per FR-S.1, the breakers for buses 33 and 43 can be opened. Opening the supply breakers to buses 33 and 43 has the same effect as opening the MG set breakers.*	F-1	Already Implemented

Table F-17. Phase 1 SAMA List (Continued)

SAMA ID	Potential Enhancement (SAMA Title)	Result of Potential Enhancement	Source Reference	Qualitative Screening
Improvements Related to ATWS (Continued)				
137	Provide capability to remove power from the bus powering the control rods.	Decreased time required to insert control rods if the reactor trip breakers fail (during a loss of feedwater ATWS which has rapid pressure excursion). *Per FR-S.1, the breakers for buses 33 and 43 can be opened.*	F-1	Already Implemented
Improvements Related to Internal Flooding				
138	Improve inspection of rubber expansion joints on main condenser.	Reduced frequency of internal flooding due to failure of circulating water system expansion joints. *KPS has inspected and replaced main condenser expansion joints. In addition, flood barriers protecting safeguards alley and the auxiliary building have been installed along with new flood detection instrumentation. Procedures have been revised to direct corrective actions in the event of a turbine building flood.*	F-1	Already Implemented
139	Modify swing direction of doors separating turbine building basement from areas containing safeguards equipment.	Prevents flood propagation. *Doors from safeguards alley open out to minimize the potential for propagation of turbine building floods. Also, flood barriers are installed around these doors.*	F-1	Already Implemented
Improvements to Reduce Seismic Risk				
140	Increase seismic ruggedness of plant components.	Increased availability of necessary plant equipment during and after seismic events.	F-1	Excessive Imp. Cost
141	Provide additional restraints for CO_2 tanks.	Increased availability of fire protection given a seismic event. *Seismic risk is small at KPS.*	F-1	Very Low Benefit

Table F-17. Phase 1 SAMA List (Continued)

SAMA ID	Potential Enhancement (SAMA Title)	Result of Potential Enhancement	Source Reference	Qualitative Screening
Improvements to Reduce Fire Risk				
142	Replace mercury switches in fire protection system.	Decreased probability of spurious fire suppression system actuation. *This SAMA would only reduce the risk of flooding caused by inadvertent actuation of deluge systems. Deluge systems are located in the turbine building and on auxiliary building ventilation systems. The internal flooding analysis shows that the overall risk from fire protection floods in the turbine building is low and the flow from deluge systems is small relative to the flooding events analyzed. Similarly, flooding events caused by inadvertent actuation of fire protection in the auxiliary building ventilations systems would have a small flow rate relative to the events analyzed in the internal flooding analysis Seismic risk is small at KPS.*	F-1	Very Low Benefit
143	Upgrade fire compartment barriers.	Decreased consequences of a fire. *There are no events in the KPS fire PRA for which fires propagate across fire barriers. Therefore, implementation of this item would show no risk reduction in a PRA evaluation.*	F-1	Very Low Benefit
144	Install additional transfer and isolation switches.	Reduced number of spurious actuations during a fire. Spurious actuations are not a contributor to the KPS fire PRA because all equipment not specifically analyzed to survive a fire is not credited.	F-1	Very Low Benefit
145	Enhance fire brigade awareness.	Decreased consequences of a fire. *The KPS fire PRA contains no sequences that credit fire brigade response. Therefore, implemen*tation of this item would show no risk reduction.	F-1	Very Low Benefit
146	Enhance control of combustibles and ignition sources.	Decreased fire frequency and consequences. *Transient combustibles contribute to only 2% of fire initiating event frequency. Implementation of this item would eliminate only a portion of this contribution.*	F-1	Very Low Benefit

Table F-17. Phase 1 SAMA List (Continued)

SAMA ID	Potential Enhancement (SAMA Title)	Result of Potential Enhancement	Source Reference	Qualitative Screening
Other Improvements				
147	Install digital large break LOCA protection system.	Reduced probability of a large break LOCA (a leak before break). *Based on the low importance of the large LOCA event to overall core damage (FV=1.17E-03), engineering judgment indicates that the costs would far out weigh the benefits.*	F-1	Very Low Benefit
148	Enhance procedures to mitigate large break LOCA.	Reduced consequences of a large break LOCA. *Operator actions are very small contributors to the large LOCA core damage frequency.*	F-1	Very Low Benefit
149	Install computer aided instrumentation system to assist the operator in assessing post-accident plant status.	Improved prevention of core melt sequences by making operator actions more reliable. *Operator actions that have the greatest impact on core damage are addressed in the plant-specific SAMA analysis.*	F-1	Very Low Benefit
150	Improve maintenance procedures.	Improved prevention of core melt sequences by increasing reliability of important equipment.	F-1	Needs Further Eval
151	Increase training and operating experience feedback to improve operator response.	Improved likelihood of success of operator actions taken in response to abnormal conditions. *Operator actions that have the greatest impact on core damage are addressed in the plant-specific SAMA analysis. Refer to items 3, 14, 22, 23, 25, 27, 30, 31, 32, 38, 39, 53, 59, 60, 64, 65, 70, 76, 78, 83, 87, 91, 100, 103, 104, 107, 110, 119, 120, 125, 129, 132, 138, 140, and 143 of Table 5 and items 1, 2, 4, 18, 21, 33, 40, and 45 of Table 6.*	F-1	Needs Further Eval
152	Develop procedures for transportation and nearby facility accidents.	Reduced consequences of transportation and nearby facility accidents. *Based on the IPEEE analyses, the total risk from transportation accidents is less than 1E-07 per year.*	F-1	Very Low Benefit

Table F-17. Phase 1 SAMA List (Continued)

SAMA ID	Potential Enhancement (SAMA Title)	Result of Potential Enhancement	Source Reference	Qualitative Screening
Other Improvements (Continued)				
153	Install secondary side guard pipes up to the main steam isolation valves.	Prevents secondary side depressurization should a steam line break occur upstream of the main steam isolation valves. Also guards against or prevents consequential multiple steam generator tube ruptures following a main steam line break event. *Based on the low importance of the steam line break event to overall core damage (FV=5.74E-03), and the fraction of those events that are upstream of the MSIVs (less than 1E-4), engineering judgment indicates that the costs would far out weigh the benefits.*	F-1	Very Low Benefit
Other US Power Plant License Renewal SAMA Review				
154	Ginna-1 – Obtain a skid-mounted 480V diesel generator	Provides electrical power to SBO mitigation loads *The ability to align the TSC diesel to bus 52 effectively implements the intent of the SAMA item described in the Ginna license renewal application.*	F-13	Already Implemented
155	Ginna-2 – Obtain a third fire water source independent of existing suction source for the motor- and diesel-driven fire pumps	Provides a source of water to the AFW pumps in the event that service water supply to AFW pump suction is needed and flow to the screenhouse from the lake is not available. *This SAMA would be implemented only if water from the makeup water storage tanks is not available. The operator action to shift AFW pump suction from CST to service water has a low Fussell-Vesely importance (1.15E-03) and this SAMA would only be used to mitigate a specific set of conditions that cause service water to be lost to the AFW pumps.*	F-13	Very Low Benefit
156	Ginna-4 – Modify procedures to allow charging pump B or C to be manually aligned to Bus 14	Provide the ability to power charging pumps from an additional power source to mitigate fires. *The ability to align the TSC diesel to bus 52 effectively implements the intent of the SAMA item described in the Ginna license renewal application.*	F-13	Already Implemented

Table F-17. Phase 1 SAMA List (Continued)

SAMA ID	Potential Enhancement (SAMA Title)	Result of Potential Enhancement	Source Reference	Qualitative Screening
Other US Power Plant License Renewal SAMA Review (Continued)				
157	Ginna-7 – Modify AOV 112C to fail closed and AOV 112B to fail open on loss of instrument air	Ensures charging suction source on a loss of air. *The analogous valves at KPS are motor-operated.*	F-13	Not Applicable
158	Palisades-10 – Power Independent Turbine Driven AFW	Modify the TD AFW train so that it can operate indefinitely without AC, DC, or pneumatic support. Provisions could be made to direct AFW flow adjustments based on decay heat level so that SG level can be maintained when instrumentation fails on DC power depletion. This SAMA would also impact the seismic sequences in which failure of EDG fuel oil tank T-10 results in loss of long-term AC and DC power. *ECA-0.0, Rev AI, step 4, provides directions to operate the TDAFW pump manually. Evaluation of improving the availability of instrumentation is considered under SAMA item 1, 3, and 5.*	F-14	Already Implemented
159	Palisades-13 – Nitrogen Station for Automatic Backup to CV-2010 Air Supply	Loss of Instrument Air is the primary contributor to the failure of CST makeup. Providing a Nitrogen Station that would automatically provide a backup air supply to CV-2010 would reduce the importance of the Loss of IA to the valve. *Providing additional makeup water to the CSTs from the MUWSTs requires only the operation of manual valves.*	F-14	Not Applicable

Table F-17. Phase 1 SAMA List (Continued)

SAMA ID	Potential Enhancement (SAMA Title)	Result of Potential Enhancement	Source Reference	Qualitative Screening
Other US Power Plant License Renewal SAMA Review (Continued)				
160	Palisades-16 – Insulate EDG Exhaust Ducts	Action to check that SW is aligned to the EDGs after a start is already taken based on previous plant experience, but the action is not proceduralized. The steps are taken immediately to prevent overheating the EDGs engines and could include credit for opening the EDG room doors for alternate room cooling if procedures were provided. However, because the time available is short, the error rate for the action would be high. Insulating the EDG exhaust ducts will reduce the heat load in the room and provide additional time to align alternate room cooling in the event that room cooling has failed. *Items 81, 160, 166, 167, 170, and 171 are analyzed together.*	F-14	Needs Further Eval
161	Palisades-22 – Replace the Undervoltage Relays for Buses 1C and 1D with a Seismically Qualified Model	Failure of the undervoltage relay results in failure of the automatic start of EDG 1-2, which provides power to the AFW pump (pump 8C) with a water source more likely to survive a seismic event (SW). This EDG also supplies two SW pumps versus one pump on bus 1C. A more durable relay would reduce the contributions from loss of power to bus 1D. Credit of the SW/FPS cross-tie would remove the model asymmetry and this SAMA would apply to both divisions. *Seismic risk at KPS is small.*	F-14	Very Low Benefit
162	Palisades-23 – Direct PCS Cooldown on Loss of RCP Seal Cooling	While Palisades has upgraded the plant's reactor coolant pumps with new N-9000 seals, the cooldown process may further reduce the probability of seal failures related to long-term high temperature exposure or thermal shock after recovery of CCW. *Items 50, 162, and163 are analyzed together.*	F-14	Needs Further Eval
163	Millstone 2-3 -Enhance Loss of RBCCW procedure to ensure cool down of RCS prior to seal LOCA	Potential reduction in the probability of RCP seal failure. The RBCCW provides seal, thermal barrier, upper and lower bearing cooling for the RCP's. *Items 50, 162, and163 are analyzed together.*	F-16	Needs Further Eval

Table F-17. Phase 1 SAMA List (Continued)

SAMA ID	Potential Enhancement (SAMA Title)	Result of Potential Enhancement	Source Reference	Qualitative Screening
Other US Power Plant License Renewal SAMA Review (Continued)				
164	Wolf Creek-2 – Modify the Controls and Operating Procedures for Sharpe Station to Allow for Rapid Response	An off-site diesel generating plant (Sharpe Station) has an agreement with Wolf Creek to provide power to the site in the event that Wolf Creek experiences a Station Blackout. While the ten 2MW diesel generators have the capacity to power the emergency loads, the time to align power to Wolf Creek Generating Station (WCGS) is long and is not expected to be complete before 4 hours after the onset of degraded AC conditions. Providing the WCGS control room with the ability to start and align these generators to the WCGS emergency buses through the switchyard would be a means of restoring power to WCGS in non-weather related LOOP events. *No such station exists near KPS.*	F-17	Not Applicable
165	Wolf Creek-4 – ISLOCA Isolation	The current Wolf Creek PSA model does not credit operator actions to isolate ISLOCAs using available motor operated valves (MOVs) as it has not been confirmed that those valves can isolate with RCS pressure against them. The plant engineering staff estimates that the motors could move the valves to a partially closed position before exceeding the torque limit of the valve operator. From that point, it would be possible to complete the valve closure locally assuming that the valves are accessible. Ensuring that procedures direct this isolation in ISLOCA events is a potential means of addressing some of the ISLOCA scenarios (those where access is possible). Alternatively, the valves could be replaced with a type that can close against RCS pressure. *ECA-1.2, Rev I, Step 1 directs that valves be closed locally.*	F-17	Already Implemented

Table F-17. Phase 1 SAMA List (Continued)

SAMA ID	Potential Enhancement (SAMA Title)	Result of Potential Enhancement	Source Reference	Qualitative Screening
Other US Power Plant License Renewal SAMA Review (Continued)				
166	Wolf Creek-5 – Open Doors for Alternate DG Room Cooling	For cases when DGHVAC fails and inside air temperatures are high, the EDG Room doors could be opened to provide outside air exchange cooling to the EDG rooms. *Items 81, 160, 166, 167, 170, and 171 are analyzed together.*	F-17	Needs Further Eval
167	Harris-9 – Proceduralize Actions to Open EDG Room Doors on Loss of HVAC and Implement Portable Fans	Loss of EDG Room HVAC is assumed to result in EDG failure during the summer months. Loss of EDG Room HVAC could be mitigated if plant operating procedures were enhanced to direct operators to open the EDG room doors when HVAC is lost during periods of expected high heat (between the March 28th and October 29th) or whenever room temperatures are high. As a room heatup analysis is not available to show that the EDG rooms would remain sufficiently cool without forced ventilation, portable fans are assumed to be required as part of the alternate cooling strategy. *Items 81, 160, 166, 167, 170, and 171 are analyzed together.*	F-18	Needs Further Eval
Plant Specific SAMA Improvements				
168	Provide the ability to manually close electrically operated valves needed to isolate flooding events.	Removes the dependence of flood isolation on electrical power.	Table F-3	Needs Further Eval
169	Provide flood protection for MCCs 52E, 62E, and 62H.	Helps ensure availability of CCW and other equipment located in the auxiliary building by lowering the probability of flood isolation failure. Protecting these MCCs provides greater availability of ventilation and cooling needed to support equipment credited in the PRA.	Table F-3	Needs Further Eval
170	Provide a backup method for safeguards alley room cooling. For example, staging of temporary fans and ducts along with power cords could be used.	This item would lower the dependence of safeguards alley room cooling on the installed HVAC systems. *Items 81, 160, 166, 167, 170, and 171 are analyzed together.* *Items 82, 83, 170, and 171 are analyzed together.*	Table F-3	Needs Further Eval

Table F-17. Phase 1 SAMA List (Continued)

SAMA ID	Potential Enhancement (SAMA Title)	Result of Potential Enhancement	Source Reference	Qualitative Screening
Plant Specific SAMA Improvements (Continued)				
171	Provide room high temperature alarms for safeguards alley.	This item would improve the detection and mitigation of a loss of room cooling. *Items 81, 160, 166, 167, 170, and 171 are analyzed together.* *Items 82, 83, 170, and 171 are analyzed together.*	Table F-3	Needs Further Eval
172	Provide an additional alarm to indicate that the CSTs are nearing depletion	This item would reduce the diagnostic error associated with switching AFW pump suction on CST depletion.	Table F-3	Needs Further Eval
173	Protect auxiliary building mezzanine cooling units from spray.	Minimizes the importance of flooding events that initiate on the mezzanine level.	Table F-3	Needs Further Eval
174	Protect boric acid transfer pumps from spray.	Minimizes the importance of flooding events that initiate on the mezzanine level.	Table F-3	Needs Further Eval
175	Protect A-train CCW pump from spray.	Minimizes the importance of flooding events that initiate on the mezzanine level.	Table F-3	Needs Further Eval
176	Install larger capacity sump pumps in safeguards alley.	Removes water from flooding events thereby helping prevent submergence-induced failure of the electrical buses.	Table F-3	Needs Further Eval
177	Provide a watertight barrier between the A-train and B-train 480 VAC switchgear rooms.	Would eliminate the potential for a flood to propagate and cause failure of both 480 VAC buses.	Table F-3	Needs Further Eval
178	Install flood detection instruments in the battery rooms.	Would provide cues to the operators that a pipe break had occurred in the battery rooms thereby providing faster response to diagnose and isolate the event.	Table F-3	Needs Further Eval
179	Add a diverse means of indicating AFW flow to the control room.	Would reduce the importance of miscalibrated flow instruments to a loss of secondary heat sink.	Table F-3	Needs Further Eval
180	Remove the low lube oil pressure interlock from the AFW pump start circuitry.	Would eliminate the need for the ALOPS and their associated power supplies.	Table F-3	Needs Further Eval

Table F-17. Phase 1 SAMA List (Continued)

SAMA ID	Potential Enhancement (SAMA Title)	Result of Potential Enhancement	Source Reference	Qualitative Screening
Plant Specific SAMA Improvements (Continued)				
181	Install breakaway mechanisms on the doors from the diesel generator rooms to the screenhouse tunnel so that the doors open before water level in the rooms would exceed 18 inches.	Provides an opportunity for isolation of pipe breaks in the rooms before offsite power is lost.	Table F-3	Needs Further Eval
182	Install a large drainage path from the screenhouse to the lake.	Eliminates the need to isolate flooding events in the screenhouse in order to prevent propagation to the switchgear rooms.	Table F-3	Needs Further Eval
183	Install flood detection indication in control room HVAC room (Room 301).	Provides early indication of a pipe break thus allowing isolation before other equipment fails.	Table F-3	Needs Further Eval
184	Change the failure position of MU-3A from fail-open to fail-closed.	Eliminates a diversion path for CST water, thus extending availability of secondary cooling for events where DC or air is lost. . *Items 76 and184 are analyzed together.*	Table F-3	Needs Further Eval
185	Improve the reliability of turbine-driven AFW pump.	Improves the availability of secondary cooling.	Table F-3	Already Implemented
186	Add an additional air-cooled air compressor.	Improves availability of air systems. *KPS has two air-cooled service air compressors.*	Table F-3	Already Implemented
187	Prevent charging relief valves from spuriously lifting.	Eliminates flow diversion for RCP seal injection. *DCR 748 installed a suction stabilizer in the charging line. This greatly reduced the problem of relief valves opening.*	Table F-3	Already Implemented
188	Install larger sump pumps in the turbine building	Extends the time available to isolate flooding events in the turbine building.	Table F-18	Needs Further Eval
189	Install a redundant and diverse instrument to indicate SI flow.	Improves the reliability of operator actions to extend RWST inventory and ECCS injection on a loss of ECCS recirculation	Table F-18	Needs Further Eval

Table F-18. List of Additional Basic Events from KPS PRA Cutset Review

Item	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
1	02-SWHDRISOX4HE	3.780e-004	4.515E-003	OPERATOR FAILS TO ISOLATE A SMALL SERVICE WATER BREAK IN DG A OR 51/52 ROOM	Installation of sump pumps in safeguards alley could lessen the importance of this event. Refer to SAMA item 176.
2	08-FPHDRISOX6HE	2.169e-003	3.786e-003	OPERATOR FAILS TO ISOLATE SPRINKLERS AFTER TURBINE BUILDING FEEDWATER LINE BREAK	Installation of larger sump pumps in the turbine building alley could lessen the importance of this event. Refer to SAMA item 188.
3	IE-W--6B—M	1.350e-004	3.883e-003	FEEDWATER LINE BREAK IN TURBINE BUILDING CAUSES FIRE PROTECTION ACTUATION	Installation of larger sump pumps in the turbine building alley could lessen the importance of this event. Refer to SAMA item 188.
4	08-FPHDRISOX5HE	8.435e-004	2.759e-003	OPERATOR FAILS TO ISOLATE SPRINKLERS AFTER TURBINE BUILDING STEAM LINE BREAK	Installation of larger sump pumps in the turbine building alley could lessen the importance of this event. Refer to SAMA item 188.
5	IE-T--6B—M	2.530e-004	2.941e-003	STEAM LINE BREAK IN TURBINE BUILDING CAUSES FIRE PROTECTION ACTUATION	Installation of larger sump pumps in the turbine building alley could lessen the importance of this event. Refer to SAMA item 188.
6	31-PM--CCW1B-TM	7.110e-003	4.685e-003	CCW PUMP B UNAVAILABLE DUE TO TEST OR MAINTENANCE	This basic event represents unavailability of the B-train CCW pump. SAMA items 58 and 59 would reduce the importance of this item.

Table F-18. List of Additional Basic Events from KPS PRA Cutset Review (Continued)

Item	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
7	IE-SB-5B2-U	3.110e-005	2.550e-003	TRAIN B SW FLOOD IN ROOM 5B-2 EXCEEDS DRAIN CAPACITY (A-train MDAFW pump room)	This initiating event leads to core damage due to flood-induced failure of equipment used to mitigate the event. Predominantly, accident sequences that lead to core damage are caused by a failure to isolate the break before the volume of water released would cause a loss of both trains of 480 VAC. Installation of sump pumps in safeguards alley could lessen the importance of this event. Installation of a flood barrier between the A and B-train 480 VAC switchgear rooms would prevent a loss of both buses if this event fails. Refer to SAMA items 176 and 177.
8	IE-SB-5B1-U	3.070e-005	2.541e-003	TRAIN B SW FLOOD IN ROOM 5B-1 EXCEEDS DRAIN CAPACITY (B-train 480 VAC switchgear room)	This initiating event leads to core damage due to flood-induced failure of equipment used to mitigate the event. Predominantly, accident sequences that lead to core damage are caused by a failure to isolate the break before the volume of water released would cause a loss of both trains of 480 VAC. Installation of sump pumps in safeguards alley could lessen the importance of this event. Installation of a flood barrier between the A and B-train 480 VAC switchgear rooms would prevent a loss of both buses if this event fails. Refer to SAMA items 176 and 177.
9	IE-E------M	1.590e-005	3.604e-003	LARGE UNISOLABLE BREAK IN RWST PIPING	This initiating event leads to core damage due to flood-induced failure of equipment needed to maintain RCP seal cooling, specifically, failure of MCCs 52E, 62E, and 62H. Loss of these MCCs leads to a loss of charging pumps and a loss of ventilation needed to ensure continued functioning of CCW pumps. Refer to SAMA item 169.
10	IE-SA-22B1M	1.330e-005	2.068e-003	MAJOR TRAIN A SW FLOOD IN ROOM 22B-1 (A-train service water pump area)	This event is important because failure to isolate the break in a timely manner leads to flooding the switchgear rooms. Installation of a drainage path from the screenhouse to the lake would eliminate the need for isolation. See SAMA item 182.
11	FAULT-A	5.000e-001	3.875e-003	STEAM GENERATOR A IS FAULTED	This basic event is a flag-type of event used to facilitate the overall quantification and represents no physical failures. No SAMA items are generated as a result of this basic event.
12	FAULT-B	5.000e-001	3.905e-003	STEAM GENERATOR B IS FAULTED	This basic event is a flag-type of event used to facilitate the overall quantification and represents no physical failures. No SAMA items are generated as a result of this basic event.

Table F-18. List of Additional Basic Events from KPS PRA Cutset Review (Continued)

Item	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
13	IE-SA-8B—M	1.350e-005	4.357e-003	MAJOR TRAIN A SW PIPE BREAKS IN ROOM 8B (Auxiliary building basement)	This initiating event leads to core damage due to flood-induced failure of equipment needed to maintain RCP seal cooling, specifically, failure of MCCs 52E, 62E, and 62H. Loss of these MCCs leads to a loss of charging pumps and a loss of ventilation needed to ensure continued functioning of CCW pumps. Refer to SAMA item 169.
14	IE-SB-8B--M	1.340e-005	3.034e-003	MAJOR TRAIN B SW PIPE BREAKS IN ROOM 8B (Auxiliary building basement)	This initiating event leads to core damage due to flood-induced failure of equipment needed to maintain RCP seal cooling, specifically, failure of MCCs 52E, 62E, and 62H. Loss of these MCCs leads to a loss of charging pumps and a loss of ventilation needed to ensure continued functioning of CCW pumps. Refer to SAMA item 169.
15	IE-SB-301-U	6.150e-004	4.675e-003	TRAIN B SW FLOOD IN ROOM 301 (Control room HVAC area)	This initiating event causes a loss of main feedwater because there is no means to detect pipe failures in the room before water would rise to a level that would fail the door. Installation of flood detection instruments in the room could provide a means to detect and isolate a pipe break before MFW would be lost. Refer to SAMA item 183.
16	IE-MLO	6.278e-005	2.168e-003	MEDIUM LOSS OF COOLANT ACCIDENT OCCURS	The frequency for this initiating event is taken from generic industry data. Any specific actions taken to lower this frequency would not make a statistically meaningful change in the overall frequency. Therefore, no SAMA items are identified to address the importance of this initiating event.
17	IE-W--8B5-U	6.380e-005	4.326e-003	MODERATE BREAK FROM AFW PIPE IN ROOM 8B5 (Auxiliary building basement MCC corridor)	This initiating event leads to core damage due to flood-induced failure of equipment needed to maintain RCP seal cooling, specifically, failure of MCCs 52E, 62E, and 62H. Loss of these MCCs leads to a loss of charging pumps and a loss of ventilation needed to ensure continued functioning of CCW pumps. Refer to SAMA item 169.
18	33-F925—CAL-AE	4.842e-003	4.344e-003	TECHNICIAN MISCALIBRATES SI FLOW CHANNEL F925	This basic event represents a pre-initiator (type A) operator action failure that results in an inaccurate reading of safety injection flow. The addition of a second instrument to indicate SI flow would eliminate the importance of this event. Refer to SAMA item 189.
19	SLB-A-ISOL	3.019e-001	2.457e-003	BREAK IN STEAM LINE A IN AUX BUILDING DOWNSTREAM OF MSIV	This event represents the fraction of all secondary line breaks that occur on the A main steam line downstream of the MSIV. Given the low importance of this event, very little benefit would be obtained from efforts to reduce the importance further. Therefore, no SAMA items are added.

Table F-18. List of Additional Basic Events from KPS PRA Cutset Review (Continued)

Item	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
20	06-AV-KFCCCF12	4.900e-004	2.699e-003	DOUBLE COMMON CAUSE FAILURE (CCF) AVMS-1A/1B FC	This event is common cause failure of both MSIVs to close. Given the low importance of this event, very little benefit would be obtained from efforts to reduce the importance further. Therefore, no SAMA items are added.
21	06--OCD-SLB—HE	7.737e-002	2.641e-003	OPERATOR FAILS TO DEPRESSURIZE AFTER A STEAM LINE BREAK	Given the low importance of this event, very little benefit would be obtained from efforts to reduce the importance further. Therefore, no SAMA items are added.
22	38-CBA102-04-CO	7.512e-006	4.369e-003	BKR FROM BUS BRA-102 TO BUS BRA-104 TRANS OPEN	This basic event is important because it causes a loss of A-train DC power initiating event. The importance of this initiating event is driven by sequences where failure of room cooling causes a loss of AFW pumps and other equipment located in safeguards alley and subsequences where a long-term source of water to AFW pump suction is not available. The ability to provide alternate room cooling for safeguards alley would lower the importance of this initiating event to overall core damage. Refer to SAMA items 170 and 171. Additional alarms to indicate CST depletion, an automatic switchover to an alternate water source, or larger CSTs would lower the importance of this event. Refer to SAMA items 172, 71, and 66.
23	34-CVSI3034AVCO	1.009e-007	1.305e-003	CHECK VALVES RHR-5A SI-303A AND SI304A TRANS OPEN VAR TERM	This event causes an interfacing system LOCA initiating event. Given the low importance of this event, very little benefit would be obtained from efforts to reduce the importance further. Therefore, no SAMA items are added.
24	IE-ISL	1.000e+000	3.559e-003	INTERFACING SYSTEM LOSS OF COOLANT ACCIDENT OCCURS	This basic event is a tag event that is attached to all cutsets representing an interfacing systems LOCA initiating event. This event causes an interfacing system LOCA initiating event. Given the low importance of this event, very little benefit would be obtained from efforts to reduce the importance further. Therefore, no SAMA items are added.
25	34-CVSI3034BVCO	1.009e-007	1.305e-003	CHECK VALVES RHR-5A SI-303B AND SI304B TRANS OPEN VAR TERM	This event causes an interfacing system LOCA initiating event. Given the low importance of this event, very little benefit would be obtained from efforts to reduce the importance further. Therefore, no SAMA items are added.

Table F-18. List of Additional Basic Events from KPS PRA Cutset Review (Continued)

Item	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
26	IE-F--22B1M	2.460e-004	3.881e-003	MAJOR FLOOD FROM FIRE PROTECTION IN ROOM 22B-1 (A-train service water pump area)	This event is important because failure to isolate the break in a timely manner leads to flooding the switchgear rooms. Installation of a drainage path from the screenhouse to the lake would eliminate the need for isolation. See SAMA item 182.
27	05BPT--AFW1C-PR	2.637e-003	4.875e-003	TD AFW PUMP INDEPENDENT FAILURE TO RUN	The importance of the turbine-driven AFW pump is caused mainly by loss of room cooling inducing failure of the motor-driven AFW pumps. The loss of room cooling could be caused directly by a loss of the coolers or by flood-induced failure of the power supplies. Instituting measures to ensure adequate room cooling to safeguards alley after a loss of room cooling would lower the importance of the turbine-driven AFW pump. The ability to provide alternate room cooling for safeguards alley would lower the importance of this initiating event to overall core damage. Refer to SAMA items 170 and 171.
28	SL480	2.500e-003	4.170e-003	LARGE REACTOR COOLANT PUMP SEAL LOCA (480 GPM)	The importance of RCP seal LOCAs is addressed by preventing the loss of seal cooling. SAMA item 58 addresses improved RCP seals.
29	03-CVS-MU301-FO	5.000e-005	3.119e-003	CHECK VALVE MU-301 FAILS TO OPEN	Failure of this check valve to open prevents CST water from reaching the AFW pumps. Given the low importance of this event, very little benefit would be obtained from efforts to reduce the importance further. Therefore, no SAMA items are added.
31	16-FN-TBB1A—PR	5.510e-004	3.950e-003	INDEPENDENT FAILURE TURB BLDG BSMT FAN COIL UNIT A FTR	This event then results in failure of the AFW pumps and safety-related 480 VAC equipment. Provision of room temperature alarms or the ability to provide alternate room cooling for safeguards alley would lower the importance of this initiating event to overall core damage. Refer to SAMA items 170 and 171.
32	IE-LLO	4.999e-006	1.170e-003	LARGE BREAK LOSS OF COOLANT ACCIDENT OCCURS	Given the low importance of this event, very little benefit would be obtained from efforts to reduce the importance further. Therefore, no SAMA items are added.
33	34--LR1------HE	1.613e-002	1.204e-003	OPERATOR FAILS TO ESTABLISH LOW PRESSURE RECIRC	Given the low importance of this event, very little benefit would be obtained from efforts to reduce the importance further. Therefore, no SAMA items are added.

Table F-18. List of Additional Basic Events from KPS PRA Cutset Review (Continued)

Item	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
34	IE-SA-156-S	2.130e-003	2.689e-003	SMALL TRAIN A SW PIPE BREAKS IN ROOM 156 (Auxiliary Building Mezzanine)	This initiating event leads to core damage due to flood-induced failure of equipment needed to maintain RCP seal cooling, specifically, failure of MCCs 52E, 62E, and 62H. Loss of these MCCs leads to a loss of charging pumps and a loss of ventilation needed to ensure continued functioning of CCW pumps. Refer to SAMA item 169.
35	IE-SA-22B1U	7.890e-004	3.624e-003	SW TRAIN A FLOOD <2000 GPM IN ROOM 22B-1 (A-train service water pump area)	This event is important because failure to isolate the break in a timely manner leads to flooding the switchgear rooms. Installation of a drainage path from the screenhouse to the lake would eliminate the need for isolation. See SAMA item 182.
36	33-PM-KPSCCF12	1.100e-004	2.025e-003	DOUBLE COMMON CAUSE FAILURE (CCF) 33-PMKPSCCF12	Given the low importance of this event, very little benefit would be obtained from efforts to reduce the importance further. Therefore, no SAMA items are added.
37	IE-SA-2B--S	7.220e-004	4.375e-003	TRAIN A SW FLOOD IN ROOM 2B WITHIN DRAIN CAPACITY (A-train DG room)	A large part of the importance of this basic event is driven by the need to isolate flooding events (refer to item 2 above). This event is important to the KPS results because power is needed to operate the valves that are used to isolate many of the internal flooding initiating events. Failure of offsite power coupled with failure of the diesel-generator to operate causes the inability to isolate some flooding events. In actuality, however, flooding isolation must occur early in the event, typically in less than one hour. The ability to isolate flooding events without requiring power would greatly lower the importance of this event. Refer to SAMA item 168.
38	IE-W--8B—U	1.290e-004	1.598e-003	MODERATE BREAK FROM AFW PIPE IN ROOM 8B (Auxiliary Building Basement)	Given the low importance of this event, very little benefit would be obtained from efforts to reduce the importance further. Therefore, no SAMA items are added.
39	16-FNAKPLCCF123	3.400e-006	4.506e-003	TRIPLE COMMON CAUSE FAILURE (CCF) AFWA, TBBAB FCU PLUGS	This event then results in failure of the AFW pumps and safety-related 480 VAC equipment. Provision of room temperature alarms or the ability to provide alternate room cooling for safeguards alley would lower the importance of this initiating event to overall core damage. Refer to SAMA items 170 and 171.
40	06--OCD-RSL—HE	8.849e-003	3.594e-003	OPERATOR FAILS TO CD AND DEPRESS RCS – RXCP SEAL LOCA	Given the low importance of this event, very little benefit would be obtained from efforts to reduce the importance further. Therefore, no SAMA items are added.

Table F-18. List of Additional Basic Events from KPS PRA Cutset Review (Continued)

Item	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
41	05BMV-AFW10B-FC	1.905e-003	9.957e-004	MOV AFW-10B FAILS TO CLOSE	Given the low importance of this event, very little benefit would be obtained from efforts to reduce the importance further. Therefore, no SAMA items are added.
42	05BMV-AFW10A-FC	1.905e-003	9.957e-004	MOV AFW-10A FAILS TO CLOSE	Given the low importance of this event, very little benefit would be obtained from efforts to reduce the importance further. Therefore, no SAMA items are added.
43	02-MV-SW10B—FC	1.905e-003	1.868e-003	MOV SW-10B FAILS TO CLOSE	Given the low importance of this event, very little benefit would be obtained from efforts to reduce the importance further. Therefore, no SAMA items are added.
44	IE-SA-5B—S	6.020e-004	4.006e-003	TRAIN A SW FLOOD IN ROOM 5B WITHIN DRAIN CAPACITY (A-train 480 VAC switchgear room)	A large part of the importance of this basic event is driven by the need to isolate flooding events. This event is important to the KPS results because power is needed to operate the valves that are used to isolate many of the internal flooding initiating events. Failure of offsite power coupled with failure of the diesel-generator to operate causes the inability to isolate some flooding events. In actuality, however, flooding isolation must occur early in the event, typically in less than one hour. The ability to isolate flooding events without requiring power would greatly lower the importance of this event. Refer to SAMA item 168.
45	05A-MF2------HE	4.307e-003	2.695e-003	OPERATOR FAILS TO ESTABLISH MAIN FEEDWATER	Given the low importance of this event, very little benefit would be obtained from efforts to reduce the importance further. Therefore, no SAMA items are added.
46	IE-SB-14B1S	5.920e-004	3.183e-003	SPRAY EVENT FROM TRAIN B SW IN CHARGING ROOM	Given the low importance of this event, very little benefit would be obtained from efforts to reduce the importance further. Therefore, no SAMA items are added.
47	IE-SA-14B1S	5.700e-004	2.860e-003	SPRAY EVENT FROM TRAIN B SW IN CHARGING ROOM	Given the low importance of this event, very little benefit would be obtained from efforts to reduce the importance further. Therefore, no SAMA items are added.

Table F-19. Cost-Benefit Analyses Using 7% Discount Rate for Potential SAMAs Not Screened

Case ID	Base Case	SAMA 1	SAMA 19	SAMA 21	SAMA 26	SAMA 31	SAMA 32
Potential SAMAs Evaluated by Case (See Table F-17)		1,3,5,6,74	19,20	21	26	31	32
CDF After Enhancements		8.088E-005	8.252E-005	8.076E-005	4.797E-005	8.088E-005	7.961E-005
Total Expected Person-REM/year Offsite (F_AD_{PA})	30.19	30.18	29.92	30.13	22.17	30.19	30.09
Total Expected Offsite Property Damage $/year Offsite ($F_AP_{DA}$)	$49,700	$49,684	$48,759	$49,614	$39,377	$49,700	$49,506
Averted Public Exposure (APE)	$649,864	$192	$5,775	$1,190	$172,555	$0	$1,992
Averted Offsite Property Damage Costs (AOC)	$534,916	$165	$10,126	$923	$111,097	$0	$2,083
Averted Immediate Occupational Exposure Costs (W_{IO})	(-)$5,746	$1	(-)$116	$9	$2,339	$1	$91
Averted Long-Term Occupational Exposure Costs (W_{LTO})	(-)$25,044	$3	(-)$504	$40	$10,193	$3	$397
Total Averted Occupational Exposure Costs (AOE)	(-)$30,790	$4	(-)$620	$50	$12,531	$4	$488
Averted Cleanup and Decontamination Costs (U_{CD})	(-)$939,128	$125	(-)$18,916	$1,519	$382,225	$125	$14,871
Averted Replacement Power Costs (U_{RP})	(-)$389,963	$52	(-)$7,854	$631	$158,708	$52	$6,175
Averted Onsite Costs (AOSC)	(-)$1,329,091	$177	(-)$26,770	$2,149	$540,932	$177	$21,045
Total Averted Costs (APE + AOC + AOE +AOSC)	$2,544,661	$4	(-)$620	$50	$12,531	$4	$488
Significant Costs Not Considered? (Yes/No)		Yes	Yes	Yes	Yes	Yes	Yes
Double Calculated Benefit	$5,089,322	$1,077	(-)$22,978	$8,622	$1,674,233	$363	$51,215
Cost of Enhancement (COE)	$0	$50,000	$50,000	$50,000	$2,000,000	$50,000	$100,000
NPV of twice benefit		(-)$48,923	(-)$72,978	(-)$41,378	(-)$325,767	(-)$49,637	(-)$48,785
Potentially Cost Beneficial? (Yes/No)		No	No	No	No	No	No

Table F-19. Cost-Benefit Analyses Using 7% Discount Rate for Potential SAMAs Not Screened (Continued)

Case ID	SAMA 46	SAMA 50	SAMA 55	SAMA 56	SAMA 58	SAMA 59	SAMA 66
Potential SAMAs Evaluated by Case (See Table F-17)	46	50, 162, 163	55	56	58	59	66
CDF After Enhancements	6.649E-005	8.059E-005	5.414E-005	5.775E-005	5.414E-005	6.091E-005	7.544E-005
Total Expected Person-REM/year Offsite (F_AD_{PA})	25.65	30.10	24.38	26.01	24.38	26.05	27.61
Total Expected Offsite Property Damage $/year Offsite ($F_AP_{DA}$)	$43,283	$49,622	$44,904	$47,526	$44,904	$43,618	$45,591
Averted Public Exposure (APE)	$97,733	$1,828	$124,941	$89,912	$124,941	$88,944	$55,373
Averted Offsite Property Damage Costs (AOC)	$69,063	$831	$51,620	$23,398	$51,620	$65,453	$44,216
Averted Immediate Occupational Exposure Costs (W_{IO})	$1,023	$21	$1,900	$1,644	$1,900	$1,419	$387
Averted Long-Term Occupational Exposure Costs (W_{LTO})	$4,459	$93	$8,282	$7,165	$8,282	$6,186	$1,688
Total Averted Occupational Exposure Costs (AOE)	$5,482	$114	$10,183	$8,808	$10,183	$7,606	$2,075
Averted Cleanup and Decontamination Costs (U_{CD})	$167,199	$3,492	$310,588	$268,675	$310,588	$231,986	$63,286
Averted Replacement Power Costs (U_{RP})	$69,425	$1,450	$128,963	$111,559	$128,963	$96,325	$26,278
Averted Onsite Costs (AOSC)	$236,624	$4,942	$439,551	$380,234	$439,551	$328,311	$89,564
Total Averted Costs (APE + AOC + AOE +AOSC)	$408,902	$7,716	$626,294	$502,352	$626,294	$490,314	$191,228
Significant Costs Not Considered? (Yes/No)	Yes	No	Yes	Yes	Yes	Yes	Yes
Double Calculated Benefit	$817,804	$15,433	$1,252,589	$1,004,705	$1,252,589	$980,628	$382,457
Cost of Enhancement (COE)	$2,700,000	$50,000	$2,000,000	$1,500,000	$1,432,000	$1,215,000	$50,000
NPV of twice benefit	(-)$1,882,196	(-)$34,567	(-)$747,411	(-)$495,295	(-)$170,411	(-)$234,372	$332,457
Potentially Cost Beneficial? (Yes/No)	No	No	No	No	No	No	Yes

Table F-19. Cost-Benefit Analyses Using 7% Discount Rate for Potential SAMAs Not Screened (Continued)

Case ID	SAMA 71	SAMA 76	SAMA 80	SAMA 81	SAMA 82	SAMA 86	SAMA 87
Potential SAMAs Evaluated by Case (See Table F-17)	71	76, 184	80	81, 160, 166, 167, 170, 171	82, 83, 170, 171	86	87
CDF After Enhancements	6.513E-005	8.082E-005	7.058E-005	7.720E-005	7.375E-005	8.071E-005	8.032E-005
Total Expected Person-REM/year Offsite (F_AD_{PA})	24.74	30.16	28.37	28.65	27.35	30.12	30.07
Total Expected Offsite Property Damage $/year Offsite ($F_AP_{DA}$)	$38,536	$49,654	$46,303	$47,415	$45,966	$49,611	$49,645
Averted Public Exposure (APE)	$117,307	$499	$39,123	$33,169	$60,984	$1,391	$2,618
Averted Offsite Property Damage Costs (AOC)	$120,150	$494	$36,559	$24,590	$40,183	$955	$591
Averted Immediate Occupational Exposure Costs (W_{IO})	$1,120	$5	$748	$262	$507	$13	$41
Averted Long-Term Occupational Exposure Costs (W_{LTO})	$4,880	$22	$3,260	$1,143	$2,211	$56	$177
Total Averted Occupational Exposure Costs (AOE)	$5,999	$27	$4,009	$1,405	$2,718	$69	$217
Averted Cleanup and Decontamination Costs (U_{CD})	$182,990	$822	$122,267	$42,852	$82,908	$2,099	$6,627
Averted Replacement Power Costs (U_{RP})	$75,981	$341	$50,768	$17,793	$34,425	$872	$2,752
Averted Onsite Costs (AOSC)	$258,971	$1,163	$173,035	$60,645	$117,333	$2,971	$9,379
Total Averted Costs (APE + AOC + AOE +AOSC)	$502,427	$2,183	$252,726	$119,809	$221,218	$5,386	$12,805
Significant Costs Not Considered? (Yes/No)	Yes	Yes	No	No	No	No	Yes
Double Calculated Benefit	$1,004,855	$4,365	$505,452	$239,617	$442,437	$10,772	$25,610
Cost of Enhancement (COE)	$1,700,000	$100,000	$250,000	$399,746	$399,746	$50,000	$100,000
NPV of twice benefit	(-)$695,145	(-)$95,635	$255,452	(-)$160,129	$42,691	(-)$39,228	(-)$74,390
Potentially Cost Beneficial? (Yes/No)	No	No	Yes	No	Yes	No	No

Table F-19. Cost-Benefit Analyses Using 7% Discount Rate for Potential SAMAs Not Screened (Continued)

Case ID	SAMA 111	SAMA 112	SAMA 114	SAMA 118	SAMA 122	SAMA 124	SAMA 125
Potential SAMAs Evaluated by Case (See Table F-17)	111, 113	112	114	118	122	124	125, 129
CDF After Enhancements	8.000E-005	8.000E-005	8.089E-005	8.083E-005	8.079E-005	8.079E-005	8.083E-005
Total Expected Person-REM/year Offsite (F_AD_{PA})	29.04	29.03	30.17	30.15	30.17	28.93	10.75
Total Expected Offsite Property Damage $/year Offsite ($F_AP_{DA}$)	$47,252	$47,215	$49,666	$49,645	$49,683	$47,019	$6,728
Averted Public Exposure (APE)	$24,675	$24,985	$270	$772	$466	$26,958	$418,384
Averted Offsite Property Damage Costs (AOC)	$26,339	$26,740	$359	$593	$175	$28,846	$462,501
Averted Immediate Occupational Exposure Costs (W_{IO})	$63	$63	$0	$4	$7	$43	$4
Averted Long-Term Occupational Exposure Costs (W_{LTO})	$276	$276	$0	$19	$31	$186	$19
Total Averted Occupational Exposure Costs (AOE)	$339	$339	$0	$23	$38	$229	$23
Averted Cleanup and Decontamination Costs (U_{CD})	$10,342	$10,342	$9	$706	$1,170	$6,975	$706
Averted Replacement Power Costs (U_{RP})	$4,294	$4,294	$4	$293	$486	$2,896	$293
Averted Onsite Costs (AOSC)	$14,637	$14,637	$13	$999	$1,656	$9,872	$999
Total Averted Costs (APE + AOC + AOE +AOSC)	$65,990	$66,702	$642	$2,387	$2,336	$65,905	$881,907
Significant Costs Not Considered? (Yes/No)	Yes	Yes	Yes	No	Yes	Yes	Yes
Double Calculated Benefit	$131,980	$133,403	$1,284	$4,773	$4,671	$131,809	$1,763,814
Cost of Enhancement (COE)	$190,000	$149,746	$100,000	$50,000	$100,000	$149,746	$2,700,000
NPV of twice benefit	(-)$58,020	(-)$16,343	(-)$98,716	(-)$45,227	(-)$95,329	(-)$17,937	(-)$936,186
Potentially Cost Beneficial? (Yes/No)	No	No	No	No	No	No	No

Table F-19. Cost-Benefit Analyses Using 7% Discount Rate for Potential SAMAs Not Screened (Continued)

Case ID	SAMA 126	SAMA 131	SAMA 150	SAMA 168	SAMA 169	SAMA 172	SAMA 173
Potential SAMAs Evaluated by Case (See Table F-17)	126	131	150	168	169	172	173
CDF After Enhancements	7.796E-005	7.819E-005	7.972E-005	7.995E-005	7.088E-005	6.919E-005	7.799E-005
Total Expected Person-REM/year Offsite (F_AD_{PA})	29.35	29.14	30.00	30.16	28.88	26.10	29.32
Total Expected Offsite Property Damage $/year Offsite ($F_AP_{DA}$)	$48,131	$48,107	$49,325	$49,688	$48,621	$41,279	$47,872
Averted Public Exposure (APE)	$18,054	$22,518	$4,111	$523	$28,151	$88,041	$18,590
Averted Offsite Property Damage Costs (AOC)	$16,886	$17,144	$4,037	$123	$11,607	$90,629	$19,670
Averted Immediate Occupational Exposure Costs (W_{IO})	$208	$192	$83	$67	$711	$831	$206
Averted Long-Term Occupational Exposure Costs (W_{LTO})	$907	$836	$362	$291	$3,099	$3,623	$898
Total Averted Occupational Exposure Costs (AOE)	$1,116	$1,028	$446	$358	$3,811	$4,454	$1,104
Averted Cleanup and Decontamination Costs (U_{CD})	$34,028	$31,357	$13,593	$10,923	$116,230	$135,851	$33,679
Averted Replacement Power Costs (U_{RP})	$14,129	$13,020	$5,644	$4,535	$48,261	$56,408	$13,984
Averted Onsite Costs (AOSC)	$48,157	$44,378	$19,238	$15,458	$164,491	$192,260	$47,664
Total Averted Costs (APE + AOC + AOE +AOSC)	$84,213	$85,068	$27,831	$16,462	$208,059	$375,383	$87,028
Significant Costs Not Considered? (Yes/No)	Yes	Yes	Yes	Yes	No	No	No
Double Calculated Benefit	$168,426	$170,136	$55,662	$32,924	$416,119	$750,766	$174,055
Cost of Enhancement (COE)	$2,700,000	$700,000	$100,000	$100,000	$284,000	$249,676	$150,000
NPV of twice benefit	(-)$2,531,574	(-)$529,864	(-)$44,338	(-)$67,076	$132,119	$501,090	$24,055
Potentially Cost Beneficial? (Yes/No)	No	No	No	No	Yes	Yes	Yes

Table F-19. Cost-Benefit Analyses Using 7% Discount Rate for Potential SAMAs Not Screened (Continued)

Case ID	SAMA 174	SAMA 175	SAMA 176	SAMA 177	SAMA 178	SAMA 179	SAMA 180
Potential SAMAs Evaluated by Case (See Table F-17)	174	175	176	177	178	179	180
CDF After Enhancements	7.826E-005	7.769E-005	7.386E-005	7.304E-005	7.931E-005	7.828E-005	7.886E-005
Total Expected Person-REM/year Offsite (F_AD_{PA})	29.43	29.31	28.16	27.56	29.44	29.40	29.38
Total Expected Offsite Property Damage $/year Offsite ($F_AP_{DA}$)	$48,083	$47,852	$47,790	$46,736	$48,572	$48,030	$48,262
Averted Public Exposure (APE)	$16,388	$18,866	$43,631	$56,561	$16,099	$16,864	$17,273
Averted Offsite Property Damage Costs (AOC)	$17,395	$19,884	$20,552	$31,894	$12,141	$17,967	$15,477
Averted Immediate Occupational Exposure Costs (W_{IO})	$187	$227	$499	$558	$112	$185	$146
Averted Long-Term Occupational Exposure Costs (W_{LTO})	$815	$991	$2,177	$2,431	$489	$808	$638
Total Averted Occupational Exposure Costs (AOE)	$1,001	$1,218	$2,676	$2,988	$602	$994	$784
Averted Cleanup and Decontamination Costs (U_{CD})	$30,545	$37,163	$81,631	$91,151	$18,354	$30,312	$23,927
Averted Replacement Power Costs (U_{RP})	$12,683	$15,431	$33,895	$37,848	$7,621	$12,586	$9,935
Averted Onsite Costs (AOSC)	$43,227	$52,593	$115,525	$128,999	$25,975	$42,899	$33,862
Total Averted Costs (APE + AOC + AOE +AOSC)	$78,011	$92,561	$182,384	$220,442	$54,817	$78,724	$67,396
Significant Costs Not Considered? (Yes/No)	No	No	No	No	No	Yes	No
Double Calculated Benefit	$156,023	$185,123	$364,768	$440,885	$109,633	$157,448	$134,791
Cost of Enhancement (COE)	$150,000	$150,000	$269,000	$162,000	$149,746	$200,000	$150,000
NPV of twice benefit	$6,023	$35,123	$95,768	$278,885	(-)$40,113	(-)$42,552	(-)$15,209
Potentially Cost Beneficial? (Yes/No)	Yes	Yes	Yes	Yes	No	No	No

Table F-19. Cost-Benefit Analyses Using 7% Discount Rate for Potential SAMAs Not Screened (Continued)

Case ID	SAMA 181	SAMA 182	SAMA 183	SAMA 188	SAMA 189
Potential SAMAs Evaluated by Case (See Table F-17)	181	182	183	188	189
CDF After Enhancements	7.873E-005	7.974E-005	8.070E-005	7.863E-005	8.055E-005
Total Expected Person-REM/year Offsite (F_AD_{PA})	28.80	29.75	30.06	29.53	30.03
Total Expected Offsite Property Damage $/year Offsite ($F_AP_{DA}$)	$47,313	$49,044	$49,472	$49,085	$49,372
Averted Public Exposure (APE)	$29,939	$9,390	$2,794	$14,045	$3,370
Averted Offsite Property Damage Costs (AOC)	$25,689	$7,053	$2,446	$6,614	$3,530
Averted Immediate Occupational Exposure Costs (W_{IO})	$153	$82	$14	$161	$24
Averted Long-Term Occupational Exposure Costs (W_{LTO})	$669	$356	$59	$700	$106
Total Averted Occupational Exposure Costs (AOE)	$822	$438	$73	$861	$130
Averted Cleanup and Decontamination Costs (U_{CD})	$25,088	$13,361	$2,215	$26,249	$3,957
Averted Replacement Power Costs (U_{RP})	$10,417	$5,548	$920	$10,899	$1,643
Averted Onsite Costs (AOSC)	$35,505	$18,909	$3,135	$37,148	$5,600
Total Averted Costs (APE + AOC + AOE +AOSC)	$91,955	$35,790	$8,448	$58,668	$12,629
Significant Costs Not Considered? (Yes/No)	No	Yes	Yes	No	Yes
Double Calculated Benefit	$183,910	$71,580	$16,896	$117,335	$25,259
Cost of Enhancement (COE)	$100,000	$100,000	$100,000	$269,000	$100,000
NPV of twice benefit	$83,910	(-)$28,420	(-)$83,104	(-)$151,665	(-)$74,741
Potentially Cost Beneficial? (Yes/No)	Yes	No	No	No	No

Table F-20. Cost-Benefit Analyses Using 3% Discount Rate for Potential SAMAs Not Screened

Case ID	Base Case	SAMA 1	SAMA 19	SAMA 21	SAMA 26	SAMA 31	SAMA 32
Potential SAMAs Evaluated by Case (See Table F-17)		1,3,5,6,74	19,20	21	26	31	32
CDF After Enhancements		8.088E-005	8.252E-005	8.076E-005	4.797E-005	8.088E-005	7.961E-005
Total Expected Person-REM/year Offsite (F_AD_{PA})	30.19	30.18	29.92	30.13	22.17	30.19	30.09
Total Expected Offsite Property Damage $/year Offsite ($F_AP_{DA}$)	$49,700	$49,684	$48,759	$49,614	$39,377	$49,700	$49,506
Averted Public Exposure (APE)	$907,993	$268	$8,070	$1,663	$241,121	$0	$2,783
Averted Offsite Property Damage Costs (AOC)	$747,463	$231	$14,150	$1,289	$155,242	$0	2,911
Averted Immediate Occupational Exposure Costs (W_{IO})	$8,029	$1	(-)$162	$13	$3,268	$1	$127
Averted Long-Term Occupational Exposure Costs (W_{LTO})	$42,042	$6	(-)$847	$68	$17,110	$6	$666
Total Averted Occupational Exposure Costs (AOE)	$50,071	$7	(-)$1,008	$81	$20,378	$7	$793
Averted Cleanup and Decontamination Costs (U_{CD})	$1,576,559	$210	(-)$31,752	$2,549	$641,625	$210	$24,963
Averted Replacement Power Costs (U_{RP})	$766,062	$102	(-)$15,429	$1,239	$311,771	$102	$12.130
Averted Onsite Costs (AOSC)	$2,342,621	$312	(-)$47,182	$3,788	$953,396	$313	$37,092
Total Averted Costs (APE + AOC + AOE +AOSC)	$4,048,149	$818	(-)$25,971	$6,820	$1,370,138	$319	$43,579
Significant Costs Not Considered? (Yes/No)		Yes	Yes	Yes	Yes	Yes	Yes
Double Calculated Benefit	$8,096,298	$1,636	-$51,942	$13,641	$2,740,275	$638	$87,158
Cost of Enhancement (COE)	$0	$50,000	$50,000	$50,000	$2,000,000	$50,000	$100,000
NPV of twice benefit		(-)$48,364	(-)$101,942	(-)$36,359	$740,275	(-)$49,362	(-)$12,842
Potentially Cost Beneficial? (Yes/No)		No	No	No	Yes	No	No

Table F-20. Cost-Benefit Analyses Using 3% Discount Rate for Potential SAMAs Not Screened (Continued)

Case ID	SAMA 46	SAMA 50	SAMA 55	SAMA 56	SAMA 58	SAMA 59	SAMA 66
Potential SAMAs Evaluated by Case (See Table F-17)	46	50, 162, 163	55	56	58	59	66
CDF After Enhancements	6.649E-005	8.059E-005	5.414E-005	5.775E-005	5.414E-005	6.091E-005	7.544E-005
Total Expected Person-REM/year Offsite (F_AD_{PA})	25.65	30.10	24.38	26.01	24.38	26.05	27.61
Total Expected Offsite Property Damage $/year Offsite ($F_AP_{DA}$)	$43,283	$49,622	$44,904	$47,526	$44,904	$43,618	$45,591
Averted Public Exposure (APE)	$136,569	$2,555	$174,587	$125,638	$174,587	$124,287	$77,376
Averted Offsite Property Damage Costs (AOC)	$96,505	$1,162	$72,131	$32,696	$72,131	$91,461	$61,786
Averted Immediate Occupational Exposure Costs (W_{IO})	$1,429	$30	$2,655	$2,297	$2,655	$1,983	$541
Averted Long-Term Occupational Exposure Costs (W_{LTO})	$7,485	$156	$13,903	$12,027	$13,903	$10,385	$2,833
Total Averted Occupational Exposure Costs (AOE)	$8,914	$186	$16,559	$14,324	$16,559	$12,368	$3,374
Averted Cleanup and Decontamination Costs (U_{CD})	$280,671	$5,862	$521,372	$451,013	$521,372	$389,425	$106,236
Averted Replacement Power Costs (U_{RP})	$136,380	$2,849	$253,339	$219,151	$253,339	$189,225	$51,621
Averted Onsite Costs (AOSC)	$417,051	$8,711	$774,711	$670,164	$774,711	$578,650	$157,857
Total Averted Costs (APE + AOC + AOE +AOSC)	$659,039	$12,613	$1,037,988	$842,822	$1,037,988	$806,766	$300,393
Significant Costs Not Considered? (Yes/No)	Yes	No	Yes	Yes	Yes	Yes	Yes
Double Calculated Benefit	$1,318,078	$25,227	$2,075,975	$1,685,645	$2,075,975	$1,613,531	$600,786
Cost of Enhancement (COE)	$2,700,000	$50,000	$2,000,000	$1,500,000	$1,423,000	$1,215,000	$50,000
NPV of twice benefit	(-)$1,381,922	(-)$24,773	$75,975	$185,645	$652,975	$398,531	$550,786
Potentially Cost Beneficial? (Yes/No)	No	No	Yes	Yes	Yes	Yes	Yes

Table F-20. Cost-Benefit Analyses Using 3% Discount Rate for Potential SAMAs Not Screened (Continued)

Case ID	SAMA 71	SAMA 76	SAMA 80	SAMA 81	SAMA 82	SAMA 86	SAMA 87
Potential SAMAs Evaluated by Case (See Table F-17)	71	76, 184	80	81, 160, 166, 167, 170, 171	82, 83, 170, 171	86	87
CDF After Enhancements	6.513E-005	8.082E-005	7.058E-005	7.720E-005	7.375E-005	8.071E-005	8.032E-005
Total Expected Person-REM/year Offsite (F_AD_{PA})	24.74	30.16	28.37	28.65	27.35	30.12	30.07
Total Expected Offsite Property Damage $/year Offsite ($F_AP_{DA}$)	$38,536	$49,654	$46,303	$47,415	$45,966	$49,611	$49,645
Averted Public Exposure (APE)	$163,920	$697	$54,669	$46,348	$85,217	$1,944	$3,658
Averted Offsite Property Damage Costs (AOC)	$167,893	$690	$51,086	$34,362	$56,151	$1,335	$827
Averted Immediate Occupational Exposure Costs (W_{IO})	$1,564	$7	$1,045	$366	$709	$18	$57
Averted Long-Term Occupational Exposure Costs (W_{LTO})	$8,191	$37	$5,473	$1,918	$3,711	$94	$297
Total Averted Occupational Exposure Costs (AOE)	$9,756	$44	$6,518	$2,285	$4,420	$112	$353
Averted Cleanup and Decontamination Costs (U_{CD})	$307,177	$1,380	$205,245	$71,933	$139,174	$3,524	$11,125
Averted Replacement Power Costs (U_{RP})	$149,260	$670	$99,730	$34,953	$67,626	$1,712	$5,406
Averted Onsite Costs (AOSC)	$456,437	$2,050	$304,975	$106,886	$206,799	$5,236	$16,530
Total Averted Costs (APE + AOC + AOE +AOSC)	$798,005	$3,481	$417,249	$189,881	$352,587	$8,627	$21,368
Significant Costs Not Considered? (Yes/No)	Yes	Yes	No	No	No	No	Yes
Double Calculated Benefit	$1,596,011	$6,961	$834,498	$379,762	$705,174	$17,253	$42,736
Cost of Enhancement (COE)	$1,700,000	$100,000	$250,000	$399,746	$399,746	$50,000	$100,000
NPV of twice benefit	(-)$103,989	(-)$93,039	$584,498	(-)$19,984	$305,428	(-)$32,747	(-)$57,264
Potentially Cost Beneficial? (Yes/No)	No	No	Yes	No	Yes	No	No

Table F-20. Cost-Benefit Analyses Using 3% Discount Rate for Potential SAMAs Not Screened (Continued)

Case ID	SAMA 111	SAMA 112	SAMA 114	SAMA 118	SAMA 122	SAMA 124	SAMA 125
Potential SAMAs Evaluated by Case (See Table F-17)	111, 113	112	114	118	122	124	125, 129
CDF After Enhancements	8.000E-005	8.000E-005	8.089E-005	8.083E-005	8.079E-005	8.079E-005	8.083E-005
Total Expected Person-REM/year Offsite (F_AD_{PA})	29.04	29.03	30.17	30.15	30.17	28.93	10.75
Total Expected Offsite Property Damage $/year Offsite ($F_AP_{DA}$)	$47,252	$47,215	$49,666	$49,645	$49,683	$47,019	$6,728
Averted Public Exposure (APE)	$34,480	$34,913	$378	$1,079	$651	$37,670	$584,632
Averted Offsite Property Damage Costs (AOC)	$36,805	$37,366	$501	$828	$245	$40,308	$646,279
Averted Immediate Occupational Exposure Costs (W_{IO})	$88	$88	$0	$6	$10	$60	$6
Averted Long-Term Occupational Exposure Costs (W_{LTO})	$463	$463	$0	$32	$52	$312	$32
Total Averted Occupational Exposure Costs (AOE)	$551	$551	$0	$38	$62	$372	$38
Averted Cleanup and Decontamination Costs (U_{CD})	$17,362	$17,362	$15	$1,185	$1,964	$11,709	$1,185
Averted Replacement Power Costs (U_{RP})	$8,436	$8,436	$8	$576	$955	$5,690	$576
Averted Onsite Costs (AOSC)	$25,798	$25,798	$23	$1,761	$2,919	$17,399	$1,761
Total Averted Costs (APE + AOC + AOE +AOSC)	$97,634	$98,628	$902	$3,705	$3,877	$95,749	$1,232,709
Significant Costs Not Considered? (Yes/No)	Yes	Yes	Yes	No	Yes	Yes	Yes
Double Calculated Benefit	$195,267	$197,256	$1,804	$7,410	$7,754	$191,498	$2,465,418
Cost of Enhancement (COE)	$190,000	$149,746	$100,000	$50,000	$100,000	$149,746	$2,700,000
NPV of twice benefit	$5,267	$47,510	(-)$98,196	(-)$42,590	(-)$92,246	$41,752	(-)$234,582
Potentially Cost Beneficial? (Yes/No)	Yes	Yes	No	No	No	Yes	No

Table F-20. Cost-Benefit Analyses Using 3% Discount Rate for Potential SAMAs Not Screened (Continued)

Case ID	SAMA 126	SAMA 131	SAMA 150	SAMA 168	SAMA 169	SAMA 172	SAMA 173
Potential SAMAs Evaluated by Case (See Table F-17)	126	131	150	168	169	172	173
CDF After Enhancements	7.796E-005	7.819E-005	7.972E-005	7.995E-005	7.088E-005	6.919E-005	7.799E-005
Total Expected Person-REM/year Offsite (F_AD_{PA})	29.35	29.14	30.00	30.16	28.88	26.10	29.32
Total Expected Offsite Property Damage $/year Offsite ($F_AP_{DA}$)	$48,131	$48,107	$49,325	$49,688	$48,621	$41,279	$47,872
Averted Public Exposure (APE)	$25,228	$31,466	$5,744	$730	$39,338	$123,024	$25,976
Averted Offsite Property Damage Costs (AOC)	$23,596	$23,956	$5,641	$172	$16,219	$126,641	$27,486
Averted Immediate Occupational Exposure Costs (W_{IO})	$291	$268	$116	$93	$994	$1,161	$288
Averted Long-Term Occupational Exposure Costs (W_{LTO})	$1,523	$1,404	$608	$489	$5,203	$6,081	$1,508
Total Averted Occupational Exposure Costs (AOE)	$1,814	$1,672	$725	$582	$6,197	$7,243	$1,796
Averted Cleanup and Decontamination Costs (U_{CD})	$57,121	$52,638	$22,819	$18,336	$195,110	$228,048	$56,536
Averted Replacement Power Costs (U_{RP})	$27,756	$25,577	$11,088	$8,910	$94,806	$110,810	$27,471
Averted Onsite Costs (AOSC)	$84,877	$78,216	$33,906	$27,246	$289,916	$338,858	$84,008
Total Averted Costs (APE + AOC + AOE +AOSC)	$135,515	$135,310	$46,016	$28,730	$351,669	$595,766	$139,266
Significant Costs Not Considered? (Yes/No)	Yes	Yes	Yes	Yes	No	No	No
Double Calculated Benefit	$271,030	$270,620	$92,033	$57,459	$703,337	$1,191,532	$278,532
Cost of Enhancement (COE)	$2,700,000	$700,000	$100,000	$100,000	$284,000	$249,676	$150,000
NPV of twice benefit	(-)$2,428,970	(-)$429,380	(-)$7,967	(-)$42,541	$419,337	$941,856	$128,532
Potentially Cost Beneficial? (Yes/No)	No	No	No	No	Yes	Yes	Yes

Table F-20. Cost-Benefit Analyses Using 3% Discount Rate for Potential SAMAs Not Screened (Continued)

Case ID	SAMA 174	SAMA 175	SAMA 176	SAMA 177	SAMA 178	SAMA 179	SAMA 180
Potential SAMAs Evaluated by Case (See Table F-17)	174	175	176	177	178	179	180
CDF After Enhancements	7.826E-005	7.769E-005	7.386E-005	7.304E-005	7.931E-005	7.828E-005	7.886E-005
Total Expected Person-REM/year Offsite (F_AD_{PA})	29.43	29.31	28.16	27.56	29.44	29.40	29.38
Total Expected Offsite Property Damage $/year Offsite ($F_AP_{DA}$)	$48,083	$47,852	$47,790	$46,736	$48,572	$48,030	$48,262
Averted Public Exposure (APE)	$22,900	$26,362	$60,968	$79,036	$22,496	$23,566	$24,136
Averted Offsite Property Damage Costs (AOC)	$24,306	$27,785	$28,718	$44,567	$16,965	$25,106	$21,627
Averted Immediate Occupational Exposure Costs (W_{IO})	$261	$318	$698	$779	$157	$259	$205
Averted Long-Term Occupational Exposure Costs (W_{LTO})	$1,367	$1,664	$3,654	$4,080	$822	$1,357	$1,071
Total Averted Occupational Exposure Costs (AOE)	$1,628	$1,981	$4,352	$4,860	$979	$1,616	$1,276
Averted Cleanup and Decontamination Costs (U_{CD})	$51,274	$62,383	$137,030	$153,012	$30,810	$50,884	$40,165
Averted Replacement Power Costs (U_{RP})	$24,914	$30,313	$66,584	$74,350	$14,971	$24,725	$19,516
Averted Onsite Costs (AOSC)	$76,189	$92,696	$203,614	$227,361	$45,780	$75,609	$59,681
Total Averted Costs (APE + AOC + AOE +AOSC)	$125,023	$148,825	$297,652	$355,824	$86,221	$125,898	$106,720
Significant Costs Not Considered? (Yes/No)	No	No	No	No	No	Yes	No
Double Calculated Benefit	$250,047	$297,649	$595,303	$711,648	$172,441	$251,795	$213,439
Cost of Enhancement (COE)	$150,000	$150,000	$269,000	$162,000	$149,746	$200,000	$150,000
NPV of twice benefit	$100,047	$147,649	$326,303	$549,648	$22,695	$51,795	$63,439
Potentially Cost Beneficial? (Yes/No)	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table F-20. Cost-Benefit Analyses Using 3% Discount Rate for Potential SAMAs Not Screened (Continued)

Case ID	SAMA 181	SAMA 182	SAMA 183	SAMA 188	SAMA 189
Potential SAMAs Evaluated by Case (See Table F-17)	181	182	183	188	189
CDF After Enhancements	7.873E-005	7.974E-005	8.070E-005	7.863E-005	8.055E-005
Total Expected Person-REM/year Offsite (F_AD_{PA})	28.80	29.75	30.06	29.53	30.03
Total Expected Offsite Property Damage $/year Offsite ($F_AP_{DA}$)	$47,313	$49,044	$49,472	$49,085	$49,372
Averted Public Exposure (APE)	$41,836	$13,121	$3,905	$19,626	$4,709
Averted Offsite Property Damage Costs (AOC)	$35,897	$9,855	$3,418	$9,242	$4,932
Averted Immediate Occupational Exposure Costs (W_{IO})	$214	$114	$19	$224	$34
Averted Long-Term Occupational Exposure Costs (W_{LTO})	$1,123	$598	$99	$1,175	$177
Total Averted Occupational Exposure Costs (AOE)	$1,338	$712	$118	$1,399	$211
Averted Cleanup and Decontamination Costs (U_{CD})	$42,114	$22,429	$3,719	$44,063	$6,642
Averted Replacement Power Costs (U_{RP})	$20,463	$10,898	$1,807	$21,410	$3,227
Averted Onsite Costs (AOSC)	$62,577	$33,327	$5,525	$65,473	$9,869
Total Averted Costs (APE + AOC + AOE +AOSC)	$141,647	$57,016	$12,966	$95,741	$19,722
Significant Costs Not Considered? (Yes/No)	No	Yes	Yes	No	Yes
Double Calculated Benefit	$283,294	$114,032	$25,932	$191,482	$39,444
Cost of Enhancement (COE)	$100,000	$100,000	$100,000	$269,000	$100,000
NPV of twice benefit	$183,294	$14,032	(-)$74,068	(-)$77,518	(-)$60,556
Potentially Cost Beneficial? (Yes/No)	Yes	Yes	No	No	No

Table F-21. Cost-Benefit Analyses Using 26-Year Evaluation Period for Potential SAMAs Not Screened

	Base Case	**SAMA 1**	**SAMA 19**	**SAMA 21**	**SAMA 26**	**SAMA 31**	**SAMA 32**
Potential SAMAs Evaluated by Case (See Table F-17)		1,3,5,6,74	19,20	21	26	31	32
CDF After Enhancements		8.088E-005	8.252E-005	8.076E-005	4.797E-005	8.088E-005	7.961E-005
Total Expected Person-REM/year Offsite (F_AD_{PA})	30.19	30.18	29.92	30.13	22.17	30.19	30.09
Total Expected Offsite Property Damage $/year Offsite ($F_AP_{DA}$)	$49,700	$49,684	$48,759	$49,614	$39,377	$49,700	$49,506
Averted Public Exposure (APE)	$722,813	$214	$6,423	$1,323	$191,925	$0	$2,215
Averted Offsite Property Damage Costs (AOC)	$594,962	$184	$11,263	$1,026	$123,568	$0	$2,317
Averted Immediate Occupational Exposure Costs (W_{IO})	$6,391	$1	(-)$129	$10	$2,601	$1	$101
Averted Long-Term Occupational Exposure Costs (W_{LTO})	$27,856	$4	(-)$561	$45	$11,337	$4	$441
Total Averted Occupational Exposure Costs (AOE)	$34,247	$5	(-)$690	$55	$13,938	$5	$542
Averted Cleanup and Decontamination Costs (U_{CD})	$1,044,602	$139	(-)$21,039	$1,689	$425,130	$139	$16,540
Averted Replacement Power Costs (U_{RP})	$596,816	$80	(-)$12,020	$965	$242,891	$80	$9,450
Averted Onsite Costs (AOSC)	$1,641,418	$219	(-)$33,060	$2,654	$668,021	$219	$25,990
Total Averted Costs (APE + AOC + AOE +AOSC)	$2,878,994	$621	$16,063	$5,059	$997,452	$224	$31,064
Significant Costs Not Considered? (Yes/No)		Yes	Yes	Yes	Yes	Yes	Yes
Double Calculated Benefit	$5,757,988	$1,241	-$32,126	$10,118	$1,994,905	$447	$62,129
Cost of Enhancement (COE)	$0	$50,000	$50,000	$50,000	$2,000,000	$50,000	$100,000
NPV of twice benefit		(-)$48,759	(-)$82,126	(-)$39,882	(-)$5,095	(-)$49,553	(-)$37,871
Potentially Cost Beneficial? (Yes/No)		No	No	No	No	No	No

Table F-21. Cost-Benefit Analyses Using 26-Year Evaluation Period for Potential SAMAs Not Screened (Continued)

Case ID	SAMA 46	SAMA 50	SAMA 55	SAMA 56	SAMA 58	SAMA 59	SAMA 66
Potential SAMAs Evaluated by Case (See Table F-17)	46	50, 162, 163	55	56	58	59	66
CDF After Enhancements	6.649E-005	8.059E-005	5.414E-005	5.775E-005	5.414E-005	6.091E-005	7.544E-005
Total Expected Person-REM/year Offsite (F_AD_{PA})	25.65	30.10	24.38	26.01	24.38	26.05	27.61
Total Expected Offsite Property Damage $/year Offsite ($F_AP_{DA}$)	$43,283	$49,622	$44,904	$47,526	$44,904	$43,618	$45,591
Averted Public Exposure (APE)	$108,704	$2,033	$138,966	$100,004	$138,966	$98,928	$61,589
Averted Offsite Property Damage Costs (AOC)	$76,815	$925	$57,414	$26,025	$57,414	$72,800	$49,180
Averted Immediate Occupational Exposure Costs (W_{IO})	$1,138	$24	$2,114	$1,828	$2,114	$1,579	$431
Averted Long-Term Occupational Exposure Costs (W_{LTO})	$4,959	$104	$9,212	$7,969	$9,212	$6,881	$1,877
Total Averted Occupational Exposure Costs (AOE)	$6,097	$128	$11,326	$9,797	$11,326	$8,459	$2,308
Averted Cleanup and Decontamination Costs (U_{CD})	$185,968	$3,884	$345,453	$298,834	$345,453	$258,027	$70,390
Averted Replacement Power Costs (U_{RP})	$106,250	$2,219	$197,369	$170,734	$197,369	$147,419	$40,216
Averted Onsite Costs (AOSC)	$292,218	$6,103	$542,822	$469,568	$542,822	$405,446	$110,606
Total Averted Costs (APE + AOC + AOE +AOSC)	$483,834	$9,189	$750,527	$605,394	$750,527	$585,634	$223,683
Significant Costs Not Considered? (Yes/No)	Yes	No	Yes	Yes	Yes	Yes	Yes
Double Calculated Benefit	$967,668	$18,378	$1,501,053	$1,210,788	$1,501,053	$1,171,267	$447,366
Cost of Enhancement (COE)	$2,700,000	$50,000	$2,000,000	$1,500,000	$1,423,000	$1,215,000	$50,000
NPV of twice benefit	(-)$1,732,332	(-)$31,622	(-)$498,947	(-)$289,212	$78,053	(-)$43,733	$397,366
Potentially Cost Beneficial? (Yes/No)	No	No	No	No	Yes	No	Yes

Table F-21. Cost-Benefit Analyses Using 26-Year Evaluation Period for Potential SAMAs Not Screened (Continued)

Case ID	SAMA 71	SAMA 76	SAMA 80	SAMA 81	SAMA 82	SAMA 86	SAMA 87
Potential SAMAs Evaluated by Case (See Table F-17)	71	76, 184	80	81, 160, 166, 167, 170, 171	82, 83, 170, 171	86	87
CDF After Enhancements	6.513E-005	8.082E-005	7.058E-005	7.720E-005	7.375E-005	8.071E-005	8.032E-005
Total Expected Person-REM/year Offsite (F_AD_{PA})	24.74	30.16	28.37	28.65	27.35	30.12	30.07
Total Expected Offsite Property Damage $/year Offsite ($F_AP_{DA}$)	$38,536	$49,654	$46,303	$47,415	$45,966	$49,611	$49,645
Averted Public Exposure (APE)	$130,475	$555	$43,515	$36,892	$67,830	$1,547	$2,911
Averted Offsite Property Damage Costs (AOC)	$133,637	$549	$40,663	$27,351	$44,694	$1,063	$658
Averted Immediate Occupational Exposure Costs (W_{IO})	$1,245	$6	$832	$292	$564	$14	$45
Averted Long-Term Occupational Exposure Costs (W_{LTO})	$5,427	$24	$3,626	$1,271	$2,459	$62	$197
Total Averted Occupational Exposure Costs (AOE)	$6,673	$30	$4,458	$1,563	$3,023	$77	$242
Averted Cleanup and Decontamination Costs (U_{CD})	$203,531	$914	$135,992	$47,662	$92,214	$2,335	$7,371
Averted Replacement Power Costs (U_{RP})	$116,284	$522	$77,697	$27,231	$52,685	$1,334	$4,211
Averted Onsite Costs (AOSC)	$319,814	$1,436	$213,688	$74,893	$144,899	$3,669	$11,582
Total Averted Costs (APE + AOC + AOE +AOSC)	$590,599	$2,570	$302,325	$140,698	$260,447	$6,355	$15,393
Significant Costs Not Considered? (Yes/No)	Yes	Yes	No	No	No	No	Yes
Double Calculated Benefit	$1,181,199	$5,141	$604,650	$281,396	$520,893	$12,710	$30,787
Cost of Enhancement (COE)	$1,700,000	$100,000	$250,000	$399,746	$399,746	$50,000	$100,000
NPV of twice benefit	(-)$518,801	(-)$94,859	$354,650	(-)$118,350	$121,147	(-)$37,290	(-)$69,213
Potentially Cost Beneficial? (Yes/No)	No	No	Yes	No	Yes	No	No

Table F-21. Cost-Benefit Analyses Using 26-Year Evaluation Period for Potential SAMAs Not Screened (Continued)

Case ID	SAMA 111	SAMA 112	SAMA 114	SAMA 118	SAMA 122	SAMA 124	SAMA 125
Potential SAMAs Evaluated by Case (See Table F-17)	111, 113	112	114	118	122	124	125, 129
CDF After Enhancements	8.000E-005	8.000E-005	8.089E-005	8.083E-005	8.079E-005	8.079E-005	8.083E-005
Total Expected Person-REM/year Offsite (F_AD_{PA})	29.04	29.03	30.17	30.15	30.17	28.93	10.75
Total Expected Offsite Property Damage $/year Offsite ($F_AP_{DA}$)	$47,252	$47,215	$49,666	$49,645	$49,683	$47,019	$6,728
Averted Public Exposure (APE)	$27,445	$27,790	$301	$859	$518	$29,984	$465,349
Averted Offsite Property Damage Costs (AOC)	$29,295	$29,742	$399	$659	$195	$32,084	$514,418
Averted Immediate Occupational Exposure Costs (W_{IO})	$70	$70	$0	$5	$8	$47	$5
Averted Long-Term Occupational Exposure Costs (W_{LTO})	$307	$307	$0	$21	$35	$207	$21
Total Averted Occupational Exposure Costs (AOE)	$377	$377	$0	$26	$43	$254	$26
Averted Cleanup and Decontamination Costs (U_{CD})	$11,503	$11,503	$10	$785	$1,302	$7,758	$785
Averted Replacement Power Costs (U_{RP})	$6,572	$6,572	$6	$449	$744	$4,433	$449
Averted Onsite Costs (AOSC)	$18,076	$18,076	$16	$1,234	$2,045	$12,191	$1,234
Total Averted Costs (APE + AOC + AOE +AOSC)	$75,193	$75,985	$716	$2,777	$2,801	$74,514	$981,026
Significant Costs Not Considered? (Yes/No)	Yes	Yes	Yes	No	Yes	Yes	Yes
Double Calculated Benefit	$150,386	$151,970	$1,432	$5,554	$5,602	$149,027	$1,962,052
Cost of Enhancement (COE)	$190,000	$149,746	$100,000	$50,000	$100,000	$149,746	$2,700,000
NPV of twice benefit	(-)$39,614	$2,224	(-)$98,568	(-)$44,446	(-)$94,398	(-)$719	(-)$737,948
Potentially Cost Beneficial? (Yes/No)	No	Yes	No	No	No	No	No

Table F-21. Cost-Benefit Analyses Using 26-Year Evaluation Period for Potential SAMAs Not Screened (Continued)

Case ID	SAMA 126	SAMA 131	SAMA 150	SAMA 168	SAMA 169	SAMA 172	SAMA 173
Potential SAMAs Evaluated by Case (See Table F-17)	126	131	150	168	169	172	173
CDF After Enhancements	7.796E-005	7.819E-005	7.972E-005	7.995E-005	7.088E-005	6.919E-005	7.799E-005
Total Expected Person-REM/year Offsite (F_AD_{PA})	29.35	29.14	30.00	30.16	28.88	26.10	29.32
Total Expected Offsite Property Damage $/year Offsite ($F_AP_{DA}$)	$48,131	$48,107	$49,325	$49,688	$48,621	$41,279	$47,872
Averted Public Exposure (APE)	$20,081	$25,046	$4,572	$581	$31,312	$97,924	$20,676
Averted Offsite Property Damage Costs (AOC)	$18,782	$19,068	$4,490	$137	$12,910	$100,802	$21,878
Averted Immediate Occupational Exposure Costs (W_{IO})	$232	$213	$93	$74	$791	$924	$229
Averted Long-Term Occupational Exposure Costs (W_{LTO})	$1,009	$930	$403	$324	$3,447	$4,029	$999
Total Averted Occupational Exposure Costs (AOE)	$1,241	$1,143	$496	$398	$4,238	$4,954	$1,228
Averted Cleanup and Decontamination Costs (U_{CD})	$37,847	$34,877	$15,119	$12,149	$129,277	$151,101	$37,460
Averted Replacement Power Costs (U_{RP})	$21,624	$19,927	$8,638	$6,941	$73,860	$86,329	$21,402
Averted Onsite Costs (AOSC)	$59,471	$54,804	$23,757	$19,090	$203,137	$237,430	$58,862
Total Averted Costs (APE + AOC + AOE +AOSC)	$99,575	$100,062	$33,315	$20,206	$251,596	$441,109	$102,645
Significant Costs Not Considered? (Yes/No)	Yes	Yes	Yes	Yes	No	No	No
Double Calculated Benefit	$199,149	$200,124	$66,631	$40,413	$503,192	$882,219	$205,289
Cost of Enhancement (COE)	$2,700,000	$700,000	$100,000	$100,000	$284,000	$249,676	$150,000
NPV of twice benefit	(-)$2,500,851	(-)$499,876	(-)$33,369	(-)$59,587	$219,192	$632,543	$55,289
Potentially Cost Beneficial? (Yes/No)	No	No	No	No	Yes	Yes	Yes

Table F-21. Cost-Benefit Analyses Using 26-Year Evaluation Period for Potential SAMAs Not Screened (Continued)

Case ID	SAMA 174	SAMA 175	SAMA 176	SAMA 177	SAMA 178	SAMA 179	SAMA 180
Potential SAMAs Evaluated by Case (See Table F-17)	174	175	176	177	178	179	180
CDF After Enhancements	7.826E-005	7.769E-005	7.386E-005	7.304E-005	7.931E-005	7.828E-005	7.886E-005
Total Expected Person-REM/year Offsite (F_AD_{PA})	29.43	29.31	28.16	27.56	29.44	29.40	29.38
Total Expected Offsite Property Damage $/year Offsite ($F_AP_{DA}$)	$48,083	$47,852	$47,790	$46,736	$48,572	$48,030	$48,262
Averted Public Exposure (APE)	$18,228	$20,983	$48,528	$62,910	$17,906	$18,758	$19,212
Averted Offsite Property Damage Costs (AOC)	$19,347	$22,116	$22,859	$35,474	$13,504	$19,984	$17,214
Averted Immediate Occupational Exposure Costs (W_{IO})	$208	$253	$555	$620	$125	$206	$163
Averted Long-Term Occupational Exposure Costs (W_{LTO})	$906	$1,102	$2,421	$2,704	$544	$899	$710
Total Averted Occupational Exposure Costs (AOE)	$1,114	$1,355	$2,977	$3,324	$669	$1,105	$872
Averted Cleanup and Decontamination Costs (U_{CD})	$33,973	$41,334	$90,794	$101,383	$20,414	$33,715	$26,613
Averted Replacement Power Costs (U_{RP})	$19,410	$23,616	$51,873	$57,923	$11,663	$19,263	$15,205
Averted Onsite Costs (AOSC)	$53,383	$64,950	$142,677	$159,307	$32,077	$52,978	$41,817
Total Averted Costs (APE + AOC + AOE +AOSC)	$92,072	$109,404	$217,031	$261,015	$64,157	$92,824	$79,115
Significant Costs Not Considered? (Yes/No)	No	No	No	No	No	Yes	No
Double Calculated Benefit	$184,144	$218,809	$434,062	$522,029	$128,314	$185,649	$158,231
Cost of Enhancement (COE)	$150,000	$150,000	$269,000	$162,000	$149,746	$200,000	$150,000
NPV of twice benefit	$34,144	$68,809	$165,062	$360,029	(-)$21,432	(-)$14,351	$8,231
Potentially Cost Beneficial? (Yes/No)	Yes	Yes	Yes	Yes	No	No	Yes

Table F-21. Cost-Benefit Analyses Using 26-Year Evaluation Period for Potential SAMAs Not Screened (Continued)

Case ID	SAMA 181	SAMA 182	SAMA 183	SAMA 188	SAMA 189
Potential SAMAs Evaluated by Case (See Table F-17)	181	182	183	188	189
CDF After Enhancements	7.873E-005	7.974E-005	8.070E-005	7.863E-005	8.055E-005
Total Expected Person-REM/year Offsite (F_AD_{PA})	28.80	29.75	30.06	29.53	30.03
Total Expected Offsite Property Damage $/year Offsite ($F_AP_{DA}$)	$47,313	$49,044	$49,472	$49,085	$49,372
Averted Public Exposure (APE)	$33,300	$10,444	$3,108	$15,622	$3,749
Averted Offsite Property Damage Costs (AOC)	$28,573	$7,844	$2,720	$7,357	$3,926
Averted Immediate Occupational Exposure Costs (W_{IO})	$171	$91	$15	$179	$27
Averted Long-Term Occupational Exposure Costs (W_{LTO})	$744	$396	$66	$779	$117
Total Averted Occupational Exposure Costs (AOE)	$915	$487	$81	$957	$144
Averted Cleanup and Decontamination Costs (U_{CD})	$27,904	$14,861	$2,464	$29,195	$4,401
Averted Replacement Power Costs (U_{RP})	$15,942	$8,491	$1,408	$16,680	$2,514
Averted Onsite Costs (AOSC)	$43,846	$23,352	$3,872	$45,875	$6,915
Total Averted Costs (APE + AOC + AOE +AOSC)	$106,633	$42,127	$9,781	$69,811	$14,734
Significant Costs Not Considered? (Yes/No)	No	Yes	Yes	No	Yes
Double Calculated Benefit	$213,267	$84,255	$19,561	$139,622	$29,468
Cost of Enhancement (COE)	$100,000	$100,000	$100,000	$269,000	$100,000
NPV of twice benefit	$113,267	(-)$15,745	(-)$80,439	(-)$129,378	(-)$70,532
Potentially Cost Beneficial? (Yes/No)	Yes	No	No	No	No

Table F-22. KPS Fire Zone Contribution to CDF and LERF

Rank	Event ID	Description	Initiating Event Frequency	CDF	LERF
1	IE-FIR14	FIRE IN DIESEL GENERATOR ROOM A	2.31E-04	4.16E-05	1.47E-08
2	IE-FIR5	FIRE IN RELAY ROOM	3.00E-04	3.26E-05	1.15E-08
3	IE-FIR8	FIRE NEAR BUSES 51 AND 52	1.33E-04	2.40E-05	8.41E-09
4	IE-FIR4	FIRE IN DIESEL GENERATOR ROOM B	2.31E-04	1.77E-05	6.32E-09
5	IE-FIR6	AUXILIARY FEEDWATERPUMP A OIL FIRE	6.54E-05	1.18E-05	4.11E-09
6	IE-FIR10	FIRE IN BUS 5 SWITCHES IN ECCA	6.81E-05	5.49E-06	1.93E-09
7	IE-FIR11	FIRE IN BUS 6 SWITCHES IN ECCA	6.81E-05	5.23E-06	1.85E-09
8	IE-FIR7	AUXILIARY FEEDWATERPUMP B OIL FIRE	3.27E-06	3.52E-07	8.11E-11
9	IE-FIR2	FIRE IN CABLE SPREADING ROOM	2.21E-06	2.34E-07	4.94E-11
10	IE-FIR9	FIRE DUE TO GAS BOTTLES ON FAN FLOOR	1.28E-03	1.13E-08	0.00E+00
11	IE-FIR13	FIRE IN PRZR PORV SWITCHES IN MCCC	4.68E-05	1.12E-08	0.00E+00
12	IE-FIR12	FIRE IN SG PORV SWITCHES IN MCCA	5.92E-06	1.04E-08	1.25E-12
13	IE-FIR3	FIRE IN BUS 1 AND 2 ROOM	1.18E-04	9.66E-10	0.00E+00
14	IE-FIR1	FIRE NEAR MCC-62J	5.17E-05	0.00E+00	0.00E+00
		Total for All Zones		1.39E-04	4.90E-08

Figure F-1. KPS Containment Event Tree

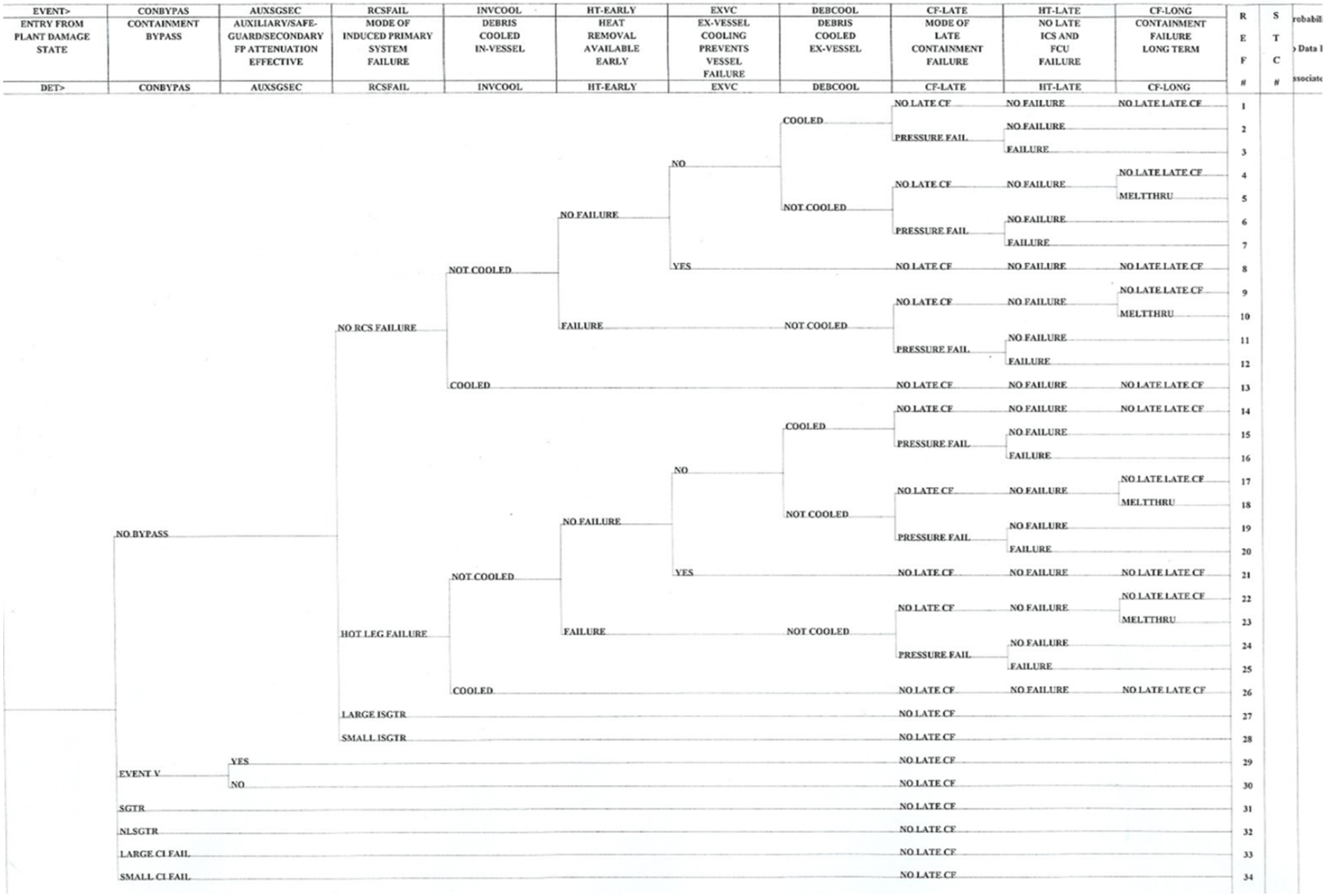

Figure F-2. KPS Release Category Diagram

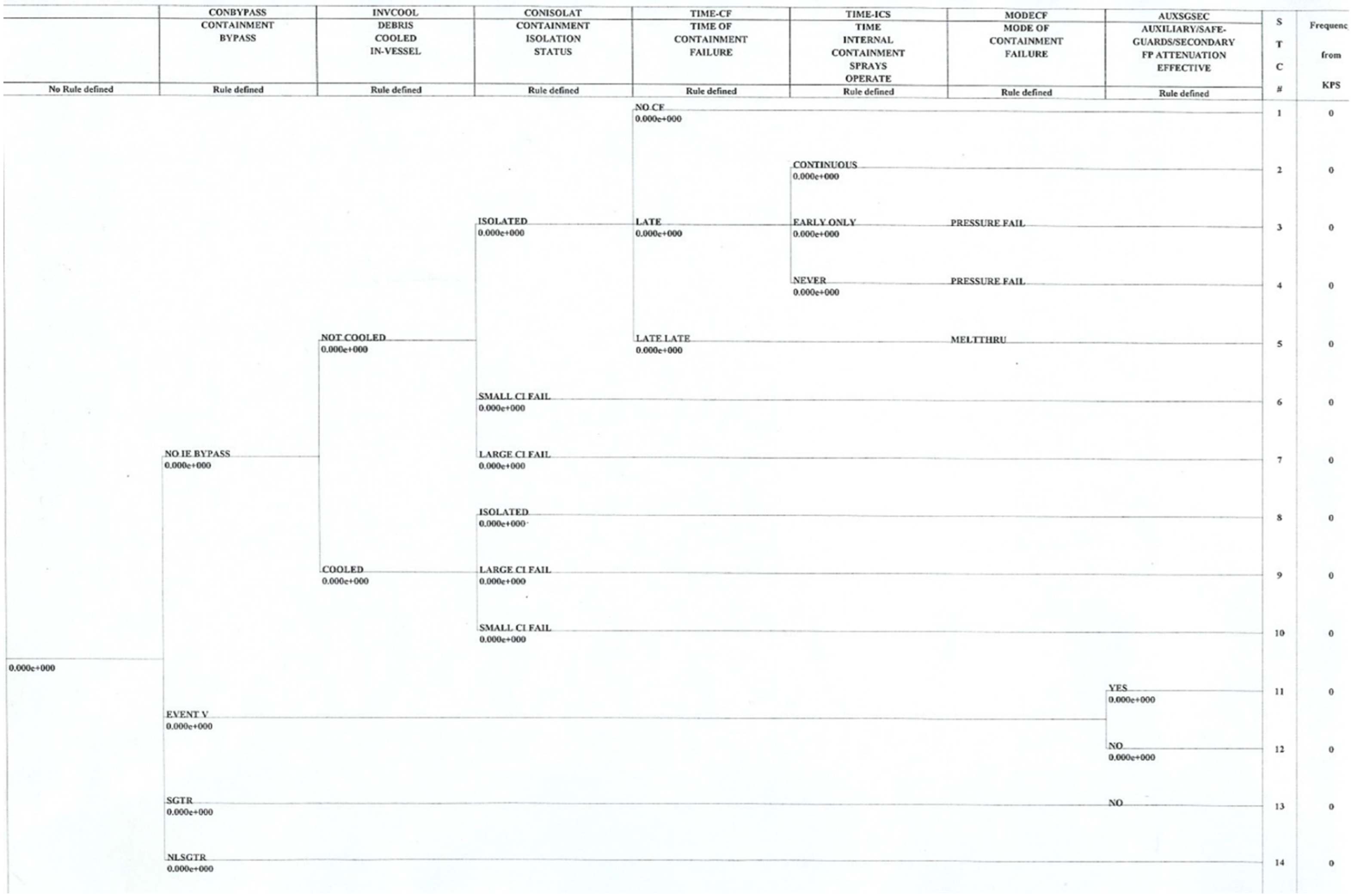

Figure F-3. Year 2033 Population Distribution Within 10-Mile Radius Surrounding KPS

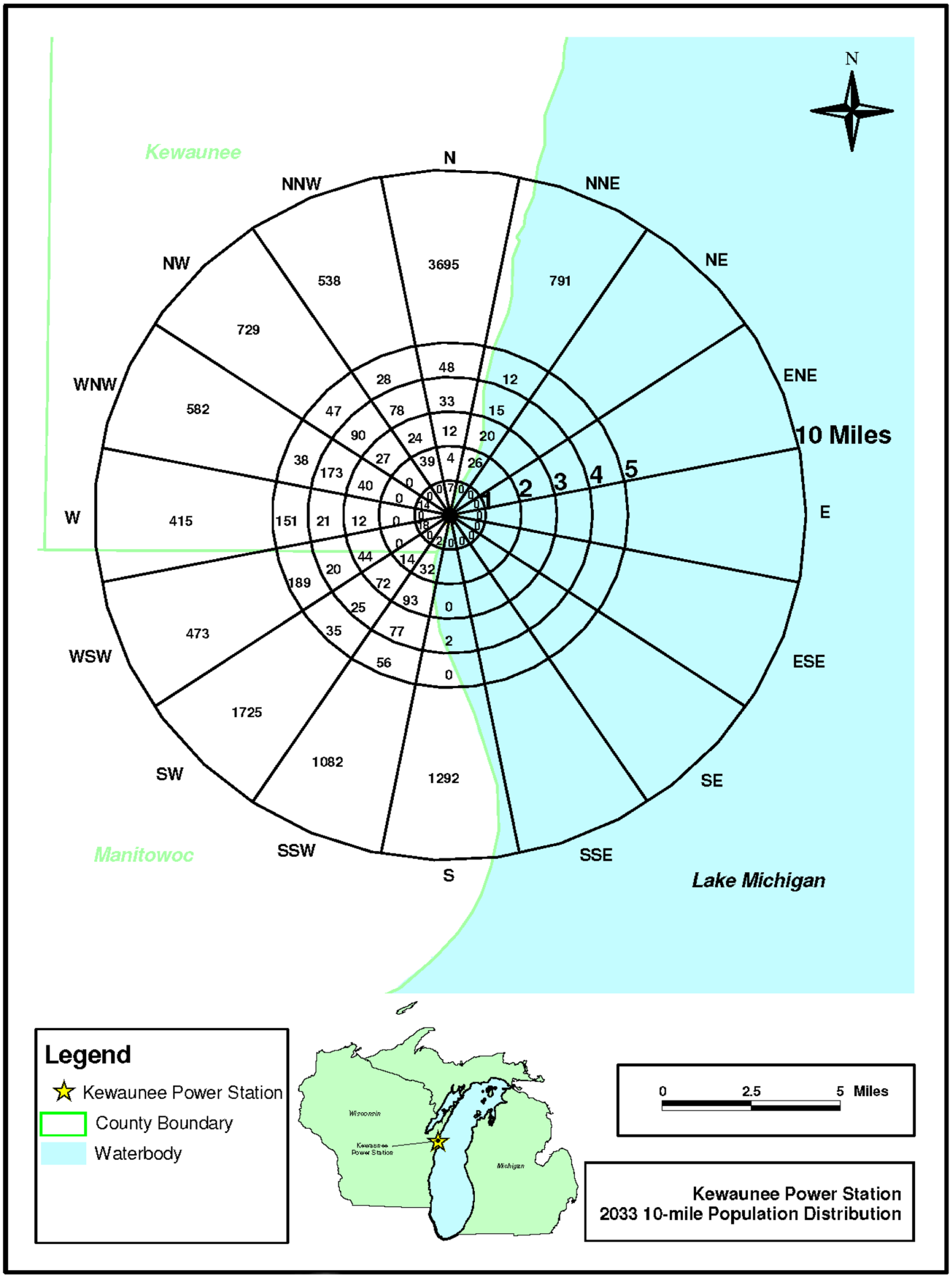

Figure F-4. Year 2033 Population Distribution within 50-Mile Radius Surrounding KPS