ATTACHMENT C
THERMOPHILIC ORGANISM CORRESPONDENCE

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George T. Jones
Vice President
Special Projects

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gtjones@pplweb.com

ppl

March 24, 2005

Mr. Frederick Marrocco
Director of Bureau of Water Supply and
Wastewater Management
Pennsylvania Department of Environmental Protection
400 Market Street
PO Box 8467, 11th Floor
Rachel Carson State Office Building
Harrisburg, PA 17105-8467

PPL SUSQUEHANNA, LLC
REQUEST FOR INFORMATION ON THERMOPHILIC MICROORGANISMS
LICREN ER 101013
PLR-054

Dear Mr. Marrocco:

PPL Susquehanna, LLC (PPL Susquehanna) is preparing an application to the U. S. Nuclear Regulatory Commission (NRC) to renew the operating licenses for Susquehanna Steam Electric Station (SSES) Units 1 and 2. Current operating licenses for the two-unit plant expire in 2022 and 2024. Renewing the licenses would provide for an additional 20 years of operation beyond the original license expiration dates. NRC requires license applicants to provide "…an assessment of the impact of the proposed action {license renewal} on public health from thermophilic organisms in the affected water" (10 CFR 51.53). Organisms of concern include the enteric pathogens Salmonella and Shigella, the *Pseudomonas aeruginosa* bacterium, thermophilic Actinomycetes ("fungi"), the many species of Legionella bacteria, and pathogenic strains of the free-living Naegleria amoeba.

As part of the license renewal process, PPL Susquehanna is consulting with your office to determine whether there is any concern about the potential occurrence of these organisms in the Susquehanna River at the SSES location. By contacting you early in the application process, we hope to identify any issues that we need to address or any information that we should provide to your office to expedite the NRC consultation.

PPL Susquehanna has operated SSES since 1982. The facility is located on the west bank of the Susquehanna River in Salem Township, Luzerne County, Pennsylvania, approximately 5 miles northeast of Berwick, Pennsylvania (see attached map). SSES uses two natural draft cooling towers to transfer waste heat from the condensers to the atmosphere. Thermal modeling conducted for the initial operation of SSES indicated that outside of a small (less than one acre) mixing zone, the station's discharge would have a modest (0.5 to 2.0˚F) effect on downstream river temperature in summer. The SSES NPDES permit does not require monitoring of blowdown or discharge temperatures, but temperatures measured at the Bell Bend monitoring station immediately downstream of the station's discharge to the Susquehanna River are typically indistinguishable from those measured upstream of the plant's intake.

Maximum daily mean temperatures at a monitoring station upstream of the plant's intake were 25.3˚C (77.5˚F) in 2000 (September 4), 29.1˚C (84.4˚F) in 2001 (August 8), and 28.9˚C (84.0˚F) in 2002 (August 4). The highest temperature measured over the same period at the Bell Bend monitoring station, downstream of SSES, was 26˚C (78.8˚F). Water temperatures between 77˚F and 85˚F are well below the optimal temperature range (122˚F-140˚F) for growth and reproduction of thermophilic microorganisms.

Fecal coliform bacteria are regarded as indicators of other pathogenic microorganisms, and are the organisms normally monitored by state health agencies. The NPDES permit for SSES requires monitoring of fecal coliforms in sewage treatment plant effluent. Samples are collected once per month for fecal coliform analysis and other parameters. The SSES NPDES permit calls for "effective disinfection" to control disease-producing organisms during the swimming season (May 1 through September 30) and imposes a limit of 200 fecal coliform cells (geometric average value) per 100 ml sample. The NPDES permit also stipulates that no more than 10 percent of samples tested may contain 1,000 cells.

Given the thermal characteristics of the Susquehanna River at the SSES thermal discharge and disinfection of the station's sewage treatment plant effluent, PPL does not expect station operations to stimulate growth or reproduction of thermophilic microorganisms. Under certain circumstances, these organisms might be present in limited numbers in the station's discharge, but would not be expected in concentrations high enough to pose a threat to recreational users of the Susquehanna River.

-3- PLR-054

We would appreciate your relating any concerns you may have about these organisms and potential public health effects over the license renewal term by April 22, 2005, or your confirming PPL Susquehanna's conclusion that operation of SSES over the license renewal term would not stimulate growth of thermophilic pathogens. This will enable us to meet our application preparation schedule. PPL Susquehanna will include a copy of this letter and your response in the Environmental Report that will be submitted to the NRC as part of the SSES license renewal application. Please do not hesitate to call Jerry Fields (610) 774-7889 if you have any questions or require any additional information.

Sincerely,

George T. Jones

Attachment – Figure 2.1-1, 50-Mile Vicinity Map

Response Requested: YES __X__ by April 22, 2005

Cc:
Ms. Kate Crowley
Water Management Program Manager
Pennsylvania Department of Environmental Protection
Northeast Regional Office
2 Public Square
Wilkes-Barre, PA 18711-0790

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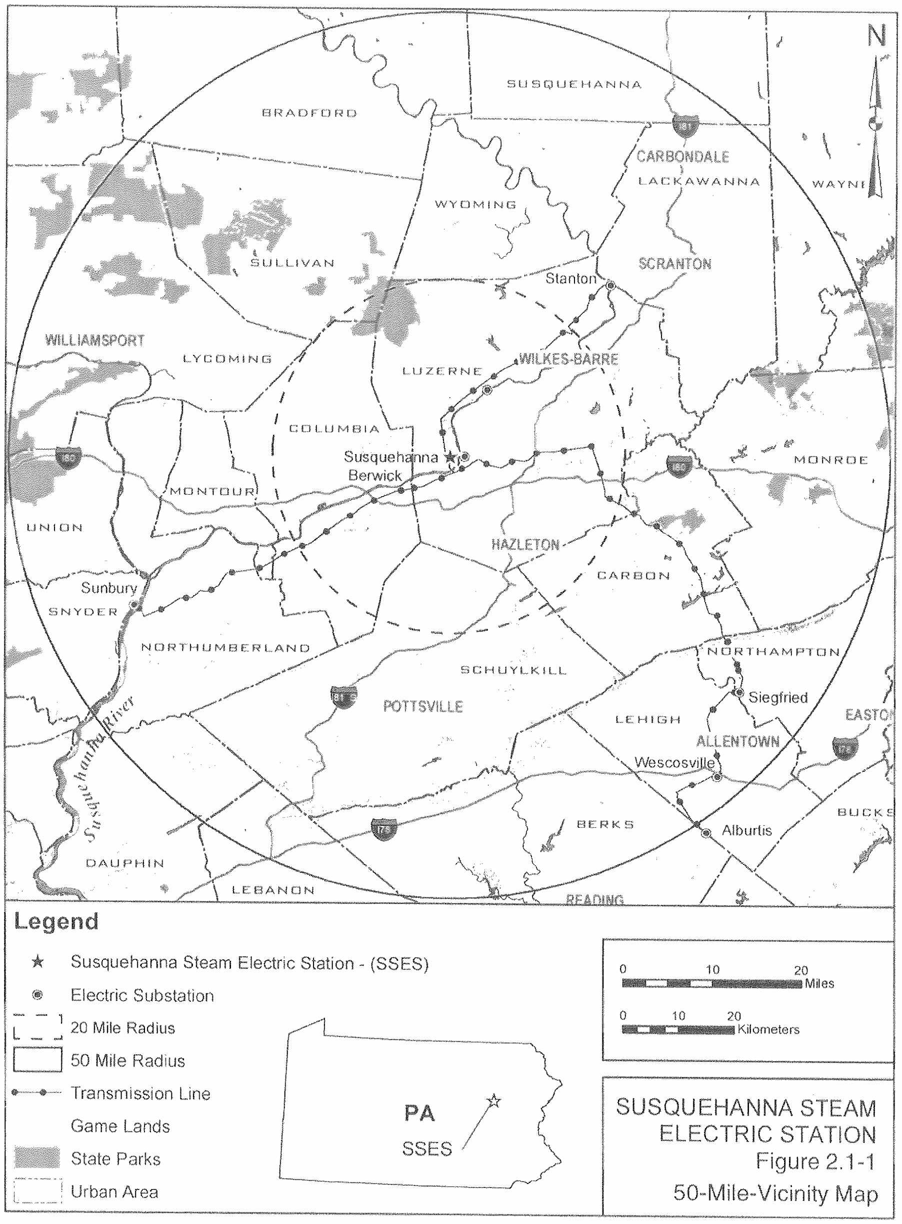
Susquehanna Steam Electric Station Units 1 & 2
License Renewal Application



SUSQUEHANNA STEAM ELECTRIC STATION
Figure 2.1-1
50-Mile-Vicinity Map

Pennsylvania Department of Environmental Protection

Rachel Carson State Office Building
P. O. Box 8457
Harrisburg, PA 17105-8457
June 2, 2005

Bureau of Water Supply and Wastewater Management 717-787-9637

George T. Jones
Vice President Special Projects
PPL-Susquehanna, LLC
2 North 9th Street
Allentown, PA 18101-1179

Dear Mr. Jones:

This letter is a follow-up to your request for microorganism data on the North Branch Susquehanna River. Currently, the Pennsylvania Department of Environmental Protection, Bureau of Water Supply and Wastewater Management, Division of Water Quality Assessment and Standards does not collect any microorganism data (i.e., Salmonella) at your site on the North Branch Susquehanna River.

If you have questions or concerns or need further assistance, please feel free to contact me at 717-787-9637.

Sincerely,

for

Richard H. Shertzer
Acting Chief
Division of Water Quality Assessment and Standards

cc: Jerry Fields

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ATTACHMENT D
STATE HISTORIC PRESERVATION OFFICER CORRESPONDENCE

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ppl

March 24, 2005

Ms. Jean Cutler, Deputy State Historic Preservation Officer
Pennsylvania Historical and Museum Commission
Bureau for Historic Preservation
Commonwealth Keystone Building, Second Floor
400 North Street
Harrisburg, PA 17120-0093

PPL SUSQUEHANNA, LLC
REQUEST FOR INFORMATION ON HISTORIC AND ARCHAEOLOGICAL RESOURCES
LICREN ER 101013
PLR-053

Dear Ms. Cutler:

PPL Susquehanna, LLC (PPL Susquehanna) is preparing an application to the U. S. Nuclear Regulatory Commission (NRC) to renew the operating licenses for Susquehanna Steam Electric Station (SSES) Units 1 and 2. Current operating licenses expire in 2022 and 2024. The renewal term would be for an additional 20 years beyond the original license expiration date. As part of the license renewal process, NRC requires license applicants to "assess whether any historic or archaeological properties will be affected by the proposed project." NRC may also request an informal consultation with your office at a later date under Section 106 of the National Historic Preservation Act of 1966, as amended (16 USC 470), and Federal Advisory Council on Historic Preservation regulations (36 CFR 800). By contacting you early in the application process, we hope to identify any issues that need to be addressed or any information your office may need to expedite the NRC consultation.

PPL Susquehanna has operated SSES and associated transmission lines since 1982. The facility is located on the west bank of the Susquehanna River in Salem Township, Luzerne County, Pennsylvania, approximately 5 miles northeast of Berwick, Pennsylvania (see attached map).

Six transmission lines connect the station to the regional grid, and are thus relevant to license renewal. They include:

- Short ties in the SSES vicinity (3) – These three lines (approximately 6.3 total miles) identified in the FES as necessary to connect SSES to the 230-kilovolt electrical system are primarily in areas controlled by SSES and not accessible to the public; however, U.S. Highway 11, Pennsylvania State Highway 239, and other paved roads in the immediate plant vicinity are crossed by the short ties.

- Stanton #2 – This single circuit 230-kilovolt line runs generally northeast from SSES for approximately 30 miles in a 100- to 400-footwide corridor.

- Wescosville – This 500-kilovolt line connects SSES with the Alburtis substation. It runs generally southeast for approximately 76 circuit miles in a corridor ranging from 100 to 350 feet wide.

- Sunbury #2 – This 500-kilovolt line shares a corridor with the pre-existing Sunbury #1 line and runs west-southwest. The corridor is about 325 feet wide and approximately 30 miles long.

In total, for the specific purpose of connecting SSES to the transmission system, PPL Susquehanna has approximately 150 miles of corridor that occupy approximately 3,341 acres. The corridors pass through land that is primarily agricultural or forest land. The areas are mostly remote, with low population densities. The longer lines cross numerous state and U.S. highways. Impact of these corridors on land usage is minimal; farmlands that have corridors passing through them generally continue to be used as farmland.

Pennsylvania counties crossed by the transmission lines include Luzerne (the location of SSES), Carbon, Columbia, Lehigh, Northampton, Northumberland, Montour, and Snyder. Using the National Register Information System (NRIS) on-line database, we have compiled a list of sites on the National Register of Historic Places within a six-mile radius of the SSES property. The Bittenbender Covered Bridge, Benjamin Evans House, Berwick Armory, Fowlersville Covered Bridge, and Jackson Mansion and Carriage House all fall within a 6-mile radius of the Station. We will provide this information to the NRC to aid in its evaluation of the license application.

Additionally, two PPL Susquehanna-funded cultural resource studies of SSES property have taken place since the construction of the SSES units.

The first study, *The Knouse Site, an Historical Site in Luzerne County, Pennsylvania (McIntyre 1979)*, was conducted in 1978 in response to an effort by PPL Susquehanna to develop land across the Susquehanna River from the SSES site. It was a study and salvage excavation of an historic Native American cemetery in an area called the Knouse site. Twenty-one burials and associated artifactual materials were removed by the Pennsylvania Historical and Museum Commission for further study.

The second study, *Archeological Investigations at the Susquehanna Steam Electric Station (CAI 1981)*, was conducted in 1980. The investigation identified prehistoric cultural resources on the floodplain below the site and within SSES boundaries. Eight sites were identified. Of the eight sites, three were considered to be significant and offered possibilities for recommendation to the National Register by the Pennsylvania State Archaeologist. One additional site was considered to be potentially significant. Of the three significant sites, only one was considered to be in danger of adverse impact. Mitigating actions were recommended and, at the time of publication, PPL Susquehanna was in the process of implementing the recommendations. The other two significant sites and the potential site required preservation only from future re-landscaping and construction activities. It was concluded that, "[n]one of these recommendations should significantly alter Pennsylvania Power and Light's plans or schedule of activities for completion of the SES project."

A field review of the four archeological sites of interest at the SSES was conducted on October 11, 2004. These sites have been monitored periodically since the initial report of 1981.

The first site is located along the access road to the Environmental Laboratory. The site has not been disturbed and is covered either by the access road or dense shrub vegetation maintained under the power lines. No future disturbance is anticipated.

The second site is located along a drainage way between agricultural fields opposite Lake Took-a-while. Although this area was flooded during Hurricane Ivan in September, 2004, there was no erosion and planted vegetative cover remains in place. The banks of the cut have been covered with grass after grading pursuant to the recommendations in the Commonwealth Associates (1981) report. There are no plans to disturb this area.

The third site is located in agricultural fields. At the time of this survey, field corn and potatoes were present (neither had been harvested). This area has been in continuous agriculture, but no disturbance below the plow line is evident.

The fourth site lies in a secondary floodplain forest near the Susquehanna River opposite Gould Island. This area has been undisturbed and is vegetated with a young forest of river birch, silver maple, and black cherry. No disturbance is evident or is planned at this site.

PPL Susquehanna does not expect SSES operation through the license renewal term (an additional 20 years) to adversely affect cultural resources in the area because PPL Susquehanna has no plans to alter current operations over the license renewal period. No expansion of existing facilities is planned, and no major structural modifications have been identified for the purpose of supporting license renewal.

Please do not hesitate to call Jerry Fields [(610) 774-7889] if you have any questions or require any additional information. After your review, we would appreciate receiving your input by April 22, 2005, detailing any concerns you may have about cultural resources in the area or confirming PPL Susquehanna's conclusion that operation of SSES over the license renewal term would have no effect on cultural resources. This will enable us to meet our application preparation schedule. PPL Susquehanna will include a copy of this letter and your response in the Environmental Report that will be submitted to the NRC as part of the SSES license renewal application.

Sincerely,

G. T. Jones

George T. Jones

Attachment – Figure 2.1-1, 50-Mile Vicinity Map

Response Requested: YES __X__ by April 22, 2005

References:

McIntyre, J. 1979. *The Knouse Site, an Historical Site in Luzerne County, Pennsylvania. 1978.* WCORPO Dayton Museum of Natural History and Pennsylvania Historical and Museum Commission. March 1979.

CAI (Commonwealth Associates, Inc.). 1981. Archeological Investigations at the Susquehanna Steam Electric Station. The Susquehanna SES Floodplain. Management Summary. R-2282B. Pennsylvania Power and Light Company. March 26.

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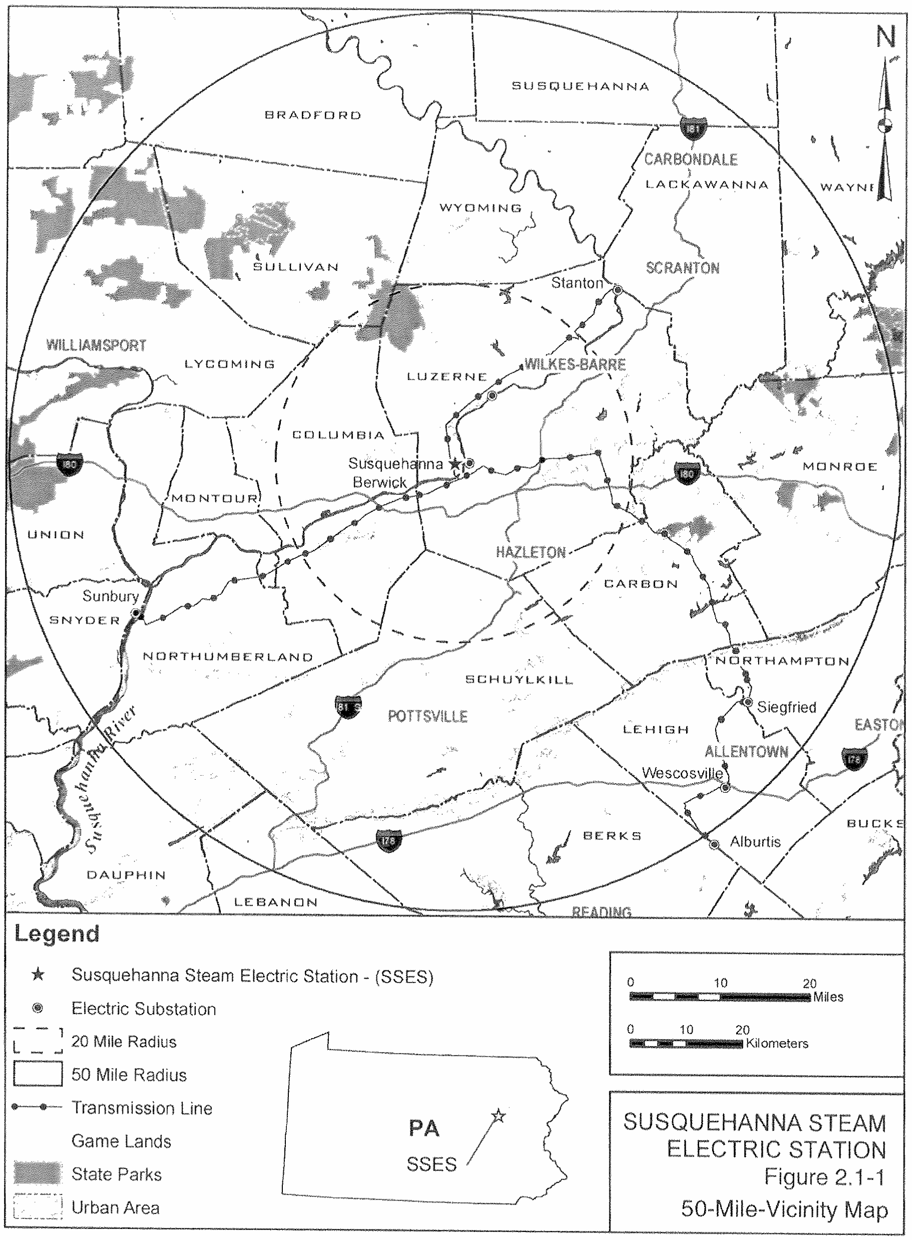
N
SUSQUEHANNA
BRADFORD
CARBONDALE
LACKAWANNA
WAYNE
WYOMING
SULLIVAN
SCRANTON
Stanton
WILLIAMSPORT
LYCOMING
LUZERNE
WILKES-BARRE
COLUMBIA
Susquehanna
Berwick
MONTOUR
MONROE
UNION
HAZLETON
CARBON
Sunbury
SNYDER
NORTHUMBERLAND
NORTHAMPTON
SCHUYLKILL
Siegfried
POTTSVILLE
LEHIGH
ALLENTOWN
Wescosville
Susquehanna River
BERKS
Alburtis
BUCKS
DAUPHIN
LEBANON
READING
Legend
Susquehanna Steam Electric Station - (SSES)
Electric Substation
20 Mile Radius
50 Mile Radius
Transmission Line
Game Lands
State Parks
Urban Area
PA
SSES
0 10 20 Miles
0 10 20 Kilometers
SUSQUEHANNA STEAM ELECTRIC STATION
Figure 2.1-1
50-Mile-Vicinity Map

Commonwealth of Pennsylvania
Pennsylvania Historical and Museum Commission
Bureau for Historic Preservation
Commonwealth Keystone Building, 2nd Floor
400 North Street
Harrisburg, PA 17120-0093
www.phmc.state.pa.us

May 20, 2005

PPL
Attn: George T. Jones, Vice President, Special Projects
Two North Ninth Street
Allentown, PA 18101-1179

TO EXPEDITE REVIEW USE
BHP REFERENCE NUMBER

RE: 05-1588-079-A
NRC: PPL Susquehanna, License Renewal,
Susquehanna Steam Electric Station Units 1 and 2,
Salem Township, Luzerne County

Dear Mr. Jones:

The Bureau for Historic Preservation (the State Historic Preservation Office) has reviewed the above named project in accordance with Section 106 of the National Historic Preservation Act of 1966, as amended in 1980 and 1992, and the regulations (36 CFR Part 800) of the Advisory Council on Historic Preservation as revised in 1999. Our comments are as follows:

The information you submitted indicates PPL Susquehanna has no plans to alter current operations over the renewal period and no expansion of existing facilities is planned. Based on this we agree that the license renewals shall have no adverse effect on significant cultural resources within the project area.

Should you become aware, from any source, that historic or archaeological properties are located at or near the project site, please notify the Bureau for Historic Preservation at (717) 783-8946.

Sincerely,

Douglas C. McLearen, Chief
Division of Archaeology & Protection

cc: NRC

ATTACHMENT E
SEVERE ACCIDENT MITIGATION ALTERNATIVES

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List of Tables

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Acronyms Used in Attachment E

ABWR	Advanced Boiling Water Reactor
ADS	Automatic Depressurization System
ARI	Alternate Rod Insertion
ATWS	Anticipated Transient Without Scram
BOC	Break Outside Containment
BWR	Boiling Water Reactor
CCF	Common Cause Failure
CDF	Core Damage Frequency
CIG	Containment Instrument Gas
COPF	Containment Overpressure Failure
CRD	Control Rod Drive
CST	Condensate Storage Tank
DCH	Direct Containment Heating
DFP	Diesel Fire Pump
DG	Diesel Generator
DW	Drywell
ECCS	Emergency Core Cooling System
EDG	Emergency Diesel Generator
EOC RPT	End Of Cycle - Recirculation Pump Trip
EOPs	Emergency Operating Procedures
EPZ	Emergency Planning Zone
ESW	Emergency Service Water
F&Os	Facts and Observations
FP	Fire Protection
FPS	Fire Protection System
FW	Feedwater
GSW	General Service Water
HCTL	Heat Capacity Temperature Limit
HEP	Human Error Probability
HP	High Pressure
HPCI	High Pressure Coolant Injection
HPI	High Pressure Injection
HPSI	High Pressure Safety Injection
HRA	Human Reliability Analysis
HVAC	Heating Ventilating Air Conditioning
IPE	Individual Plant Examination
IPEEE	Individual Plant Examination – External Events
ISI	In-Service Inspection
ISLOCA	Interfacing Systems Loss of Coolant Accident
LDWC	Loss of Drywell Cooling
LERF	Large Early Release Frequency

Acronyms Used in Attachment E

LOCA	Loss of Coolant Accident
LOAI	Loss of Instrument Air
LOOP	Loss of Offsite Power
LP	Low Pressure
LPCI	Low Pressure Coolant Injection
MAAP	Modular Accident Analysis Program
MACCS2	MELCOR Accident Consequences Code System, Version 2
MACR	Maximum Averted Cost-Risk
MCC	Motor Control Center
MMACR	Modified Maximum Averted Cost-Risk
MRI	Manual Rod Insertion
MSIV	Main Steam Isolation Break
NPSH	Net Positive Suction Head
NRC	U.S. Nuclear Regulatory Commission
OECR	Off-site economic cost risk
OSP	Off Site Power
PMF	Probable Maximum Flood
PPL	PPL Susquehanna, LLC*
PRA	Probabilistic Risk Assessment
PSA	Probabilistic Safety Assessment
PSL	Pressure Suppression Limit
RCIC	Reactor Core Isolation Cooling
RDR	Real Discount Rate
RHR	Residual Heat Removal
RHRSW	Residual Heat Removal Service Water
RLE	Review Level Earthquake
RPT	Recirculation Pump Trip
RPV	Reactor Pressure Vessel
RRW	Risk Reduction Worth
RWCU	Reactor Water Cleanup
RWST	Refueling Water Storage Tank
SAMA	Severe Accident Mitigation Alternative
SAMDA	Severe Accident Mitigation Design Alternative
SBLC	Standby Liquid Control
SBO	Station Blackout
SER	Safety Evaluation Report
SLC	Standby Liquid Control
SLCS	Standby Liquid Control System
SP	Suppression Pool
SPC	Suppression Pool Cooling
SORV	Stuck Open Relief Valve
SRV	Safety Relief Valve

Acronyms Used in Attachment E

SSES	Susquehanna Steam Electric Station
SW	Service Water
ZPA	Zero Period Acceleration

*** PPL Susquehanna, LLC is the present name of the owner (90%) and operator of the Susquehanna Steam Electric Station. Previous names included Pennsylvania Power and Light Co. and PP&L, Inc. Allegheny Electric Cooperative Inc. owns the remaining 10% of the station.**

E.0 SEVERE ACCIDENT MITIGATION ALTERNATIVES

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

E.1 METHODOLOGY

The methodology selected for this analysis involves identifying SAMA candidates that have 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 offsite 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:

- Susquehanna Steam Electric Station (SSES) Probabilistic Risk Assessment (PRA) Model – Use the SSES Internal Events PRA model as the basis for the analysis (Section E.2). Incorporate External Events contributions as described in Section E.5.1.8.

- Level 3 PRA Analysis – Use SSES 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 using the MELCOR Accident Consequences Code System Version 2 (MACCS2) (Section E.3). Incorporate External Events contributions as described in Section E.5.1.8.

- Baseline Risk Monetization – Use U.S. Nuclear Regulatory Commission (NRC) regulatory analysis techniques to calculate the monetary value of the unmitigated SSES severe accident risk. This becomes the maximum averted cost-risk that is possible (Section E.4).

- Phase 1 SAMA Analysis – Identify potential SAMA candidates based on the SSES Probabilistic Risk Assessment (PRA), Individual Plant Examination – External Events (IPEEE), and documentation from the industry and the NRC. Screen out SAMA candidates that are not applicable to the SSES design or are of low benefit in boiling water reactors (BWRs) such as SSES, candidates that have already been implemented at SSES or whose benefits have been achieved at SSES using other means, and candidates whose estimated cost exceeds the maximum possible averted cost-risk (Section E.5).

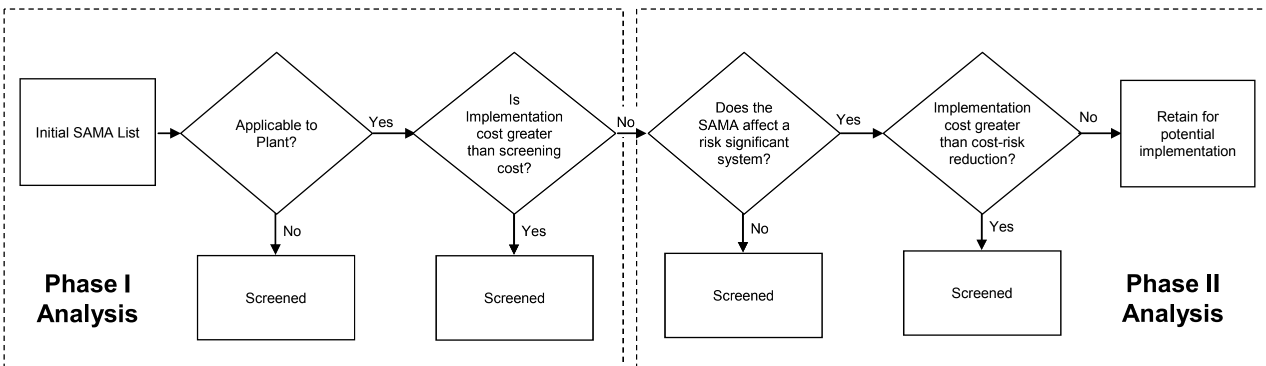
- Phase 2 SAMA Analysis – Calculate the risk reduction attributable to each remaining SAMA candidates and compare to a more detailed cost analysis to identify the net cost-benefit. PRA insights are also used to screen SAMA candidates in this phase (Section E.6).

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

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

The steps outlined above are described in more detail in the subsections of this appendix. The graphic below summarizes the high level steps of the SAMA process.

SAMA Screening Process



For SSES, the SAMA process is complicated by the concurrent Extended Power Uprate (EPU) application. The EPU application implies that future operation of the plant will not necessarily be consistent with what is modeled in the current PRA. While there may be many issues in the future life of the plant that fall into this category, EPU has been identified as a likely change; therefore, the SAMA analysis has been developed to account for EPU implementation.

For completeness, two parallel SAMA analyses have been performed in order to address both the pre-EPU and post-EPU[1] conditions for SSES. The calculations and results for both of these analyses are documented in the following subsections.

[1] Post-EPU occurs after implementation of EPU changes to the station.

E.2 SSES PRA MODEL

This section provides a summary of the PRA model used to support the SAMA analysis and the changes that have been made to the model since the individual plant examination (IPE). The external events models are not specifically discussed in this section; however Sections E.5.1.6 through E.5.1.8 provide a description of the process used to integrate the external events contributions into the SSES SAMA process.

E.2.1 Current Level 1 SSES PRA Models

In order to clearly represent the impact of EPU implementation, two different versions of the PRA were developed (FEB06preEPU and FEB06EPU). The only differences between the models are those based on EPU implementation. The SAMA analysis uses both models in a parallel evaluation to document how the proposed EPU could impact the results.

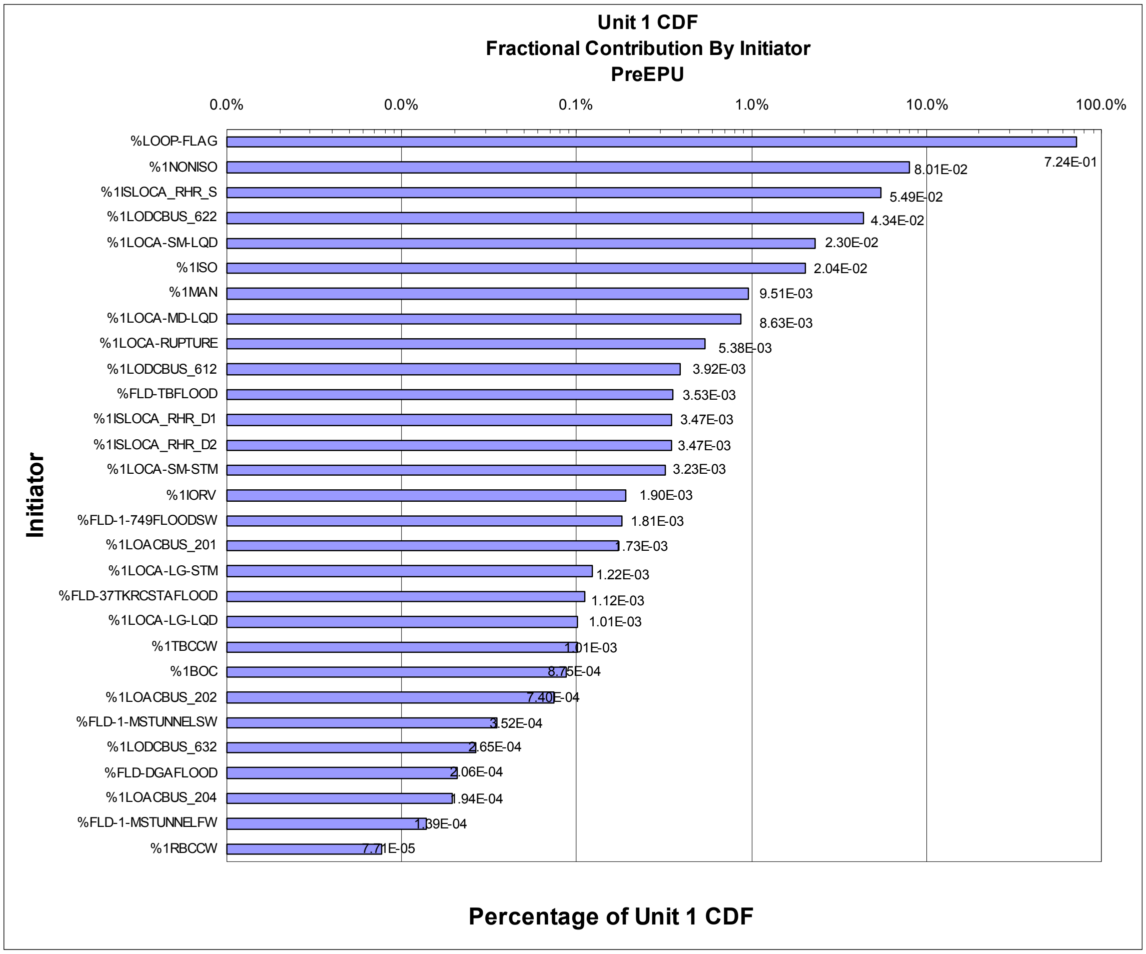
While the two models are similar, there are some differences in the calculated CDFs, as shown in the following table:

SSES CDF Summary

Unit	FEB06preEPU	FEB06EPU
Unit 1	1.86E-06	1.97E-06
Unit 2	1.83E-06	1.94E-06

These models are the average maintenance models and includes the plant specific, average maintenance terms that were developed by SSES.

The following graphs summarize the initiating event contributions to CDF for each unit for both pre and post EPU conditions. As shown in the graphs, the loss of offsite power (LOOP) events (%LOOP-FLAG) dominate the profiles for both units. The table following the graphs provides a description of the initiating event names used in the graphs for Unit 1. Unit 2 events are similar.


Unit 1 CDF
Fractional Contribution By Initiator
PreEPU
0.0%
0.0%
0.1%
1.0%
10.0%
100.0%
Initiator
%LOOP-FLAG
7.24E-01
%1NONISO
8.01E-02
%1ISLOCA_RHR_S
5.49E-02
%1LODCBUS_622
4.34E-02
%1LOCA-SM-LQD
2.30E-02
%1ISO
2.04E-02
%1MAN
9.51E-03
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8.63E-03
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3.92E-03
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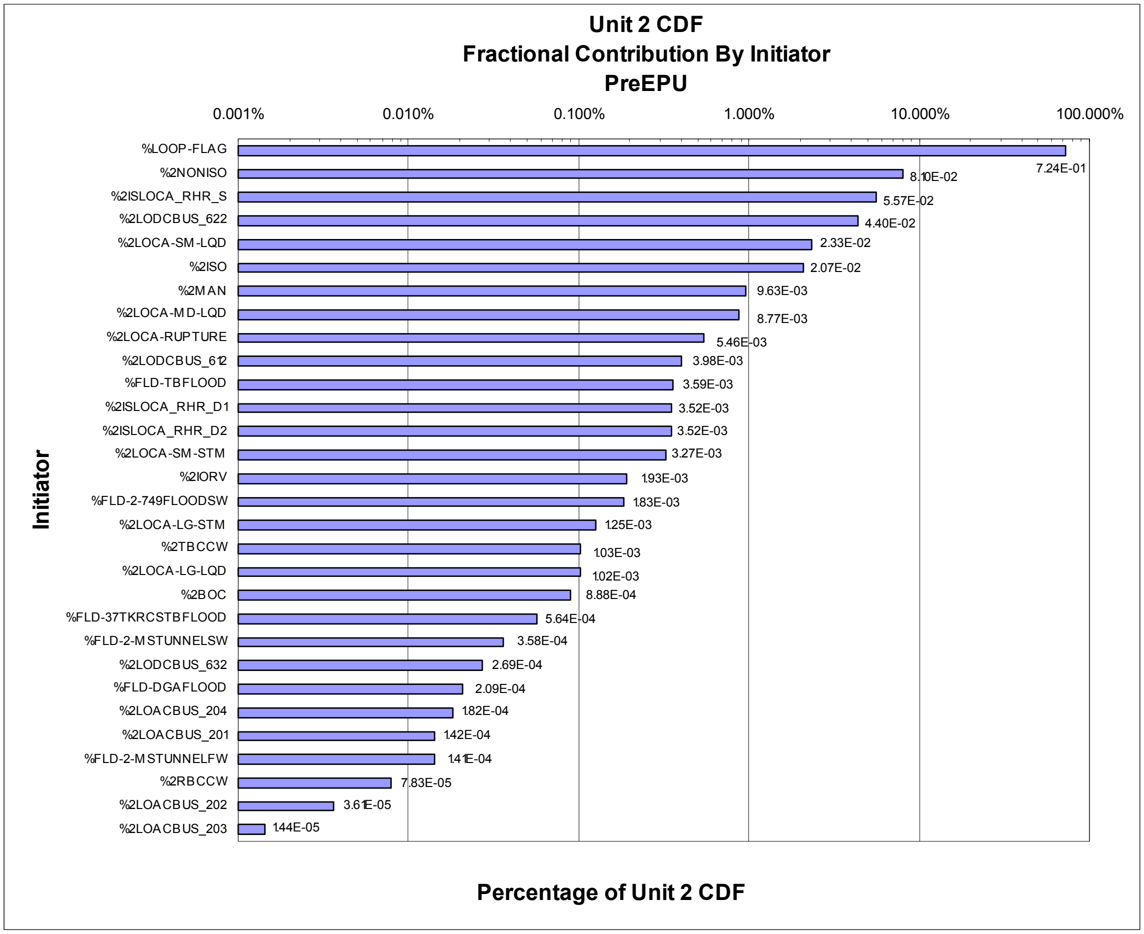
7.71E-05
Percentage of Unit 1 CDF


Unit 2 CDF
Fractional Contribution By Initiator
PreEPU
0.001%
0.010%
0.100%
1.000%
10.000%
100.000%
Initiator
%LOOP-FLAG
7.24E-01
%2NONISO
8.10E-02
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5.57E-02
%2LODCBUS_622
4.40E-02
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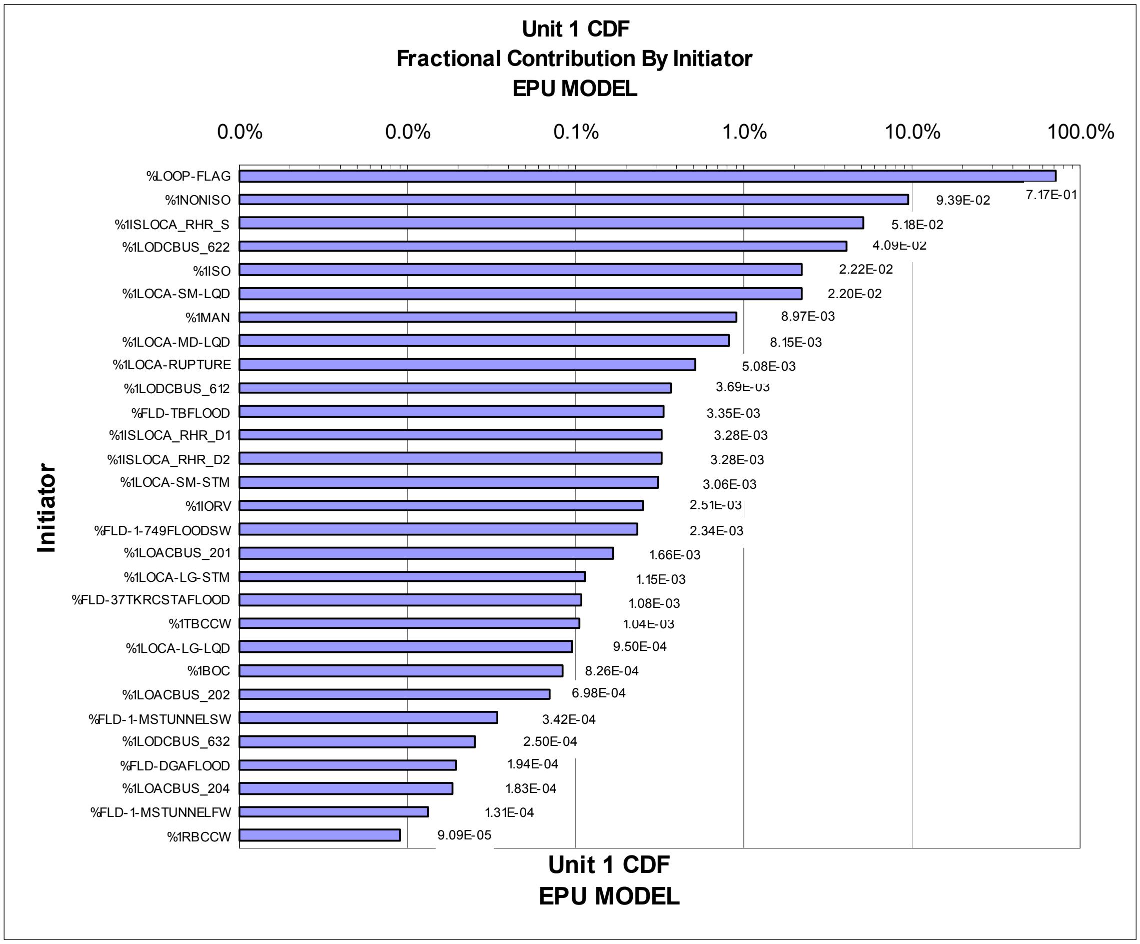
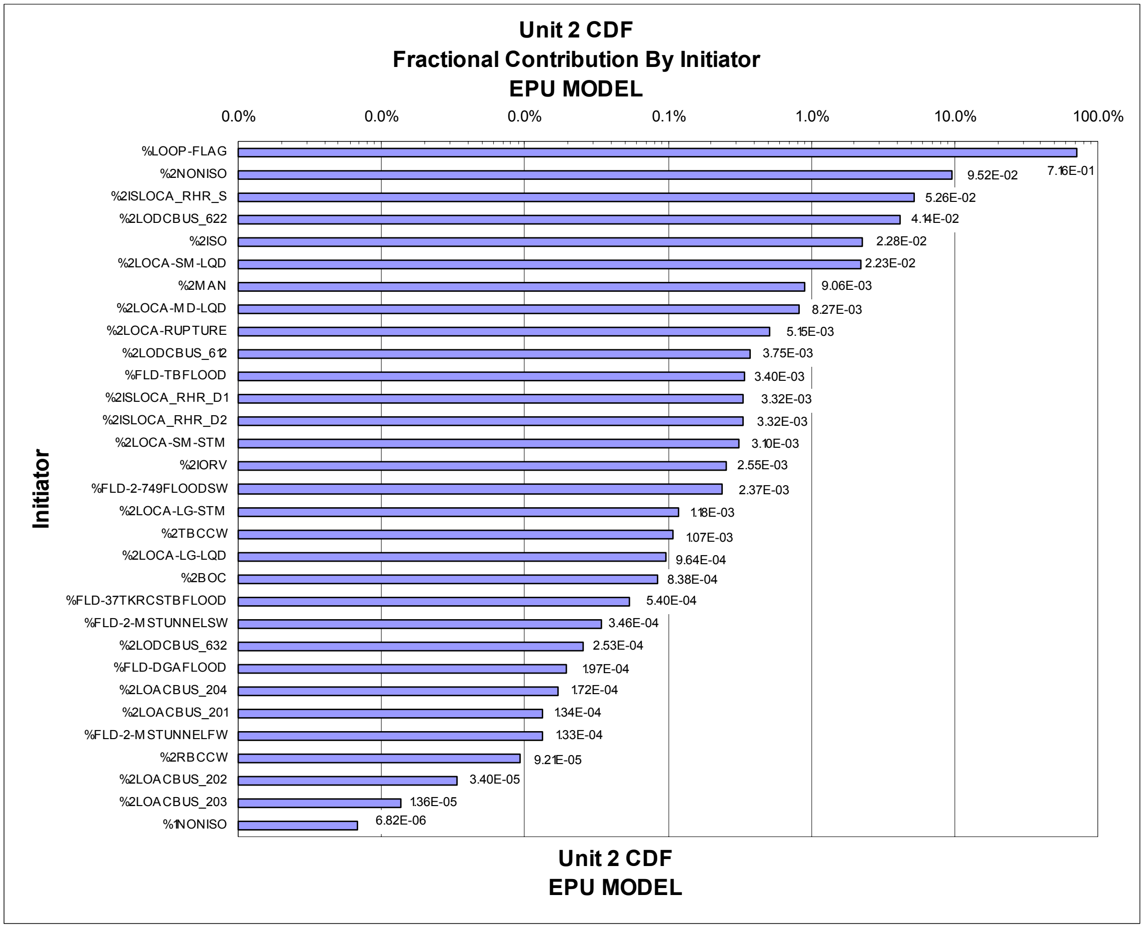
%2RBCCW
7.83E-05
%2LOACBUS_202
3.61E-05
%2LOACBUS_203
1.44E-05
Percentage of Unit 2 CDF


Unit 1 CDF
Fractional Contribution By Initiator
EPU MODEL
0.0%
0.0%
0.1%
1.0%
10.0%
100.0%
Initiator
%LOOP-FLAG
7.17E-01
%1NONISO
9.39E-02
%1ISLOCA_RHR_S
5.18E-02
%1LODCBUS_622
4.09E-02
%1ISO
2.22E-02
%1LOCA-SM-LQD
2.20E-02
%1MAN
8.97E-03
%1LOCA-MD-LQD
8.15E-03
%1LOCA-RUPTURE
5.08E-03
%1LODCBUS_612
3.69E-03
%FLD-TBFLOOD
3.35E-03
%1ISLOCA_RHR_D1
3.28E-03
%1ISLOCA_RHR_D2
3.28E-03
%1LOCA-SM-STM
3.06E-03
%1IORV
2.51E-03
%FLD-1-749FLOODSW
2.34E-03
%1LOACBUS_201
1.66E-03
%1LOCA-LG-STM
1.15E-03
%FLD-37TKRCSTAFLOOD
1.08E-03
%1TBCCW
1.04E-03
%1LOCA-LG-LQD
9.50E-04
%1BOC
8.26E-04
%1LOACBUS_202
6.98E-04
%FLD-1-MSTUNNELSW
3.42E-04
%1LODCBUS_632
2.50E-04
%FLD-DGAFLOOD
1.94E-04
%1LOACBUS_204
1.83E-04
%FLD-1-MSTUNNELFW
1.31E-04
%1RBCCW
9.09E-05
Unit 1 CDF
EPU MODEL


Unit 2 CDF
Fractional Contribution By Initiator
EPU MODEL
0.0%
0.0%
0.0%
0.1%
1.0%
10.0%
100.0%
Initiator
%LOOP-FLAG
7.16E-01
%2NONISO
9.52E-02
%2ISLOCA_RHR_S
5.26E-02
%2LODCBUS_622
4.14E-02
%2ISO
2.28E-02
%2LOCA-SM-LQD
2.23E-02
%2MAN
9.06E-03
%2LOCA-MD-LQD
8.27E-03
%2LOCA-RUPTURE
5.15E-03
%2LODCBUS_612
3.75E-03
%FLD-TBFLOOD
3.40E-03
%2ISLOCA_RHR_D1
3.32E-03
%2ISLOCA_RHR_D2
3.32E-03
%2LOCA-SM-STM
3.10E-03
%2IORV
2.55E-03
%FLD-2-749FLOODSW
2.37E-03
%2LOCA-LG-STM
1.18E-03
%2TBCCW
1.07E-03
%2LOCA-LG-LQD
9.64E-04
%2BOC
8.38E-04
%FLD-37TKRCSTBFLOOD
5.40E-04
%FLD-2-MSTUNNELSW
3.46E-04
%2LODCBUS_632
2.53E-04
%FLD-DGAFLOOD
1.97E-04
%2LOACBUS_204
1.72E-04
%2LOACBUS_201
1.34E-04
%FLD-2-MSTUNNELFW
1.33E-04
%2RBCCW
9.21E-05
%2LOACBUS_202
3.40E-05
%2LOACBUS_203
1.36E-05
%1NONISO
6.82E-06
Unit 2 CDF
EPU MODEL

Event Name	Description
%LOOP-FLAG	LOOP FLAG FOR INITIATING EVENT
%1NONISO	TRIP W/O MSIV CLOSURE
%1ISLOCA_RHR_S	INTERFACING SYSTEM LOCA FOR RHR PUMP SUCTION (F008-F009) BREAK
%1LODCBUS_622	LOSS OF 1D622
%1LOCA-SM-LQD	SMALL LIQUID LINE BREAK LOCA
%1ISO	INADVERTENT ISOLATION - MSIV
%1MAN	MANUAL SHUTDOWN
%1LOCA-MD-LQD	MEDIUM LIQUID LINE BREAK LOCA
%1LOCA-RUPTURE	VESSEL RUPTURE OR EXCESSIVE LOCA
%1LODCBUS_612	LOSS OF 1D612
%FLD-TBFLOOD	MAJOR TURBINE BUILDING FLOODING EVENT OCCURS IN U1 OR U2
%1ISLOCA_RHR_D1	INTERFACING SYSTEM LOCA FOR RHR PUMP DISCHARGE DIVISION I
%1ISLOCA_RHR_D2	INTERFACING SYSTEM LOCA FOR RHR PUMP DISCHARGE DIVISION II
%1LOCA-SM-STM	SMALL STEAM LINE BREAK LOCA
%1IORV	INADVERTENT OPENING OF A RELIEF VALVE
%FLD-1-749FLOODSW	ROOM I-500 FLOOD (63%)
%1LOACBUS_201	LOSS OF AC BUS 1A201
%1LOCA-LG-STM	LARGE STEAM LINE BREAK LOCA
%FLD-37TKRCSTAFLOOD	CST A RUPTURES OR RWST RUPTURES (2 TANKS X 1 YEAR)
%1LOCA-LG-LQD	LARGE LIQUID LINE BREAK LOCA
%1TBCCW	INITIATING EVENT FLAG - LOSS OF TURBINE BUILDING CLOSED COOLING WATER 3E-02
%1BOC	BREAK OUTSIDE CONTAINMENT
%1LOACBUS_202	LOSS OF BUS 1A202
%FLD-1-MSTUNNELSW	WING SLAB FLOOD (11%) ROOM I-411
%1LODCBUS_632	LOSS OF 1D632
%FLD-DGAFLOOD	ESW BREAK AT DG A
%1LOACBUS_204	LOSS OF AC BUS 1A204
%FLD-1-MSTUNNELFW	FW BREAK IN WING SLAB
%1RBCCW	INITIATING EVENT FLAG - LOSS OF REACTOR BUILDING CLOSED COOLING WATER

E.2.2 Current Level 2 SSES PRA Model

The FEB05RA model focused on discriminating between large early release frequency (LERF) and non-LERF end states consistent with the ASME Probabilistic Risk Analysis (PRA) Standard (ASME 2003), the Regulatory Guides 1.174 (NRC 2002), 1.177 (NRC 1998b), etc., and the PSA Application Guide (EPRI 1995). However, for license renewal and EPU, an extended set of radionuclide release categories is desired to support the cost benefit evaluation required as part of the SAMA assessment.

The release end states have been expanded from previous SSES PRA versions to include multiple radionuclide release end states to support the SAMA evaluation by extending the FEB05RA model event trees to consider additional Level 2 phenomenon logic and system based top events.

The frequency of radionuclide release is characterized by the quantification of the integrated Level 1 and Level 2 PRA model event trees. For SAMA, the Level 2 radioactive release frequency event tree end states are delineated by the magnitude and timing bins of the calculated radionuclide release as shown in Table E.2-1.

Integrating the severity and timing categories yields twelve separate event tree release category end states using a two-term matrix (severity, time) as shown in the Table E.2-2.

Each of the event tree end states are assigned to one of these categories and a representative release is assigned to each category. The "H/E" category is assigned as the representative LERF category. The change in frequencies of all of the individual release categories are used as one of the inputs in determining the potential cost-benefit for the SAMA analysis. The baseline release category frequencies for the SAMA model are provided in Table E.2-3 for both pre-EPU and Post-EPU conditions. The baseline source term information for the release categories considered in the SAMA analysis is provided in Tables E.2-4a and E.2-4b for pre-EPU and Post-EPU conditions, respectively.

E.2.3 PRA Model Review and Evolution Summary

The Level 1 and Level 2 SSES PRA analyses were originally submitted to the NRC in December 1991 as the SSES IPE Submittal. Pennsylvania Power and Light's (PPL 1991) IPE received an NRC safety evaluation report (SER) in 1998. Since the time the IPE was submitted, there have been several extensive revisions produced prior to the Boiling Water Reactor Owners Group (BWROG) Peer Review in 2003. The model that underwent the Peer Review was not an upgrade to the IPE but, a new model based on thermal hydraulic calculations for the current fuel type and current rated power. New event trees were developed based on the calculated accident progression and current emergency operating procedures (EOPs). Subsequent to the BWROG Peer Review, the SSES model was updated to address the comments generated from that review.

The significant, recent reviews of the SSES PRA model include the NRC activities related to the development of the SSES IPE SER and the 2003 BWROG Peer Review. The major findings of these reviews are summarized below.

E.2.3.1 Critical Review Overview

PPL's IPE was submitted to the NRC and received an SER on August 11, 1998. There were three weaknesses identified in the SER, which were related to the following issues:

- The evaluation of sequences with containment failure prior to core damage ended with the assumption of core damage and did not analyze the consequences of these sequences,
- The impact on conditional containment failure probability of some severe accident phenomena and resulting containment failure modes appeared to have been understated,
- The treatment of Interfacing System LOCA (ISLOCA) was not as robust as required.

These issues were addressed and corresponding changes were incorporated into the PRA prior to the 2003 BWROG Peer Review, as described in Section E.2.3.2.

The consensus of the Peer Review team, as stated in the exit meeting, was that the SSES PRA was "top quartile" in the industry. The BWROG peer review provided PPL Susquehanna, LLC (PPL) with Level B, C, D and S Facts and Observations (F&Os). PPL did not receive any Level A F&Os. The definition of each level is listed in the following table.

Importance Level	Definition
A.	Extremely important and necessary to address to assure the technical adequacy of the PRA or the quality of the PRA or the quality of the PRA update process. (Contingent Item for Certification).
B.	Important and necessary to address, but may be deferred until the next PRA update. (Contingent Item for Certification).
C.	Marginal importance, but considered desirable to maintain maximum flexibility in PRA Applications and consistency in the Industry.
D.	Editorial or Minor Technical Items left to the discretion of the host utility.
S.	Considered a major strength of the PRA.

PPL incorporated approximately half of the B level F&Os and some of the C Level F&Os into the FEB05RA model, as described in Section E.2.3.3.

PPL also performed a self-assessment using the guidance included in RG 1.200 (NRC 2004) that supplements NEI 00-02 (NEI 2000). This review indicated the necessity to address some of the remaining 'B' open items to adequately support EPU implementation. Other identified 'Gaps' to Capability Category II of the ASME PRA Standard (ASME 2003) were judged to not have an impact on the EPU evaluation. The remaining open B level comments were reviewed to determine if any outstanding F&Os had the potential to significantly impact the EPU results. The result of the review is summarized in Table E.2-5. All issues that were identified as important for resolution in the model prior to performing the EPU application were resolved in the FEB06preEPU and FEB06EPU models. It was determined that the remaining items and Gaps would not to have a significant impact on the EPU application and were therefore deferred until the next update.

E.2.3.2 Resolution of IPE SER Weaknesses

Three major weaknesses were identified as result of the NRC's review of the SSES IPE. As described below, these issues were addressed in subsequent model updates and are no longer open items for SSES.

Identified Weakness #1

"In the licensee's analysis, the accident sequence progression was terminated if the containment failed prior to core damage; all sequences were then assumed to go to core damage in the reported CDF. Radionuclide releases were not calculated for these containment failures nor was a detailed understanding of the plant response obtained."

Response

Subsequent to the SER on PPL's IPE, substantial changes to the event trees were made that addressed the issue of accident sequence progression. In PPL's Peer Review model and the model used for this submittal, events progress beyond containment failure given no prior core damage. In the case of containment failure and no prior core damage, available sources of injection into the core are evaluated. If injection is successful, the end-state is no core damage and containment failure. If injection is not successful, core damage occurs and a Level 2 release category is assigned depending on the sequence timing and expected magnitude of the release.

The event trees used for the Peer Review and for this submittal include injection from sources outside the reactor building given containment failure and no prior core damage. The success criteria are based on detailed thermal hydraulic analyses. The event trees are also annotated with the timing for a General Emergency declaration and timing for containment failure and core damage, if it occurs. Thus, the sequence can be readily identified as a LERF sequence if appropriate. Additional non-LERF release categories are also assigned in the updated Level 2 model. The event tree logic is reflected in the fault tree model.

Identified Weakness #2

"The impact on conditional containment failure probability of some severe accident phenomena and resulting containment failure modes appear to have been understated. As a result, all early and late containment failures, other than the containment failures resulting from loss of decay heat removal (DHR) discussed in item 1 above, are reported by the licensee to occur in less than one percent of core damage events, including anticipated transient without scram (ATWS) and station blackout.

Appendix 1 to GL 88-20 recommended that licensees consider a maximum coolable debris bed to be 25 cm. For depths in excess of that (as proposed by the SSES IPE) both coolable and noncoolable outcomes should be considered and documented, even in the presence of a water layer provided by the drywell sprays, because of the possibility of the formation of a noncoolable debris crust. Noncoolable outcomes may lead to the occurrence of phenomena such as COPF from noncondensible gas generation due to core-concrete interaction or containment failure from corium attack on the drywell liner/concrete containment boundary (PPL 1991).

The licensee assumed, however, that core debris released from the vessel post-accident will always be quenched on the drywell floor and, consequently, core-concrete interactions with the drywell floor, steel liner, or concrete containment will be prevented, as long as the drywell sprays provide a water pool on the drywell floor. Similarly, core debris attack on other structures, such as the downcomer vents, resulting in suppression pool bypass or loss of pool scrubbing, would not be possible, according to the licensee, given spray operation. Additionally, the licensee did not consider the possible negative effects of water on the drywell floor, such as containment pressurization due to ex-vessel steaming resulting from fuel-coolant interactions."

Response:

Subsequent to the SER on PPL's IPE, substantial changes to the event trees were made that address the issues of containment failure modes. The current SSES PRA model considers the following containment failure modes:

a. Containment Overpressure
b. Containment isolation failure
c. In-vessel steam explosion (Alpha Mode failure)
d. Ex-vessel steam explosion (Shock loading)
e. Direct containment heating (DCH)
f. Failure Induced by Corium Attack on the Containment Structures, including:
    1. Drywell head flange failure
    2. Loss of vapor suppression due to downcomer melt through
    3. Drywell liner melt through
    4. Overpressure failure due to non-condensable gas generation

The Susquehanna containment design is not susceptible to in-vessel and ex-vessel steam explosions. In addition, evidence from NUREG/CR-5623 exists to show that any core debris generated is not expected to cover a uniform area greater than that extending to the innermost ring of downcomers. Therefore, the drywell liner is not susceptible to failure in the event of vessel melt-through. Each of the other containment failure mechanisms is considered in the current PRA model.

NUREG/CR-5623 calculates containment conditions for core melt core-concrete interaction and the production of non-condensable gases. These calculations conclude that containment pressure will remain less than the ultimate pressure capacity, as long as sufficient drywell spray is available to establish a water pool on the drywell floor up to the downcomer overflow. The drywell spray flow must also continue in sufficient quantity to remove decay heat from the corium. This drywell spray requirement is transferred to the event tree model by requiring that the containment spray function be available in sufficient time to generate the required pool on the drywell floor prior to reactor vessel failure.

Under loss of coolant accident (LOCA) sequences, a further requirement for containment integrity is that the vacuum breakers between drywell and suppression chamber are required to operate following the initiation of the containment spray function. It is assumed in the LOCA evaluations that, at the time when drywell spray is initiated, the drywell will be devoid of non-condensable gases and filled with steam from the break. Therefore, the drywell spray will cause a rapid drywell depressurization and at least one vacuum breaker must operate in order to prevent containment failure resulting from implosion.

Based on this discussion, it is concluded that the current PRA model does include both the coolable geometry issue and the potential negative effects of water vapor and noncondensable gas generation following core melt extrusion from the reactor vessel.

Identified Weakness #3

"The treatment of interfacing systems LOCA (ISLOCA) was characterized as limited in the staff's October 27, 1997, SER. The licensee has not revisited its ISLOCA analysis and, consequently, it remains a weakness."

Response

PPL has fully addressed ISLOCA in the model used for the Peer Review. PPL has performed a formal calculation to evaluate the initiation frequency of an ISLOCA for the following systems:

- RCIC
- HPCI
- Core Spray
- Reactor Water Cleanup
- RHR

PPL has included in the model ISLOCA initiators, which are greater than the ISLOCA cutoff frequency outlined in NUREG-CR-5928 (NRC 1993).

The contribution of ISLOCAs to the CDF is about 6% and the contribution to the LERF is about 66%. The location of the ISLOCA in both cases is from the RHR system.

E.2.3.3 Peer Review Results and F&O Dispositions for the FEB05RA Model

The October 2003 BWROG peer review provided PPL with Level B, C, D and S F&Os; PPL did not receive any Level A F&Os. As part of the next model revision, PPL resolved the Level B F&Os that were determined to be the most significant in their effect on PRA results (more than half of the Level B F&Os) and incorporated them into the FEB05RA model. The remainder of the Level B F&Os were scheduled to be resolved prior to the next scheduled model periodic update. As mentioned in Section E.2.3.1, these comments were reviewed and addressed to support EPU and SAMA implementation.

The peer review team used NEI draft “Probabilistic Risk Assessment (PRA) Peer Review Process Guidance” (NEI 2000) as the basis for the review.

The Peer Review process uses grades to assess the relative technical merits and capabilities of each technical element and sub-element reviewed. The grades and criteria were developed, in the BWROG program, considering attributes of a PRA necessary to ensure quality, elements of a PRA that are critical to its technical adequacy, and elements needed to support PRA applications. The grades and criteria, which have been adopted for this program, provide guidance on appropriate use of the information covered by the sub-element for risk-informed applications, and convey the ability of the PRA sub-element to support particular types of applications. Four grade levels are used to indicate the relative quality level of each technical element and sub-element based on the criteria at hand. The grading and criteria are:

- Grade 1 – Supports Assessments of Plant Vulnerabilities
- Grade 2 – Supports Risk-Ranking Applications
- Grade 3 – Supports Risk Significance Evaluations w/Deterministic Input (Risk-Informed Decisions)
- Grade 4 – Provides Primary Basis For Application (Risk-Based Decisions)

It is important to note that the PRA does not receive one overall grade. Each element is graded based on the criteria for the element. Then, based on the criteria grades, a summary grade is provided for each of the eleven technical elements.

The minimum grade, the average grade, and the summary grade for each of the eleven elements are listed in the following table along with the overall assessment [extracted from the 2003 Peer Review Report (ERIN 2003)]:

PRA PEER REVIEW REPORT
OVERALL ASSESSMENT

PRA ELEMENT	GRADE BASED ON SUB-ELEMENTS		
	Minimum	Average	Summary
Initiating Events	2	2.86	3
Accident Sequence Evaluation	2	2.92	3
Thermal Hydraulic Analysis	2	3.00	3
System Analysis	3	3.04	3
Data Analysis	2	2.94	3
Human Reliability Analysis (HRA)	2	2.89	3
Dependencies	2	3.00	3
Structural Response	3	3.40	3
Quantification	2	2.97	3
Containment Performance	2	2.57	2
Maintenance & Update	2	2.27	2

Overall Assessment: Based on the PRA Peer Review Team review, the PRA can be effectively used to support applications involving absolute risk determination. The Level 1 PRA is fully supportive of Grade 3 applications when the footnotes identified on sub-elements are dispositioned. Level 2 is a useful screening tool to assess applications.

Areas Requiring Enhancement:

Re-examine the following specific issues.

Conservatisms:

The human reliability analysis (HRA) Peer review identified the quantitative assessment of dependencies among HEPs as an area potential of improvement that could reduce excess conservatisms for absolute risk determination.

Reassess the DCH conditional probability.

Reassess the over-temperature failure assumption used in Level 2.

LERF and CDF definitions.

PRA PEER REVIEW REPORT
OVERALL ASSESSMENT

Non-Conservatisms:

Station blackout (SBO) events may have sequence dependencies not fully accounted for. This may adversely impact the SBO sequence frequency.

Other Issues:

- The accident sequence evaluation should be reviewed to ensure that the key safety functions are included [e.g., consider including reactivity control, safety relief valve (SRV) reset (i.e., no stuck open relief valve (SORV) for ATWS, and control rod drive (CRD) as a long-term "required" injection method] in those sequences that would challenge the safety functions].
- A search for plant-unique uncertainties and the associated sensitivity studies to support the uncertainty ranges should be performed.
- The Level 2 analysis has a number of items that would appear useful to re-examine. These include:
- Inclusion of containment isolation in selected sequences.
- Inclusion of energetic failure modes including hydrodynamic loads.
- Removal of excess conservatisms in the LERF definition.

Areas Recommended For Enhancement: See Facts and Observations sheets for specific recommendations.

E.2.3.3.1 Level B Facts and Observations

In addition to the high level comments discussed above, the SSES Level B Facts and Observations are provided below along with the corresponding resolutions from the FEB05PRA model for information purposes. Amendments to the responses have been added to include the current disposition based on the FEB06PreEPU and FEB06EPU models. The Level C and D F&Os are not provided as they are not considered to have a meaningful impact on the conclusions of the SAMA analysis.

Element AS Subelement 5 Observation 1A INDES 2

250V DC Load Shed

One of the assumptions used in the model is that procedure EO-100-030 is implemented to shed 250V DC loads. There is currently not an explicit HEP in the model to represent the failure of this action and the consequential inability to achieve at least 4 hours of HPCI/RCIC operation. The procedure directs this to be accomplished after 30 min. and before 45 min.

Disposition:

Created new HEP where the operator fails to shed 250VDC loads. This 250VDC load shed only impacts Unit 1. Unit 2 does not require 250VDC load shed because Unit 2 has a separate non-1E battery bank. Incorporated the new basic event into the PRA model and updated the HRA Notebook with all information relevant to this HEP. This F&O and resolution is a duplicate of F&O Index 59.

EPU/SAMA PRA Model Comment: None. The original disposition is still applicable.

Element: AS Subelement: 5 Observation 1B INDEX: 3

Control of HPCI/RCIC

After 4 hours into an SBO, 250V DC may be unavailable, this creates the need to control HPCI and RCIC flow such that they do not trip and require restart. The ability to perform such control actions does not appear to be included as a HEP.

Disposition:

An HEP for operator failure to control level was developed, analyzed, documented, and included in the PRA model. Nothing further required for this F&O.

EPU/SAMA PRA Model Comment: None. The original disposition is still applicable.

Element: AS Subelement: 5 Observation 4 INDEX: 5

ATWS – Sequence TR-6, TR-7

These sequences assume HPCI operated initially but SLC has failed and Manual Rod Insertion (MRI) is underway. If such a scenario could be successful, it would likely make pool temperature above HCL.

The SSES EOPs deviate from the BWROG recommended guidelines by allowing operation under ATWS conditions above PSP and HCL. The consequences of subsequent RPV emergency depressurization due to low RPV water level does not currently account for the plant conditions above PSP and above HCL on the accident sequence impacts.

Disposition:

The ATWS event tree has been revised to require success of high-pressure injection and suppression pool cooling in order to have a successful outcome for sequences where SLCS is failed and MRI is available for reactor shutdown.

Simulation of reactor shutdown with MRI shows that pool temperature is well above the HCTL (Heat Capacity Temperature Limit) and suppression chamber pressure is well above the Pressure Suppression Limit. If high-pressure makeup were to fail in an accident sequence where MRI alone accomplishes shutdown, it is likely that RPV depressurization would cause containment pressure to exceed 82 psig, the pressure at which SRVs close on insufficient pneumatic supply. This would lead directly to core melt, vessel failure, and containment failure.

Venting of the containment at 65 psig would also be a concern in this situation if sufficient time were available to carry out the venting. Venting would disable all low-pressure ECCS due to the harsh environment in the reactor building. Consequently, there are no ATWS success paths that involve failure of high-pressure makeup and SLCS, which is reflected in the event trees.

EPU/SAMA PRA Model Comment: None. The original disposition is still applicable.

Element: AS Subelement: 5 Observation 10 INDEX: 11

The RPT is credited in ATWS to prevent early core damage. There is logic to generate an RPT on Level 2, EOC turbine trip[1], and high RPV pressure. The Level 2 trip occurs too late to be effective in preventing very high RPV pressure under certain accident sequences. Therefore, it should not be credited in the model[2]. The risk model credits the high RPV pressure trip and the EOC RPT. The present structure of the model, has these two trips as redundant methods for the RPT. The fault tree should be revised for the RPT to remove the EOC RPT for non-turbine-trip events. The PRA group identified this would be incorporated into the model.

[1] Turbine stop valve position.
[2] This has been confirmed by the PRA group.

Disposition:

PPL agrees with the comment that the Rx level 2 trip will come in too late to be effective for mitigating an ATWS, and that the EOC - RPT (End Of Cycle - Recirculation Pump Trip) is ineffective for non-turbine-trip events.

The resolution of the Rx level 2 issue requires no changes to the RPT logic. The fault tree does not credit Rx level 2 for RPT. However, Rx level 2 was credited in the PRA for automatic ARI initiation. PPL's review of level 2 for ARI automatic initiation indicated that this input should be removed, since the reactor may not reach level 2 for some ATWS transients (e.g., those with feedwater available. Hence, the Rx level 2 gates were removed as inputs from the ARI logic gates.

The resolution of the EOC-RPT issue required adding input to fail the EOC-RPT "OR" gate for non-turbine-trip events. Gate %1MSIVATWS was added as input to EOC-RPT. %1MSIVATWS is an "OR" gate including all initiators that would close the MSIVs (i.e. non-turbine-trip events).

The described changes have been incorporate into the current PRA.

EPU/SAMA PRA Model Comment: None. The original disposition is still applicable.

Element: AS Subelement: 6 Observation 1 INDEX: 13

SRVs

The successful prevention of overpressure failure under ATWS conditions requires RPT and SRVs opening. The ATWS event tree should include both.

Disposition:

The ATWS event tree has been revised to require successful RPT and SRV operation in order to have a successful outcome. The ATWS event tree in the revised Event Tree Notebook contains a branch which goes to core damage, vessel failure, and containment over-pressure failure if the ATWS RPT and a sufficient number of SRVs are not both successful.

EPU/SAMA PRA Model Comment: The original disposition is still applicable. The evaluation for the number of SRV failures that are acceptable in ATWS conditions has been reassessed for EPU conditions as described in the updated Event Tree Notebook.

Element: AS Subelement: 6 Observation 3 INDEX: 15

ATWS (E.T. Notebook p. H.2 and p. H.21) Sequence TR-6-1

End State sequence TR-6-1 appears to be optimistic given the fact that no reactivity control method has been successful.

It is judged important to incorporate an evaluation of a successful reactivity control method before assigning success.

Disposition:

A requirement for reactivity control, either SLCS or MRI, was added to the ATWS event trees replacing TR6-1 with three new sequences. The three new sequences are: level reduction with SLCS success (no core damage), level reduction with SLCS failure and MRI success (no core damage), and level reduction with both SLCS and MRI failure (core damage).

EPU/SAMA PRA Model Comment: None. The original disposition is still applicable.

Element: AS Subelement: 6 Observation 4 INDEX: 16

ATWS

There are a number of functional failures that are not addressed in the ATWS event tree. These include the following:

- Reactivity Control for Main Condenser Available
- Failure of all high pressure and low pressure injection

Initiation of Containment Vent and consequential failure of ECCS is not asked on Branches 27, 29, 37, and 39 of the ATWS tree where pressure is above 82 psig. The procedural direction to open the containment vent does not appear to be accounted for in the ATWS scenarios for Branches 27, 29, 37, and 39. This could lead directly to core damage due to the loss of ECCS makeup.

Disposition:

1. A requirement for reactivity control, either SLCS or MRI, was added to the ATWS event trees replacing TR6-1 with three new sequences. The three new sequences are: level reduction with SLCS success (no core damage), level reduction with SLCS failure and MRI success (no core damage), and level reduction with both SLCS and MRI failure (core damage).

2. A branch corresponding to failure of all high-pressure and low-pressure injection has been added to the ATWS event tree. The additional branch is Branch 34 described in the Event Tree Notebook.

3. On ATWS Event Tree branches 27 and 29, the containment vent would not be opened because core damage from power/flow instabilities exists on these branches. Plant procedures recommend against containment venting with large core damage, however, the venting decision still resides with the TSC. As such, venting with prior core damage is conservatively not credited in the PRA model. Similarly, core damage exists on Branches 37 and 39. On branch 37, core damage exists from the operator failing to throttle low-pressure injection after reactor depressurization. While on branch 39 of the ATWS event tree calculation, core damage exists from operation of a critical reactor in a depressurized state without reactivity control (SLCS is failed and MRI is too slow to stabilize core when depressurization is required).

4. Branch 27 of the peer-reviewed ATWS event tree is equivalent to branches 39 and 41 in the revised event tree. On branches 39 and 41, core damage exists and, as discussed above, the containment would not be vented at 65 psig. The equivalent of branch 29 in the peer-reviewed event tree does not exist in the revised ATWS event tree because credit is no longer taken for MRI when core damage exists. Branches 37 and 39 in the peer-reviewed event tree correspond to branches 36 and 22, respectively, in the revised event tree. Branch 36 goes to LERF because failure of the operator to control low-pressure injection is now assumed to lead to loss of the RPV and containment integrity. Branch 22 also goes directly to LERF because credit is no longer taken for MRI in scenarios involving RPV depressurization and failure of SLCS. In scenarios where SLCS is failed and RPV depressurization is required, containment pressure will likely exceed 82 psig, the pressure at which SRVs go closed. Closure of the SRVs will cause loss of low-pressure injection, which will lead to vessel failure and containment over-pressurization.

EPU/SAMA PRA Model Comment: For the most part, the original disposition is still applicable. However, the branches have been renumbered and expanded to include more than just LERF and non-LERF end states as described in the updated event tree notebook.

Element: AS Subelement: 7 Observation 1 INDEX: 18

MRI as an option for successful control of reactivity requires control rods to be individually inserted into the core.

There may be mechanical common cause failure modes that defeat both the scram function and MRI. The combination of all of these mechanical modes of failure (e.g., channel obstruction possibly due to high fuel burn-up effects or interference due to movement of vessel internals) should be factored into the assessment regarding whether MRI offers a truly independent method of reactivity insertion.

Disposition:

Previously at Susquehanna, control rod friction due to channel bow was identified as a potentially significant issue. Although there is no expectation that channel bow would prevent control rods from inserting to at least notch position 02 during a scram, it could cause significant degradation in the insertion speed when rods are driven manually using the CRD system. Calculations show that there is little margin available to the containment venting pressure (65 psig) in an isolation ATWS where SLCS is failed and shutdown is achieved by MRI (manual rod insertion). If control cell friction causes rods to insert significantly slower than the 60 sec/rod, then the containment will reach the venting pressure before hot shutdown is achieved. Venting of the containment would lead to failure of RCIC, HPCI, and all low-pressure ECCS. In the ATWS event tree, these sequences proceed to LERF. In order to account for failure of MRI to achieve shutdown before the containment vent pressure is reached, a failure probability of 0.5 associated with control cell friction is included in the MRI fault tree. The probability of MRI failure due to movement of vessel internals is expected to be orders of magnitude smaller than for channel bow, and therefore, this effect is already included in the specified failure probability of 0.5.

Discussion addressing MRI failure due to high control cell friction has been included in the Event Tree Notebook.

EPU/SAMA PRA Model Comment: Based on MAAP calculations for both pre-EPU and EPU conditions and a revised success criteria requirement to maintain the pool temperature below 260^{O}F for early ATWS conditions, MRI is not credited for success at all in these scenarios. MRI is only credited for success if the condenser is maintained available.

Element: AS Subelement: 7 Observation 4 INDEX: 21

RPV Rupture

The excessive LOCA evaluation has been included as an initiating event in the quantification. Core damage and LERF is assumed. This is conservative because core spray would be a potential success for prevention of core damage by design of the core spray system. Containment should remain intact and capable of mitigating the event, i.e., vapor suppression is adequate for mitigation of the initial pressurization for the spectrum of excessive LOCAs, except possibly the largest of postulated instantaneous ruptures of the RPV.

Disposition:

The evaluation for peak containment pressure following a complete reactor vessel rupture has been written into the event tree notebook (Appendix O). The conclusion is that peak containment pressure exceeds 250 psig following complete reactor vessel rupture, therefore, reactor vessel rupture leads directly to LERF. The frequency for reactor vessel rupture has been documented in the initiating event notebook.

EPU/SAMA PRA Model Comment: The original disposition is still applicable. Additionally, the frequency of this initiator has been re-evaluated to be 1.0E-8/yr instead of 1.0E-7/yr for consistency with many other industry BWR PRA models.

Element: AS Subelement: 8 Observation 3 INDEX: 24

ATWS Event Tree (Appendix H) Section H.23

The discussion of the low pressure makeup use in ATWS response is subject to the following comments:

- The success of LP injection conflicts with discussions in Section 2.8 of the main report.
- The sequences with controlling RPV level too low are neglected as probabilistically insignificant,

The assertion that containment failure can be prevented even though there is a loss of control of low pressure injection would appear optimistic without significantly more analysis regarding boron washout, RPV integrity during the reactivity excursion, and the power level following loss of low pressure injection control.

Disposition:

1. The conflict between the discussion in Section 2.8 of the Event Tree Notebook and the success criteria for low-pressure injection during ATWS appears to be caused by unclear wording in Section 2.8. Based on wording in the EOP calculation that formed the basis of the event tree success criterion, it could have been concluded that use of LP ECCS always leads to early containment failure and core damage regardless of RPT success, but this was not the intent. The wording in Section 2.8 has been clarified to indicate that low-pressure makeup cannot prevent core damage if the RPT is failed.

2. Accident sequences that lead to core damage from insufficient low-pressure injection have been added to the ATWS event tree. The ATWS event tree also includes sequences that lead to core damage if the operator fails to take control of LP RPV injection.

3. The ATWS event tree has been revised to specify core damage, vessel failure, and COPF if the operator fails to take control of low-pressure makeup.

EPU/SAMA PRA Model Comment: For the most part, the original disposition is still applicable. Additionally, the sequence modeling following core damage has been expanded to include more than just LERF and non-LERF end states as described in the updated event tree notebook.

Element: AS Subelement: 9 Observation 1 INDEX: 26

Injection Without Heat Removal

Sequences involving no available heat removal result in SRVs reclosing as containment pressure exceeds 82 psig. For such sequences, a high pressure injection source is required for core damage prevention. CRD is such a viable long term injection source.

CRD should be credited consistently in the ability to prevent core damage when no heat removal is available and adequate core cooling has been maintained for an extended time by other means.

For TR-3 Branch 35 – only CRD is a success?

For TR-8 Following Branch 14 – Should CRD be credited as a success?

On branch 35 of TR-3, any of the following are currently credited as success: 1 CRD pump, condensate pump, fire pump, or RHRSW pump. This appears incorrect since the SRVs would reclose on high containment pressure causing SRVs to close and the RPV to repressurize. For TR-3 Branch 35, only CRD is capable of injection prior to containment overpressure failure because the RPV repressurizes. This node should be re-evaluated because it apparently credits a low pressure system as a success (i.e., RHRSW).

On branch 14 of TR-8, availability of 1 CRD pump would provide success, but at this time it is only credited on Branch 1 along with the other low pressure injection systems. The fact that CRD will continue to inject after SRVs close on High DW pressure is not included in the event tree logic. It is recommended to include CRD as a separate Top, after the containment vent top. If CRD is available and the vent fails, then core damage could be avoided on the COPF branch. For TR-8, CRD would be a success following Branch 14. This should be credited. This will reduce conservatism in this sequence. A branch for late injection should be added to credit CRD here.

PPL indicated that this is currently under investigation to be added to the model. Note CRD pumps are located in the Turbine Building and are therefore not subjected to the adverse environment in the R.B. following vent or containment overpressure failure (COPF).

Disposition:

Event Tree TR-2, High-pressure boil off, has been modified to include a top event which checks for availability of 2 CRD pumps to save the vessel in scenarios where HPCI, RCIC, FW, and ADS are failed.

Success criteria for extended high-pressure makeup (HP makeup after 4 hours) in the Event Tree Notebook have been revised to include 2 CRD pumps. Two CRD pumps can maintain the core covered at high reactor pressure for times greater than 4 hours.

Therefore, the extended high pressure makeup top event (LATE_INJ2) has been revised to include functional success (i.e., no core damage) if 2 CRD pumps are available in sequences where the vent fails and SP Cooling is unavailable. Failure of the containment vent leads to DW pressure >82 psig which causes SRVs to close on insufficient gas supply pressure. The reactor repressurizes until SRVs open in safety mode via springs. Injection from 2 CRD pumps prevents core damage in sequences of this type. LATE_INJ2 has been revised to fail injection from Condensate, RHRSW, and fire pumps if the vent fails because SRVs will close and reactor will repressurize. This revision has been incorporated into the event trees (TR-3, TR-5, and TR-8).

It is not necessary to check for availability of CRD injection after branch 14 on TR-8 because extended high-pressure makeup (high-pressure makeup after 4 hours) has been revised to be successful if 2 CRD pumps are available (see Revision 5 to §A.9). Since it has already been determined that extended high-pressure makeup is failed before TR-8 is entered (determination is made on branch 10 of main transient tree in Appendix A), it is not necessary to check for availability of 2 CRD pumps again after branch 14 on TR-8.

EPU/SAMA PRA Model Comment: For the most part, the original disposition is still applicable. Additionally, all of the success criteria have been re-examined and re-developed using MAAP as described in the updated event tree notebook.

Element: AS Subelement: 22 Observation 1 INDEX: 31

Core Damage

The definition of core damage is critical to the quantification process and the understanding of the resulting risk measures. (As background, see Attachment AS-22A)

The PSA Applications Guide offers a core damage definition of the following:

> A state of "Uncovery and heatup of the reactor core to the point where prolonged clad oxidation and severe fuel damage is anticipated."

The ASME PRA Standard provides an example definition:

> Collapsed liquid level less than 1/3 core height or code-predicted peak core temperature >2,500^{O}F (BWR)

Finally, an alternative definition of severe core damage used in many BWR PRAs is:

> RPV water level below 1/3 core height
>
> AND
>
> Core nodal temperature (using a nodalization like MAAP) to be greater than 1800°F for more than 1 min.

To this could be added the criteria regarding excessive reactivity insertion to require it to be less than 280 cal/sec.

The Susquehanna PRA uses a core damage definition for ATWS events that:

NEDE-24222 demonstrates significant margin to 10 CFR 50.46 fuel limits for non-oscillation ATWS event and these are not considered core damage events in the Susquehanna PRA. However, due to the potential for fuel cladding dryout and clad melt, any ATWS which exhibits unstable core power oscillations is assumed to lead to gross clad failure in multiple fuel pins and is defined as a core damage event.

The above definitions are quite close and all are generally consistent. The Susquehanna definition is the most restrictive and results in the possibility of assigning “core damage” to states where there is large flow/power oscillations (“instabilities”) due to ATWS conditions.

Disposition:

A formal calculation was performed to document a revised ATWS core damage criterion for use in the PRA. This criterion is related to the amount of time before feedwater flow is reduced to suppress large power oscillations that can result in excessive cladding temperatures. PPL also defines core damage as core nodal temperature greater than 1800°F.

EPU/SAMA PRA Model Comment: The scenarios in question that result in unstable core power oscillations that are assumed to lead to gross clad failure in multiple fuel pins have been redefined as fuel damage events (rather than core damage events), and are not included in the reported core damage frequency. This is more consistent with standard BWR industry practice. These sequences are maintained, however, in the Level 2 model evaluation to determine their impact on the release characterization.

Element: DA Subelement: 15 Observation 2 INDEX: 130

Conditional LOOP

LOOP given a scram and LOOP given a LOCA event have not been included in the model.

Disposition:

The fault tree was revised to incorporate the conditional LOOP given LOCA and LOOP given a trip. The conditional probability for LOOP given LOCA is 2.4E-2 and for LOOP given plant trip is 2.4E-3. The referenced letters from the Office of Nuclear Regulatory Research provide the bases for these numbers. The Kuritzky letter (June 14, 2002) provides a basis for the LOOP given plant trip. The Thadani letter (July 31, 2002) establishes a factor of 10 difference between the two conditional probabilities with the LOOP given LOCA being 10 times higher than LOOP given plant trip. Therefore the conditional probability of a LOOP given a LOCA is 2.4E-2. Erin Engineering is also using these values in the risk models for the Exelon plants.

EPU/SAMA PRA Model Comment: None. The original disposition is still applicable.

Element: DE Subelement: 8 Observation 1 INDEX: 45

2nd DC Bus Failure

The CCF of a 2nd DC Bus failing given failure of the first is considered underestimated. Consider use of NUREG-0666 or alternative to assess.

1. Common Hardware issues
2. Common Environment
3. Crew error is post initiator repair actions

Disposition:

The final analysis of the F&O concludes that the CCF value used in the model is adequate.

The CCF number used in the model is not directly comparable to the value listed in NUREG – 0666. The NUREG – 0666 value, 6E-5, for the CCF of two buses failing is a probability for two buses failing per reactor year and is considered the total probability of two buses failing. The total probability is the sum of the probability of A bus failing and the CCF probability for B bus failing plus the probability of B bus failing and the CCF for the A bus. The two bus CCF value used in the SSES model is 9.88E-9. This number is based on CCF multiplier from NUREG/CR-5485 adjusted for run time common cause failure by dividing the Table 5-11 value by 2 and the independent failure rate of 1.166E-7, reference EC-RLIB-0504 p. 18.

To make a valid comparison, the model number will be adjusted for total probability and expressed in terms of a yearly frequency. Also NUREG – 0666 only addresses a CCF of two buses while the model has CCF for 2, 3, and 4 buses. The CCF for the 3 and 4 buses failing must be added to the CCF for the two buses failing since any failure mode that can fail 3 or 4 buses will also fail two buses.

Model Data

CCF for 2 of 4 buses 9.88E-9

CCF for 3 of 4 buses 4.67E-9

CCF for 4 of 4 buses 2.59E-8

CCF for 24 hours	Total CCF probability for 24 hours	Total CCF probability for one year
CCF probability for 2 of 4 buses * # of combinations of 2	9.88E-9*6 = 5.93E-8	
CCF probability for 3 of 4 buses* # of combinations of 3	4.67E-9*4 = 1.87E-8	
CCF probability for 4 of 4 buses* # of combinations of 4	2.59E-8*1 = 2.59E-8	
Total	1.04E-7	1.04E-7*365= 3.79E-5

Hence, the equivalent “model” CCF is 3.79E-5 and is somewhat lower than the NUREG – 0666 value of 6E-5. However, the NUREG number includes common cause due to closing a tiebreaker between DC buses, which is cited as causing most of the two bus failures. Since SSES does not have any tiebreaker between DC channels, this failure mode does not need to be considered. Recognizing that “most” dual failures were attributable to closing the bus tiebreaker it can be reasonably assumed that the other dual bus failures would have amounted to less than 3E-5 per year. Therefore it is concluded that the SSES dual DC bus failure CCF value of 3.79E-5 compares well with the value from NUREG – 0666, 3E-5, and does not need to change as a result of this F&O. Thus, no change to the model is required.

EPU/SAMA PRA Model Comment: None. The original disposition is still applicable.

Element: HR Subelement: 10 Observation 1 INDEX: 53

MRI

The model takes significant credit for Manual Rod Insertion (MRI). SSES has made a plant modification to make this action more efficient and easier to perform. This is a very positive reflection of the active risk management program at PPL.

The MRI action has been reassessed with revised timing by PPL reflecting the power uprate condition and the latest T&H calculations. The HEP was readjusted using the IPE HRA methods to reflect the latest timings (time available). However, the following items are considered not to have been assessed as part of the analysis:

Confirmation of the feasibility of the assumed manipulation and diagnosis time by simulator observation.

Confirmation that sufficient manpower is available within the time frame.

Confirmation that the T&H case performed adequately models that situation. Specifically, for the events involving MSIV closure, does it include FW coastdown,

enhanced CRD injection, maximum HPCI and RCIC flows

Failure of CST refill

Finally, the success of MRI in overcoming the mechanical common cause failure is difficult to assess and has not been attempted by other BWR utilities. It involves an assessment of the conditional failure probability of MRI to insert control rods given a mechanical common cause failure to scram has occurred due to the following:

Core barrel tilted or loose and was the cause of the control rod and fuel movement that caused binding of the control rods.

Other mechanical failures that interfere with control rod movement.

Disposition:

1. Based on simulator data (seventeen data points) for MRI during an ATWS, MRI initiation times range from 5 minutes to 12.5 minutes with only one data point exceeding 12 minutes. In the PRA, Manual Rod Insertion must begin by 12 minutes or it is considered to be failed. The operator failure rate for initiation of MRI within 12 minutes is specified as 0.061 in the PRA (Susquehanna Human Reliability Analysis Notebook). This error rate shows excellent agreement with the available simulator data. Using a lognormal distribution, the error rate based on simulator data is 0.066.

2. Simulator exercises demonstrate that sufficient manpower would be available in the control room to initiate MRI during an ATWS event.

3. Thermal-hydraulic calculations for reactor shutdown via MRI account for continued feedwater injection after the MSIVs are closed. In a SABRE code analysis, feedwater continues to inject to the RPV for 100 seconds after the MSIVs are closed. At 100 seconds into the event, the SABRE model indicates that steam line pressure decays to the point where it can no longer power the feedwater turbines. As discussed in calculations supporting the Emergency Procedures, successful shutdown via MRI requires operator action to throttle HPCI injection by 20 minutes. Prior to 20 minutes, full HPCI and RCIC flow (5600 gpm) is assumed. CRD flow is not included in the SABRE Run; however, the CRD injection rate is very small (63 gpm) compared to full HPCI and RCIC flow (5600 gpm). Success of MRI also requires makeup to the CST within 18 minutes using demineralized water transfer pumps and a condensate pump.

4. The PRA has been revised to include failure of MRI due to control cell friction caused by channel bow. MRI failure due to channel-bow induced friction is deemed possible and its probability is specified as 0.5. The probability of MRI failure due to core barrel tilt is expected to be orders of magnitude smaller than that assigned for channel bow, and therefore, this effect is already included in the specified failure probability of 0.5.

EPU/SAMA PRA Model Comment: Based on MAAP calculations for both pre-EPU and EPU conditions and a revised success criteria requirement to maintain the pool temperature below 260^{O}F for early ATWS conditions, MRI is no longer credited for success at all in these scenarios. MRI is only credited for success if the condenser is maintained available.

Element: HR Subelement: Observation 3 INDEX: 56

MANUAL LOCAL RECOVERIES

There is extensive use of local manual recoveries in the assessment of RHR for suppression pool cooling and RHRSW for very late RPV injection. The following 6 items are of note:

1. The HEPs apply at long times

2. The HEPs are quite low (6E-4)

   Disposition: Both observations are correct. All non-ATWS sequences in the PRA model require local valve manipulation at a time period of greater than 5hrs. Applying Table 5-54 of the Human Reliability & Safety Analysis Handbook; Gertman

& Blackman; 1994, the data only goes out to 300 minutes. For HEP evaluation >300 minutes, as is the case in our PRA model, the reference instructs use of the 300 minutes human error probability of 6E-04. For ATWS sequences that would require valve manipulation <300 minutes, values are used from the same referenced table for the appropriate time. The ATWS valve recovery times are logically differentiated in the model as required per the sequence into HEP values corresponding to 2, 3.4, and 5 hours. No model changes required.

3. The HEPs need to be dependent on the HEP for suppression pool cooling initiation (i.e., applies to the use of HEPs for RHRSW injection initiation)

   Disposition: An extensive HEP dependency analysis was performed on the PRA model. All significant dependent HEP combinations (HEP combinations recurring in the top 1500 cutsets) have been analyzed and incorporated into the PRA model.

4. The access, cue, timing, training, manipulation time need to be addressed for each valve or group of valves under the assumed conditions.

   Disposition: The HEPs given to these groups of valves rely not only on the research conducted by Gertman and Blackman (Human Reliability & Safety Analysis Handbook; Gertman & Blackman; 1994), but also on the large time available to complete the local recovery based on thermal-hydraulic accident analyses performed. Manipulation time is assumed negligible when compared to available time. Operator qualification is assumed to be sufficient training (also based on available time).

   Valve use and access is described in parts 5 and 6 of this response.

5. Specifically, has the valve been physically manipulated locally to demonstrate that it is feasible to accomplish the assumed action.

   Disposition: The valves have been physically manipulated locally at least once during start-up testing.

6. A specific access related issue that should be addressed on an accident sequence specific basis is the following related to high radiation:

6a. For ATWS scenarios it should be assumed that noble gases are present in the containment causing both shine and leakage related radiation in the reactor building. Under such conditions, access to the SPC return valves and RHR HX valves may be compromised. (See HR-12-4)

6b. For core damage events, the HEPs for local action are even more in question because of the high radiation environment likely to exist.

   Disposition: High radiation considerations in questions 6, 6a, and 6b have been handled as follows: Manual valve recoveries have been logically updated in the model as guaranteed failed in sequences where core damage occurs prior to valve recovery via local manipulation. The assumption in the PRA model is that operators will not operate the valves locally if core damage has occurred.

EPU/SAMA PRA Model Comment: The original disposition is still applicable. Additionally, the HEPs and dependent HEPs have been updated for EPU conditions as described in the HRA notebook.

Element: HR Subelement: Observation 4 INDEX: 57

ATWS – RHR Recoveries-Local Manual Actions

For ATWS, we cannot preclude core fuel perforations and radiation in the containment. This plant state may preclude crew actions to effectively complete the local action because of health physics concerns i.e., high radiation to personnel.

Disposition:

The PRA model was changed such that no credit is given for manual recovery of Rx Bldg valves if core damage has occurred. Impact on U1 & U2 PRA models determined to be minimal upon implementation and sensitivity analysis. Manual recovery of Rx Bldg valves is credited if core damage has not occurred.

EPU/SAMA PRA Model Comment: None. The original disposition is still applicable.

Element: HR Subelement: 16 Observation 1 INDEX: 58

CONTROL OF HPCI/RCIC

After 4 hours into an SBO with successful load shed, 250 VDC may be unavailable. This creates the need to control HPCI and RCIC flow such that they do not trip and require restart. The ability to perform such control actions does not appear to be included as an HEP.

This same issue may also be present prior to 4 hours in an SBO w/o successful 250V DC load shed.

Disposition:

An HEP for operator failure to control level was developed, analyzed, documented, and included in the PRA model. Nothing further required for this F&O.

EPU/SAMA PRA Model Comment: None. The original disposition is still applicable.

Element: HR Subelement: 16 Observation 2 INDEX: 59

250 VDC LOAD SHED

One of the assumptions used in the model is that procedure EO-100-030 is implemented to shed 250VDC loads. There is currently not an explicit HEP in the model to represent the failure of this action and the consequential inability to achieve at least 4 hours of HPCI/RCIC operation.

The procedure directs this to be accomplished after 30 min and before 45 min.

Disposition:

Created new HEP - Operator fails to shed 250VDC loads. This 250VDC load shed only impacts Unit 1. Unit 2 does not require 250VDC load shed because Unit 2 has a separate non-1E battery bank. Incorporated new basic event into the PRA model and updated the HRA Notebook with all information relevant to this HEP. This F&O and resolution is a copy of F&O Index 2.

EPU/SAMA PRA Model Comment: None. The original disposition is still applicable.

Element: HR Subelement: 17 Observation 1 INDEX: 60

Recovery

Manual manipulation of valves has been included in the model with very high reliability.

The valves and their manipulation need to be examined for:

1. Accessibility

2. Time Available
3. 3. Cue
4. 4. Time Required
5. 5. Environment

These performances shape factors are not currently documented in the HRA.

Disposition:

This F&O is covered by F&O Index 56. The analysis and actions performed to resolve the F&O Index 56 correspondingly resolve this F&O as well. See resolution to F&O Index 56.

EPU/SAMA PRA Model Comment: None. The original disposition is still applicable.

Element: HR Subelement: 26 Observation 1 INDEX: 65

ATWS HEP DEPENDENCY (see HR-26-2)

The HEPs that model response to ATWS may have dependencies that are not yet explicitly addressed. These dependencies can be incorporated into the model by:

Making the actions dependent (conditional); “hardwire” the conditional probabilities

OR

Performing a second HEP dependent sensitivity case with RPS mechanical failure set higher than 2.1 E-6. This will allow the ATWS HEPs to be included in the top cutsets examined.

Disposition:

A full SSES PRA HEP dependency analysis was completed for <u>all</u> HEPs in the model (which includes ATWS HEP dependencies addressed/questioned in this F&O.) All updated HEP dependency analyses are documented in the HRA notebook and are included in the model.

EPU/SAMA PRA Model Comment: The original disposition is still applicable. Additionally, the HEPs and dependent HEPs have been updated for EPU conditions as described in the HRA notebook.

Element: HR Subelement: 26 Observation 2 INDEX: 66

ATWS (see HR-26-1)

ADS inhibit and SLC Failure may need to be treated explicitly

They can show up together. Their combination may not have been captured in the dependent HEP assessment.

(There may be a need for a diagnosis error that applies to all ATWS HEP combinations.)

Disposition:

A full SSES PRA HEP dependency analysis was completed for all HEPs in model (which includes the specific HEP dependencies addressed/questioned in this F&O.) All updated HEP dependency analyses are documented in the HRA notebook and included in the model.

EPU/SAMA PRA Model Comment: The original disposition is still applicable. Additionally, the HEPs and dependent HEPs have been updated for EPU conditions as described in the HRA notebook.

Element: IE Subelement: 5 Observation 3 INDEX: 73

Initiating event Loss of Drywell Cooling (LDWC) is not modeled because "The drywell chillers provide cooling to the drywell during normal operation. If they are lost, a manual SCRAM or, ultimately an automatic SCRAM, on high drywell pressure will occur. No safety systems are affected. Loss of the drywell chillers is considered to be bounded by the turbine trip initiating event."

But, HPCI initiation occurs from High Drywell Pressure Relays 95E211K5A/B and 95E211K6A/B. This initiating of HPCI would more likely cause a level 8 trip, which causes a feedwater trip.

Disposition:

Loss of drywell cooling leads directly to high drywell pressure resulting from the increased drywell temperature. The high drywell pressure condition causes the HPCI system to initiate and begin reactor vessel injection, an event that would be very similar to an inadvertent HPCI startup initiator. The inadvertent HPCI startup initiator is evaluated in Section 15.5 of the SSES FSAR. The reload licensing analysis evaluation of the inadvertent HPCI start event from rated conditions concludes that the level control system is expected to reduce feedwater flow in time to prevent reactor vessel level from reaching the level 8 trip setting.

The reload licensing analysis also concludes that the inadvertent HPCI start at normal power level is similar to the loss of feedwater heating (LFWH) event. This conclusion is based on the fact that the feedwater flow reduction resulting from decreased feedwater demand combined with the low injection enthalpy of the water injected by the HPCI system will cause an increase in core inlet subcooling. In the event that the Level 8 trip and subsequent scram does not occur (as the full power analysis shows), the reactor stays at power and the event is not considered an initiating event for the PRA. If the lower power HPCI initiator causes a Level 8 trip, the result is a turbine trip. The inadvertent HPCI initiation event initiator is already classified as a turbine trip with bypass initiator in the PRA (see Appendix A, Section 2.6 of the Initiating Event Notebook, EC-RISK-1121, revision 0), thus, no further action is warranted.

EPU/SAMA PRA Model Comment: None. The original disposition is still applicable.

Element: IE Subelement: 6 Observation 2 INDEX: 75

Dual Unit Effects

Dual unit effects and insights with a single diesel operating should be included in the summary notebook discussion (as sensitivities if desired) to address:

Effects of switching RHR high AMP loads

On RHR Motors

On D/G

RWST adequacy to support

Loss of SW on Unit 1

Loss of Instrument Air on Unit 1, should also be discussed

Disposition:

A dual unit shutdown with less than 4 diesels would require cycling the RHR pumps on and off in each unit for suppression pool cooling due to the present electrical restrictions on the bus and DG. Only one RHR pump is presently allowed to be on any one channel for both units. This process is required per Susquehanna Operating Procedure. Thus, the dual unit shutdown will not change the generated cutsets (results). This discussion covers the dual unit effects on:

- Effects of switching RHR high AMP loads
- On RHR Motors
- On D/G

The dual unit effects of requiring makeup from the RWST have been addressed in the event tree notebook in the development of the success criteria. Therefore the dual unit effects on the RWST have been addressed.

The loss of service water and the loss of instrument air on Unit 1 really have no dual unit effects. There is outage capability to cross tie certain service water loads between units but this cross tie is normally closed and is not credited in the PRA. The instrument air system can be cross-tied between units but this is not normally done and again is not credited in the PRA. Therefore there are no dual unit effects on service water and instrument air.

EPU/SAMA PRA Model Comment: None. The original disposition is still applicable.

Element: IE Subelement: 15 Observation 1 INDEX: 92

A grid reliability of GR1 was selected for Susquehanna. Do calculations and procedures exist that verify black start capability from off-site power within 30 minutes?

Disposition:

The Initiating Event Note Book only cites GR1 as one of two comparisons to the grid loss frequency used in the model. The main comparison was against actual PJM experience. As discussed in the response to F&O Index Number 88, the Susquehanna LOOP initiation frequencies and recovery times provide reasonable results compared to the results which would be obtained if INEEL/EXT-04-02326, “Evaluation of Loss of Offsite Power Events at Nuclear Power Plants: 1986-2003” were used as a basis for LOOP initiation frequency

EPU/SAMA PRA Model Comment: The updated pre-EPU and EPU models have been revised to utilize the information from INEEL/EXT-04-02326 directly for the LOOP initiating event frequency and failure to recover probability values.

Element: MU Subelement: 4 Observation 1 INDEX: 115

The monitoring and collection of new information for an update is not presently a fully implemented and controlled process. The update guidance procedure provides for sending a model update information package to designated site personnel but does not establish a process for interface with the operator training program to ensure that insights are reviewed with the plant operators and EOOS support personnel. This may provide additional feedback pertaining to the fidelity of the PRA model.

Disposition:

Subsequent to the peer review, the above mentioned PRA maintenance and update procedure (NDAP-QA-1002) was formally issued. The purpose of this procedure is to define the basic process used by PPL to develop, control, and update the Susquehanna Probabilistic Risk Assessment (PRA). The procedure provides criteria to determine when updates are needed plus requirements for the PRA group to review changes in plant procedures and plant modifications to ensure the PRA continues to be consistent with the as-built / as-operated plant. The procedure also provides requirements for communicating PRA results to the organization, including Training, Work Management, Operations, Nuclear Regulatory Affairs, the Maintenance Rule expert panel, and station management. A revision to the maintenance and update procedure made after the peer review requires that the Training group be informed of significant PRA changes (risk significant systems, risk significant operator actions, risk significant scenarios, etc.).

Training modules on risk concepts have been developed and presented to Engineering, Operators, and the STAs. Other training has been provided to Work Management and the STAs (users of EOOS). Significant changes to the model would be reflected in the training modules.

EPU/SAMA PRA Model Comment: None. The original disposition is still applicable.

Element: MU Subelement: 6 Observation 1 INDEX: 117

No detailed process has been established for the configuration control of the PSA model files including backup, storage and retrieval from a secure controlled location. Also, no formal benchmark process has been established to validate that retrieved model files are satisfactory for use in performing an application.

Disposition:

Three procedures are currently in place for management of controlled model files. These controls will apply to the CAFTA developed model and it’s associated files. PPL’s SQA procedure is the primary procedure that addresses control of software and data products. This procedure requires that all controlled data sets (i.e. PRA models) be placed in a "QA" data directory. PPL has established a directory that will be used to store the controlled PRA models. The SQA procedure also requires that controlled files must be documented, reviewed, and approved prior to being released for use.

The documentation for the PRA models will be done in accordance with PPL’s recorded calculation procedure. Once the controlled files are moved into the QA directory, access permissions are set to “Read Only”, preventing unintentional changes and assuring that the files as documented will be the same files that will be used in application calculations.

Finally, the PPL SQA procedure requires that a data custodian be established for all controlled data files. The data custodian will be notified of system or environment changes that may impact the correct operation of the data file. The data custodian will be notified prior to changes to the PPLNet environment so that he or she can evaluate the impact of the change. This protocol will assure that the controlled files will continue to yield the expected results.

EPU/SAMA PRA Model Comment: None. The original disposition is still applicable.

Element: MU Subelement: 11 Observation 1 INDEX: 119

A process for review of prior PRA applications has not been fully implemented.

Disposition:

A process for review of prior PRA applications has been implemented through procedure NDAP-QA-1002. NDAP-QA-1002 states that, following a PRA Model Update, an information package describing the changes, the new PRA Taxonomy (risk significant operator actions and systems, and most risk significant MOV's and AOV's, ISI inputs, etc.), and the review of previous applications shall be prepared. This information package shall be transmitted to the following individuals via a calculation package so that review by each is formally documented:

1. Manager – Nuclear Fuels & Analysis
2. Manager – Station Engineering
3. Manager – Work Management
4. Manager – Nuclear Operations
5. Manager – Nuclear Regulatory Affairs
6. Manager – Nuclear Design Engineering
7. Manager – Nuclear Training
8. Manager – Quality Assurance
9. General Manager – Nuclear Assurance
10. General Manager – Nuclear Engineering
11. VP-Nuclear Operations
12. Nuclear Records
13. PORC Secretary
14. Supervisor NDE - SSES

EPU/SAMA PRA Model Comment: None. The original disposition is still applicable.

Element: MU **Subelement:** **Observation 1** **INDEX:** **120**

Sufficient documentation reflecting the process used for configuration control of the current PRA model update and maintenance does not exist. This detailed documentation of the update process is important to the configuration control and traceability of the model changes and review process provided for on PRA model update.

Disposition:

Subsequent to the peer review, NDAP-QA-1002, was formally issued. The purpose of this procedure is to define the process used by Plant Analysis to develop, control and update the Susquehanna Probabilistic Risk Assessment (PRA). Details on the process used to develop the current SSES PRA are provided below.

The current PRA model is documented and controlled under PPL QA procedures. All documentation packages include an independent technical review and final approval by qualified PPL engineers. Extensive model documentation includes:

1. Individual System Notebooks for all key systems important to risk (e.g. HPCI, RCIC, ADS and MSIVs, RHR, Electrical Distribution system, etc.),

2. Event Tree Notebook which documents the accident or transient progression from an initiating event to a plant damage state,

3. Initiating Events Notebook which documents the initiating events which are considered in the Susquehanna PRA and their associated frequencies,

4. Human Reliability Notebook which identifies human actions and their associated failure probabilities,

5. Dependency Matrix Notebook which provides an overall summary of the inter-relationships of plant systems

6. Internal Flooding Notebook which identifies the impact of internal floods on key equipment and equipment or train availability, and

7. Summary Notebook which documents the final PSA model including all software files developed as part of the model and the sensitivities on key input parameters.

Changes to any of the above documentation packages is also done under PPL QA procedures. As with the initial preparation, all changes are prepared, independently reviewed and approved prior to releasing the revised model for general use by plant personnel.

Plant procedures are in-place which assure that the Plant Analysis group will be informed of any plant or procedure changes which may affect the current risk model. If changes are warranted, all affected documentation will be revised to assure the PRA reflects the current as-built, as-operated plant.

The fault tree model and associated databases, which are developed and documented in the packages discussed above, are controlled via applicable PPL QA procedures. These procedures provide requirements and guidance for configuration control. After these files have been developed and approved for use, the model files are stored in special directories to prevent inadvertent changes by users.

The software used for risk analysis is controlled and documented in accordance with PPL QA procedures. These procedures provide requirements that must be met for all quality-related software, including configuration control of the software and future updates. Documentation packages have been developed for all risk analysis software to document the procurement, installation, verification and validation and configuration control of this software. Changes to the software must be documented in revisions to these software packages and are thus subject to independent technical review and approval prior to their use in risk related analyses.

EPU/SAMA PRA Model Comment: None. The original disposition is still applicable.

Element: QU Subelement: 9 Observation 1 INDEX: 33

Common Cause of 4 EDGs and D/G "E"

The CCF of the 5th D/G may be too conservative. This dependency should be assessed considering diverse features of the D/G "E."

- Location
- Environment
- Manufacturer

- Design
- Maintenance Practices

Disposition:

This F&O states that the Common Cause Failure (CCF) probability of the fifth diesel may be too conservative. The CCF probability for the diesel generators was developed from NUREG/CR-5497. The CCF probability for the E diesel generator (E DG) is a conditional probability of it failing given one or more of the A – D diesel generators fails. The CCF probability for the A – D diesel generators is based on a group of four while the CCF probability for the E diesel generator is based on a group of 5. There is not much of an argument to be made for maintaining that the E DG should have a different CCF probability because:

- The E DG is manufactured by Cooper Bessmer as are the A – D
- The E DG model type is KSV as is the model type of the other four, except that DG E has 20 cylinders and the A – D have 16.
- The same maintenance practices are used on all five DGs.

Therefore, the CCF currently being used is considered appropriate.

EPU/SAMA PRA Model Comment: For the most part, the original disposition is still applicable. However, the common cause failure probabilities have been updated to utilize the most recently available CCF alpha-factor information from INEEL.

Element: QU Subelement: 14 Observation 1 INDEX: 34

The Summary Document does not identify how circular logic is identified and resolved in the PRA model. A consistent means of highlighting circular logic paths in the model, such as a gate naming convention, is not being employed.

Disposition:

Circular logic breaks are discussed in the Summary Notebook, which has been prepared, reviewed and approved per PPL documentation procedures. However, the model is not completely consistent with regard to a gate naming convention for circular logic. It should be noted that if circular logic exists in the model, the fault tree will not quantify. The naming convention does not affect the model results.

EPU/SAMA PRA Model Comment: None. The original disposition is still applicable.

Element: QU Subelement: 19 Observation 1 INDEX: 35

Designed Documentation

Using the fault tree recovery method allows for sequence based recoveries. This portion of the quantification is the least documented. The tree is large enough to require a documentation section.

Disposition:

The Summary Notebook section discussing recoveries was expanded following the Peer Review to include more detailed discussions of the approaches used for using sequence based recoveries in the model.

EPU/SAMA PRA Model Comment: None. The original disposition is still applicable.

Element: QU Subelement: 31 Observation 1 INDEX: 39

The PSA results summary should identify dominant contributors

A detailed description of the Top 10 accident cutsets should be provided because they are important in ensuring that the model results are well understood and that modeling assumption impacts are likewise well known.

Similarly, the dominant accident sequence groups or functional failure groups should also be discussed. These functional failure groups should be based on a scheme similar to that identified by NEI 91-04, Appendix B.

Disposition:

A discussion of the top 10 cutsets is included in the Summary Notebook. The "SCHEME SIMILAR TO THAT IDENTIFIED BY NEI IN NEI 91-04" would require revising the event trees for different plant damage states. The plant damage states as defined for SSES are technically adequate and do not require revision to resolve this F&O.

EPU/SAMA PRA Model Comment: The original disposition is still applicable. Additionally, the expanded Level 2 modeling utilizes release characterizations that are more in line with BWR industry standards.

Element: QU Subelement: 34 Observation 2 INDEX: 41

The PRA model update is still in progress and will require a comprehensive review once the model is finalized to ensure consistency between the model content and all supporting documentation, including the results presented in the Summary Document.

Disposition:

The Summary notebook was in draft form when the Peer Review Team evaluated it. It was since issued as a formal calculation (prepared, reviewed and approved per PPL documentation procedures) in April 2004. The model content, supporting documentation, and detailed model results were provided in the calculation.

EPU/SAMA PRA Model Comment: The original disposition is still applicable. A detailed summary notebook is completed for each model revision.

Element: SY Subelement: 5 Observation 1 INDEX: 141

HPCI

For transient events with the flow rate for injection relatively low, HPCI minimum flow valve could remain open and increase the drain rate from the CST.

Disposition:

The relevant technical evaluation in the Event Tree Notebook has been revised to address the effect of HPCI min-flow valve operation on CST inventory. The model now includes logic representing the timing evaluations related to the CST drain rates.

EPU/SAMA PRA Model Comment: None. The original disposition is still applicable.

Element: SY Subelement: 13 Observation 1 INDEX: 149

ADEQUATE INVENTORIES

The following "inventories" do not appear to address the demands that may be imposed under accident conditions:

250 VDC adequacy (i.e., required DC load shed which is not currently included in the model)

CST/RWST inventory is not explicitly addressed

Disposition:

The 250V DC load shed is applicable to Unit 1 only. Unit 2 does not require 250VDC load shed because Unit 2 has a separate non-1E battery bank. The system fault tree model was revised to include dependency on the 250V DC load shed by creating the new HEP where the operator fails to shed 250VDC loads. Incorporated new basic event into PRA model and updated the HRA Notebook with all information relevant to this HEP.

Event Tree Notebook has been revised to address CST/RWST inventory. Effect of HPCI min-flow valve operation on CST inventory is also addressed in the Event Tree Notebook. The model now includes logic related to CST/RWST inventory demands during accident conditions.

EPU/SAMA PRA Model Comment: The original disposition is still applicable. Additionally, the updated event tree notebooks for pre-EPU and EPU conditions have been updated using MAAP including revised timing for CST inventory depletion.

Element: TH Subelement: 4 Observation 1 INDEX: 162

Technical Support (See AS-5-3)

The technical support for some of the success criteria should be re-examined to consider the following issues:

DW/T when recirc pump seal leakage is induced during an SBO

Effect of min flow valve being opened

Effect of HCL on timing of sequence

In addition, the description of the procedure directions in an SBO appear to give directions different than those assumed in the T&H calculations used in support of the PRA sequence for SBO.

Disposition:

Technical evaluation in Event Tree Notebook has been revised to address the effect of recirculation pump seal leakage on Drywell temperature response during a SBO.

Effects of RCIC and HPCI min-flow valves failed open on CST inventory are addressed in the revised Event Tree Notebook.

The effect of the HCTL on operation of HPCI and RCIC is also addressed in the revised Event Tree Notebook.

Additional discussion has been provided in the Event Tree Notebook to show that the TH calculations are consistent with the expected response of the plant in a SBO event. The discussion pertains specifically to the situation where the HCTL is reached and RCIC is the only injection system available in the plant. Based on discussion in the SBO procedure, it is not expected that the operator would deliberately depressurize the RPV in this case because the action would lead directly to core melt and vessel failure.

EPU/SAMA PRA Model Comment: The original disposition is still applicable.

Element: TH Subelement: 8 Observation 3 INDEX: 166

Charger Room Cooling

No evidence of an evaluation of charger room cooling has been performed.

It is noted that the team walkdown of the plant on Wednesday of the visit identified that the chargers were likely not subject to thermal conditions that would induce failure within the PRA mission time despite loss of ventilation based on the size of the room and its normal temperature.

Disposition:

This F&O states that no evidence of an evaluation of charger room cooling was performed. However, a formal calculation had been prepared that addresses the charger room cooling requirements. This calculation concludes that no cooling is required to the charger rooms. The calculation does require that the battery charger room doors be open prior to 6 hours from the time of loss of Control Structure HVAC. A plant off-normal procedure addresses this requirement. Therefore, the charger rooms do not require cooling which is how they are modeled.

EPU/SAMA PRA Model Comment: None. The original disposition is still applicable.

Element: DA Subelement: 4 Observation 2 INDEX: 124

A limited set of failure data was updated with plant specific data prior to 1999. The majority of the failure data is based on generic values.

Generic data tends to be more conservative than plant data. Using plant data would also help identify any potential plant outliers.

Develop program to periodically update failure data using accumulated plant data.

Disposition:

PPL intends to develop and implement, prior to a future PRA model update, a program to periodically update component failure data with plant specific data. The program will consider utilizing plant specific data to define failure rates for the most risk significant components. (HPCI, for example, will be considered as a potential candidate for update with plant specific data.)

The 'generic' values currently used in the plant PRA model are accepted industry values. Although utilizing overly conservative component failure data in the plant PRA model can theoretically distort quantification results, industry accepted component failure rates generally have the tendency (as stated in the F&0) of being somewhat conservative relative to plant data. The industry accepted data used in the plant PRA is not considered to be overly conservative (i.e., use of the generic data does not skew the results or the risk insights obtained from the PRA), and is thus deemed sufficient for risk informed applications.

EPU/SAMA PRA Model Comment: None. The original disposition is still applicable.

Element: DA Subelement: 4 Observation 4 INDEX: 126

The plant specific components receiving a data update do not include the HPCI pump which has a relatively high Fussell-Vesely importance.

Include the HPCI pump in the component population for periodic plant specific data update. Consider whether any other components merit plant specific data update.

Disposition:

PPL intends to develop and implement, prior to a future PRA model update, a program to periodically update component failure data with plant specific data. The program will consider utilizing plant specific data to define failure rates for the most risk significant components. (HPCI, for example, will be considered as a potential candidate for update with plant specific data.)

The ‘generic’ values currently used in the plant PRA model are accepted industry values. Although utilizing overly conservative component failure data in the plant PRA model can theoretically distort quantification results, industry accepted component failure rates generally have the tendency (as stated in the F&O) of being somewhat conservative relative to plant data. The industry accepted data used in the plant PRA is not considered to be overly conservative (i.e., use of the generic data does not skew the results or the risk insights obtained from the PRA), and is thus deemed sufficient for risk informed applications.

EPU/SAMA PRA Model Comment: None. The original disposition is still applicable.

Element: DE Subelement: 7 Observation 1 INDEX: 42

Missing Human Interactions (see also DE-7-3)

The human interactions that can cut across system trains and can cause failure of multiple trains due to pre-initiator should be identified and documented. (See Element HR-26)

Identify and document pre-initiator unavailabilities and ensure that it is consistently treated for all relevant systems.

Disposition:

Twenty-one pre-initiator human errors are currently documented in the HRA Notebook and are included in the plant PRA model. Pre-initiators have been evaluated for the diesel generators, LPCI, RCIC, HPCI, Core Spray, SLC, and CRD. In the model quantification, the pre-initiators contribute 3.66% of the Unit 1 CDF and 3.67% of the Unit 2 CDF with more than half of the contribution coming from the A and B diesel generators. In general, the pre-initiators are comparable to the 16 pre-initiators included in the Limerick PRA model.

With regard to this F&O, SSES HRA pre-initiators are currently deemed sufficient for risk informed applications. The pre-initiators will, however, be comprehensively reevaluated in a future model update. Adding more pre-initiators is not expected to affect the insights presently realized.

EPU/SAMA PRA Model Comment: The original disposition is still applicable although the percent contributions have changed slightly.

Element: HR Subelement: 4 Observation 1 INDEX: 50

Missing Pre-initiator Human Error probabilities.

Only a limited number of pre- initiator Human Errors are included in the fault trees.

The pre-initiators included in the model are considered to be adequate except for possible common cause events. However, further consideration of plant specific procedures could identify other pre-initiators for inclusion.

Disposition:

Twenty-one pre-initiator human errors are currently documented in the HRA Notebook and are included in the plant PRA model. Pre-initiators have been evaluated for the diesel generators, LPCI, RCIC, HPCI, Core Spray, SLC, and CRD. In the model quantification, the pre-initiators contribute 3.66% of the Unit 1 CDF and 3.67% of the Unit 2 CDF with more than half of the contribution coming from the A and B diesel generators. In general, the pre-initiators are comparable to the 16 pre-initiators included in the Limerick PRA model.

With regard to this F&O, SSES HRA pre-initiators are currently deemed sufficient for risk informed applications. The pre-initiators will, however, be comprehensively reevaluated in a future model update. Adding more pre-initiators is not expected to affect the insights presently realized.

EPU/SAMA PRA Model Comment: The original disposition is still applicable although the percent contributions have changed slightly.

Element: IE Subelement: Observation 1 INDEX: 88

LOOP frequencies developed for Susquehanna are not based on NUREG 1032.

However, EPRI database was used as a source of LOOP data for the Susquehanna area. An attempt was made to sub-divide the LOOP events into grid related, severe weather and extremely severe weather related events. This approach differs from using NUREG-1032 to develop the LOOP frequency and recovery terms. Using NUREG 1032 a value for the plant-centered frequency would be obtained and then using the correlations provided estimates for the grid-related, severe weather and extremely severe weather contributions to LOOP would be computed. The LOOP contributions due to non-plant centered events would be added to the plant centered LOOP frequency to obtain the total LOOP frequency.

Susquehanna started with a total frequency, however, rather than using NUREG 1032 to obtain additional contributions due to rare weather events, NUREG 1032 and Regulatory Guide 1.155 were used to sub-divide the total frequency into plant centered, grid related, severe weather and extremely severe weather related contribution. Comparisons to NUREG 1032 were made to valid results.

Using the Susquehanna approach, if the plant-centered LOOP frequency is 3.0E-02 per year and the plant is susceptible to severe weather events (say once every 50 years) it is likely that a severe weather event would not be included in the prior data distribution, which typically would cover a time span of 10 to 20 years. A 1 in 50 years severe weather event, according to the Susquehanna approach would reduce the plant center LOOP frequency to about 1.0E-02 per year.

The result of the Susquehanna approach is that the plant-centered LOOP frequency is less for Susquehanna than the national average (1.58E-02/yr versus 1.86E-02/yr). The Susquehanna plant-centered LOOP frequency is also less than what would be obtained using the 4 of 5 PJM events and the 2.98E-02/yr updated mean LOOP frequency (i.e., a plant-centered LOOP of 2.38E-02/yr).

Since the rare events (grid related, severe weather and extremely severe weather events) may not be included in the database used for the prior distribution, these terms should be added to the mean LOOP frequency. Since LOOP is a significant contributor to CDF, LOOP frequency/recovery will have a significant impact on results.

Disposition:

The main issue in this F&O is the inconsistency in references for the development of the LOOP initiator frequency and LOOP recoveries. A future update of the model will consider using INEEL/EXT-04-02326, "Evaluation of Loss of Offsite Power Events at Nuclear Power Plants: 1986-2003" which includes the August 14, 2003 power outage. This source of data has a LOOP initiator frequency specific to SSES and recovery curves for five different causes of a LOOP. The use of this document will provide a consistent data source for the LOOP initiator frequency and recoveries.

An assessment of the impact of the proposed change was performed by running a sensitivity case with the Grid, Extreme Weather and Severe Weather frequencies set to the INEEL values for SSES. To account for the less optimistic recoveries, the least optimistic recovery curve, extreme weather, values were manually inserted for the highest worth LOOP cutsets caused by extreme weather. The result of this effort was an increase of 10% for CDF. It is concluded, from this sensitivity case, that changing to the INEEL data would not result in a substantial change to the model results.

EPU/SAMA PRA Model Comment: The updated pre-EPU and EPU models have been revised to utilize the information from INEEL/EXT-04-02326 directly for the LOOP initiating event frequency and failure to recover probability values.

Element: IE Subelement: 5 Observation 2 INDEX: 72

Missing or incomplete documentation for exclusion.

1. Loss of GSW is not included in the fault tree. It is assumed to be no worse than the Loss of RBCCW or TBCCW. This does not account for the impact on both RBCCW and TBCCW being lost at the same time. If this has been taken into account, then the basis should be documented.

2. Medium Steam LOCA, or SORV3 (3 or more SORVs).

3. Feedwater ramp-up initiator.

4. Reference Leg break initiator should be added to the model.

Disposition:

1. The loss of general service water (GSW), referred to as normal service water (NSW or SW) at SSES, is discussed in the Initiating Events Notebook. The Initiating Events Notebook discussion states that the 'loss of normal service water is subsumed by and conservatively reflected in the loss of offsite power initiator category.'

   The conclusion that the loss of normal service water is subsumed by the LOOP event is based on the fact that the loss of normal service water event has impacts similar to those of the LOOP event (MSIV closure). Loss of normal service water is; however, less severe because the emergency on-site AC power sources are not the only AC power sources required for mitigation. In addition, the event frequency for loss of normal service water is evaluated to be much smaller than the LOOP frequency. Therefore, the loss of normal service water event is assumed to be subsumed by the LOOP event and a separate initiating event is not included in the current model. Since this approach may be slightly conservative, consideration will be given to including the loss of service water event as a specific initiating event as part of a future PRA update.

2. The Event Tree Notebook discusses the LOCA sequences in detail. A determining factor for a steam break is whether or not the high pressure makeup systems (HPCI or RCIC) are sufficient to mitigate the event and prevent core damage. Small steam breaks are defined as those breaks for which the high pressure makeup systems are required for mitigation. Large steam breaks are defined as those for which the break depressurizes the reactor vessel in sufficient time so that the low pressure injection systems (LPCI and core spray) prevent core damage. Small break events will result in success by having 3 ADS valves (to effect depressurization) and injection via low pressure injection systems. Therefore, the break consisting of three or more open SRVs will depressurize the reactor vessel and is already analyzed and considered to be a large steam break event.

3. The feedwater ramp-up initiator is discussed in Section 15.1.2 of the SSES FSAR as feedwater controller failure – maximum demand. An increase in feedwater flow at

power would lead directly to feedwater pump trips on high reactor level. Therefore, the feedwater ramp-up event is already included as part of the loss of feedwater initiator. The loss of feedwater initiator frequency includes loss of feedwater events caused by the feedwater ramp-up.

4. The Initiating Events Notebook discusses the methodology for evaluating the LOCA event frequencies (instrument line breaks are considered small steam or liquid breaks, depending on location). The frequency of breaks in the reference leg piping is part of the total frequency calculation for small liquid breaks. Breaks in the reference leg would also cause false high level signals to be generated from the affected instruments. However, the resulting high pressure in the drywell will cause the reactor to scram and the high pressure systems required for level control following LOCA (HPCI and RCIC) have redundant level instrumentation. Therefore, the false high level signal generated by the affected instrumentation would have no effect on the resulting small break LOCA event mitigation, and including a reference leg break as a specific initiating event is not required.

EPU/SAMA PRA Model Comment: For the most part, the original disposition is still applicable. However, sensitivity studies for the loss of service water and loss of instrument air events are included as part of the EPU sensitivity study evaluations.

Element: IE Subelement: 6 Observation 1 INDEX: 74

LOIA

Loss of Instrument Air can result in the shutdown of both plants and have relatively significant impacts:

MSIV closure

Loss of TBCCW

Disposition:

The loss of instrument air (LOIA) event can cause a shutdown of both units (resulting from the loss of TBCCW and the subsequent MSIV closure) only if the instrument air systems are cross-tied between the units. Operating with the instrument air system cross-tied is not a normal mode of operation at SSES, therefore, should the instrument air systems need to be cross-tied for any reason, a specific risk assessment would be required prior to such operation.

The loss of instrument air (LOIA) event is considered to be subsumed by the loss of TBCCW initiating event, as discussed in the Initiating Event Notebook. However, consideration will be given to adding the LOIA event to the SSES PRA model as an initiating event as part of a future PRA update.

EPU/SAMA PRA Model Comment: For the most part, the original disposition is still applicable. However, sensitivity studies for the loss of service water and loss of instrument air events are included as part of the EPU sensitivity study evaluations.

Element: IE Subelement: 7 Observation 1 INDEX: 76

BOC

The BOC should be retained in the quantitative model and not prematurely screened.

The BOC could be a significant LERF contributor.

Disposition:

Breaks outside containment (BOC) have not been prematurely screened. BOC's have been evaluated in the Initiating Events Notebook. The frequency of BOC events has been evaluated to be a factor of at least 15 less than the frequency of interfacing system LOCA (ISLOCA) events. ISLOCA events are included as initiating events in the current PRA model and the highest frequency ISLOCA event contributes approximately 3.5% to the overall CDF and approximately 8.4% to LERF. Based on the evaluated initiating event frequency for BOC events, BOC would contribute approximately 0.2% to CDF and 0.5% to LERF. These frequencies were evaluated as insignificant for the current PRA model for SSES. However, since BOC events have been included in PRA's performed by other utilities, PPL will evaluate adding BOC events to the PRA model.

EPU/SAMA PRA Model Comment: Due to their potential importance as LERF contributors, the BOC sequences have been added to the event sequence modeling as described in the updated event tree notebook.

Element: IE Subelement: 7 Observation 2 INDEX: 77

Loss of Instrument Air and BOCs are not modeled because of their core damage frequency contribution. Although this may be true, they should be modeled for use in Maintenance Rule A4 calculations and SDP.

Disposition:

The loss of instrument air (LOIA) event is considered to be subsumed by the loss of TBCCW initiating event, as discussed in the Initiating Event Notebook. However, consideration will be given to adding the LOIA event to the SSES PRA model as an initiating event as part of a future PRA update.

Breaks outside Containment (BOC's) were evaluated for their frequency in the Initiating Events Notebook. It was demonstrated, following the frequency evaluation, that BOC's have 'an insignificant impact on both CDF (<1%) and LERF (<1%). As such, the Break outside of Containment Initiating Events are not explicitly included in the SSES model.'

Thus, results of the current model would not be significantly impacted by including the LOIA and BOC as initiating events.

EPU/SAMA PRA Model Comment: Due to their potential importance as LERF contributors, the BOC sequences have been added to the event sequence modeling as described in the updated event tree notebook. Additionally, sensitivity studies for the loss of service water and loss of instrument air events are included as part of the EPU sensitivity study evaluations.

Element: IE Subelement: 13 Observation 2 INDEX: 89

Missing from the analysis

The results of the initiating event analysis should be compared with generic data sources to provide a reasonableness check of the quantitative and qualitative results.

Disposition:

The data sources for the event frequencies generated in the Initiating Events Notebook incorporated both SSES specific and external industry sources. The results of the SSES PRA model for CDF and LERF appear to be consistent with other industry analyses, therefore, the frequency of initiating events used in the model should not be significantly different from other analyses in the industry.

However, an examination of the SSES initiating event frequencies versus industry sources will be undertaken and documented as part of the SSES full Level 2 PRA, currently under development as part of the License Renewal and Extended Power Uprate Projects.

EPU/SAMA PRA Model Comment: This is not anticipated to impact the results of the analysis.

Element: L2 Subelement: 5 Observation 1 INDEX: 99

SUCCESS CRITERIA

If needed use RMIEP (LaSalle) NUREG/CR-5305 analysis to support success criteria decisions regarding phenomena for which no plant specific thermal hydraulic analysis is available. This includes:

- Containment overtemperature failure

Disposition:

The SSES success criteria for preventing Containment over-temperature failure are discussed in the Performance Criteria Notebook. These success criteria are considered acceptable for the current SSES PRA that evaluates CDF and LERF. Further definition of these success criteria will be considered as part of the SSES Level 2 PRA, currently under development as part of the License Renewal and Extended Power Uprate Projects.

EPU/SAMA PRA Model Comment: The timing of containment failure (including overtemperature failures) for pre-EPU and EPU conditions have been updated based on MAAP calculations as described in the updated event tree notebook.

Element: L2 Subelement: 8 Observation 2 INDEX: 101

CONTAINMENT ISOLATION

The placement of the CI node at the end of the event tree is workable. However, in certain cases (see LT2, BRANCH LT-2-3, LT-2-7, LT-2-10;TR-3 BRANCHES TR-3-1 TO TR-3-9) the event tree does not branch at CI. The end state is currently identified as core damage and a release, but it is not LERF. However, if the CI node was asked, the contribution due to LERF would be calculated.

Disposition:

The event tree package will be reexamined as part of the full SSES Level 2 PRA model development currently being undertaken as part of the License Renewal and Extended Power Uprate projects.

The LT2 branch, referenced above should reflect the LERF potential resulting from CI failure, because core damage exists on entry into LT2. Therefore, the failure of the containment isolation function would lead directly to radioactive material release and LERF.

Revising the LT2 branch to include the CI failure event as LERF will result in a minimal increase for the SSES LERF value. However, the LERF value, as evaluated by the present PRA model, is conservative. Therefore, the LERF increase resulting from the CI failure events is judged to be inconsequential to the overall result.

Adding the CI node to TR3 would have no effect on the LERF calculation. In the TR3 event, core damage does not occur until at least 6 hours following the General Emergency declaration.

EPU/SAMA PRA Model Comment: The CI node has been moved to early in the event trees for all scenarios as described in the updated event tree notebook. This allows for proper determination of the release characterization given CI fails.

Element: L2 Subelement: 10 Observation 1 INDEX: 105

CONTAINMENT OVERTEMPERATURE FAILURE(COTF)

The assumption that COTF occurs for RPV breach events without drywell sprays is considered to be too pessimistic. MAAP and MELCOR calculations for Mark II plants demonstrate substantial containment temperature and pressure capability for extended times (many hours) after RPV breach. This can occur both with LPCI/CS injection to the failed RPV or with no RPV injection. (See related comment on the definition of "early").

Disposition:

A Susquehanna specific calculation for RPV breach was added to the Event Tree Notebook (EC-RISK-1092, Appendix O, added in revision 5) concluded that the pressure generated by the water from the reactor vessel flashing to steam would result in immediate containment failure on overpressure (COPF). A MAAP input file for Susquehanna is being prepared as part of a full Level 2 PRA (being developed to support the License Extension and Extended Power Uprate (EPU) projects). The RPV breach event will be reconsidered during the development of the Level 2 PRA.

EPU/SAMA PRA Model Comment: The timing of containment failure (including overtemperature failures) for pre-EPU and EPU conditions have been updated based on MAAP calculations as described in the updated event tree notebook.

Element: L2 Subelement: 15 Observation 1 INDEX: 108

Class 4 Containment Failure

The definition of containment failure during an ATWS and its size and location should be identified. The attached discussion of ATWS-induced dynamic loads is included for your use in considering the plant specific evaluation. Attachment L2-15 provides some considerations regarding containment failure modes that may require consideration under ATWS conditions.

Disposition:

The current Susquehanna PRA evaluates Core Damage Frequency (CDF) and Large Early Release Frequency (LERF). As such, no specifics on containment failure modes or quantification of release amounts or paths are documented in the current PRA. A full Level 2 PRA, with quantification of containment failure releases and locations, is under development in support of the License Renewal project. The impact of ATWS induced dynamic loads on containment failure size and location is being included as part of the full Level 2 PRA model development.

EPU/SAMA PRA Model Comment: The timing of containment failure (including ATWS induced dynamic loads) for pre-EPU and EPU conditions has been incorporated into the event sequence modeling based on MAAP calculations as described in the updated event tree notebook.

Element: L2 Subelement: 22 Observation 3 INDEX: 112

LERF

The magnitude of the release is not included as a determining factor in the LERF definition in the SSES simplified LERF model. Only the fact that a release occurs (greater than leakage) is included as the basis for the LERF determination. This would appear to be extremely conservative.

The timing definition for LERF used for the SSES PRA is within 12 hours after a General Emergency. This is atypical in the industry (usually 4-6 hours). The bad weather evacuation for SSES may indicate as much as 9 hours. This time estimate should be made to be more consistent (i.e., not overly conservative) relative the definition in Regulatory Guide 1.174.

Disposition:

For the current SSES PRA (which evaluates CDF and LERF), no quantification of magnitude of the radioactivity release rate is performed. A full Level 2 PRA, with quantification of containment failure releases and locations, is under development in support of the License Renewal project.

The 12-hour break point for LERF following the declaration of General Emergency was judged to be overly conservative. The current version of the Event Tree Notebook re-evaluated the LERF timing definition as within 6 hours of a General Emergency declaration. Thus, the current Susquehanna PRA defines LERF as a release within 6 hours of declaration of a General Emergency.

EPU/SAMA PRA Model Comment: The pre-EPU and EPU models defines LERF as a "high" release (i.e., > 10% CsI) within 6 hours of declaration of a General Emergency. Other release categories are also defined as described in the updated event tree notebook.

Element: MU Subelement: Observation 1 INDEX: 113

The update process is currently defined by only a high level Maintenance and Update guidance procedure. The procedure does not go into effect until December 31, 2003. As such, the Peer Review team was unable to review the implementation of the Maintenance and Update process. The intent of the program as specified in the procedure was evaluated. Grades recorded that reflect the lack of an active program. The overall process is deemed inadequate for configuration control of the details of the change process and does not allow review by affected plant programs consistent with current industry practice. A detailed procedure driven process should be implemented for PRA model updates to ensure consistency in work practices and to capture detailed information such as specific model modifications performed, the revised model assembly, the quantification plan, results evaluation, required reviews and approvals, and review of prior applications.

Disposition:

Subsequent to the peer review, the above mentioned PRA maintenance and update procedure (NDAP-QA-1002) was formally issued. The purpose of this procedure is to define the basic process used by PPL to develop, control, and update the Susquehanna Probabilistic Risk Assessment (PRA). The procedure provides: criteria to determine when updates are needed, requirements for the PRA group to review changes in plant procedures and plant modifications, and requirements for documentation. The procedure also provides requirements for communicating PRA results to the organization, including Training, Work Management, Operations, Nuclear Regulatory Affairs, the Maintenance Rule expert panel, and station management. Details on the process used to develop and control the current SSES PRA are provided below:

The current PRA model is documented and controlled under PPL QA procedures. All documentation packages include an independent technical review and final approval by qualified PPL engineers. Extensive model documentation includes:

1. System Notebooks for all key systems important to risk (e.g. HPCI, RCIC, ADS and MSIVs, RHR, Electrical Distribution system, etc.),

2. An Event Tree Notebook which documents the accident or transient progression from an initiating event to a plant damage state,

3. An Initiating Events Notebook which documents the initiating events considered in the Susquehanna PRA and their associated frequencies,

4. A Human Reliability Notebook which identifies human actions and their associated failure probabilities,

5. A Dependency Matrix Notebook which provides an overall summary of the inter-relationships of plant systems

6. An Internal Flooding Notebook which identifies the frequencies and the impact of internal floods on key equipment and equipment or train availability, and

7. A Summary Notebook which documents the final PSA model including all software files developed as part of the model and the sensitivities on key input parameters.

Changes to any of the above documentation packages is also done under PPL QA documentation procedures. As with the initial preparation, all changes are prepared, independently reviewed and approved prior to releasing the revised model for general use by plant personnel.

The fault tree model and associated databases, which are also developed and documented in the packages discussed above, are controlled via applicable PPL QA procedures. These procedures provide requirements and guidance for configuration control. After these files have been developed and approved for use, the model files are stored in special directories to prevent inadvertent changes by users.

The software used for risk analysis is controlled and documented in accordance with PPL Software QA procedures. These procedures provide requirements that must be met for all quality-related software, including configuration control of the software and future updates. Documentation packages have been developed for all risk analysis software to document the procurement, installation, V&V and configuration control of this software. Changes to the software must be documented in revisions to these software packages and are thus subject to independent technical review and approval prior to their use in risk related analyses.

A more detailed procedure for documenting the PRA model assembly process could help ensure consistent model development in the future. The absence of this procedure does not have any impact on the current model results. Any changes to the current model will still need to go through the calculation process, which provides for a review and approval of the revision.

EPU/SAMA PRA Model Comment: None. The original disposition is still applicable.

Element: QU Subelement: Observation 1 INDEX: 32

A process for documenting PRA model assembly does not exist that describes how the different elements (functional top logic, event tree and fault tree development, system model integration, circular logic resolution, recovery fault tree development, mutually exclusive file development, and flag file development and model file use) of the PRA model are developed. Such documentation ensures consistency in model assembly and awareness of the process employed for future model and file updates.

Disposition:

The current PRA model and associated PRA elements are documented, reviewed and approved in calculation packages per PPL calculation procedure (with the exception of a few system notebooks for the less important systems).

A detailed written procedure for documenting the PRA model assembly would help provide consistent model development in the future. Lack of this procedure does not have any impact on the current model results. Any changes to the model will need to go through the calculation process, which provides for a review and approval of the revision. Therefore, it is not necessary to have this documentation in place to have a model that represents the "as-built/as-operated" plant.

EPU/SAMA PRA Model Comment: None. The original disposition is still applicable.

Element: ST Subelement: 5 Observation 2 INDEX: 136

CONTAINMENT OVERTEMPERATURE FAILURE (COTF)

The mechanistic treatment of containment failure due to the combination of high temperatures and pressures is not included in the structural analysis. A default conservative assumption is used.

Disposition:

A PPL recorded calculation addresses the success criteria for maintaining an intact containment on the basis of both temperature and pressure. Containment over-pressure failure (COTF) is defined to occur at 140 psig, as discussed in the calculation. Containment over-temperature failure is defined to occur when RPV melt-through occurs with the drywell floor dry and with insufficient drywell spray available. Containment failure due to COPF or COTF is evaluated on these bases in the Event Tree Notebook. However, because the current PRA model is a modified Level 1 PRA (CDF and LERF are evaluated), no quantification of containment break location or radioactivity release rate has been performed. The evaluation of containment break location and radioactivity release rates will be undertaken as part of the full Level 2 PRA model for SSES, currently under development as part of the License Renewal and Extended Power Uprate projects.

EPU/SAMA PRA Model Comment: The containment failure timings (due to COPF or COTF) have been re-assessed using MAAP as described in the event tree notebook. Probabilities have also been assigned to the location of the failures as described in the updated event tree notebook.

Element: ST Subelement: 5 Observation 3 INDEX: 137

HYDRODYNAMIC LOADS

The structural analysis does not examine the possible effects associated with containment barrier unavailability due to ATWS events that include:

- Hydrodynamic loads
- Pool bypass above temperatures above 240F (Sonin experiments) Containment vent

Stuck open tailpipe vacuum breakers

- High pool water level (and hydrodynamic loading)

See discussion associated with L2-15.

Disposition:

In the current SSES PRA (which evaluates CDF and LERF), no quantification of containment breach location or radioactivity release rate is performed. A full Level 2 PRA, with quantification of containment failure releases and locations, is under development in support of the License Renewal project. The impact of ATWS induced dynamic loads on containment failure size and location is being included as part of the full Level 2 PRA model development.

EPU/SAMA PRA Model Comment: The timing of containment failure (including ATWS induced dynamic loads) for pre-EPU and EPU conditions has been incorporated into the event sequence modeling based on MAAP calculations as described in the updated event tree notebook.

Element: SY Subelement: 4 Observation 1 INDEX: 140

The quality and content of system notebooks are good. Several other system notebooks are in various stages of development. All modeled systems should have these books completed and reviewed.

Disposition:

It was planned to develop system notebooks for the 27 systems credited in the PRA model. Of the 27, notebooks were issued for 17 of the most risk significant systems. Of the 10 remaining, five notebooks have been drafted and five have not yet been prepared. PPL intends to complete and formally document the remaining 10 system notebooks. However, given that the most important systems have been addressed by specific system notebooks and that the remaining systems are relatively straightforward to model, no significant model impacts are foreseen once the 10 remaining system notebooks are issued.

EPU/SAMA PRA Model Comment: None. The original disposition is still applicable.

Element: SY Subelement: 8 Observation 2 INDEX: 144

Missing Pre- initiator Human Errors Probabilities (HEPs)

Selected Pre- initiator Human Errors are included in the system model. PPL should ensure that the pre-initiators are examined relative to plant design and procedures and are incorporated and quantified.

Disposition:

Twenty-one pre-initiator human errors are currently documented in the HRA Notebook and are included in the plant PRA model. Pre-initiators have been evaluated for the diesel generators, LPCI, RCIC, HPCI, Core Spray, SLC, and CRD. In the model quantification, the pre-initiators contribute 3.66% of the Unit 1 CDF and 3.67% of the Unit 2 CDF with more than half of the contribution coming from the A and B diesel generators. In general, the pre-initiators are comparable to the 16 pre-initiators included in the Limerick PRA model.

With regard to this F&O, SSES HRA pre-initiators are currently deemed sufficient for risk informed applications. The pre-initiators will, however, be comprehensively reevaluated in a future model update. Adding more pre-initiators is not expected to affect the insights presently realized.

EPU/SAMA PRA Model Comment: None. The original disposition is still applicable although the percent contributions have changed slightly.

E.3 LEVEL 3 PRA ANALYSIS

This section addresses the critical input parameters and analysis of the Level 3 portion of the probabilistic risk assessment. In addition, Section E.7.3 summarizes a series of sensitivity evaluations to potentially critical parameters.

E.3.1 Analysis

The MACCS2 code (NRC 1998a) was used to perform the Level 3 probabilistic risk assessment (PRA) for the Susquehanna Steam Electric Station. Susquehanna specific parameters are used for population distribution and economic parameters. Other input parameters given with the MACCS2 “Sample Problem A”, formed the basis for the present analysis. Plant-specific release data included the time-dependent nuclide distribution of releases and release frequencies. The behavior of the population during a release (evacuation parameters) was based on plant and site-specific set points. These data were used in combination with site-specific meteorology to simulate the probability distribution of impact risks (both exposures and economic effects) to the surrounding 50-mile radius population as a result of the release accident sequences at Susquehanna.

E.3.2 Population

The population surrounding the Susquehanna site was estimated for the year 2044.

Population projections within 50 miles of Susquehanna were determined using SECPOP2000, (NRC 2003) utilizing a geographic information system (GIS), U.S Census block-group level population data allocated to each sector based on the area fraction of the census block-groups in each sector, and population growth rate estimates. U.S. Census data from 1990 and 2000 were used to determine an annual average population growth estimate for each of the 50-mile radius rings. The annual population growth estimate for each ring was applied uniformly to all sectors in the ring to calculate the year 2044 population distribution.

The distribution is given in terms of population at distances to 1, 2, 3, 4, 5, 10, 20, 30, 40 and 50 miles from the plant and in the direction of each of the 16 compass points (i.e., N, NNE, NE……NNW).

The total year 2044 population for the 160 sectors (10 distances × 16 directions) in the region is estimated as 2,025,499. The population multiplier (in parenthesis) and distribution of the population is given for the 10-mile radius from Susquehanna and for the 50-mile radius from Susquehanna in Tables E.3-1 and E.3-2, respectively.

E.3.3 Economy

MACCS2 requires the spatial distribution of certain 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 done by using the SECPOP2000 code (NRC 2003) for each of the counties surrounding the plant to a distance of 50 miles. SECPOP2000 utilizes economic data from the U.S. Department of Agriculture, “1997 Census of Agriculture” (USDA 1998) and from other 1998 and 1999 data sources. Economic values for up to 97 economic zones were calculated and allocated to each of the 160 sectors.

In addition, generic economic data that are applied to the region as a whole were revised from the MACCS2 sample problem input when better information was available. These revised parameters include per diem living expenses (applied to owners of interdicted properties and relocated populations), relocation costs (for owners of interdicted properties), and value of farm and non-farm wealth. These values were updated to the year 2000 value using the Consumer Price Index ratio.

Susquehanna MACCS2 economic parameters include the following:

Susquehanna MACCS2 Economic Parameters

Variable	Description	SSES Value
DPRATE(1)	Property depreciation rate (per yr)	0.2
DSRATE(1)	Investment rate of return (per yr)	0.12
EVACST(2)	Daily cost for a person who has been evacuated ($/person-day)	41.15
POPCST(2)	Population relocation cost ($/person)	7600.00
RELCST(2)	Daily cost for a person who is relocated ($/person-day)	41.15
CDFRM0(2)	Cost of farm decontamination for various levels of decontamination ($/hectare)	855.00 1900.00
CDNFRM(2)	Cost of non-farm decontamination per resident person for various levels of decontamination ($/person)	4560.00 12160.00
DLBCST(2)	Average cost of decontamination labor ($/man-year)	53200.00
VALWF0(3)	Value of farm wealth ($/hectare)	6139.00
VALWNF(3)	Value of non-farm wealth ($/person)	121627.00

(1) DPRATE and DSRATE are based on NUREG/CR-4551 value (NRC 1990).
(2) These parameters for Susquehanna use the NUREG/CR-4551 value and updates them to the 2000 CPI value (NRC 1990).
(3) VALWF0 and VALWNF are based on SECPOP2000 values for Susquehanna.

E.3.4 Food and Agriculture

Food ingestion was modeled using the COMIDA2 methodology consistent with Sample Problem A. The COMIDA2 model utilizes national based food production parameters derived from the annual food consumption of an average individual such that site specific food production values are not utilized. The fraction of population dose due to food ingestion is typically small compared to other population dose sources. For Susquehanna, approximately 5% of the total population dose is due to food ingestion. A sensitivity case was performed to determine the impact of using site specific food production data obtained from the counties surrounding the site (USDA 2004). The results are discussed in Section E.7.3.

E.3.5 Nuclide Release

The core inventory at the time of the accident is based on a plant specific ORIGEN 2.1 calculation performed in 2004. The core inventory corresponds to the best estimate, end-of-cycle values (i.e., 24 month fuel cycle) for the Susquehanna core.

Susquehanna nuclide release categories are related to the MACCS categories as shown in Table E.3-3. All releases are modeled as occurring at 60.0 meters (top of the Reactor Building). The thermal content of each of the releases are assumed to be 1.0E+07 watts based on values provided in Sample Problem A and NUREG/CR-4551 (NRC 1990).

Two nuclide release sensitivity cases were performed to determine the effect of release height and thermal content assumptions. One sensitivity case modeled the releases occurring at ground level (0.0 meters). The second sensitivity case modeled the thermal content of each release to be the same as ambient (i.e., buoyant plane rise is not modeled). The results are discussed in Section E.7.3.

E.3.6 Evacuation

Reactor scram signal begins each evaluated accident sequence. 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. Therefore, the timing of the General Emergency declaration is sequence specific and ranges from 6 minutes to 18 hours for the release sequences evaluated.

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 have been used in similar studies (e.g., Hatch, Calvert Cliffs, (SNOC 2000) and (BGE 1998)) and are conservative relative to the NUREG-1150 study, which assumed evacuation of 99.5 percent of the population within the EPZ. The evacuees are assumed to begin evacuating 60 minutes after a General Emergency has been declared and are evacuated at an average radial speed of 2.2 miles per hour (0.97 m/sec). This speed is the time weighted value accounting for season, day of the week, time of day, weather conditions, and special events. The evacuation time weighted average of 338 minutes is for the full 0-10 mile EPZ, an assumed 15 minute notification time, 15 minutes for evacuation preparation, and 30 minutes average departure time. (HMM 1981)

Two evacuation sensitivity cases were also performed to determine the impact of evacuation assumptions. One sensitivity case reduced the evacuation speed by a factor of two (0.49 m/sec). The second sensitivity case assumed a 90 minute delay (in lieu of 60 minute delay) prior to the start of physical evacuation movement. The results are discussed in Section E.7.3.

E.3.7 Meteorology

Annual Susquehanna meteorology data from year 2001 was used in MACCS2 for the base case results. Year 2001 was the most complete and contained Susquehanna site specific precipitation data as well as mid tower data.[(1)] The 2001 Susquehanna meteorological data set contained two gaps of missing dates (57 total hours, representing 0.65% of the hourly readings). One of the gaps contained more than six consecutive hours of missing data and was filled by substituting data from previous hours or days. One of the gaps contained six or fewer consecutive hours of missing data and was filled by interpolation. The year 2001 meteorological data set was utilized for the Susquehanna base case MACCS2 analysis based on the fact that the year 2001 provided the highest population dose risk and offsite economic cost risk and is judged to be the most conservative.

The year 2001 meteorological data set consisted of 2 gaps of missing data (57 hours, 0.65%). Traditionally, up to 10% of missing data is considered acceptable. Of the

(1) Based on the meteorological sensitivity cases, year 2001 MET data was found to result in the highest population cost and highest dose and was therefore chosen for the Base Case.

missing gaps, one gap consisted of 6 hours or fewer and interpolation was used to fill in the missing meteorological data. One gap consisted of 52 hours of missing data. Missing meteorological data gaps of more than 6 hours were filled based on substituting data from the same time of day from the period just before or after the missing data in order to account for seasonal variations and the onset of severe weather. It is noted that MACCS results used in the SAMA analysis are the statistical mean of 406 weather sequences (each sequence contains 120 hours of data) chosen at random from pre-sorted weather bins. Due to the large number of samples analyzed, the adjustment of any particular weather sequence has negligible impact on the mean results.

Susquehanna MACCS2 analysis evaluated three meteorological data sets (Calendar years 2000, 2001, and 2003) to ensure that the meteorological data set used in the analysis is adequate. The use of the most conservative data set (year 2001) accounts for any weather sequences that may have been misrepresented by substitute data. Based on the multiple years analyzed, minimum data gaps in the year 2001 meteorological data, and the sampling methodology used, the reported mean results are judged acceptable and appropriate for use in averted cost risk calculations.

Meteorological data was prepared for MACCS2 input as follows:

1. Wind speed and direction from the 10-meter sensor of the site tower were combined with precipitation (hourly cumulative). If the lower wind direction was unavailable, mid and/or upper directions were used to estimate the lower wind direction. Onsite precipitation from Susquehanna Steam Electric Station was utilized.

2. If a brief period (i.e., few hours) of missing data existed for all tower sensors, interpolation was used between hours.

3. For larger data voids (i.e., days), tower data from the previous or following week was utilized to fill data gaps (for the same time of day).

4. Atmospheric stability was calculated according to the vertical temperature gradient of the tower temperature data.

5. Atmospheric mixing heights were specified for morning and afternoon. These values were taken from the document *Mixing Heights, Windspeeds, and Potential for Urban Air Pollution throughout the Contiguous United States* (EPA 1972).

   This source defined morning as being the four-hour period from 0200 to 0600 Local Standard Time and afternoon as being the four-hour period from 1200 to 1600 Local Standard Time.

The Code Manual for MACCS2: Volume 1 (from Appendix A, pages A-1 and A-2) states the following:

“The first of these two values corresponds to the morning mixing height and the second to the afternoon height. In the current implementation, the larger of these two values and the value of the boundary weather mixing height is used by the code.”

“In its present form, that atmospheric model implemented in MACCS2 does not allow a change in the mixing layer to occur during transport of the plume. Mixing layer height is assumed to be constant and therefore only a single value is used by the code.”

For the Susquehanna MACCS2 analyses, these conditions mean that, only the afternoon mixing height is used since it is larger than the morning mixing height. Note that the boundary weather mixing height, wind speed and stability category are only used when there is no meteorological data. These fixed boundary weather values are ignored by the code when an hourly meteorological data file is supplied by the user, as was the case in the MACCS2 runs for Susquehanna.

As noted above, site meteorological data for years 2002 and 2003 are also evaluated as sensitivity cases to ensure year 2001 data is an appropriate data set. The results are discussed in Section E.7.3.

E.3.8 MACCS2 Results

Tables E.3-4a and E.3-4b show the mean off-site doses and economic impacts to the region within 50 miles of Susquehanna for each of nine release categories calculated using MACCS2 for pre-EPU and post-EPU conditions, respectively. These impacts are multiplied by the annual frequency for each release category and then summed to obtain the dose-risk and offsite economic cost-risk (OECR).

E.4 BASELINE RISK MONETIZATION

This section explains how PPL calculated the monetized value of the status quo (i.e., accident consequences without SAMA implementation). PPL also used this analysis to establish the maximum benefit that could be achieved if all on-line SSES risk were eliminated, which is referred to as the Maximum Averted Cost-Risk (MACR).

The calculations below have been performed using the Unit 1, pre-EPU input. The same process used for the pre-EPU Unit 1 case is also used to establish the MACR for the following cases:

- Unit 2 pre-EPU
- Unit 1 post-EPU
- Unit 2 post-EPU

Section 4.6 summarizes the results for these cases.

E.4.1 Off-Site Exposure Cost

The baseline annual off-site exposure risk was converted to dollars using the NRC's conversion factor of $2,000 per person-rem, and discounted to present value using NRC standard formula (NRC 1997):

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

Where:

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

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

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

r = real discount rate (as fraction) = 0.03 per year

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

The Level 3 analysis showed an annual off-site population dose risk of 1.67 person-rem. The calculated value for C using 20 years and a 3 percent discount rate is approximately 15.04. Therefore, calculating the discounted monetary equivalent of accident dose-risk involves multiplying the dose (person-rem per year) by $2,000 and by the C value (15.04). The calculated off-site exposure cost is $50,232.

E.4.2 Off-Site Economic Cost Risk

The Level 3 analysis showed an annual off-site economic risk of $9,665. Calculated values for off-site economic costs caused by severe accidents must be discounted to present value as well. This is performed in the same manner as for public health risks and uses the same C value. The resulting value is $145,358.

E.4.3 On-Site Exposure Cost Risk

Occupational health was evaluated using the NRC methodology that involves separately evaluating immediate and long-term doses (NRC 1997).

For immediate dose, the NRC recommends using the following equation:

Equation 1:

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

Where:

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

R = monetary equivalent of unit dose ($2,000 per person-rem)

F = accident frequency (events per year) (1.86E-06 (total CDF))

D_{IO} = immediate occupational dose [3,300 person-rem per accident (NRC estimate)]

$_S$ = subscript denoting status quo (current conditions)

$_A$ = subscript denoting after implementation of proposed action

r = real discount rate (0.03 per year)

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

Assuming F_A is zero, the best estimate of the immediate dose cost is:

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

= $2{,}000*1.86E\text{-}06 *3{,}300*\{[1 – \exp(-0.03*20)]/0.03\}$

= $185

For long-term dose, the NRC recommends using the following equation:

Equation 2:

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

Where:

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

D_{LTO} = long-term dose [20,000 person-rem per accident (NRC estimate)]

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

Using values defined for immediate dose and assuming F_A is zero, the best estimate of the long-term dose is:

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

= $2{,}000*1.86E\text{-}06 *20{,}000*\{ [1 – \exp(-0.03*20)]/0.03\} \{[1 –\exp(-0.03*10)]/0.03*10\}$

= $967

The total occupational exposure is then calculated by combining Equations 1 and 2 above. The total accident related on-site (occupational) exposure risk (W_O) is:

W_O = $W_{IO} + W_{LTO}$ = ($185 + $967) = $1,152

E.4.4 On-Site Cleanup and Decontamination Cost

The total undiscounted cost of a single event in constant year dollars (C_{CD}) that NRC provides for cleanup and decontamination is $1.5 billion (NRC 1997). The net present value of a single event is calculated as follows. NRC uses the following equation to integrate the net present value over the average number of remaining service years:

$$PV_{CD} = [C_{CD}/mr][1-\exp(-rm)]$$

Where:

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

C_{CD} = total undiscounted cost for a single accident in constant dollar years

r = real discount rate (0.03)

m = years required to return site to a pre-accident state

The resulting net present value of a single event is $1.3E+09. The NRC uses the following equation to integrate the net present value over the average number of remaining service years:

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

Where:

PV_{CD} = net present value of a single event ($1.3E+09)

r = real discount rate (0.03)

t_f = 20 years (license renewal period)

The resulting net present value of cleanup integrated over the license renewal term, $1.65E+10, must be multiplied by the total CDF (1.86E-06) to determine the expected value of cleanup and decontamination costs. The resulting monetary equivalent is $30,771.

E.4.5 Replacement Power Cost

Long-term replacement power costs was determined following the NRC methodology in NRC, 1997. The net present value of replacement power for a single event, PV_{RP}, was determined using the following equation:

$$PV_{RP} = [\$1.2\times10^8/r] * [1 - \exp(-rt_f)]^2$$

Where:

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

r = 0.03

t_f = 20 years (license renewal period)

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

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

Where:

U_{RP} = net present value of replacement power over life of facility ($-year)

After applying a correction factor to account for SSES's size relative to the "generic" reactor described in NUREG/BR-0184 (NRC 1997)(i.e., 1204 megawatt electric/910 megawatt electric, the replacement power costs are determined to be 7.31E+09 ($-year). Multiplying this value by the CDF (1.86E-06) results in a replacement power cost of $13,598.

E.4.6 Total Cost-Risk

The calculations presented in Sections E.4-1 through E.4-5 provide the on-line, internal events based MACR for a single unit. Given that the SSES SAMA analysis is performed on a site basis and must consider the external events contributions, further steps are required to obtain a site based maximum averted cost-risk estimate that accounts for external events. This estimate, which is referred to as the Modified Maximum Averted Cost-Risk (MMACR) is calculated according to the following steps:

1. For presentation purposes, round each unit's MACR to the next highest thousand,

2. Multiply each unit's rounded MACR from the previous step by a factor of 2 to account for External Events contributions (refer to Section E.5.1.8 for additional details related to the basis for this factor),

3. Add the Unit 1 and Unit 2 results from step 2 together to obtain the MMACR.

4. Repeat steps 1-3 using the post-EPU PRA results to obtain the post-EPU MMACR.

The following table summarizes the results of this process.

SSES MMACR DEVELOPMENT SUMMARY

Input	Pre-EPU		Post-EPU	
	Unit 1	**Unit 2**	**Unit 1**	**Unit 2**
CDF (per year)	1.86E-06	1.83E-06	1.97E-06	1.94E-06
Dose-Risk (person-REM, single year)	1.67	1.63	1.90	1.86
OECR ($/yr)	9,665	9,405	11,151	10,845
Plant Net MWe	1204	1209	1304	1306
Output				
Offsite Exposure Cost-Risk	$50,232	$49,029	$57,151	$55,947
Offsite Economic Cost-Risk	$145,358	$141,448	$167,707	$163,105
Onsite Exposure Cost-Risk	$1,152	$1,133	$1,220	$1,201
Onsite Cleanup Cost-Risk	$30,771	$30,275	$32,591	$32,095
Replacement Power Cost-Risk	$13,598	$13,434	$15,598	$15,384
Total Unit MACR	$241,111	$235,319	$274,267	$267,732
Rounded to Next Highest Thousand	$242,000	$236,000	$275,000	$269,000
Unit MMACR (Includes External Events (MACR x 2))	$484,000	$472,000	$550,000	$538,000
Site MMACR	$956,000		$1,088,0000	

E.5 PHASE 1 SAMA ANALYSIS

The Phase 1 SAMA analysis, as discussed in Section E.1, 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.

E.5.1 SAMA Identification

The initial list of SAMA candidates for SSES was developed from a combination of resources. These include the following:

- SSES PRA results and PRA Group Insights
- Industry Phase 2 SAMAs (review of the potentially cost effective Phase 2 SAMAs for selected plants)
- SSES Individual Plant Examination IPE (SSES IPE) (PPL 1991)
- SSES IPEEE (PPL 1994)

These resources are judged to provide a list of potential plant changes that are most likely to reduce risk in a cost-effective manner for SSES.

In addition to the "Industry Phase 2 SAMA" review identified above, an industry based SAMA list was used in a different way to aid in the development of the SSES plant specific SAMA list. While the industry SAMA review cited above was used to identify SAMAs that might have been overlooked in the development of the SSES SAMA list due to PRA modeling issues, a generic SAMA list was used as an idea source to identify the types of changes that could be used to address the areas of concern identified through the SSES importance list review. For example, if Instrument Air availability was determined to be an important issue for SSES, the industry list would be reviewed to determine if a plant enhancement had already been conceived that would address Susquehanna's needs. If an appropriate SAMA was found to exist, it would be used in the SSES list to address the Instrument Air issue; otherwise, a new SAMA would be developed that would meet the site's needs. This generic list was compiled as part of the development of several industry SAMA analyses and has been provided in Addendum 1 for reference purposes.

It should be noted that the process used to identify SSES SAMA candidates focuses on plant specific characteristics and is intended to address only those issues important to the site. In this case, the existing capabilities of the plant preclude the need to include many of the potential SAMAs that have been identified for other BWRs. As a result, the types of changes that might be cost effective for SSES are reduced and the SAMA list is relatively short. For example,

- A portable 480V AC generator is available to provide long term power to the 125V DC battery chargers in SBO conditions. The availability of 125V DC supports SRV operation to allow diesel fire pump (DFP) injection after HCTL requires emergency depressurization, which challenges HPCI/RCIC operability.
- Nitrogen bottles are available to support long term ADS valves. The nitrogen bottle supply is sized to be available for the entire PRA mission time of 24 hours.
- Local, manual containment vent capability exists. This provides for an alternate means of venting the containment in the event that the remote vent capability fails.
- 2 loops of RHRSW provide a low pressure injection source that is not dependent on the suppression pool or CST and can be aligned to either RHR loop. In addition, these pumps are located outside the reactor building and would potentially be available after containment venting/failure.
- The DFP can be aligned for injection in SBO conditions through either a hard piped connection or a fire hose (credit currently limited by flow considerations)
- RCIC can be operated without DC power (not credited in the PRA)
- Given HCTL violation, procedures allow for maintaining reactor pressure at a level capable of sustaining RCIC if the DFP is not available for injection.
- The “E” emergency diesel generator (EDG) is available to replace any of the four primary EDGs in the event of a failure.
- ADS not inhibited for non ATWS conditions, which reduces the importance of the manual depressurization action.

The fact that the SSES SAMA list is relatively small compared with previous SAMA submittals is considered to be driven by actual plant capability. The plant features identified above provide effective means of reducing important areas of plant risk.

E.5.1.1 Level 1 SSES Importance List Review

The SSES PRA was used to generate a list of events sorted according to their risk reduction worth (RRW) values. The top events in this list are those events that would provide the greatest reduction in the SSES CDF if the failure probability were set to zero. The events were reviewed down to the 1.02 level for both the pre-EPU and post-EPU models, which approximately corresponds to a 2 percent change in the CDF given 100 percent reliability of the event. If the dose-risk and offsite economic cost-risk were also assumed to be reduced by a factor of 1.02, the corresponding averted cost-risk would be $4,728 for Pre-EPU Unit 1. After applying a factor of 2 to estimate the potential impact of External Events (refer to Section E.5.1.8), the result is about $9,457. Similarly, the Pre-EPU Unit 2 result was determined to be $9,338, which yields a pre-EPU site total of $18,795 for both units. Similarly, for post-EPU conditions, the total is $21,304.

The lower end of implementation costs for SAMAs are expected to apply to procedural changes, which have previously been estimated to cost about $50,000 (CPL 2004). Given that the SSES important list was reviewed down to a level corresponding to a site-wide averted cost-risk of less than $21,304 (post-EPU), all events that are likely to yield cost beneficial improvements are believed to have been addressed by the review process. In fact, if the $50,000 lower end implementation cost were used to set the RRW threshold for SSES, the cut off RRW value would be about 1.05 rather than 1.02. Due to the relatively low CDF calculated for SSES, additional events were reviewed to develop a more robust SAMA list.

Table E.5-1a through E.5-1d document the disposition of each event in the pre-EPU and post-EPU Level 1 SSES RRW list for both Units 1 and 2. Note that no basic events were preemptively screened from the process even if they solely represent sequence flags. Whatever the event, the intent of the process is to determine if insights can be gleaned to reduce the risk of the accident evolutions represented by the events listed. However, unique SAMAs are not identified for all of the events in the RRW list. Previously identified SAMAs are suggested as mitigating enhancements when those SAMAs (or similarly related changes) would reduce the RRW importance of the identified event. It is recognized that in some cases, additional requirements may need to be imposed on the SAMA to get a reduction in the RRW value for the basic event listed. In these cases, if an existing SAMA can approximate such an impact, then it is considered to address the relevant event and provide a first order indication of the potential benefit. A more detailed PRA analysis may then be performed to better estimate the potential cost-benefit if it is determined to be warranted.

E.5.1.2 Level 2 SSES Importance List Review

A similar review was performed on the importance listings from the Level 2 results. In this case, a composite file based on the top 90 percent of all dose-risk (and over 96 percent of offsite economic cost-risk) was used to identify the largest contributors to Level 2 risk. This file was composed of the following release category results: High/Early, High/Intermediate, Moderate/Intermediate, and Moderate/Late. This method was chosen to prevent high frequency-low consequence events from dominating the importance listing.

The Level 2 RRW values were reviewed down to the 1.02 level. As described for the Level 1 RRW list, events below the 1.02 threshold value are estimated to yield an averted cost-risk less than $21,304 and are not considered to be likely candidates for identifying cost effective SAMAs. As such, the events with RRW values below 1.02 were not reviewed. Tables E.5-2a through E.5-2d document the disposition of each event in the pre-EPU and post-EPU Level 2 SSES RRW list for both Units 1 and 2. The same groundrules related to event disposition in the Level 1 importance tables were utilized in the Level 2 importance tables.

E.5.1.3 SSES PRA Group Insights

While the PRA model's importance lists identify the highest contributors to plant risk based on the latest available information, previous PRA models provided some insights that are considered to be potentially valuable even if they do not impact the largest contributors in the current risk profile. One potential plant enhancement that was identified based on previous PRA model insights has been added to the SAMA list for completeness:

- Install 100 Percent Capacity Battery Chargers (SAMA 4)

SAMA 4 is related to ensuring the plant's DC requirements can be met even when the batteries are unavailable. For scenarios in which the batteries have failed or are out of service for maintenance, the chargers could supply the DC loads if they were replaced with higher capacity units and procedures were developed to remove the failed batteries from the circuit. Currently, the chargers cannot support the full DC load requirements early in LOOP or LOCA sequences.

In this case, the importance list review has also identified this as a potential SAMA based on loss of DC scenarios caused by battery failure/unavailability.

E.5.1.4 Industry SAMA Analysis review

The SAMA identification process for SSES is primarily based on the PRA importance listings/insights, the IPE, and the IPEEE. In addition to these plant specific sources, selected industry SAMA analyses were reviewed to identify any Phase 2 SAMAs that were determined to be potentially cost beneficial at other plants. These SAMAs were further analyzed and included in the SSES SAMA list if they were considered to be potentially cost beneficial for SSES. The following subsections provide a more detailed description of the identification process.

While many of these SAMAs are ultimately shown not to be cost beneficial, some are close contenders and a small number have been shown to be cost beneficial at other plants. Use of the SSES importance ranking should identify the types of changes that would most likely be cost beneficial for SSES, but review of selected industry Phase 2 SAMAs may capture potentially important changes not identified for SSES due to PRA modeling differences. Given this potential, it was considered prudent to include a review of selected industry Phase 2 SAMAs in the SSES SAMA identification process.

The Phase 2 SAMAs from the following U.S. nuclear sites have been reviewed:

- V.C. Summer (SCE&GC 2002)
- H.B. Robinson (CPL 2002)
- Palisades (NMC 2005b)
- Dresden (Exelon 2003a)
- Quad Cities (Exelon 2003b)
- Brunswick (CPL 2004)
- Monticello (NMC 2005a)

Three pressurized water reactor (PWR) and four BWR sites were chosen from available documentation to serve as the Phase 2 SAMA sources. Most of the Phase 2 SAMAs from these sources are not included in the SSES SAMA list. The industry Phase 2 SAMAs that were considered to have the potential to be cost effective for SSES were independently identified through the SSES importance list review. The remaining industry Phase 2 SAMAs were judged not to provide any significant benefit to the plant, were determined to already in place at SSES, or were addressed by SAMAs more suitable to SSES's needs. These SAMAs were not considered further and no SAMAs unique to the review of the industry Phase 2 SAMAs were included in the SSES SAMA list.

E.5.1.5 SSES IPE Plant Improvement Review

The SSES IPE generated a list of risk-based insights and potential plant improvements. Typically, changes identified in the IPE process are implemented and closed out; however, there are some items that are not completed due to high projected costs or other criteria. Because the criteria for implementation of a SAMA may be different than what was used in the post-IPE decision-making process, these recommended improvements are re-examined in this analysis. The following table summarizes the status of the potential plant enhancements resulting from the IPE process and their treatment in the SAMA analysis:

Description of Potential Enhancement	Status of Implementation	Disposition
Revision of the control strategy for HPCI suction transfer, and raising of the HPCI/RCIC backpressure trip setpoints in order to ensure timely availability and alignment of HPCI and RCIC for high pressure injection.	Implemented.	No further review required.
Revision of the control logic which would allow immediate operator control of LPCI and Core Spray injection and installation of a bypass switch on the Low Pressure Permissive.	Implemented on Core Spray.	The current PRA indicates these control issues are no longer an important issue. No further review required.
Provide an alternate, independent power supply for the Condensate Transfer Pumps.	Not Implemented. This improvement was designed to achieve two purposes: RHR keep fill following a LOOP and a source of low pressure water should the fire pump fail. A head tank has been installed for a passive ECCS keep fill.	The keep fill issue has been adequately addressed. Fire pump reliability is not an important issue for SSES and requires no further review.
Guidance for aligning the Control Rod Drive system for reactor vessel high pressure makeup.	Implemented.	No further review required.

Description of Potential Enhancement	Status of Implementation	Disposition
Revised guidance regarding primary containment control; e.g., use of RWCU for heat removal, water mass addition to the suppression pool as a means of slowing containment pressurization, redefinition of the HCTL, and priority on core integrity protection rather than containment integrity.	Implemented.	No further review required.
Revised guidance regarding RPV flooding actions to allow adequate core cooling to be verified even when reactor water level instrumentation is not available.	Implemented.	No further review required.
Revise guidance regarding reactor vessel level control to allow SRVs to cycle automatically rather than to be manually operated.	Not implemented.	Determined not to be required for safe operation of the plant. No further review required.
Revise guidance regarding reactor scram recovery actions to ensure that a plant cool down does not occur unless the reactor is shutdown with control rods.	Implemented.	No further review required.
Guidance to vent primary containment when fission products have not been released from the core and specific plant conditions exist.	Implemented. SSES procedures address containment venting with and without core damage.	No further review required.

E.5.1.6 SSES IPEEE Plant improvement review

Similar to the IPE, there may be a number of proposed plant changes that were previously rejected based on non-SAMA criteria that should be re-examined. In addition, there may be issues that are in the process of being resolved, which could be important to the disposition of some SAMAs. The IPEEE was used to identify these items.

The following table summarizes the status of the potential plant enhancements resulting from the IPEEE process and their treatment in the SAMA analysis:

Description of Potential Enhancement	Status of Implementation	Disposition
Address miscellaneous equipment issues that may impact the plant response during a seismic event (office furniture that may impact safety related equipment, transient items that are in close proximity to safety related equipment, equipment with missing screws or broken latches).	Implemented.	No further review required.
Improve housekeeping procedures and training on seismic issues (transient equipment control, performance of periodic walkdowns, and training to improve seismic awareness)	Implemented	No further review required.
Secure equipment with interaction concerns (electrical load centers, control and instrumentation panels and cabinets, CRTs in the MCR).	Implemented.	The issue with the CRTs in the main control room was thought to be that the CRTs were incorrectly fastened to the panel. A subsequent walkdown revealed that the fastenings were correct. No further review required.
Add a second restraining ring to the bottom of the H2/O2 bottles where they are only attached by a single ring.	Not implemented.	The subject H2/O2 bottles were spares and were removed. No further review required.
Investigate the need for drip shields for panels 1(2)Y115 and 1(2)Y125.	Not implemented	Determined not to be required. A redundant power source is available if the subject fails due to spray. No further review required.
Revise "natural Phenomena" procedures to discuss the potential impact a large seismic event could have on the fire protection system.	Implemented.	No further review required.

E.5.1.7 Use of External Events in the SSES SAMA Analysis

In addition to the incorporation of previous IPEEE insights, an effort was made to make further use of the IPEEE in the SAMA process. However, the SSES IPEEE was not maintained as a "living" analysis. This limits the capability of the models that make up the IPEEE as they do not include the latest PRA practices nor do they necessarily represent the current plant configuration or operating characteristics. The fact that the models are not currently in a quantifiable state presents further difficulty because the results are limited to what has been retained from the original analysis. These factors limit the qualitative insights and quantitative estimates that can be made with regard to external events contributors.

On a larger scale, given that the industry has generally not pursued external events modeling at a level consistent with internal events models, the technology for external events analysis is not as robust or refined. The result is that the CDF values yielded by the internal and external events models are not necessarily comparable.

The type of information available for these events is also dependent on the manner in which they were addressed in the IPEEE. For instance, the fire analysis was performed using the methodology prescribed in the PRA Procedures Guide (NRC 1983a), which produced results similar to those yielded by the internal events analysis. However, the Seismic Margins Analysis (SMA) does not produce a CDF and is predicated on the ability to evaluate the seismic durability of the equipment required to safely shut the plant down. The results of this kind of analysis do not directly lend themselves to the type of frequency-based analysis used in the SAMA evaluation.

The external events models are considered to be useful tools for identifying important accident sequences and mitigative equipment, but for the reasons stated above, the quantitative results can not be directly combined with those from the internal events models. Section E.5.1.8 provides a description of the method used to estimate the quantitative contribution of external events in the SAMA analysis.

Qualitatively, the IPEEE was used in the SSES SAMA analysis primarily to identify the highest risk external events based accident sequences and the potential means of reducing the risk posed by those sequences. The SSES IPEEE examined the risk due to the following types of initiators:

- Internal Fires
- Seismic Events

- High Winds
- External Flooding and Probable Maximum Precipitation
- Transportation and Nearby Facility Accidents

The IPEEE indicated that the other external hazards listed in Section 2 of NUREG-1407 were not included in the IPEEE because they were either not applicable to SSES or because they were included in other analyses (IPE or Station Blackout Analysis) (NRC 1991a). For the SAMA analysis, the same exclusions are considered to apply and only the five initiating event types addressed in the IPEEE are used in the SAMA identification process. The following subsections document this process and the results.

E.5.1.7.1 Fires

As discussed above, the techniques used to model external events vary according to the type of initiating event being analyzed. The SSES Fire model shared many of the same characteristics as its contemporary internal events model. However, limitations on the state of technology for Fire PRA, lack of an update program, and some divergences from what were typical fire modeling techniques produced results that are not comparable to the current internal events results.

While the ability to directly compare the results of the internal events and fire models is limited, information is available that may be used to identify potential fire related plant enhancements. For each Fire Zone contributing to the CDF, a description of the impacted equipment and corresponding CDF is available. This information is used to determine which Fire Zones are the most important to SSES and the type of equipment or function that could be used mitigate an accident resulting from a fire in that fire zone (i.e., a SAMA candidate). As details of the accident progression and component level results are not available, a more specific SAMA identification process is not readily available.

Given that the Fire Zone Results were updated in response to the NRC's audit of the IPEEE, the audit response results are used in this process. The results for all contributing Fire Zones are summarized below and are included in the SAMA review:

Fire Zone	Equipment Lost	CDF, Per cycle
1-2B	Division I and II emergency service water (ESW), HPCI	2.1E-9
0-28B-II	Battery Charger Area, Channels A and B DC	1.3E-9
0-27C	UCSR, Channels A and B DC Power	3.5E-10
0-25E	LCSR, HPCI and Div. I RHR	3.3E-9
Various	HPCI and RCIC	3.3E-8
0-26H	Panel 1C601 – Auto Initiation of ECCS	5.1E-9
Total		4.5E-8

Fire Zone 1-2B

The initial assessment of Fire Zone 1-2B in the IPEEE was performed assuming that fires did not spread between cabinets. The re-evaluation performed during the NRC audit resulted in the alteration of this assumption such that multiple cabinet fires were considered. At the time of the IPEEE assessment and in the initial stages of the IPEEE audit, a large fire in zone 1-2B was assumed to result in a LOOP for this Fire Zone. Given that this fire would also cause a loss of the four ESW pumps (taking no credit for raceway wrap), the consequence would be a Station Blackout. As the IPEEE audit calculations were prepared, the cable database was searched and it was determined that there are no cables in Fire Zone 1-2B that would affect off site power (OSP). The audit response does indicate, however, that a fire can cause the loss of the high pressure systems.

Loss of the high pressure systems is considered to be addressed by the installation of an engine driven HPI pump (SAMA 1).

Fire Zone 0-28B-II

This fire zone includes multiple permanent ignition sources, including 21 cabinets and 6 battery chargers that support both divisions of DC power. Given the wide range of equipment in this zone, a fire that consumed the entire zone would fail significant portions of both divisions of 125V DC power. However, based on COMPBRN IIIe calculations, cabinet fires were restricted to the cabinet of origin and no spreading was assumed to occur between cabinets. As a result, the importance of a fire in this zone depends on the equipment that is supported by the ignition source.

Based on a review of the IPEEE, the critical fires in zone 0-28B-II are those that impact Class 1E 125V DC channel A. These include fire events for:

- 1D612 – 125V DC class 1E load center
- 1D613 – 125V DC class 1E channel A charger (fails both the charger and battery and leads to loss of 1D612)
- 1D614 – 125V DC class 1E distribution panel (powered by 1D612)

Fires in these sources result in loss of an entire channel of emergency DC power, which impacts the following equipment:

- CIG (MSIV closure)
- RCIC
- Division I of ADS
- Division I of ESW
- Division I of CRD
- Division I of Core Spray
- Division I of RHRSW (by loss of breaker control)
- Division I of RHR

Given that loss of a single division of DC power alone leaves the remaining division's equipment available, additional failures are required in order for core damage to occur. However, random failure of the alternate division DC load center or bus is a critical failure that can eliminate most means of providing core cooling and/or heat removal.

In order to address this scenario, any mitigating effort would have to function without DC power support or include a means of bypassing the failed DC buses. Review of the internal events importance results revealed that DC bus failure is also an important internal events contributor and the SAMA developed to address non-fire related bus failures could also be used to reduce fire risk:

- Provide Direct Feeds to Required DC Loads (SAMA 9)

This SAMA provides a means of providing power to critical loads when the bus supplying the equipment is unavailable. Aligning direct leads from the Division II battery chargers or batteries to the critical Division I equipment could provide a means of cooling the core when a fire has damage the Division I DC distribution system and random equipment failures prevent an adequate response from the Division II equipment.

Fire Zone 0-27C

Fire Zone 0-27C (Upper Cable Spreading Room) contains cables for both divisions of 125V DC power for both units (1/2D614 and 1/2D624). While the buses themselves are not impacted by this fire, the same SAMA that addresses the bus failures identified for Fire Zone 0-28B-II would be effective here:

- Provide Direct Feeds to Required DC Loads (SAMA 9)

Burn-up and failure of the power cable to required loads could be mitigated by running direct feeds from available DC sources to the equipment.

Fire Zone 0-25E

Fire Zone 0-25E (Lower Cable Spreading Room) contains conductors for HPCI and Division I of RHR. Loss of this equipment alone does not present a critical challenge to the plant given that RCIC is available for HPI, ADS is available, and at least one division of heat removal and low pressure injection are available. Some maintenance conditions could present a challenge to HPI capabilities, but heat removal is possible through venting even if RHR heat removal is lost through the fire event and a coincidental maintenance task.

Additional HPI capability could be added through the installation of a high pressure diesel driven injection pump (SAMA 1).

Fifteen Various Fire Zones

In the original IPEEE, fifty five Fire Zones were screened from further review based on a low combustible loading. The IPEEE audit resulted in further evaluation of these zones to determine if potentially important fire consequences were masked as a result of that screening assumption. A more detailed review performed during the audit demonstrated that thirty one of these zones met the SSES defense in depth criteria and did not require additional analysis. Of the fire zones that did not meet the defense in depth criteria, seven were evaluated in conjunction with Control Room fire calculation EC-013-0859 (PPL 2002) and it was determined that the control capability and procedural guidance for operating the plant outside of the Main Control Room was adequate. No SAMAs are considered to be required to address Main Control Room abandonment. The remaining seventeen were subjected to a CDF analysis. Two of the seventeen zones for which CDFs were calculated are zones 0-27C and 0-25E, which are addressed above.

The final fifteen zones could not demonstrate defense in depth since the availability of either HPCI or RCIC was not certain. The CDF calculations for these rooms were performed assuming that both HPCI and RCIC were failed. Given that HPI is the main function impacted by a fire in these zones, installation of a high pressure, drive diesel injection pump (SAMA 1) would reduce the risk for these fire zones.

Fire Zone 0-26H

This fire zone includes the Main Control Room cabinets for a single unit and the cabinets that are shared between units (common cabinets). The IPEEE identified three cabinets that were the most significant to Main Control Room fire risk at SSES: 1C614, 0C653, and 1C601.

Cabinet 1C614 contains two subsections that are divided by a full metal barrier to maintain divisional separation. It was determined in the IPEEE, however, that a fire in either division would disable both RCIC and HPCI. While loss of this equipment in not trivial, defense in depth was met given that a diverse body of equipment remained available, including CRD, both divisions of ADS, both divisions of Core Spray, and both divisions of RHR in LPCI mode. The installation of diesel driven HPI pump (SAMA 1) is considered to address the loss of HPI capability presented by a SAMA in this cabinet. In addition, the original IPEEE Fire analysis did not consider the need to evacuate the Main Control Room in the event of a fire. If required, the operators could use the electrically isolated RCIC controls on the Remote Shutdown panel to meet HPI requirements.

Cabinet 0C653 controls breakers for both sources of offsite power, as well as EDG power, to all four ESS buses for each unit. Based on the information provided in the IPEEE, the only significant impact of a fire in this cabinet is a consequential LOOP/SBO. In order for a LOOP to occur, a hot short trip would be required for each startup bus (0A103 and 0A104). Both hot shorts are required for a LOOP because a single hot short will only cause loss of a single division of power. After these events initiate a LOOP, there are two other hot short scenarios in this cabinet that could lead to an SBO. The first is a combination of four hot shorts to prevent closure of the EDG breaker to each emergency bus. The second is a combination of two hot shorts that would result in closure of the ESW spray pond bypass valves. Closure of these two valves would result in loss of ESW flow to the EDGs and subsequent over temperature failure. In the unlikely event that an SBO would occur due to such a combination of fire initiated hot shorts, HPCI, RCIC, and the fire suppression system would still be available for vessel injection. For long term SBOs, procedures exist to operate RCIC with the high backpressure trips bypassed and DC control power is available through the portable station generator. Alternatively, the SRVs could be maintained open and injection could be provided by the DFP. No additional SAMAs are considered to be required to mitigate fires in this panel; however, the high pressure diesel driven pump (SAMA 1) would reduce the risk of this fire.

The original IPEEE Fire analysis assumed the fire barriers in cabinet 1C601 would prevent the spread of a fire to the other sections of the cabinet. The IPEEE audit response did not credit these barriers and assumed loss of the entire panel and that control room abandonment was required. In this case, the Remote Shutdown Panel (RSP) would be used to cool down the reactor. In addition to the option to operate the plant from the RSP, local control is available. For example, the ADS valves can be opened from the Upper and Lower Relay Rooms and two additional RHR pumps can be started locally per procedure OP-149-002. Given that multiple control options are available to the operators and that the only equipment disabled by the fire are the controls in the MCR, no SAMAs are considered to be required to address a fire in cabinet 1C610.

Fire SAMA Identification Summary

Based on the review of the SSES Fire Zone results, no SAMAs have been identified for inclusion on the SAMA list that are unique to the Fire analysis. However, two SAMAs were identified that could reduce the SSES fire risk that were also identified as a means of reducing the internal events risk. These SAMAs include:

- Diesel Driven HPI Pump (SAMA 1)
- Provide Direct Feeds to Required DC Loads (SAMA 9)

E.5.1.7.2 Seismic

The EPRI seismic margins methodology (EPRI 1991) is used to identify the minimal set of equipment required to safely shut the reactor down and to determine if that equipment is capable of surviving the Review Level Earthquake (RLE). Equipment that is not capable of withstanding the RLE is identified and required to be addressed. While methods exist for using this information to develop a seismically induced core damage frequency, this was not performed as part of the SSES IPEEE. It should also be noted that even in a seismic analysis developed to yield a CDF, the pedigree of information is not equivalent to what is used in the internal events models. Given that there is a limited amount of seismic response information available for nuclear power plants, analysis techniques developed to model the plant response often compensate by ingraining a conservative bias in their methodologies to prevent overestimating the capabilities of the plants. While seismic risk evaluations are helpful in the identification of potential plant weaknesses, the methodologies have not evolved to a point where the results can be directly compared with the internal events models.

As indicated above, the SMA results are useful in the identification of potential plant weaknesses, but the foundations of the SMA should be acknowledged when considering the results. For example, the SSES IPEEE identifies multiple examples of the conservative biases that are present in the plant's SMA:

1. The design basis ground spectra were based on a conservative envelope of several natural earthquakes that occurred on soil and rock sites (SSES on primarily founded on bedrock).

2. A synthetic earthquake acceleration time history was derived based on the 1952 Taft Earthquake for use as input to generate floor response spectra. A response spectrum of the synthetic time history enveloped the original design basis ground response spectrum with a significant margin that varies in magnitude along the frequency range.

3. Frequency broadening of the in-structure response spectrum curves by ±15 percent introduces a substantial reserve margin in the seismic qualification of equipment and attached components.

4. With the exception of the ESSW pumphouse, the effects of structural embedments on increasing the lateral stiffness of the seismic models were not considered.

5. For the SSES design, the structural damping values used for structures and equipment are considered to be conservative. These conservative damping values result in unrealistic high seismic demand for seismic qualification of structures and equipment.

6. Seismic design of Category I structures was performed by using linear elastic techniques. However, experience tells us that past near failures and failures involve some degree of yielding, which results in nonlinear inelastic energy absorption. The original seismic design documents did not account for these inelastic energy absorption mechanisms and consequently substantial factors of safety were built in at various design states.

7. The design concrete compressive strength is 4000 psi for all seismic Category I structures. But, the increase in concrete strength as it ages was not accounted for in the development of the two dimensional lumpe-mass models. This increase will inevitably increase the stiffness of the primary lateral load carrying system and, hence, change the fundamental building frequencies creating a better structural safety margin.

8. Whenever dynamic analysis was performed for structures and equipment, the dynamic response was obtained by performing modal analysis in the frequency domain in lieu of the time domain. It is industry recognized that the results of the frequency domain analysis are generally 5 percent to 30 percent higher than the respective more-realistic time domain results.

9. For seismic equipment qualification by testing, the test response spectra usually envelop the required response spectra over the frequency range of interest with a reserve margin of 10 percent or higher.

10. For dynamic qualification of similar pieces of equipment, dynamic demand was usually calculated by conservatively enveloping demand at different floor locations. This usually results in unrealistic dynamic demand with more than one peak and broad frequency content.

11. The flexibility of floor slabs in the vertical direction was conservatively represented by adding uncoupled linear springs to the lumped mass models representing the primary lateral load carrying systems. This simple representation overlooks the structural continuity of the structure and consequently overestimates the in-structure response spectra.

With these limitations in mind, the SSES IPEEE seismic results and history were reviewed in order to determine if there were any unresolved issues that could impact SSES risk. The types of issues that were of interest included:

- Unfinished plant enhancements that were determined to be required to ensure the equipment on the Safe Shutdown List would be capable of withstanding the RLE,

- Additional plant enhancements that were identified as means of reducing seismic risk but were not implemented at the plant.

An effort was also made to use the results of the equipment and structural screening documentation to determine if any outlier issues that were screened in the IPEEE could impact seismic risk at SSES. The following subsections summarize this review.

Unimplemented Plant Enhancements

As documented in section E.5.1.6, all of the seismic based plant enhancements for SSES have been addressed. No further review is required.

Motor Control Centers

The High Confidence of Low Probability of Failure (HCLPF) value for motor control center (MCC) 2B237 was determined to be 0.26 in the IPEEE, which is below the 0.3 value required for equipment on the Safe Shutdown Equipment List (SSEL). The SSES

Seismic Review Team (SRT) reviewed this equipment and determined that no plant modification was required based on the following:

- The HCLPF value is more than twice higher than the design basis Safe Shutdown Earthquake's (SSE) peak ground acceleration.
- It is not certain that the potential impact between the MCC and the adjacent HVAC duct could lead to malfunction of internal components.
- There is some safety margin available between the required Seismic Margins Earthquake (SME) (which is the same as the RLE) loads and test loads for the internal components to compensate for some or all of the additional dynamic loads due to impact.
- MCC 2B237 is not required for core protection. It is only on the SSEL to provide depth for suppression pool cooling. MCC 2B237 controls valves for Div. 1 RHR and RHRSW associated with heat exchanger A and RHR flow to the suppression pool. Even if MCC 2B237 fails, time is available for local manual valve operation.

As indicated in the SRT's assessment, even if it is assumed that a seismic event disables MCC 2B237, the RHR heat removal valves can be operated locally without time stress as a meaningful factor. The internal events model has analyzed these operator actions and includes credit for local valve manipulations given the failure of remote operation for loss of DHR scenarios. In those cases, the failure probability of the local valve manipulation has been estimated to be 6E-4. Similar credit is likely available after a seismic event. Given that the RHR and RHRSW valves are located in a seismically sound structure, the environmental performance shaping factors due to building failures should not be an issue. If the Extreme Stress multiplier of 10 from NUREG/CR-1278 (NRC 1983b) is applied to this HEP to account for any psychological effects of the earthquake, the failure probability increases to only 6E-3, which is comparable to the mitigating equipment and alignment failures in previous SAMA submittals (NMC 2005a) (CPL 2004). Given that a reasonably reliable means of opening the RHR/RHRSW valves is available without motive power from MCC 2B237, that conservatism is built into the judgment that MCC 2B237 could fail under the RLE loads, and that an additional division of RHR is available to support the decay heat removal function, no SAMAs are considered to be required to address this outlier.

Low Voltage Switchgear and Distribution Panels

It was noted during the IPEEE Seismic walkdown that there were breaker hoists stored on top of low voltage switchgear and distribution panels. As indicated in Section

E.5.1.6, action was taken to change the storage location of the breaker hoists and this issue has been closed out. No SAMAs are required for these outliers.

Motor Operated Valves

The outliers for this category include valves HV-155-F006 (HPCI injection valve) and HV-251-F024B (SPC return valve). The HCLPF value for each of these valves was determined to be 0.21g in the IPEEE, which is below the value of 0.3g required for items on the SSEL. The SSES SRT considered these results in conjunction with the operational requirements of the valves during seismic events and determined that no plant changes were required to improve their HCLPF values for the following reasons, as stated in the IPEEE:

- The HCLPF values are more than twice the design basis SSE's peak ground acceleration,
- It is not certain that the potential impact between the operator of the valve and the adjacent item could lead to malfunction of the valve. In the case of HV-155-F006, the dynamic interaction between the valve's stem protector and PSV-15513 is the controlling item in the calculated HCLPF value. A gap of approximately 0.75 inches is provided between the stem and the stem protector and should impact occur, only slight bending of the protector would result.
- Past earthquake experience and generic testing results strongly indicate that the actual structural damping values for piping systems are higher than the recommended damping value in EPRI NP-6041-SL or the value used in calculating dynamic displacements.
- The calculated valve displacement values were obtained by performing modal piping analyses in the frequency domain in lieu of the time domain. It is industry recognized that the results of the frequency domain analysis are generally 5 percent to 30 percent higher than the respective more realistic time domain results.
- Similar to failure of MCC 2B237, the consequence of failing valve HV-251-F024B impacts the DHR function. In this case, there are at least two mitigating factors that marginalize the importance of this failure. The first is that failure of HV-251-F024B does not preclude the use of alternate SDC. Once the reactor is depressurized, the "B" loop of RHR can still be used to provide DHR by taking suction from the suppression pool, injecting through the RHR heat exchangers, and returning flow to the suppression pool through the SRVs. The second mitigating factor is that the seismically induced failure of HV-251-F024B is only expected to fail the valve operator such that local, manual operation of the valve is still possible.

Given the existence of an alternate means of using the "B" RHR loop for DHR when valve HV-251-F024B has failed, the capability to open the valve locally for the expected failure mode, and the margin present in the methodologies used to assess the HCLPF value of 0.21g, no SAMAs are considered to be required to address the seismically induced failure of this valve. Also, as noted in the discussion for failure of MCC 2B237 above, an analysis of local valve manipulations for DHR recovery has been performed for the internal events analysis. The estimated reliability of this action is comparable to what has been estimated for other SAMAs even when potential stress factors related to a seismic event are considered and local manipulation of the valve is considered to be a viable recovery path.

The circumstances related to the potential failure of the HPCI injection valve (HV-155-F006) are similar to those for valve HV-251-F024B in that the assessment of the 0.21g HCLPF value is considered to be conservative and that another means of providing the affected function is available. In this case, the alternate HPI source is another system on the SSEL (RCIC) rather than an alternate use of the same train of the same system. In both cases, the affected function is still available. In the event that RCIC fails in conjunction with HV-155-F006, the ADS valves and low pressure injection/DHR would still be available to provide core cooling. No SAMAs are considered to be required to address the seismically induced failure of this valve.

Control and Instrumentation Panels and Cabinets

Two types of outliers were identified during the review of the plant control and instrumentation panels and cabinets. The first was that multiple close proximity panels In the Main Control Room and Relay Rooms were not fastened together. As indicated in Section E.5.1.6, these panels have been fastened together and the issue has been closed out.

The second outlier that was identified was the means used to secure the CRTs to the panels in the MCR. This issues was investigated and it was subsequently determined that the supports for the CRTs were adequate (PPL 1998). No SAMAs are required.

Automatic Transfer Switches

Walkdown of the "A" through "E" Diesel Generator Buildings revealed that the gap between an HVAC support and the top of automatic transfer switch #OATS556 (about ½ inch) in Diesel Generator Building "E" is inadequate for SME loads. The HCLPF value estimated for OATS556 in the IPEEE was 0.25g, which is less than the 0.3g value required for items on the SSEL. However, the SRT did not consider this condition to warrant a plant change for the following reasons:

- The HCLPF value is equal to 2.5 times the design basis SSE's peak ground acceleration.
- There is still available safety margin between the required SME loads and the test loads for the internal components to compensate for some or all of the additional dynamic loads due to impact.
- It is not certain that the potential impact between the switch panel and HVAC support could lead to malfunction of the internal components.
- SSES has redundant safety systems. For this condition, the availability of Diesel Generator Building "A" through "D" will provide the Class 1E power in the event that OATS556 does not survive an SME.
- It is conservatively assumed in calculating the HCLPF value of 0.25g that the zero period acceleration (ZPA) at the basement floor of Diesel Generator Building "E" is 0.3g for SME loading. However, a more accurate representation of the soil/structure interaction model will likely show a de-amplification of ground motion at basement level due to inertial and kinematic effects.

The insights provided by the SRT present an argument that indicates the failure of the "E" diesel generator automatic transfer switch is unlikely in an SME. Review of the internal events model shows that the unavailability of the "E" diesel generator would have a relatively large impact on CDF given a LOOP, which is likely during a Review Level Earthquake. However, further review of the OATS556 automatic transfer switch revealed that it has no impact on EDG availability and would likely serve no purpose in a seismic event.

The function of the OATS556 automatic transfer switch is to transfer the power supply for Class-1E MCC 0B565 to transformer 0X556 given loss of power on transformer 0X555. Given loss of power to both of these transformers, the breakers between OATS556 and MCC 0B565 automatically open and the MCC is powered from transformer 0X565, which is backed by emergency power. If the seismic event fails OATS556, the result is minimal because MCC 0B565 would receive power from transformer 0X565. No SAMA is required to address this issue.

Other Items

As part of the seismic analysis performed in the IPEEE, several other issues were reviewed in order to determine the plant's ability to respond to an RLE, including the following:

- Masonry walls

- Control Room ceiling
- Spray pond risers
- Low ruggedness relays
- Piping systems
- Electrical raceways
- Electrical conduit
- HVAC systems
- Soils (building foundations)

No areas of concern were identified during the review of these items and no additional SAMAs are required.

E.5.1.7.3 High Winds

The approach taken to analyze the high wind, flood, and “other” external event risk in the SSES IPEEE was to implement a progressive screening approach. The first three steps included 1) a review of SSES specific hazard data and licensing basis, 2) identification of significant changes since Operating License issuance, and 3) verification that the SSES design met the 1975 Standard Review Plan (SRP) criteria. The next three steps consisted of determining the hazard frequency and consequences. These steps were optional and could be bypassed provided that the first three steps were satisfied and any identified vulnerabilities were demonstrated to be insignificant. The last step was to document the process. An additional aspect of the process was to ensure that it was coordinated with any other ongoing external events programs so that the IPEEE considered all available information.

For the SAMA analysis, this process is considered adequate for screening events that do not pose a credible threat to plant operations. However, any issues that could impact plant safety are reconsidered to determine if the development of a SAMA is appropriate to address the vulnerability.

The SSES licensing bases were reviewed as part of the High Wind analysis and the new structures on the site were examined for potential wind related vulnerabilities. Most, but not all, of the site changes were designed to resist high wind loads and were not susceptible to high wind events. Those that did not meet the high wind design requirements of the SSES licensing bases did not serve any safety related function. It was determined that the failures of these plant additions/changes could be a source of tornado generated missiles; however, it was judged that any such missiles were enveloped by the existing postulated missiles considered in the design of the safety related facilities/structures. The SSES design bases were then compared to the 1975 SRP and found to be almost identical. This strict conformance to the 1975 SRP was believed to provide a reasonably high level of assurance that the SSES design basis, with respect to high winds, was sufficient. The conclusion of the IPEEE High Wind analysis was that there are no high wind vulnerabilities.

Given the low potential for identifying cost beneficial SAMAs to mitigate risk posed by high winds, no further efforts were made in the SAMA analysis to develop high wind related SAMAs.

E.5.1.7.4 External Flooding and Probable Maximum Precipitation

As indicated in Section E.5.1.7.3, the IPEEE employed a progressive screening method to examine external flooding. For the SAMA analysis, this process is considered adequate for screening events that do not pose a credible threat to plant operations. However, any issues that could impact plant safety are reconsidered to determine if the development of a SAMA is appropriate to address the vulnerability.

The review of the licensing bases, the first step in the screening process, showed that SSES was classified as a “dry” site with regard to external flooding and that the plant is secure from these threats. The dispositions of the flooding sources considered are summarized below:

- Probable Maximum Flood (PMF): The PMF water elevation, coincident with wind generated waves for the Susquehanna River, is defined as 548 feet mean sea level (MSL). This elevation is 120 feet below the site grade elevation of 670.0 feet MSL. As the Susquehanna River is the only water system adjacent to SSES that could have an impact on site flooding other than local storm runoff, it is excluded as a flooding threat. Site walkdowns were performed to examine the potential impact of storm runoff and it was confirmed that this was not an issue for SSES.

- Seismically Induced Dam Failures: Both singular and multiple upstream dam failures were investigated and determined not to be a threat to plant operations.

- Seiche Flooding: Considerations for seiche flooding are deemed inappropriate and not applicable to the SSES flood design basis.

- Storm Surge: The potential for an open coast surge upstream to the plant was not considered a credible occurrence and it was eliminated from the SSES flood design basis (not a threat).
- Tsunami Flooding: Not applicable to the Susquehanna site.
- Ice Jam Related Flooding: The elevation of the flood waters due to ice jam related issues were determined to be less than the PMF. Given that the PMF elevation was 120 feel below site grade, ice jam floods are also excluded as a flooding threat.
- Spray Pond Flooding: The design basis flood level for the spray pond was determined by superimposing the effects of coincident wind generated wave activity on various flood levels. This type of flood activity was determined not to pose a threat to any safety related features of SSES.
- River Diversion: The Susquehanna river, in the vicinity of SSES, was determined not to be subject to major realignment or diversion due to natural causes and was eliminated from the SSES flood design basis.

Review of the plant changes/additions since issuance of the operating license, step two of the screening methodology, has shown that none of them would directly affect or increase the potential vulnerabilities due to the external flood design basis.

The third require step of the screening process requires comparison of the SSES design bases to the 1975 SRP. This comparison demonstrated that the acceptance criteria of the 1975 SRP was essentially identical to the design basis in the SSES FSAR, which was considered to provide adequate assurance that the SSES design basis was sufficient. As a result, it was determined that no flood related vulnerabilities existed at SSES. A confirmatory walkdown of the site was performed to identify any potential vulnerabilities that were not included in the original design basis analysis. No other vulnerabilities were identified. A further review of the potential impacts of storm runoff and spray pond flooding was performed, but no safety related equipment was determined to be threatened by these events.

Given the low potential for identifying cost beneficial SAMAs to mitigate risk posed by external flooding, no further efforts were made in the SAMA analysis to develop SAMAs related to external flooding events.

E.5.1.7.5 Transportation and Nearby Facility Accidents

Transportation and nearby facility accidents were included in the SSES IPEEE to account for human errors or equipment failures that may occur in events not directly related to the power generation process at the plant. The types of hazards typically considered in this category include:

- Transportation Accidents due to Aircraft Activity
- Transportation Accidents due to Marine Activity
- Transportation Accidents due to Pipeline Activity
- Transportation Accidents due to Railroad Activity
- Transportation Accidents due to Truck Activity
- Nearby Industrial Facilities
- Nearby Military Facilities
- Hazardous Material Releases from Onsite Storage
- Other Onsite Hazards

At the time the IPEEE was performed, available information related to military, commercial, and general aviation traffic was used to determine that this type of traffic did not pose a threat to plant safety. It is recognized that the types of credible threats to nuclear facilities by aircraft have changed since the time the IPEEE was published. While this is true, efforts are underway within the industry to address this issue in conjunction with other forms of sabotage. Based on the fact that this topic is currently being analyzed in another forum and due to the complexity of the issue, aircraft impact events are considered to be out of the scope of the SAMA analysis.

For the remaining Transportation and Nearby Facility related events, the progressive screening approach described in Section E.5.1.7.3 was used to eliminate them from further consideration. For the SAMA analysis, this process is considered adequate for screening events that do not pose a credible threat to plant operations. However, any issues that could impact plant safety are reconsidered to determine if the development of a SAMA is appropriate to address the vulnerability.

For part 1 of the IPEEE screening process, the licensing basis was reviewed related to Nearby Industrial, Military and Transportation Facilities. The information reviewed included:

- Transportation routes within five miles of the plant, including highways and rail lines,

- Locations and routes of oil and natural gas pipelines,
- Locations of industrial and military facilities,
- Locations of airports and control areas.
- Descriptions of the nature and operations of the facilities, pipelines, waterways, and airports as well as their possible impact on SSES.

The second stage of the screening process revealed that there had been no changes to the transportation routes since issuance of the operating license; however, a new natural gas pipeline was installed. This pipeline was addressed in the SSES FSAR (PPL 2005a) and determined not to be a threat to the safe operation of the plant.

The third step of the screening process required that the SSES design criteria could be shown to satisfy the 1975 SRP criteria. It was determined in the IPEEE that SRP acceptance criteria were met and that Transportation and Nearby Facility accidents did not pose a threat to safe operation of the plant.

SSES has also performed a Control Room habitability analysis (PPL 2004) to assess the potential of a chemical release to impact the ability of the operators to control the plant. This analysis included the review of chemicals that were stored on-site at SSES, those stored off-site in fixed facilities within 5 miles of the plant, and chemicals being transported within 5 miles of the site. The results of the study indicated that none of the chemicals in these areas posed a threat to the Control Room operators. In addition, SSES staff has indicated that the chemical load review performed as part of the Control Room habitability study revealed that no new chemical explosion hazards have been introduced to the SSES area that were not addressed by the IPEEE (ERIN 2005).

Given the low potential for identifying cost beneficial SAMAs to mitigate risk posed by Transportation and Nearby Facility Accidents, no further efforts were made in the SAMA analysis to develop SAMAs related to these hazards.

E.5.1.8 Quantitative Strategy for External Events

The quantitative methods available to evaluate external events risk at SSES are limited, as discussed above. In order to account for the external events contributions in the SAMA analysis, a multi-staged process has been implemented to provide gross estimates of the averted cost-risk based on external events accidents.

The first part of this process is used in the Phase 1 analysis and is based on the assumption that the risk posed by external and internal events is approximately equal. While no CDF estimates are available for seismic, high wind, external flooding, or other external events, the final internal fire CDF estimate of 4.5E-8 per 15 month cycle (PPL 1998) was more than a factor of 2 lower than the internal events CDF from the IPE of the same time period. As the fire CDF is often the greatest of the external events considered in the IPEEE, the assumption that the SSES external events CDF is approximately equivalent to the internal events CDF does not appear to be non-conservative.

Continuing on with the assumption that the internal and external events risks are assumed to be equal, the MACR calculated for the internal events model has been doubled to account for external events contributions. As identified in Section E.4.6, this total is referred to as the MMACR. The MMACR is used in the Phase 1 screening process to represent the maximum achievable benefit if all risk related to on-line power operations was eliminated. Therefore, those SAMAs with costs of implementation that are greater than the MMACR were eliminated from further review.

The second stage of this strategy is to also apply the doubling factor to the Phase 2 analysis. Any averted cost-risk calculated for a SAMA was multiplied by two to account for the corresponding reduction in external events risk.

The final stage of the process is used for SAMAs that were identified based on IPEEE insights. For these cases, IPEEE insights and the Internal Events PRA are used, as appropriate, to develop an averted cost-risk for the SAMA that accounts for the external and internal events risk reductions. For instance, the IPEEE typically provides information that can be used to estimate bounding changes in risk that would be realized if the SAMAs were implemented. These risk changes are used to approximate averted cost-risks based on external events contributions. Then, if it can be determined that the SAMA would impact the internal events model, the PRA is used to quantify the averted cost-risk based on its internal events contributions. The cost-risks from the external and internal events results are then added to yield the total for the SAMA. In some cases, the SAMAs do not impact the internal events models and the calculations do not require the use of the PRA model.

E.5.2 Phase 1 Screening Process

The initial list of SAMA candidates is presented in Table E.5-3. The process used to develop the initial list is described in Section E.5.1.

The purpose of the Phase 1 analysis is to use high-level knowledge of the plant and SAMAs to preclude the need to perform detailed cost-benefit analyses on them. The following screening criteria were used:

- Applicability to the Plant: If a proposed SAMA does not apply to the SSES design, it is not retained.
- Implementation Cost Greater than Screening Cost: If the estimated cost of implementation is greater than the Modified Maximum Averted Cost-Risk, the SAMA cannot be cost beneficial and is screened from further analysis.

Table E.5-3 provides a description of how each SAMA was dispositioned in Phase 1. Those SAMAs that required a more detailed cost-benefit analysis are evaluated in Section E.6.

E.6 PHASE 2 SAMA ANALYSIS

Not all of the Phase 2 SAMA candidates require detailed analysis. The Phase 2 process allows for the screening of SAMAs known to be related to non-risk significant systems or to components/functions with low importance rankings. Due to the nature of the PRA based process used to develop the SSES SAMA list, there are limited avenues for SAMAs of this type to be included in the list. However, potential pathways do exist:

- Inclusion of unresolved proposed plant changes from previous SSES risk analyses,
- Inclusion of SAMAs based on the results of conservative modeling methods.

While no calculations are required for eliminating a SAMA that is linked to a non-risk significant system or components, some quantitative efforts are usually required to screen SAMAs that were developed to address risk contributors based on conservative modeling techniques. These cases are identified in Table E.6-1 and discussed in detail in the SAMA specific subsections of E.6.

For the SAMAs requiring detailed analysis, a more detailed conceptual design was prepared along with a more detailed estimated cost. This information was then used to evaluate the effect of the candidates' changes upon the plant safety model.

The final cost-risk based screening method is defined by the following equation:

Net Value = (baseline cost-risk of site operation (MMACR) – cost-risk of site operation with SAMA implemented) – cost of implementation

If the net value of the SAMA is negative, the cost of implementation is larger than the benefit associated with the SAMA and the SAMA is not considered beneficial. The baseline cost-risk of plant operation was derived using the methodology presented in Section E.4. The cost-risk of plant operation with the SAMA implemented is determined in the same manner with the exception that the revised PRA results reflect implementation of the SAMA.

The implementation costs used in the Phase 2 analysis include both SSES specific estimates developed by plant personnel and estimates taken from other SAMA submittals for those SAMAs that were determined to be highly similar. It should be noted that the SSES specific implementation costs do include contingency costs for unforeseen difficulties, but they do not account for any replacement power costs that may be incurred due to consequential shutdown time.

Sections E.6.1 – E.6.11 describe the detailed cost-benefit analysis that was used for each of the remaining candidates. It should be noted that the release category results provided for each SAMA do not include contributions from the negligible release category. The results for both pre-EPU and post-EPU conditions are provided.

E.6.1 SAMA Number 1: Diesel Driven High Pressure Injection Pump

The estimated cost of implementation for this SAMA was assessed by plant personnel and determined to be $2,798,000 for the site (PPL 2006c). While this cost estimate exceeds even the Post-EPU MMACR by more than a factor of 2.5, a detailed analysis of the SAMA was performed to demonstrate the large potential risk reduction that is available through implementation of a SAMA of this type.

This SAMA represents the use of a diesel-driven high pressure injection pump (DDHPIP) to provide makeup to the RPV. The DDHPIP has the potential of reducing the risk of SBO scenarios by providing an injection source that does not require the station's DC power to support SRV operation, valve manipulations, or pump control. Proceduralizing the use of decay heat curves to makeup with boiloff as a function of time is a means of ensuring core coverage after the loss of DC powered instrumentation in long term SBO scenarios. Use of the hotwell as the primary source of water and the circulating water as the secondary source is required to address the need of a large, cool suction source in these scenarios.

This injection system would also provide benefit in non-SBO LOOP cases in which power and injection equipment failures result in the loss makeup to the RPV.

In order to represent this SAMA, the model was modified by adding a DDHPIP gate (199DDP) to the following gates:

- 1HPM : FAILURE OF HPM SYSTEMS TO FEED THE VESSEL (FW AVAIL)
- 1EXTHPM_E: FAILURE OF EXTENDED HIGH PRESSURE MAKEUP
- 155-N-N-1PP_E: FAILURE OF ONE CRD PUMP WITH E DG BACKUP

The 199DP gate includes start and run failures for the DDHPIP:

- 199DGRNEWDDP: 1.6E-02
- 199DGSNEWDDP: 2.4E-02

These are the only failures modeled for the DDHPIP. For simplicity, other failures such as operator alignment errors, and injection valve failures are assumed to be non-contributors. In addition, no power dependencies are assumed and the injection source is always assumed to be available.

Results

Implementation of this SAMA yields a reduction in the CDF, Dose-risk, and Offsite Economic cost-risk. The results are summarized in the following table for Units 1 and 2 for both pre-EPU and post-EPU conditions:

	Pre-EPU			Post-EPU		
	CDF	Dose-Risk	OECR	CDF	Dose-Risk	OECR
Unit 1_{Base}	1.86E-06	1.67	$9,665	1.97E-06	1.90	$11,151
Unit 1_{SAMA}	3.05E-07	0.43	$2,371	7.65E-07	0.67	$2,954
Unit 1 Percent Change	83.6%	74.3%	75.5%	61.2%	64.7%	73.5%
Unit 2_{Base}	1.83E-06	1.63	$9,405	1.94E-06	1.86	$10,845
Unit 2_{SAMA}	3.05E-7	0.43	$2,363	7.66E-07	0.67	$2,947
Unit 2 Percent Change	83.3%	73.6%	$2,363	60.5%	64.0%	72.8%

A further breakdown of the Dose-risk and OECR information is provided below according to release category.

SAMA 1, Unit 1 Results By Release Category (Pre-EPU)

Release Category	H/E	H/I	H/L	M/E	M/I	M/L	L/E	L/I	L/L	LL/I	LL/L	Total
$Frequency_{BASE}$	1.71E-07	1.47E-07	1.21E-10	0.00E+00	5.05E-07	1.33E-07	7.43E-08	4.20E-07	5.58E-08	0.00E+00	2.37E-08	**1.53E-06**
$Frequency_{SAMA}$	1.45E-07	4.45E-09	5.96E-12	0.00E+00	1.78E-08	5.53E-09	7.43E-08	9.69E-09	1.78E-09	0.00E+00	9.13E-09	**2.68E-07**
Dose-$Risk_{BASE}$	0.45	0.22	0.00	0.00	0.69	0.15	0.01	0.13	0.02	0.00	0.00	**1.67**
Dose-$Risk_{SAMA}$	0.38	0.01	0.00	0.00	0.02	0.01	0.01	0.00	0.00	0.00	0.00	**0.43**
$OECR_{BASE}$	$2,497	$1,764	$3	$0	$4,338	$757	$10	$252	$44	$0	$0	**$9,665**
$OECR_{SAMA}$	$2,117	$53	$0	$0	$153	$31	$10	$6	$1	$0	$0	**$2,371**

SAMA 1, Unit 2 Results By Release Category (Pre-EPU)

Release Category	H/E	H/I	H/L	M/E	M/I	M/L	L/E	L/I	L/L	LL/I	LL/L	Total
$Frequency_{BASE}$	1.71E-07	1.30E-07	1.07E-10	0.00E+00	5.14E-07	1.13E-07	7.43E-08	4.31E-07	2.28E-08	0.00E+00	2.18E-08	**1.48E-06**
$Frequency_{SAMA}$	1.45E-07	3.76E-09	5.96E-12	0.00E+00	1.79E-08	5.33E-09	7.43E-08	9.88E-09	7.05E-10	0.00E+00	8.24E-09	**2.65E-07**
$Dose\text{-}Risk_{BASE}$	0.45	0.20	0.00	0.00	0.70	0.13	0.01	0.13	0.01	0.00	0.00	**1.63**
$Dose\text{-}Risk_{SAMA}$	0.38	0.01	0.00	0.00	0.02	0.01	0.01	0.00	0.00	0.00	0.00	**0.43**
$OECR_{BASE}$	$2,497	$1,560	$3	$0	$4,415	$643	$10	$259	$18	$0	$0	**$9,405**
$OECR_{SAMA}$	$2,117	$45	$0	$0	$154	$30	$10	$6	$1	$0	$0	**$2,363**

SAMA 1, Unit 1 Results By Release Category (Post-EPU)

Release Category	H/E	H/I	H/L	M/E	M/I	M/L	L/E	L/I	L/L	LL/I	LL/L	Total
$Frequency_{BASE}$	1.72E-07	1.59E-07	1.31E-10	0.00E+00	5.38E-07	1.51E-07	1.08E-07	4.87E-07	9.46E-09	1.56E-09	2.22E-08	**1.65E-06**
$Frequency_{SAMA}$	1.47E-07	5.62E-09	1.27E-11	0.00E+00	2.60E-08	5.83E-09	1.86E-07	4.60E-07	2.26E-10	0.00E+00	9.13E-09	**8.40E-07**
$Dose\text{-}Risk_{BASE}$	0.50	0.25	0.00	0.00	0.79	0.18	0.02	0.16	0.00	0.00	0.00	**1.90**
$Dose\text{-}Risk_{SAMA}$	0.43	0.01	0.00	0.00	0.04	0.01	0.03	0.15	0.00	0.00	0.00	**0.67**
$OECR_{BASE}$	$2,632	$2,099	$4	$0	$5,057	$995	$18	$337	$9	$0	$0	**$11,151**
$OECR_{SAMA}$	$2,249	$74	$0	$0	$244	$38	$31	$318	$0	$0	$0	**$2,954**

SAMA 1, Unit 2 Results By Release Category (Post-EPU)

Release Category	H/E	H/I	H/L	M/E	M/I	M/L	L/E	L/I	L/L	LL/I	LL/L	Total
$Frequency_{BASE}$	1.72E-07	1.39E-07	1.17E-10	0.00E+00	5.50E-07	1.30E-07	1.08E-07	4.73E-07	3.42E-09	6.87E-10	2.11E-08	**1.60E-06**
$Frequency_{SAMA}$	1.47E-07	4.82E-09	1.27E-11	0.00E+00	2.62E-08	5.61E-09	1.86E-07	4.63E-07	5.92E-11	0.00E+00	8.24E-09	**8.41E-07**
$Dose\text{-}Risk_{BASE}$	0.50	0.22	0.00	0.00	0.80	0.16	0.02	0.16	0.00	0.00	0.00	**1.86**
$Dose\text{-}Risk_{SAMA}$	0.43	0.01	0.00	0.00	0.04	0.01	0.03	0.15	0.00	0.00	0.00	**0.67**
$OECR_{BASE}$	$2,632	$1,835	$3	$0	$5,170	$857	$18	$327	$3	$0	$0	**$10,845**
$OECR_{SAMA}$	$2,249	$64	$0	$0	$246	$37	$31	$320	$0	$0	$0	**$2,947**

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

SAMA Number 1 Net Value

Unit	Base Case Cost-Risk (Pre-EPU)	Revised Cost-Risk (Pre-EPU)	Averted Cost-Risk (Pre-EPU)	Base Case Cost-Risk (Post-EPU)	Revised Cost-Risk (Post-EPU)	Averted Cost-Risk (Post-EPU)
Unit 1	$484,000	$113,893	$370,107	$550,000	$168,999	$381,001
Unit 2	$472,000	$113,255	$358,745	$538,000	$169,928	$368,072
Total	$956,000	$227,148	$728,852	$1,088,000	$338,927	$749,073

Based on the $2,798,000 cost of implementation, the Pre-EPU net value for this SAMA is -$2,069,148 ($728,852 - $2,798,000 = -$2,069,149), which implies that this SAMA is not cost beneficial.

For Post-EPU conditions, the net value for this SAMA is -$2,048,927 ($749,073 - $2,798,000 = -$2,048,927), which implies that this SAMA is not cost beneficial.

While this SAMA was shown not to be a cost effective change for SSES, the results appear to indicate that a large risk reduction is available through the implementation of a SAMA of this type.

E.6.2 SAMA Number 2a: Improve Cross-tie Capability between 4kv AC Emergency Buses (A-D, B-C)

Failure of an EDG combined with the failure of the “E” diesel in conjunction with non-diesel equipment in an alternate train results in the unavailability of equipment that could be used if power were aligned to it. SSES currently relies on the presence of the spare diesel (the “E” EDG) to mitigate EDG failures. While the “E” EDG is a valuable plant asset, emergency 4kV AC cross-tie capability would further reduce plant risk.

The intent of this SAMA is to provide SSES with cross-tie capability through procedure changes and minimal hardware modifications. The proposed changes include providing a mechanism to easily bypass the emergency 4kV AC feeder breaker interlocks such that new procedures would allow the operators to cross-tie buses which share a common emergency safeguards transformer. The inter-train cross-ties that would be supported by this SAMA include the “A” to “D” connection and the “B” to “C” connection. While this does not provide the full cross-tie capability that is available at some plants, the availability of these additional AC alignments still yields a significant risk reduction for SSES.

The impact of implementing this SAMA has been estimated through the following changes:

- Adding the “D” EDG as a potential means of power to the “A” emergency 4kV AC buses (1A201 and 2A201),
- Adding the “C” EDG as a potential means of power to the “B” emergency 4kV AC buses (1A202 and 2A202),
- Adding the “B” EDG as a potential means of power to the “C” emergency 4kV AC buses (1A203 and 2A203),
- Adding the “A” EDG as a potential means of power to the “D” emergency 4kV AC buses (1A204 and 2A204).

To provide a bounding cost-benefit estimate, the cross-tie action for this SAMA was conservatively assumed to be 100 percent reliable.

The cost of implementation for this SAMA was estimated to be $656,000 by PPL (PPL 2005g).

Results

Implementation of this SAMA yields a reduction in the CDF, Dose-risk, and Offsite Economic cost-risk. The results are summarized in the following table for Units 1 and 2 for both pre-EPU and post-EPU conditions:

	Pre-EPU			Post-EPU		
	CDF	Dose-Risk	OECR	CDF	Dose-Risk	OECR
Unit 1_{Base}	1.86E-06	1.67	$9,665	1.97E-06	1.90	$11,151
Unit 1_{SAMA}	8.25E-07	0.67	$3,446	8.86E-07	0.75	$3,833
Unit 1 Percent Change	55.6%	59.9%	64.3%	55.0%	60.5%	65.6%
Unit 2_{Base}	1.83E-06	1.63	$9,405	1.94E-06	1.86	$10,845
Unit 2_{SAMA}	7.92E-07	0.61	$3,064	8.53E-07	0.68	$3,361
Unit 2 Percent Change	56.7%	62.6%	67.4%	56.0%	63.4%	69.0%

A further breakdown of the Dose-risk and OECR information is provided below according to release category.

SAMA 2a, Unit 1 Results By Release Category (Pre-EPU)

Release Category	H/E	H/I	H/L	M/E	M/I	M/L	L/E	L/I	L/L	LL/I	LL/L	Total
$Frequency_{BASE}$	1.71E-07	1.47E-07	1.21E-10	0.00E+00	5.05E-07	1.33E-07	7.43E-08	4.20E-07	5.58E-08	0.00E+00	2.37E-08	**1.53E-06**
$Frequency_{SAMA}$	1.51E-07	5.11E-08	1.18E-10	0.00E+00	8.10E-09	5.88E-08	7.43E-08	2.76E-07	5.58E-08	0.00E+00	2.37E-08	**6.99E-07**
$Dose\text{-}Risk_{BASE}$	0.45	0.22	0.00	0.00	0.69	0.15	0.01	0.13	0.02	0.00	0.00	**1.67**
$Dose\text{-}Risk_{SAMA}$	0.40	0.08	0.00	0.00	0.01	0.07	0.01	0.08	0.02	0.00	0.00	**0.67**
$OECR_{BASE}$	$2,497	$1,764	$3	$0	$4,338	$757	$10	$252	$44	$0	$0	**$9,665**
$OECR_{SAMA}$	$2,205	$613	$3	$0	$70	$335	$10	$166	$44	$0	$0	**$3,446**

SAMA 2a, Unit 2 Results By Release Category (Pre-EPU)

Release Category	H/E	H/I	H/L	M/E	M/I	M/L	L/E	L/I	L/L	LL/I	LL/L	Total
$Frequency_{BASE}$	1.71E-07	1.30E-07	1.07E-10	0.00E+00	5.14E-07	1.13E-07	7.43E-08	4.31E-07	2.28E-08	0.00E+00	2.18E-08	**1.48E-06**
$Frequency_{SAMA}$	1.51E-07	3.12E-08	1.04E-10	0.00E+00	7.64E-09	3.81E-08	7.43E-08	2.85E-07	2.27E-08	0.00E+00	2.18E-08	**6.32E-07**
$Dose\text{-}Risk_{BASE}$	0.45	0.20	0.00	0.00	0.70	0.13	0.01	0.13	0.01	0.00	0.00	**1.63**
$Dose\text{-}Risk_{SAMA}$	0.40	0.05	0.00	0.00	0.01	0.04	0.01	0.09	0.01	0.00	0.00	**0.61**
$OECR_{BASE}$	$2,497	$1,560	$3	$0	$4,415	$643	$10	$259	$18	$0	$0	**$9,405**
$OECR_{SAMA}$	$2,205	$374	$3	$0	$66	$217	$10	$171	$18	$0	$0	**$3,064**

SAMA 2a, Unit 1 Results By Release Category (Post-EPU)

Release Category	H/E	H/I	H/L	M/E	M/I	M/L	L/E	L/I	L/L	LL/I	LL/L	Total
$Frequency_{BASE}$	1.72E-07	1.59E-07	1.31E-10	0.00E+00	5.38E-07	1.51E-07	1.08E-07	4.87E-07	9.46E-09	1.56E-09	2.22E-08	**1.65E-06**
$Frequency_{SAMA}$	1.51E-07	5.66E-08	1.25E-10	0.00E+00	9.07E-09	6.46E-08	1.07E-07	3.38E-07	9.45E-09	1.56E-09	2.22E-08	**7.60E-07**
$Dose\text{-}Risk_{BASE}$	0.50	0.25	0.00	0.00	0.79	0.18	0.02	0.16	0.00	0.00	0.00	**1.90**
$Dose\text{-}Risk_{SAMA}$	0.44	0.09	0.00	0.00	0.01	0.08	0.02	0.11	0.00	0.00	0.00	**0.75**
$OECR_{BASE}$	$2,632	$2,099	$4	$0	$5,057	$995	$18	$337	$9	$0	$0	**$11,151**
$OECR_{SAMA}$	$2,310	$747	$4	$0	$85	$426	$18	$234	$9	$0	$0	**$3,833**

SAMA 2a, Unit 2 Results By Release Category (Post-EPU)

Release Category	H/E	H/I	H/L	M/E	M/I	M/L	L/E	L/I	L/L	LL/I	LL/L	Total
$Frequency_{BASE}$	1.72E-07	1.39E-07	1.17E-10	0.00E+00	5.50E-07	1.30E-07	1.08E-07	4.73E-07	3.42E-09	6.87E-10	2.11E-08	**1.60E-06**
$Frequency_{SAMA}$	1.51E-07	3.37E-08	1.11E-10	0.00E+00	8.62E-09	4.24E-08	1.07E-07	3.21E-07	3.40E-09	6.87E-10	2.11E-08	**6.89E-07**
$Dose\text{-}Risk_{BASE}$	0.50	0.22	0.00	0.00	0.80	0.16	0.02	0.16	0.00	0.00	0.00	**1.86**
$Dose\text{-}Risk_{SAMA}$	0.44	0.05	0.00	0.00	0.01	0.05	0.02	0.11	0.00	0.00	0.00	**0.68**
$OECR_{BASE}$	$2,632	$1,835	$3	$0	$5,170	$857	$18	$327	$3	$0	$0	**$10,845**
$OECR_{SAMA}$	$2,310	$445	$3	$0	$81	$279	$18	$222	$3	$0	$0	**$3,361**

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

SAMA Number 2a Net Value

Unit	Base Case Cost-Risk (Pre-EPU)	Revised Cost-Risk (Pre-EPU)	Averted Cost-Risk (Pre-EPU)	Base Case Cost-Risk (Post-EPU)	Revised Cost-Risk (Post-EPU)	Averted Cost-Risk (Post-EPU)
Unit 1	$484,000	$186,118	$297,882	$550,000	$206,321	$343,679
Unit 2	$472,000	$169,036	$302,964	$538,000	$187,348	$350,652
Total	$956,000	$355,154	$600,846	$1,088,0000	$393,669	$694,331

Based on the $656,000 cost of implementation, the Pre-EPU net value for this SAMA is -$55,154 ($600,846 - $656,000 = -$55,154), which implies that this SAMA is not cost beneficial.

For Post-EPU conditions, the net value for this SAMA is $38,331 ($694,331 - $656,000 = $38,331), which implies that this SAMA is cost beneficial.

E.6.3 SAMA Number 3: Proceduralize Staggered RPV Depressurization When Fire Protection System Injection is the Only Available Makeup Source

Currently, the Fire Protection System can be aligned to the RPV for makeup, but in the cases where it is the only available injection source, only 50 percent of the system flow is credited for makeup to a given unit. This is due to the assumption that if one unit requires Fire Protection makeup, the opposite unit will also require use of the Fire Protection System for injection, thus splitting flow. SSES MAAP calculations indicate that 50 percent flow from the Fire Protection System is not enough to maintain core coverage when RPV depressurization occurs just prior to Fire Protection System injection. The flashing of RPV inventory reduces level to below 2/3 core height and level cannot be recovered prior to core damage. If the SSES procedures are modified to stagger RPV depressurization such that full Fire Protection System flow can be used to restore level to "normal" in a given unit before depressurization is performed on the opposite unit, core damage could be prevented. This procedure change would require valving out makeup flow to the initially depressurized unit while the second unit is depressurized and refilled to avoid splitting flow.

Model changes that were made to the PRA to represent the implementation of this SAMA at SSES include the addition of logic representing Fire Main injection to injection nodes used to prevent late core damage. Specific model changes are shown in the table below for the pre-EPU Unit 1 model. Unit 2 changes and those for the Post-EPU models are similar.

SAMA Number 3 Model Changes

Gate and / or Basic Event ID and Description	Description of Change
116-I-N-INJ_E: LATE INJECTION FROM DIV 1 OF RHRSW	Deleted "AND" gate 016-I-N-DIV_E Added "AND" gate 100-I-N-16&13PP_E, which includes credit for Fire Main injection.
116-II-N-INJ_E: LATE INJECTION FROM DIV 2 OF RHRSW	Deleted "AND" gate 016-II-N-DIV_E Added "AND" gate 100-II-N-16&13PP_E, which includes credit for Fire Main injection.
1LOWPPS3_E: LOW PRESSURE INJECTION WITH RHR CORE SPRAY AND CONDENATE	Added "AND" gate "1LATE_INJ_E", which is an "AND" gate of the following: 100-I-N-LATEINJ_E (FAILURE OF LATE INJECTION FROM DIV I - FROM RHRSW AND FM) 100-II-N-LATEINJ_E (FAILURE OF LATE INJECTION FROM DIV II)

The cost of procedure changes varies depending on the scope of the changes; however, the $50,000 value used in the Brunswick SAMA analysis (CPL 2004) is used here as a rough estimate of the cost for SSES. In addition to the cost of the procedure changes, flow analysis is required to confirm that the proposed changes would be effective. The cost of this analysis is estimated to be $100,000. The total cost of implementation for this SAMA is, therefore, $150,000. This estimate does not account for any changes that would be required for operator training.

Results

Implementation of this SAMA yields a reduction in the CDF, Dose-risk, and Offsite Economic cost-risk. The results are summarized in the following table for Units 1 and 2 for both pre-EPU and post-EPU conditions:

	Pre-EPU			Post-EPU		
	CDF	Dose-Risk	OECR	CDF	Dose-Risk	OECR
Unit 1_{Base}	1.86E-06	1.67	$9,665	1.97E-06	1.90	$11,151
Unit 1_{SAMA}	1.48E-06	1.44	$8,781	1.56E-06	1.63	$10,011
Unit 1 Percent Change	20.4%	13.8%	9.1%	20.8%	14.2%	10.2%
Unit 2_{Base}	1.83E-06	1.63	$9,405	1.94E-06	1.86	$10,845
Unit 2_{SAMA}	1.48E-06	1.42	$8,620	1.56E-06	1.59	$9,803
Unit 2 Percent Change	19.1%	12.9%	8.3%	19.6%	14.5%	9.6%

A further breakdown of the Dose-risk and OECR information is provided below according to release category.

SAMA 3, Unit 1 Results By Release Category (Pre-EPU)

Release Category	H/E	H/I	H/L	M/E	M/I	M/L	L/E	L/I	L/L	LL/I	LL/L	Total
$Frequency_{BASE}$	1.71E-07	1.47E-07	1.21E-10	0.00E+00	5.05E-07	1.33E-07	7.43E-08	4.20E-07	5.58E-08	0.00E+00	2.37E-08	**1.53E-06**
$Frequency_{SAMA}$	1.71E-07	1.47E-07	1.21E-10	0.00E+00	4.99E-07	2.17E-08	7.43E-08	8.96E-08	5.58E-08	0.00E+00	2.37E-08	**1.08E-06**
$Dose\text{-}Risk_{BASE}$	0.45	0.22	0.00	0.00	0.69	0.15	0.01	0.13	0.02	0.00	0.00	**1.67**
$Dose\text{-}Risk_{SAMA}$	0.45	0.22	0.00	0.00	0.68	0.03	0.01	0.03	0.02	0.00	0.00	**1.44**
$OECR_{BASE}$	$2,497	$1,764	$3	$0	$4,338	$757	$10	$252	$44	$0	$0	**$9,665**
$OECR_{SAMA}$	$2,497	$1,764	$3	$0	$4,286	$123	$10	$54	$44	$0	$0	**$8,781**

SAMA 3, Unit 2 Results By Release Category (Pre-EPU)

Release Category	H/E	H/I	H/L	M/E	M/I	M/L	L/E	L/I	L/L	LL/I	LL/L	Total
$Frequency_{BASE}$	1.71E-07	1.30E-07	1.07E-10	0.00E+00	5.14E-07	1.13E-07	7.43E-08	4.31E-07	2.28E-08	0.00E+00	2.18E-08	**1.48E-06**
$Frequency_{SAMA}$	1.71E-07	1.30E-07	1.07E-10	0.00E+00	5.09E-07	1.86E-08	7.43E-08	8.92E-08	2.28E-08	0.00E+00	2.18E-08	**1.04E-06**
$Dose\text{-}Risk_{BASE}$	0.45	0.20	0.00	0.00	0.70	0.13	0.01	0.13	0.01	0.00	0.00	**1.63**
$Dose\text{-}Risk_{SAMA}$	0.45	0.20	0.00	0.00	0.70	0.02	0.01	0.03	0.01	0.00	0.00	**1.42**
$OECR_{BASE}$	$2,497	$1,560	$3	$0	$4,415	$643	$10	$259	$18	$0	$0	**$9,405**
$OECR_{SAMA}$	$2,497	$1,560	$3	$0	$4,372	$106	$10	$54	$18	$0	$0	**$8,620**

SAMA 3, Unit 1 Results By Release Category (Post-EPU)

Release Category	H/E	H/I	H/L	M/E	M/I	M/L	L/E	L/I	L/L	LL/I	LL/L	Total
$Frequency_{BASE}$	1.72E-07	1.59E-07	1.31E-10	0.00E+00	5.38E-07	1.51E-07	1.08E-07	4.87E-07	9.46E-09	1.56E-09	2.22E-08	**1.65E-06**
$Frequency_{SAMA}$	1.72E-07	1.59E-07	1.31E-10	0.00E+00	5.32E-07	2.28E-08	1.08E-07	1.41E-07	9.46E-09	1.56E-09	2.22E-08	**1.17E-06**
$Dose\text{-}Risk_{BASE}$	0.50	0.25	0.00	0.00	0.79	0.18	0.02	0.16	0.00	0.00	0.00	**1.90**
$Dose\text{-}Risk_{SAMA}$	0.50	0.25	0.00	0.00	0.78	0.03	0.02	0.05	0.00	0.00	0.00	**1.63**
$OECR_{BASE}$	$2,632	$2,099	$4	$0	$5,057	$995	$18	$337	$9	$0	$0	**$11,151**
$OECR_{SAMA}$	$2,632	$2,099	$4	$0	$5,001	$150	$18	$98	$9	$0	$0	**$10,011**

SAMA 3, Unit 2 Results By Release Category (Post-EPU)

Release Category	H/E	H/I	H/L	M/E	M/I	M/L	L/E	L/I	L/L	LL/I	LL/L	Total
$Frequency_{BASE}$	1.72E-07	1.39E-07	1.17E-10	0.00E+00	5.50E-07	1.30E-07	1.08E-07	4.73E-07	3.42E-09	6.87E-10	2.11E-08	**1.60E-06**
$Frequency_{SAMA}$	1.72E-07	1.39E-07	1.17E-10	0.00E+00	5.43E-07	1.95E-08	1.08E-07	1.14E-07	3.42E-09	6.87E-10	2.11E-08	**1.12E-06**
$Dose\text{-}Risk_{BASE}$	0.50	0.22	0.00	0.00	0.80	0.16	0.02	0.16	0.00	0.00	0.00	**1.86**
$Dose\text{-}Risk_{SAMA}$	0.50	0.22	0.00	0.00	0.79	0.02	0.02	0.04	0.00	0.00	0.00	**1.59**
$OECR_{BASE}$	$2,632	$1,835	$3	$0	$5,170	$857	$18	$327	$3	$0	$0	**$10,845**
$OECR_{SAMA}$	$2,632	$1,835	$3	$0	$5,104	$129	$18	$79	$3	$0	$0	**$9,803**

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

SAMA Number 3 Net Value

Unit	Base Case Cost-Risk (Pre-EPU)	Revised Cost-Risk (Pre-EPU)	Averted Cost-Risk (Pre-EPU)	Base Case Cost-Risk (Post-EPU)	Revised Cost-Risk (Post-EPU)	Averted Cost-Risk (Post-EPU)
Unit 1	$484,000	$424,973	$59,027	$550,000	$478,898	$71,102
Unit 2	$472,000	$418,601	$53,399	$538,000	$471,344	$66,656
Total	$956,000	$843,574	$112,426	$1,088,000	$950,242	$137,758

Based on the $150,000 cost of implementation, the Pre-EPU net value for this SAMA is -$37,574 ($112,426 - $150,000 = -$37,574), which implies that this SAMA is not cost beneficial.

For Post-EPU conditions, the net value for this SAMA is -$12,242 ($137,758 - $150,000 = -$12,242), which implies that this SAMA is not cost beneficial.

E.6.4 SAMA Number 5: Automatic alignment of the portable station diesel generator

The operator action to align the portable station diesel generator is an important contributor to scenarios in which AC power is unavailable to the battery chargers. Typically, these are scenarios in which the “A” and “B” EDGs are unable to power their respective 4kV AC emergency buses, and the “E” diesel also fails to provide power to the “A” or “B” buses. These scenarios result in core damage due to the failure of high pressure injection after battery depletion and the inability to depressurize the RPV with the SRVs. Given that the alignment of the “E” diesel and the portable station diesel generator both currently depend on human actions, credit for further operator actions to align additional AC sources or alternate AC alignments would be difficult to justify.

The impact of automating the alignment of the portable station diesel generator has been estimated by modifying the failure probabilities of the portable station diesel generator alignment actions in the cutsets. Specifically, the following actions were set to false:

- 002-N-N-BMS-O (OPERATOR ERROR FOR ALIGNING THE STATION PORTABLE DIESEL GENERATOR)
- Z-BMS-IACIG-O (JHEP OPERATOR FAILS TO ALIGN BLUE MAX AND CROSSTIE IA TO CIG)
- Z-BMAX-EDG-O (DEPENDENT HEP FOR BLUE MAX AND E DG)

These events capture the dependent and independent failures to align the portable station diesel generator. In this case, the events have been set to “false” to eliminate all cutsets in which the action to align the portable generators has failed, which implies that the automated function is 100 percent reliable.

The cost of enhancing the portable station 480V AC generator so that it is capable of automatically starting and powering the 125V DC battery chargers has been estimated to be approximately $398,000 (PPL 2005b).

Results

Implementation of this SAMA yields a reduction in the CDF, Dose-risk, and Offsite Economic cost-risk. The results are summarized in the following table for Units 1 and 2 for both pre-EPU and post-EPU conditions:

	Pre-EPU			Post-EPU		
	CDF	Dose-Risk	OECR	CDF	Dose-Risk	OECR
Unit 1_{Base}	1.86E-06	1.67	$9,665	1.97E-06	1.90	$11,151
Unit 1_{SAMA}	1.38E-06	1.15	$6,164	1.48E-06	1.30	$7,077
Unit 1 Percent Change	25.8%	31.1%	36.2%	24.9%	31.6%	36.5%
Unit 2_{Base}	1.83E-06	1.63	$9,405	1.94E-06	1.86	$10,845
Unit 2_{SAMA}	1.35E-06	1.10	$5,865	1.45E-06	1.25	$6,726
Unit 2 Percent Change	26.2%	32.5%	37.6%	25.3%	32.8%	38.0%

A further breakdown of the Dose-risk and OECR information is provided below according to release category.

SAMA 5, Unit 1 Results By Release Category (Pre-EPU)

Release Category	H/E	H/I	H/L	M/E	M/I	M/L	L/E	L/I	L/L	LL/I	LL/L	Total
$Frequency_{BASE}$	1.71E-07	1.47E-07	1.21E-10	0.00E+00	5.05E-07	1.33E-07	7.43E-08	4.20E-07	5.58E-08	0.00E+00	2.37E-08	**1.53E-06**
$Frequency_{SAMA}$	1.59E-07	7.66E-08	1.21E-10	0.00E+00	2.18E-07	1.31E-07	7.43E-08	4.15E-07	5.58E-08	0.00E+00	2.37E-08	**1.15E-06**
$Dose\text{-}Risk_{BASE}$	0.45	0.22	0.00	0.00	0.69	0.15	0.01	0.13	0.02	0.00	0.00	**1.67**
$Dose\text{-}Risk_{SAMA}$	0.42	0.12	0.00	0.00	0.30	0.15	0.01	0.13	0.02	0.00	0.00	**1.15**
$OECR_{BASE}$	$2,497	$1,764	$3	$0	$4,338	$757	$10	$252	$44	$0	$0	**$9,665**
$OECR_{SAMA}$	$2,321	$919	$3	$0	$1,873	$745	$10	$249	$44	$0	$0	**$6,164**

SAMA 5, Unit 2 Results By Release Category (Pre-EPU)

Release Category	H/E	H/I	H/L	M/E	M/I	M/L	L/E	L/I	L/L	LL/I	LL/L	Total
$Frequency_{BASE}$	1.71E-07	1.30E-07	1.07E-10	0.00E+00	5.14E-07	1.13E-07	7.43E-08	4.31E-07	2.28E-08	0.00E+00	2.18E-08	**1.48E-06**
$Frequency_{SAMA}$	1.58E-07	5.88E-08	1.07E-10	0.00E+00	2.25E-07	1.11E-07	7.43E-08	4.26E-07	2.28E-08	0.00E+00	2.18E-08	**1.10E-06**
$Dose\text{-}Risk_{BASE}$	0.45	0.20	0.00	0.00	0.70	0.13	0.01	0.13	0.01	0.00	0.00	**1.63**
$Dose\text{-}Risk_{SAMA}$	0.42	0.09	0.00	0.00	0.31	0.13	0.01	0.13	0.01	0.00	0.00	**1.10**
$OECR_{BASE}$	$2,497	$1,560	$3	$0	$4,415	$643	$10	$259	$18	$0	$0	**$9,405**
$OECR_{SAMA}$	$2,307	$706	$3	$0	$1,933	$632	$10	$256	$18	$0	$0	**$5,865**

SAMA 5, Unit 1 Results By Release Category (Post-EPU)

Release Category	H/E	H/I	H/L	M/E	M/I	M/L	L/E	L/I	L/L	LL/I	LL/L	Total
$Frequency_{BASE}$	1.72E-07	1.59E-07	1.31E-10	0.00E+00	5.38E-07	1.51E-07	1.08E-07	4.87E-07	9.46E-09	1.56E-09	2.22E-08	**1.65E-06**
$Frequency_{SAMA}$	1.59E-07	8.39E-08	1.31E-10	0.00E+00	2.33E-07	1.49E-07	1.08E-07	4.82E-07	9.46E-09	1.56E-09	2.22E-08	**1.25E-06**
$Dose\text{-}Risk_{BASE}$	0.50	0.25	0.00	0.00	0.79	0.18	0.02	0.16	0.00	0.00	0.00	**1.90**
$Dose\text{-}Risk_{SAMA}$	0.47	0.13	0.00	0.00	0.34	0.18	0.02	0.16	0.00	0.00	0.00	**1.30**
$OECR_{BASE}$	$2,632	$2,099	$4	$0	$5,057	$995	$18	$337	$9	$0	$0	**$11,151**
$OECR_{SAMA}$	$2,433	$1,107	$4	$0	$2,190	$982	$18	$334	$9	$0	$0	**$7,077**

SAMA 5, Unit 2 Results By Release Category (Post-EPU)

Release Category	H/E	H/I	H/L	M/E	M/I	M/L	L/E	L/I	L/L	LL/I	LL/L	Total
$Frequency_{BASE}$	1.72E-07	1.39E-07	1.17E-10	0.00E+00	5.50E-07	1.30E-07	1.08E-07	4.73E-07	3.42E-09	6.87E-10	2.11E-08	**1.60E-06**
$Frequency_{SAMA}$	1.59E-07	6.34E-08	1.17E-10	0.00E+00	2.41E-07	1.28E-07	1.08E-07	4.67E-07	3.42E-09	6.87E-10	2.11E-08	**1.19E-06**
$Dose\text{-}Risk_{BASE}$	0.50	0.22	0.00	0.00	0.80	0.16	0.02	0.16	0.00	0.00	0.00	**1.86**
$Dose\text{-}Risk_{SAMA}$	0.47	0.10	0.00	0.00	0.35	0.15	0.02	0.16	0.00	0.00	0.00	**1.25**
$OECR_{BASE}$	$2,632	$1,835	$3	$0	$5,170	$857	$18	$327	$3	$0	$0	**$10,845**
$OECR_{SAMA}$	$2,433	$837	$3	$0	$2,265	$844	$18	$323	$3	$0	$0	**$6,726**

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

SAMA Number 5 Net Value

Unit	Base Case Cost-Risk (Pre-EPU)	Revised Cost-Risk (Pre-EPU)	Averted Cost-Risk (Pre-EPU)	Base Case Cost-Risk (Post-EPU)	Revised Cost-Risk (Post-EPU)	Averted Cost-Risk (Post-EPU)
Unit 1	$484,000	$323,915	$160,085	$550,000	$366,781	$183,219
Unit 2	$472,000	$310,111	$161,889	$538,000	$352,816	$185,184
Total	$956,000	$634,026	$321,974	$1,088,000	$719,597	$368,403

Based on the $398,000 cost of implementation, the Pre-EPU net value for this SAMA is -$76,026 ($321,974 - $398,000 = -$76,026), which implies that this SAMA is not cost beneficial.

For Post-EPU conditions, the net value for this SAMA is -$29,597 ($368,403 - $398,000 = -$29,597), which implies that this SAMA is not cost beneficial.

E.6.5 SAMA Number 6: Spare 480v AC Generator

The mechanical failure of the portable station diesel generator is an important contributor to scenarios in which AC power is unavailable to the battery chargers. Typically, these are scenarios in which the “A” and “B” EDGs are unable to power their respective 4kV AC emergency buses, and the “E” diesel also fails to provide power to the “A” or “B” buses. These scenarios result in core damage due to the failure of high pressure injection after battery depletion and the inability to depressurize the RPV with the SRVs. While local, manual containment venting is possible at SSES, core damage will ensue without an injection source. Given that the portable station diesel generator has failed due to mechanical issues, alignment of a spare generator could be credited due to the fact that operators have successfully completed the alignment actions for the portable generator.

The impact of procuring an additional portable station diesel generator has been estimated by "AND"ing the existing start and run failure events under gate 002-N-N-0G503 with new events representing a second portable station diesel generator. The original events were renamed to 002DGS0G503-1 (start failure) and 002DGR0G503-1 (run failure). The new events were assigned the same failure probabilities as the original events and named 002DGS0G503-2 (start failure) and 002DGR0G503-2 (run failure). No common cause failure was assumed to exist between the portable station diesel generators

The cost of procuring an additional portable station 480V AC generator has been estimated to be approximately $203,000 (PPL 2005c).

Results

Implementation of this SAMA yields a reduction in the CDF, Dose-risk, and Offsite Economic cost-risk. The results are summarized in the following table for Units 1 and 2 for both pre-EPU and post-EPU conditions:

	Pre-EPU			Post-EPU		
	CDF	Dose-Risk	OECR	CDF	Dose-Risk	OECR
Unit 1_{Base}	1.86E-06	1.67	$9,665	1.97E-06	1.90	$11,151
Unit 1_{SAMA}	1.51E-06	1.29	$7,109	1.61E-06	1.46	$8,181
Unit 1 Percent Change	18.8%	22.8%	26.4%	18.3%	23.2%	26.6%
Unit 2_{Base}	1.83E-06	1.63	$9,405	1.94E-06	1.86	$10,845
Unit 2_{SAMA}	1.49E-06	1.25	$6,853	1.59E-06	1.43	$7,874
Unit 2 Percent Change	18.6%	23.3%	27.1%	18.0%	23.1%	27.4%

A further breakdown of the Dose-risk and OECR information is provided below according to release category.

SAMA 6, Unit 1 Results By Release Category (Pre-EPU)

Release Category	H/E	H/I	H/L	M/E	M/I	M/L	L/E	L/I	L/L	LL/I	LL/L	Total
$Frequency_{BASE}$	1.71E-07	1.47E-07	1.21E-10	0.00E+00	5.05E-07	1.33E-07	7.43E-08	4.20E-07	5.58E-08	0.00E+00	2.37E-08	**1.53E-06**
$Frequency_{SAMA}$	1.62E-07	9.46E-08	1.21E-10	0.00E+00	2.96E-07	1.33E-07	7.43E-08	4.20E-07	5.58E-08	0.00E+00	2.37E-08	**1.26E-06**
$Dose\text{-}Risk_{BASE}$	0.45	0.22	0.00	0.00	0.69	0.15	0.01	0.13	0.02	0.00	0.00	**1.67**
$Dose\text{-}Risk_{SAMA}$	0.43	0.14	0.00	0.00	0.41	0.15	0.01	0.13	0.02	0.00	0.00	**1.29**
$OECR_{BASE}$	$2,497	$1,764	$3	$0	$4,338	$757	$10	$252	$44	$0	$0	**$9,665**
$OECR_{SAMA}$	$2,365	$1,135	$3	$0	$2,543	$757	$10	$252	$44	$0	$0	**$7,109**

SAMA 6, Unit 2 Results By Release Category (Pre-EPU)

Release Category	H/E	H/I	H/L	M/E	M/I	M/L	L/E	L/I	L/L	LL/I	LL/L	Total
$Frequency_{BASE}$	1.71E-07	1.30E-07	1.07E-10	0.00E+00	5.14E-07	1.13E-07	7.43E-08	4.31E-07	2.28E-08	0.00E+00	2.18E-08	**1.48E-06**
$Frequency_{SAMA}$	1.62E-07	7.72E-08	1.07E-10	0.00E+00	3.06E-07	1.13E-07	7.43E-08	4.31E-07	2.28E-08	0.00E+00	2.18E-08	**1.21E-06**
$Dose\text{-}Risk_{BASE}$	0.45	0.20	0.00	0.00	0.70	0.13	0.01	0.13	0.01	0.00	0.00	**1.63**
$Dose\text{-}Risk_{SAMA}$	0.43	0.12	0.00	0.00	0.42	0.13	0.01	0.13	0.01	0.00	0.00	**1.25**
$OECR_{BASE}$	$2,497	$1,560	$3	$0	$4,415	$643	$10	$259	$18	$0	$0	**$9,405**
$OECR_{SAMA}$	$2,365	$926	$3	$0	$2,629	$643	$10	$259	$18	$0	$0	**$6,853**

SAMA 6, Unit 1 Results By Release Category (Post-EPU)

Release Category	H/E	H/I	H/L	M/E	M/I	M/L	L/E	L/I	L/L	LL/I	LL/L	Total
$Frequency_{BASE}$	1.72E-07	1.59E-07	1.31E-10	0.00E+00	5.38E-07	1.51E-07	1.08E-07	4.87E-07	9.46E-09	1.56E-09	2.22E-08	**1.65E-06**
$Frequency_{SAMA}$	1.63E-07	1.03E-07	1.31E-10	0.00E+00	3.16E-07	1.50E-07	1.08E-07	4.87E-07	9.46E-09	1.56E-09	2.22E-08	**1.36E-06**
$Dose\text{-}Risk_{BASE}$	0.50	0.25	0.00	0.00	0.79	0.18	0.02	0.16	0.00	0.00	0.00	**1.90**
$Dose\text{-}Risk_{SAMA}$	0.48	0.16	0.00	0.00	0.46	0.18	0.02	0.16	0.00	0.00	0.00	**1.46**
$OECR_{BASE}$	$2,632	$2,099	$4	$0	$5,057	$995	$18	$337	$9	$0	$0	**$11,151**
$OECR_{SAMA}$	$2,494	$1,360	$4	$0	$2,970	$989	$18	$337	$9	$0	$0	**$8,181**

SAMA 6, Unit 2 Results By Release Category (Post-EPU)

Release Category	H/E	H/I	H/L	M/E	M/I	M/L	L/E	L/I	L/L	LL/I	LL/L	Total
$Frequency_{BASE}$	1.72E-07	1.39E-07	1.17E-10	0.00E+00	5.50E-07	1.30E-07	1.08E-07	4.73E-07	3.42E-09	6.87E-10	2.11E-08	**1.60E-06**
$Frequency_{SAMA}$	1.63E-07	8.30E-08	1.17E-10	0.00E+00	3.28E-07	1.29E-07	1.08E-07	4.73E-07	3.42E-09	6.87E-10	2.11E-08	**1.31E-06**
Dose-$Risk_{BASE}$	0.50	0.22	0.00	0.00	0.80	0.16	0.02	0.16	0.00	0.00	0.00	**1.86**
Dose-$Risk_{SAMA}$	0.48	0.13	0.00	0.00	0.48	0.16	0.02	0.16	0.00	0.00	0.00	**1.43**
$OECR_{BASE}$	$2,632	$1,835	$3	$0	$5,170	$857	$18	$327	$3	$0	$0	**$10,845**
$OECR_{SAMA}$	$2,494	$1,096	$3	$0	$3,083	$850	$18	$327	$3	$0	$0	**$7,874**

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

SAMA Number 6 Net Value

Unit	Base Case Cost-Risk (Pre-EPU)	Revised Cost-Risk (Pre-EPU)	Averted Cost-Risk (Pre-EPU)	Base Case Cost-Risk (Post-EPU)	Revised Cost-Risk (Post-EPU)	Averted Cost-Risk (Post-EPU)
Unit 1	$484,000	$367,125	$116,875	$550,000	$416,134	$133,866
Unit 2	$472,000	$355,714	$116,286	$538,000	$405,201	$132,799
Total	$956,000	$722,839	$233,161	$1,088,000	$821,335	$266,665

Based on the $203,000 cost of implementation, the Pre-EPU net value for this SAMA is $30,161 ($233,161 - $203,000 = $30,161), which implies that this SAMA is cost beneficial.

For Post-EPU conditions, the net value for this SAMA is $63,665 ($266,665 - $203,000 = $63,665), which implies that this SAMA is cost beneficial.

E.6.6 SAMA Number 7: Re-Divisionalize ESW Cooling to RHR

An insight based on a previous plant configuration prompted SSES to change the RHR cooling alignment for the “C” and “D” RHR pumps and room coolers. To address the issue, ESW trains “A” and “C” were aligned to RHR trains “A” and “D” and ESW trains “B” and “D” were aligned to RHR trains “B” and “C”. While the plant configuration that instigated this change is no longer in place, a large portion of the current risk profile is related to the previous RHR cooling changes. Typically, these are scenarios in which the “A”, “B”, and “E” EDGs are unable to power any 4kV AC emergency buses when either the “C” or “D” EDG has also failed. The station portable generator is available to support HPCI operation and depressurization, but SPC is not available to maintain the suppression pool as a suction source given the unavailability of RHR pump and room cooling. RCIC and Core Spray fail due to equipment/operator failures.

Changing the ESW cooling alignment so that a given ESW train cools the corresponding RHR train would provide a means of maintaining HPCI as a high pressure injection source and an RHR pump for low pressure makeup in the event of HPCI failure.

The impact of re-divisionalizing ESW cooling to RHR has been estimated by changing the RHR cooling support logic so that it references the same division as the pump. Specific model changes are shown in the table below for the pre-EPU Unit 1 model. Unit 2 changes and those for the Post-EPU models are similar.

SAMA Number 7 Model Changes

Gate and / or Basic Event ID and Description	Description of Change
149-I-C-SUPPORT: RESIDUAL HEAT REMOVAL CHANNEL C EQUIPMENT (BLOCK C)	Deleted gate 154-II-N-PPVLV Added gate 154-I-N-PPVLV
154-II-C-ESWFP[1]: FAILURE OF DIVISION II ESW OR FLOW PATH	Deleted gate 154-II-N-PPVLV Added gate 154-I-N-PPVLV
149-I-C-SUPPORT_E: RESIDUAL HEAT REMOVAL CHANNEL C EQUIPMENT (BLOCK C)	Deleted gate 154-II-N-PPVLV Added gate 154-I-N-PPVLV
149-II-D-SUPPORT: RESIDUAL HEAT REMOVAL CHANNEL D EQUIPMENT (BLOCK D)	Deleted gate 154-I-N-PPVLV Added gate 154-II-N-PPVLV
154-I-D-ESWFP[1]: FAILURE OR DIVISION I ESW OR FLOW PATH	Deleted gate 154-I-N-PPVLV Added gate 154-II-N-PPVLV
149-II-D-SUPPORT_E: RESIDUAL HEAT REMOVAL CHANNEL D EQUIPMENT WITH E DG BACKUP	Deleted gate 154-I-N-PPVLV Added gate 154-II-N-PPVLV

[1] This gate name was used in the model to identify that the cooling flowpath failures included under the gate were Division II failures. This gate includes only Division I powered valves and the cooling water flow path such that including the Division I flow path under the gate is appropriate even though the gate name “154-II-C-ESWFP” appears to be a Division II gate.

The cost of this SAMA has been estimated to be approximately $970,000 (PPL 2006a, PPL 2006b).

Results

Implementation of this SAMA yields a reduction in the CDF, Dose-risk, and Offsite Economic cost-risk. The results are summarized in the following table for Units 1 and 2 for both pre-EPU and post-EPU conditions:

	Pre-EPU			Post-EPU		
	CDF	Dose-Risk	OECR	CDF	Dose-Risk	OECR
Unit 1_{Base}	1.86E-06	1.67	$9,665	1.97E-06	1.90	$11,151
Unit 1_{SAMA}	1.67E-06	1.57	$9,153	1.76E-06	1.78	$10,465
Unit 1 Percent Change	10.2%	6.0%	5.3%	10.7%	6.3%	6.2%
Unit 2_{Base}	1.83E-06	1.63	$9,405	1.94E-06	1.86	$10,845
Unit 2_{SAMA}	1.65E-06	1.54	$8,928	1.74E-06	1.73	$10,192
Unit 2 Percent Change	9.8%	5.5%	5.1%	10.3%	7.0%	6.0%

A further breakdown of the Dose-risk and OECR information is provided below according to release category.

SAMA 7, Unit 1 Results By Release Category (Pre-EPU)

Release Category	H/E	H/I	H/L	M/E	M/I	M/L	L/E	L/I	L/L	LL/I	LL/L	Total
$Frequency_{BASE}$	1.71E-07	1.47E-07	1.21E-10	0.00E+00	5.05E-07	1.33E-07	7.43E-08	4.20E-07	5.58E-08	0.00E+00	2.37E-08	**1.53E-06**
$Frequency_{SAMA}$	1.71E-07	1.47E-07	1.13E-10	0.00E+00	5.05E-07	4.36E-08	7.43E-08	4.15E-07	5.50E-08	0.00E+00	2.37E-08	**1.43E-06**
Dose-$Risk_{BASE}$	0.45	0.22	0.00	0.00	0.69	0.15	0.01	0.13	0.02	0.00	0.00	**1.67**
Dose-$Risk_{SAMA}$	0.45	0.22	0.00	0.00	0.69	0.05	0.01	0.13	0.02	0.00	0.00	**1.57**
$OECR_{BASE}$	$2,497	$1,764	$3	$0	$4,338	$757	$10	$252	$44	$0	$0	**$9,665**
$OECR_{SAMA}$	$2,497	$1,764	$3	$0	$4,338	$248	$10	$249	$44	$0	$0	**$9,153**

SAMA 7, Unit 2 Results By Release Category (Pre-EPU)

Release Category	H/E	H/I	H/L	M/E	M/I	M/L	L/E	L/I	L/L	LL/I	LL/L	Total
$Frequency_{BASE}$	1.71E-07	1.30E-07	1.07E-10	0.00E+00	5.14E-07	1.13E-07	7.43E-08	4.31E-07	2.28E-08	0.00E+00	2.18E-08	**1.48E-06**
$Frequency_{SAMA}$	1.71E-07	1.30E-07	9.92E-11	0.00E+00	5.14E-07	3.02E-08	7.43E-08	4.22E-07	2.19E-08	0.00E+00	2.18E-08	**1.39E-06**
$Dose\text{-}Risk_{BASE}$	0.45	0.20	0.00	0.00	0.70	0.13	0.01	0.13	0.01	0.00	0.00	**1.63**
$Dose\text{-}Risk_{SAMA}$	0.45	0.20	0.00	0.00	0.70	0.04	0.01	0.13	0.01	0.00	0.00	**1.54**
$OECR_{BASE}$	$2,497	$1,560	$3	$0	$4,415	$643	$10	$259	$18	$0	$0	**$9,405**
$OECR_{SAMA}$	$2,497	$1,560	$3	$0	$4,415	$172	$10	$254	$17	$0	$0	**$8,928**

SAMA 7, Unit 1 Results By Release Category (Post-EPU)

Release Category	H/E	H/I	H/L	M/E	M/I	M/L	L/E	L/I	L/L	LL/I	LL/L	Total
$Frequency_{BASE}$	1.72E-07	1.59E-07	1.31E-10	0.00E+00	5.38E-07	1.51E-07	1.08E-07	4.87E-07	9.46E-09	1.56E-09	2.22E-08	**1.65E-06**
$Frequency_{SAMA}$	1.72E-07	1.59E-07	1.15E-10	0.00E+00	5.38E-07	4.78E-08	1.11E-07	4.80E-07	8.39E-09	1.56E-09	2.22E-08	**1.54E-06**
$Dose\text{-}Risk_{BASE}$	0.50	0.25	0.00	0.00	0.79	0.18	0.02	0.16	0.00	0.00	0.00	**1.90**
$Dose\text{-}Risk_{SAMA}$	0.50	0.25	0.00	0.00	0.79	0.06	0.02	0.16	0.00	0.00	0.00	**1.78**
$OECR_{BASE}$	$2,632	$2,099	$4	$0	$5,057	$995	$18	$337	$9	$0	$0	**$11,151**
$OECR_{SAMA}$	$2,632	$2,099	$3	$0	$5,057	$315	$19	$332	$8	$0	$0	**$10,465**

SAMA 7, Unit 2 Results By Release Category (Post-EPU)

Release Category	H/E	H/I	H/L	M/E	M/I	M/L	L/E	L/I	L/L	LL/I	LL/L	Total
$Frequency_{BASE}$	1.72E-07	1.39E-07	1.17E-10	0.00E+00	5.50E-07	1.30E-07	1.08E-07	4.73E-07	3.42E-09	6.87E-10	2.11E-08	**1.60E-06**
$Frequency_{SAMA}$	1.72E-07	1.39E-07	1.01E-10	0.00E+00	5.49E-07	3.35E-08	1.07E-07	4.63E-07	2.34E-09	6.87E-10	2.11E-08	**1.49E-06**
$Dose\text{-}Risk_{BASE}$	0.50	0.22	0.00	0.00	0.80	0.16	0.02	0.16	0.00	0.00	0.00	**1.86**
$Dose\text{-}Risk_{SAMA}$	0.50	0.22	0.00	0.00	0.80	0.04	0.02	0.15	0.00	0.00	0.00	**1.73**
$OECR_{BASE}$	$2,632	$1,835	$3	$0	$5,170	$857	$18	$327	$3	$0	$0	**$10,845**
$OECR_{SAMA}$	$2,632	$1,835	$3	$0	$5,161	$221	$18	$320	$2	$0	$0	**$10,192**

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

SAMA Number 7 Net Value

Unit	Base Case Cost-Risk (Pre-EPU)	Revised Cost-Risk (Pre-EPU)	Averted Cost-Risk (Pre-EPU)	Base Case Cost-Risk (Post-EPU)	Revised Cost-Risk (Post-EPU)	Averted Cost-Risk (Post-EPU)
Unit 1	$484,000	$453,282	$30,718	$550,000	$511,610	$38,390
Unit 2	$472,000	$443,416	$28,584	$538,000	$500,500	$37,500
Total	$956,000	$896,698	$59,302	$1,088,0000	$1,012,110	$75,890

Based on the $970,000 cost of implementation, the Pre-EPU net value for this SAMA is -$910,698 ($59,302 - $970,000 = -$910,698), which implies that this SAMA is not cost beneficial.

For Post-EPU conditions, the net value for this SAMA is -$894,110 ($75,890 - $970,000 = -$894,110), which implies that this SAMA is not cost beneficial.

E.6.7 SAMA Number 8: Automatic Feedwater runback

The operator action to reduce Feedwater flow (feedwater runback) is an important component of ATWS mitigation for non-isolation ATWS cases. Success of level control using Feedwater in conjunction with either SLC injection or MRI results in a successful endstate (power level controlled and core cooling available). Without successful feedwater runback, core damage can still be avoided with SLC injection (no MRI credit), but some degree of fuel damage is assumed to occur. Given that any additional power/level control action devised to mitigate an ATWS would share a high dependence with the Feedwater runback action, any SAMAs requiring operator actions are considered to be of little benefit. A potentially effective means of reducing the risk of ATWS scenarios for SSES is believed to be the automation of the Feedwater runback action.

The impact of installing automatic Feedwater runback logic at SSES has been estimated by modifying the Feedwater runback failure flag in the Level 1 and Level 2 cutsets (145-N-N-REDFWO-FLAG for unit 1 and 245-N-N-REDFWO-FLAG for unit 2). Manipulation of this flag captures both the dependent and independent operator failures related to the Feedwater runback action. In this case, the flag has been set to 0.0 to eliminate all cutsets in which the Feedwater runback action has failed, which implies that the automated function is 100 percent reliable.

The cost of installing logic to automate feedwater runback is considered to be similar in scope to the advanced boiling water reactor (ABWR) severe accident mitigation design alternative (SAMDA) to install computer aided instrumentation. This enhancement was estimated to cost approximately $600,000 for a single unit in the reactor's design phase (GE 1994). While this estimate would likely be larger for SSES to account for installation at both units, the need to retrofit an existing plant, and for inflation from the time the ABWR study was performed in 1994, $600,000 is used as a lower bound cost of implementation for this SAMA.

Results

Implementation of this SAMA yields a reduction in the CDF, Dose-risk, and Offsite Economic cost-risk. The results are summarized in the following table for Units 1 and 2 for both pre-EPU and post-EPU conditions:

	Pre-EPU			Post-EPU		
	CDF	Dose-Risk	OECR	CDF	Dose-Risk	OECR
Unit 1_{Base}	1.86E-06	1.67	$9,665	1.97E-06	1.90	$11,151
Unit 1_{SAMA}	1.80E-06	1.67	$9,659	1.89E-06	1.89	$11,140
Unit 1 Percent Change	3.2%	0.0%	0.1%	4.1%	0.5%	0.1%
Unit 2_{Base}	1.83E-06	1.63	$9,405	1.94E-06	1.86	$10,845
Unit 2_{SAMA}	1.78E-06	1.63	$9,399	1.86E-06	1.85	$10,834
Unit 2 Percent Change	2.7%	0.0%	0.1%	4.1%	0.5%	0.1%

A further breakdown of the Dose-risk and OECR information is provided below according to release category.

SAMA 8, Unit 1 Results By Release Category (Pre-EPU)

Release Category	H/E	H/I	H/L	M/E	M/I	M/L	L/E	L/I	L/L	LL/I	LL/L	Total
$Frequency_{BASE}$	1.71E-07	1.47E-07	1.21E-10	0.00E+00	5.05E-07	1.33E-07	7.43E-08	4.20E-07	5.58E-08	0.00E+00	2.37E-08	**1.53E-06**
$Frequency_{SAMA}$	1.71E-07	1.47E-07	1.21E-10	0.00E+00	5.05E-07	1.33E-07	3.47E-08	4.18E-07	5.58E-08	0.00E+00	2.37E-08	**1.49E-06**
$Dose\text{-}Risk_{BASE}$	0.45	0.22	0.00	0.00	0.69	0.15	0.01	0.13	0.02	0.00	0.00	**1.67**
$Dose\text{-}Risk_{SAMA}$	0.45	0.22	0.00	0.00	0.69	0.15	0.01	0.13	0.02	0.00	0.00	**1.67**
$OECR_{BASE}$	$2,497	$1,764	$3	$0	$4,338	$757	$10	$252	$44	$0	$0	**$9,665**
$OECR_{SAMA}$	$2,497	$1,764	$3	$0	$4,338	$757	$5	$251	$44	$0	$0	**$9,659**

SAMA 8, Unit 2 Results By Release Category (Pre-EPU)

Release Category	H/E	H/I	H/L	M/E	M/I	M/L	L/E	L/I	L/L	LL/I	LL/L	Total
$Frequency_{BASE}$	1.71E-07	1.30E-07	1.07E-10	0.00E+00	5.14E-07	1.13E-07	7.43E-08	4.31E-07	2.28E-08	0.00E+00	2.18E-08	**1.48E-06**
$Frequency_{SAMA}$	1.71E-07	1.30E-07	1.07E-10	0.00E+00	5.14E-07	1.13E-07	3.48E-08	4.30E-07	2.28E-08	0.00E+00	2.18E-08	**1.44E-06**
$Dose\text{-}Risk_{BASE}$	0.45	0.20	0.00	0.00	0.70	0.13	0.01	0.13	0.01	0.00	0.00	**1.63**
$Dose\text{-}Risk_{SAMA}$	0.45	0.20	0.00	0.00	0.70	0.13	0.01	0.13	0.01	0.00	0.00	**1.63**
$OECR_{BASE}$	$2,497	$1,560	$3	$0	$4,415	$643	$10	$259	$18	$0	$0	**$9,405**
$OECR_{SAMA}$	$2,497	$1,560	$3	$0	$4,415	$643	$5	$258	$18	$0	$0	**$9,399**

SAMA 8, Unit 1 Results By Release Category (Post-EPU)

Release Category	H/E	H/I	H/L	M/E	M/I	M/L	L/E	L/I	L/L	LL/I	LL/L	Total
$Frequency_{BASE}$	1.72E-07	1.59E-07	1.31E-10	0.00E+00	5.38E-07	1.51E-07	1.08E-07	4.87E-07	9.46E-09	1.56E-09	2.22E-08	**1.65E-06**
$Frequency_{SAMA}$	1.72E-07	1.59E-07	1.31E-10	0.00E+00	5.38E-07	1.51E-07	4.83E-08	4.86E-07	9.46E-09	1.56E-09	2.22E-08	**1.59E-06**
$Dose\text{-}Risk_{BASE}$	0.50	0.25	0.00	0.00	0.79	0.18	0.02	0.16	0.00	0.00	0.00	**1.90**
$Dose\text{-}Risk_{SAMA}$	0.50	0.25	0.00	0.00	0.79	0.18	0.01	0.16	0.00	0.00	0.00	**1.89**
$OECR_{BASE}$	$2,632	$2,099	$4	$0	$5,057	$995	$18	$337	$9	$0	$0	**$11,151**
$OECR_{SAMA}$	$2,632	$2,099	$4	$0	$5,057	$995	$8	$336	$9	$0	$0	**$11,140**

SAMA 8, Unit 2 Results By Release Category (Post-EPU)

Release Category	H/E	H/I	H/L	M/E	M/I	M/L	L/E	L/I	L/L	LL/I	LL/L	Total
$Frequency_{BASE}$	1.72E-07	1.39E-07	1.17E-10	0.00E+00	5.50E-07	1.30E-07	1.08E-07	4.73E-07	3.42E-09	6.87E-10	2.11E-08	**1.60E-06**
$Frequency_{SAMA}$	1.72E-07	1.39E-07	1.17E-10	0.00E+00	5.50E-07	1.30E-07	4.81E-08	4.71E-07	3.42E-09	6.87E-10	2.11E-08	**1.54E-06**
$Dose\text{-}Risk_{BASE}$	0.50	0.22	0.00	0.00	0.80	0.16	0.02	0.16	0.00	0.00	0.00	**1.86**
$Dose\text{-}Risk_{SAMA}$	0.50	0.22	0.00	0.00	0.80	0.16	0.01	0.16	0.00	0.00	0.00	**1.85**
$OECR_{BASE}$	$2,632	$1,835	$3	$0	$5,170	$857	$18	$327	$3	$0	$0	**$10,845**
$OECR_{SAMA}$	$2,632	$1,835	$3	$0	$5,170	$857	$8	$326	$3	$0	$0	**$10,834**

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

SAMA Number 8 Net Value

Unit	Base Case Cost-Risk (Pre-EPU)	Revised Cost-Risk (Pre-EPU)	Averted Cost-Risk (Pre-EPU)	Base Case Cost-Risk (Post-EPU)	Revised Cost-Risk (Post-EPU)	Averted Cost-Risk (Post-EPU)
Unit 1	$484,000	$480,881	$3,119	$550,000	$545,052	$4,948
Unit 2	$472,000	$469,368	$2,632	$538,000	$533,052	$4,948
Total	$956,000	$950,249	$5,751	$1,088,0000	$1,078,104	$9,896

Based on the $600,000 cost of implementation, the Pre-EPU net value for this SAMA is -$594,249 ($5,751 - $600,000 = -$594,249), which implies that this SAMA is not cost beneficial.

For Post-EPU conditions, the net value for this SAMA is -$590,104 ($9,896 - $600,000 = -$590,104), which implies that this SAMA is not cost beneficial.

E.6.8 SAMA Number 9: Direct Feeds from the 125V DC Battery Chargers to Critical Loads

The failure of a 125V DC bus can result in loss of a wide range of equipment and is currently treated as an unrecoverable failure in the PRA. Repair, replacement, or bypass of a failed bus are actions that are currently possible given sufficient time; however, it is difficult to justify credit for these types of actions when procedures are not available to provide guidance on how to address bus failures in accident conditions.

Proceduralizing the use of pre-staged, temporary cables to bypass a failed DC bus would allow the operators to provide power to critical DC loads in a timely fashion during an accident assuming that the equipment on the failed bus is not damaged. The cost-benefit of this SAMA is developed assuming that the relevant equipment remains operable, but it is possible that fire damage or the consequences of a bus failure could render the equipment normally aligned to the bus inoperable.

This SAMA has been developed to address two cases that have been identified as important contributors to risk at SSES:

1. Failure of a 125V DC bus combined with the failure/unavailability of the 125V DC battery charger in the opposite division, and

2. A fire in fire zone 0-28B-II that impacts any of the following equipment: a) 1D612 – 125V DC class 1E load center, b) 1D613 – 125V DC class 1E channel A charger (fails both the charger and battery and leads to loss of 1D612), or c) 1D614 – 125V DC class 1E distribution panel (powered by 1D612).

In order for this SAMA to effectively mitigate these failures, it is believed that direct feeds to critical DC loads would have to be permanently pre-wired to reduce alignment time. Temporary jumper connections between the battery chargers and critical load wires would be made at the battery charger in the event that they are needed. The ability to power the critical loads from either division would improve the capability of this SAMA and is assumed to be available in this assessment.

The impact of implementing this SAMA has been estimated by setting the DC bus failure initiating events, independent failure events, and common cause failure events to zero in the PRA model. The events that were modified for Unit 1 are as follows: 102BUR1D612, %1LODCBUS_612, CCFBB2BUR_12, CCFBB2BUR_13, CCFBB2BUR_14, CCFBB3BUR_123, CCFBB3BUR_124, CCFBB3BUR_134, CCFBB4BUR_ALL, 102BUR1D622, %1LODCBUS_622, CCFBB2BUR_23, CCFBB2BUR_24, CCFBB3BUR_234.

Similarly, the following Unit 2 events were set to zero: 202BUR2D622, %2LODCBUS_622, CCFBB2BUR_23-UNIT2, CCFBB2BUR_12-UNIT2, CCFBB2BUR_24-UNIT2, CCFBB3BUR_123-UNIT2, CCFBB3BUR_124-UNIT2, CCFBB3BUR_234-UNIT2, CCFBB4BUR_ALL-UNIT2, 202BUR2D612, %2LODCBUS_612, CCFBB2BUR_13-UNIT2, CCFBB2BUR_14-UNIT2, CCFBB3BUR_134-UNIT2.

In addition to the changes identified above, a separate contribution is included to specifically address the fire contributions from zone 0-28B-II. Starting with the assumption that internal and external events contribute an equal portion site risk, a rough estimate of the averted cost-risk associated with eliminating the zone 0-28B-II risk can be made by further assuming that all External Events risk corresponds to Fire risk. As zone 0-28B-II accounts for about 3 percent of the total Fire frequency (1.3E-9/cycle / 4.5E-8/cycle = 0.0288), 3 percent of the external events risk can be assigned to zone 0-28B-II. Finally, if it is assumed that all zone 0-28B-II risk is eliminated by implementing this SAMA, the corresponding averted cost-risk for pre-EPU and post-EPU conditions can be calculated:

	Pre-EPU			Post-EPU		
	Total Unit MMACR	Unit Fire Contribution	Zone 0-28B-II Contribution	Total Unit MMACR	Unit Fire Contribution	Zone 0-28B-II Contribution
Unit 1_{Base}	$484,000	$242,000	$7,260	$550,000	$275,000	$8,250
Unit 2_{Base}	$472,000	$236,000	$7,080	$538,000	$269,000	$8,070
Total Averted Cost-Risk			$14,340			$16,320

These averted cost-risk estimates are added to those calculated from the general internal and external events models. This method captures the specific risk reduction associated with zone 0-28B-II fires and the non-zone 0-28B-II risk reduction resulting from the SAMA for other external events initiators.

Overall, this treatment provides an upper bound estimate of the benefit of this SAMA given that it does not account for operator alignment error, it assumes that the alignment does not require any manipulation time, and it eliminates DC bus failures that would prevent EDG operation in a LOOP or contingent LOOP.

The cost of providing the capability to provide direct feeds to the critical 125V DC loads been estimated to be approximately $346,000 (PPL 2005e).

Results

Implementation of this SAMA yields a reduction in the CDF, Dose-risk, and Offsite Economic cost-risk. The results are summarized in the following table for Units 1 and 2 for both pre-EPU and post-EPU conditions:

	Pre-EPU			Post-EPU		
	CDF	Dose-Risk	OECR	CDF	Dose-Risk	OECR
Unit 1_{Base}	1.86E-06	1.67	$9,665	1.97E-06	1.90	$11,151
Unit 1_{SAMA}	1.73E-06	1.64	$9,584	1.84E-06	1.89	$11,072
Unit 1 Percent Change	7.0%	1.8%	0.8%	6.6%	0.5%	0.7%
Unit 2_{Base}	1.83E-06	1.63	$9,405	1.94E-06	1.86	$10,845
Unit 2_{SAMA}	1.71E-06	1.61	$9,345	1.82E-06	1.85	$10,776
Unit 2 Percent Change	6.6%	1.2%	0.6%	6.2%	0.5%	0.6%

A further breakdown of the Dose-risk and OECR information is provided below according to release category.

SAMA 9, Unit 1 Results By Release Category (Pre-EPU)

Release Category	H/E	H/I	H/L	M/E	M/I	M/L	L/E	L/I	L/L	LL/I	LL/L	Total
$Frequency_{BASE}$	1.71E-07	1.47E-07	1.21E-10	0.00E+00	5.05E-07	1.33E-07	7.43E-08	4.20E-07	5.58E-08	0.00E+00	2.37E-08	**1.53E-06**
$Frequency_{SAMA}$	1.68E-07	1.47E-07	1.21E-10	0.00E+00	5.05E-07	1.33E-07	7.41E-08	4.20E-07	8.50E-09	0.00E+00	2.22E-08	**1.48E-06**
$Dose\text{-}Risk_{BASE}$	0.45	0.22	0.00	0.00	0.69	0.15	0.01	0.13	0.02	0.00	0.00	**1.67**
$Dose\text{-}Risk_{SAMA}$	0.44	0.22	0.00	0.00	0.69	0.15	0.01	0.13	0.00	0.00	0.00	**1.64**
$OECR_{BASE}$	$2,497	$1,764	$3	$0	$4,338	$757	$10	$252	$44	$0	$0	**$9,665**
$OECR_{SAMA}$	$2,453	$1,764	$3	$0	$4,338	$757	$10	$252	$7	$0	$0	**$9,584**

SAMA 9, Unit 2 Results By Release Category (Pre-EPU)

Release Category	H/E	H/I	H/L	M/E	M/I	M/L	L/E	L/I	L/L	LL/I	LL/L	Total
$Frequency_{BASE}$	1.71E-07	1.30E-07	1.07E-10	0.00E+00	5.14E-07	1.13E-07	7.43E-08	4.31E-07	2.28E-08	0.00E+00	2.18E-08	**1.48E-06**
$Frequency_{SAMA}$	1.68E-07	1.30E-07	1.07E-10	0.00E+00	5.14E-07	1.13E-07	7.42E-08	4.31E-07	2.71E-09	0.00E+00	2.11E-08	**1.45E-06**
$Dose\text{-}Risk_{BASE}$	0.45	0.20	0.00	0.00	0.70	0.13	0.01	0.13	0.01	0.00	0.00	**1.63**
$Dose\text{-}Risk_{SAMA}$	0.44	0.20	0.00	0.00	0.70	0.13	0.01	0.13	0.00	0.00	0.00	**1.61**
$OECR_{BASE}$	$2,497	$1,560	$3	$0	$4,415	$643	$10	$259	$18	$0	$0	**$9,405**
$OECR_{SAMA}$	$2,453	$1,560	$3	$0	$4,415	$643	$10	$259	$2	$0	$0	**$9,345**

SAMA 9, Unit 1 Results By Release Category (Post-EPU)

Release Category	H/E	H/I	H/L	M/E	M/I	M/L	L/E	L/I	L/L	LL/I	LL/L	Total
$Frequency_{BASE}$	1.72E-07	1.59E-07	1.31E-10	0.00E+00	5.38E-07	1.51E-07	1.08E-07	4.87E-07	9.46E-09	1.56E-09	2.22E-08	**1.65E-06**
$Frequency_{SAMA}$	1.69E-07	1.59E-07	1.31E-10	0.00E+00	5.38E-07	1.51E-07	1.08E-07	4.41E-07	8.57E-09	0.00E+00	2.22E-08	**1.60E-06**
$Dose\text{-}Risk_{BASE}$	0.50	0.25	0.00	0.00	0.79	0.18	0.02	0.16	0.00	0.00	0.00	**1.90**
$Dose\text{-}Risk_{SAMA}$	0.50	0.25	0.00	0.00	0.79	0.18	0.02	0.15	0.00	0.00	0.00	**1.89**
$OECR_{BASE}$	$2,632	$2,099	$4	$0	$5,057	$995	$18	$337	$9	$0	$0	**$11,151**
$OECR_{SAMA}$	$2,586	$2,099	$4	$0	$5,057	$995	$18	$305	$8	$0	$0	**$11,072**

SAMA 9, Unit 2 Results By Release Category (Post-EPU)

Release Category	H/E	H/I	H/L	M/E	M/I	M/L	L/E	L/I	L/L	LL/I	LL/L	Total
$Frequency_{BASE}$	1.72E-07	1.39E-07	1.17E-10	0.00E+00	5.50E-07	1.30E-07	1.08E-07	4.73E-07	3.42E-09	6.87E-10	2.11E-08	**1.60E-06**
$Frequency_{SAMA}$	1.69E-07	1.39E-07	1.17E-10	0.00E+00	5.49E-07	1.30E-07	1.08E-07	4.53E-07	2.89E-09	0.00E+00	2.11E-08	**1.57E-06**
$Dose\text{-}Risk_{BASE}$	0.50	0.22	0.00	0.00	0.80	0.16	0.02	0.16	0.00	0.00	0.00	**1.86**
$Dose\text{-}Risk_{SAMA}$	0.50	0.22	0.00	0.00	0.80	0.16	0.02	0.15	0.00	0.00	0.00	**1.85**
$OECR_{BASE}$	$2,632	$1,835	$3	$0	$5,170	$857	$18	$327	$3	$0	$0	**$10,845**
$OECR_{SAMA}$	$2,586	$1,835	$3	$0	$5,161	$857	$18	$313	$3	$0	$0	**$10,776**

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

SAMA Number 9 Net Value

Unit	Base Case Cost-Risk (Pre-EPU)	Revised Cost-Risk (Pre-EPU)	Averted Cost-Risk (Pre-EPU)	Base Case Cost-Risk (Post-EPU)	Revised Cost-Risk (Post-EPU)	Averted Cost-Risk (Post-EPU)
Unit 1	$484,000	$473,394	$10,606	$550,000	$540,499	$9,501
Unit 2	$472,000	$463,110	$8,890	$538,000	$529,300	$8,700
Non-Fire Specific Total	$956,000	$936,504	$19,496	$1,088,000	$1,069,799	$18,201
Fire Zone 0-28B-II Contribution			$14,340			$16,320
Total			$33,836			$34,521

The total averted cost-risk for this SAMA is the sum of the averted cost-risk from internal events PRA results (e.g., $19,496 for the Pre-EPU model) and the fire zone specific averted cost-risk estimated above (e.g. $14,340 for the Pre-EPU model). The net value is then calculated in the same way as for the other SAMAs: Net Value = Total Averted Cost Risk – Cost of Implementation. It should be noted that the PRA based averted cost-risk estimate still includes the doubling factor to account for the general external events contributions even though explicit fire contributions are addressed separately.

Based on the $346,000 cost of implementation, the Pre-EPU net value for this SAMA is -$312,164 ($33,836 - $346,000 = -$312,164), which implies that this SAMA is not cost beneficial.

For Post-EPU conditions, the net value for this SAMA is -$311,479 ($34,521 - $346,000 = -$311,479), which implies that this SAMA is not cost beneficial.

E.6.9 SAMA Number 10: Install a Pressure Control Valve Between the IA and CIG Systems

The importance of the IA to CIG cross-tie is primarily to avoid a plant transient that closes the MSIVs. Closing the MSIVs fails the Feedwater system as a source of high pressure makeup. This failure and loss of DC power fails HPI and extended depressurization capability through power and air dependencies. In order to recover to a safe, stable endstate from these sequences, injection and heat removal must be restored. Installing a pressure control valve between the IA and CIG systems would automate the cross-tie and remove the primary dependence on human action.

Other means of mitigating these sequences are possible, but they would require recovery/bypass of the failed bus, the addition of an alternate source of HPI, or the addition of a means to depressurize the RPV without DC power. Some of these enhancements are investigated for SSES based on the importance of other contributors, including SAMA 9, which addresses DC bus failures, and SAMA 1, which investigates an alternate HPI method. While these other SAMAs address the sequences in which the IA to CIG cross-tie action is important, this SAMA focuses specifically on the cross-tie issue and a relatively low cost enhancement.

The impact of automating the alignment of the IA to CIG cross-tie has been estimated by modifying the failure probabilities of the dependent and independent operator actions related to the IA to CIG cross-tie. Specifically, the following actions were set to false:

- Z-IACIG-RXLC-O (JHEP OPERATOR FAILS TO XTIE IA & CIG AND CONTROL RX WATER LEVEL)
- Z-IACIG-CVLOC-O (JHEP OPERATOR FAILS TO XTIE IA & CIG AND VENT CONTAINMENT LOCALLY)
- Z-VENT-IACIG-O (JHEP OPERATOR FAILS TO VENTILATE RHRSW AND XTIE IA TO CIG)
- Z-BMS-IACIG-O (JHEP OPERATOR FAILS TO ALIGN BLUE MAX AND CROSSTIE IA TO CIG)
- Z-IACIG-RWST-O (JHEP OPERATOR FAILS TO XTIE IA & CIG AND FAILS TO XTIE RWST)
- 1(2)25-N-N-FXTIACIG-O (OPERATOR FAILS TO OPEN IA-CIG CROSSTIE VALVES)

Setting the events to “false” eliminates all cutsets in which the action to align the cross-tie has failed. This implies that the automated function is 100 percent reliable.

The cost of installing a pressure control valve between the IA and CIG systems has been estimated to be approximately $386,000 (PPL 2005d). While installation of an additional air compressor is a potential means of addressing this SAMA, installation of the pressure control valve is considered to be a more cost effective means of addressing the issue at Susquehanna.

Results

Implementation of this SAMA yields a reduction in the CDF, Dose-risk, and Offsite Economic cost-risk. The results are summarized in the following table for Units 1 and 2 for both pre-EPU and post-EPU conditions:

	Pre-EPU			Post-EPU		
	CDF	Dose-Risk	OECR	CDF	Dose-Risk	OECR
Unit 1_{Base}	1.86E-06	1.67	$9,665	1.97E-06	1.90	$11,151
Unit 1_{SAMA}	1.74E-06	1.65	$9,562	1.85E-06	1.88	$11,056
Unit 1 Percent Change	6.5%	1.2%	1.1%	6.1%	1.1%	0.9%
Unit 2_{Base}	1.83E-06	1.63	$9,405	1.94E-06	1.86	$10,845
Unit 2_{SAMA}	1.72E-6	1.61	$9,343	1.83E-06	1.85	$10,765
Unit 2 Percent Change	6.0%	1.2%	0.7%	5.7%	0.5%	0.7%

A further breakdown of the Dose-risk and OECR information is provided below according to release category.

SAMA 10, Unit 1 Results By Release Category (Pre-EPU)

Release Category	H/E	H/I	H/L	M/E	M/I	M/L	L/E	L/I	L/L	LL/I	LL/L	Total
$Frequency_{BASE}$	1.71E-07	1.47E-07	1.21E-10	0.00E+00	5.05E-07	1.33E-07	7.43E-08	4.20E-07	5.58E-08	0.00E+00	2.37E-08	**1.53E-06**
$Frequency_{SAMA}$	1.68E-07	1.47E-07	1.21E-10	0.00E+00	5.03E-07	1.31E-07	7.41E-08	4.18E-07	1.94E-08	0.00E+00	2.25E-08	**1.48E-06**
Dose-$Risk_{BASE}$	0.45	0.22	0.00	0.00	0.69	0.15	0.01	0.13	0.02	0.00	0.00	**1.67**
Dose-$Risk_{SAMA}$	0.44	0.22	0.00	0.00	0.69	0.15	0.01	0.13	0.01	0.00	0.00	**1.65**
$OECR_{BASE}$	$2,497	$1,764	$3	$0	$4,338	$757	$10	$252	$44	$0	$0	**$9,665**
$OECR_{SAMA}$	$2,453	$1,764	$3	$0	$4,321	$745	$10	$251	$15	$0	$0	**$9,562**

SAMA 10, Unit 2 Results By Release Category (Pre-EPU)

Release Category	H/E	H/I	H/L	M/E	M/I	M/L	L/E	L/I	L/L	LL/I	LL/L	Total
$Frequency_{BASE}$	1.71E-07	1.30E-07	1.07E-10	0.00E+00	5.14E-07	1.13E-07	7.43E-08	4.31E-07	2.28E-08	0.00E+00	2.18E-08	**1.48E-06**
$Frequency_{SAMA}$	1.68E-07	1.30E-07	1.07E-10	0.00E+00	5.13E-07	1.13E-07	7.42E-08	4.31E-07	9.90E-09	0.00E+00	2.13E-08	**1.46E-06**
$Dose\text{-}Risk_{BASE}$	0.45	0.20	0.00	0.00	0.70	0.13	0.01	0.13	0.01	0.00	0.00	**1.63**
$Dose\text{-}Risk_{SAMA}$	0.44	0.20	0.00	0.00	0.70	0.13	0.01	0.13	0.00	0.00	0.00	**1.61**
$OECR_{BASE}$	$2,497	$1,560	$3	$0	$4,415	$643	$10	$259	$18	$0	$0	**$9,405**
$OECR_{SAMA}$	$2,453	$1,560	$3	$0	$4,407	$643	$10	$259	$8	$0	$0	**$9,343**

SAMA 10, Unit 1 Results By Release Category (Post-EPU)

Release Category	H/E	H/I	H/L	M/E	M/I	M/L	L/E	L/I	L/L	LL/I	LL/L	Total
$Frequency_{BASE}$	1.72E-07	1.59E-07	1.31E-10	0.00E+00	5.38E-07	1.51E-07	1.08E-07	4.87E-07	9.46E-09	1.56E-09	2.22E-08	**1.65E-06**
$Frequency_{SAMA}$	1.69E-07	1.59E-07	1.31E-10	0.00E+00	5.37E-07	1.49E-07	1.07E-07	4.50E-07	8.83E-09	3.40E-10	2.22E-08	**1.60E-06**
$Dose\text{-}Risk_{BASE}$	0.50	0.25	0.00	0.00	0.79	0.18	0.02	0.16	0.00	0.00	0.00	**1.90**
$Dose\text{-}Risk_{SAMA}$	0.50	0.25	0.00	0.00	0.78	0.18	0.02	0.15	0.00	0.00	0.00	**1.88**
$OECR_{BASE}$	$2,632	$2,099	$4	$0	$5,057	$995	$18	$337	$9	$0	$0	**$11,151**
$OECR_{SAMA}$	$2,586	$2,099	$4	$0	$5,048	$982	$18	$311	$8	$0	$0	**$11,056**

SAMA 10, Unit 2 Results By Release Category (Post-EPU)

Release Category	H/E	H/I	H/L	M/E	M/I	M/L	L/E	L/I	L/L	LL/I	LL/L	Total
$Frequency_{BASE}$	1.72E-07	1.39E-07	1.17E-10	0.00E+00	5.50E-07	1.30E-07	1.08E-07	4.73E-07	3.42E-09	6.87E-10	2.11E-08	**1.60E-06**
$Frequency_{SAMA}$	1.69E-07	1.39E-07	1.17E-10	0.00E+00	5.48E-07	1.29E-07	1.08E-07	4.61E-07	3.08E-09	2.34E-10	2.11E-08	**1.58E-06**
$Dose\text{-}Risk_{BASE}$	0.50	0.22	0.00	0.00	0.80	0.16	0.02	0.16	0.00	0.00	0.00	**1.86**
$Dose\text{-}Risk_{SAMA}$	0.50	0.22	0.00	0.00	0.80	0.16	0.02	0.15	0.00	0.00	0.00	**1.85**
$OECR_{BASE}$	$2,632	$1,835	$3	$0	$5,170	$857	$18	$327	$3	$0	$0	**$10,845**
$OECR_{SAMA}$	$2,586	$1,835	$3	$0	$5,151	$850	$18	$319	$3	$0	$0	**$10,765**

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

SAMA Number 10 Net Value

Unit	Base Case Cost-Risk (Pre-EPU)	Revised Cost-Risk (Pre-EPU)	Averted Cost-Risk (Pre-EPU)	Base Case Cost-Risk (Post-EPU)	Revised Cost-Risk (Post-EPU)	Averted Cost-Risk (Post-EPU)
Unit 1	$484,000	$473,824	$10,176	$550,000	$539,917	$10,083
Unit 2	$472,000	$463,540	$8,460	$538,000	$529,471	$8,529
Total	$956,000	$937,364	$18,636	$1,088,000	$1,069,388	$18,612

Based on the $386,000 cost of implementation, the Pre-EPU net value for this SAMA is -$367,364 ($18,636 - $386,000 = -$367,364), which implies that this SAMA is not cost beneficial.

For Post-EPU conditions, the net value for this SAMA is -$367,388 ($18,612 - $386,000 = -$367,388), which implies that this SAMA is not cost beneficial.

E.6.10 SAMA Number 12: Containment Venting After Core Damage When Containment Failure is Imminent

The SSES procedure governing primary containment venting recommends that the primary containment not be vented when “large” source terms are expected to be incurred by the on-site or off-site population. Given that a core damage event would result in a “large” source term, the current PRA model conservatively precludes primary containment venting after a core damage event. For unrecovered loss of DHR scenarios, this evolution is assumed to eventually result in a drywell failure and a subsequent “unscrubbed” release of the primary containment contents to the atmosphere.

Discussions with plant operations staff indicate that procedures exist to direct containment venting irrespective of the dose, that the operators are aware of the procedures, and that the Technical Support Center would direct containment venting in the relevant circumstances to prevent containment failure. As a result, the importance rankings of the sequences in which containment venting is precluded due to high radiation levels are artificially inflated. If the existing plant capabilities are credited in the PRA, the importance of containment venting after core damage will be reduced and no plant enhancements to improve venting after core damage would be cost-beneficial.

To demonstrate this case, the baseline PRA results have been manipulated to show that the averted cost-risk associated with further improving SSES containment venting capabilities is less that the minimum expected cost of a SAMA. In this case, the minimum expected cost for a SAMA is considered to be a procedure change, which has been estimated in other SAMA submittals to be about $50,000 (CPL 2004).

In order to quantify the potential averted cost-risk for this SAMA, it was first necessary to develop a revised baseline model that credits the existing vent capabilities described by the operators. This was done by reviewing the PRA model to identify all sequences in which venting was not credited after core damage. These sequence frequencies were then modified to reflect the current SSES vent capability. For this analysis, the failure probability for venting after core damage was assumed to be 1E-1, which is relatively high given the long time that is typically available to prepare for containment venting. As a result, the contributions to the original release categories were reduced by a factor of 10. Because wetwell venting also results in a release, 90 percent of the original release category frequency was added to the release category characterizing a scrubbed release for the sequence in order to account for the impact of a successful containment vent.

The tables below summarize the changes that were made to the Unit 1 and Unit 2 sequences to obtain the revised baseline release category frequencies. Each contributing sequence impacted by changes to the venting assumptions is identified along with information about the frequency redistribution. For some sequences, venting did not impact the magnitude of the release. These sequences are included for completeness.

Unit 1 Sequence Changes (Pre-EPU)

Sequence Name	Original Release Category	Original Sequence Frequency (/yr)	Contribution to Original Release Category After Crediting Venting (/yr)	Release Category with WW Vent	Contribution to Release Category With Wetwell Vent (/yr)
RCVSEQ1LT-2-012	LLL	1.97E-10	1.97E-11	LLL	1.77E-10
RCVSEQ1LT-2-016	LL	6.65E-09	6.65E-10	LLL	5.99E-09
RCVSEQ1LT-3-017	ML	6.54E-12	6.54E-13	LLL	5.89E-12
RCVSEQ1LT-3-030	LLL	1.72E-13	1.72E-14	LLL	1.55E-13
RCVSEQ1LT-3-032	LLL	5.31E-14	5.31E-15	LLL	4.78E-14
RCVSEQ1LT-3-034	LL	1.85E-11	1.85E-12	LLL	1.67E-11
RCVSEQ1LT-3-035	HL	8.93E-12	8.93E-13	LLL	8.04E-12
RCVSEQ1LT-3-040	LLL	1.27E-11	1.27E-12	LLL	1.14E-11
RCVSEQ1LT-3-042	LLL	7.29E-10	7.29E-11	LLL	6.56E-10
RCVSEQ1LT-3-046	LLL	2.12E-08	2.12E-09	LLL	1.91E-08
RCVSEQ1LT-6-014	LE	2.85E-09	2.85E-10	LE	2.57E-09
RCVSEQ1LT-6-033	LE	1.04E-10	1.04E-11	LE	9.36E-11
RCVSEQ1LT-6-040	LE	9.14E-10	9.14E-11	LE	8.23E-10
RCVSEQ1LT-6-047	LE	1.03E-09	1.03E-10	LE	9.27E-10
RCVSEQ1TR-2-017	LLL	1.56E-09	1.56E-10	LLL	1.40E-09
RCVSEQ1TR-2-021	LL	4.66E-08	4.66E-09	LLL	4.19E-08
RCVSEQ1TR-2-022	ML	1.53E-10	1.53E-11	LLL	1.38E-10
RCVSEQ1TR-3-040	LLL	8.25E-14	8.25E-15	LLL	7.43E-14
RCVSEQ1TR-3-042	LL	1.67E-09	1.67E-10	LLL	1.50E-09
RCVSEQ1TR-5-087	ML	6.92E-10	6.92E-11	LL	6.23E-10
RCVSEQ1TR-5-101	LL	4.00E-11	4.00E-12	LLL	3.60E-11
RCVSEQ1TR-6AH-001	HE	9.02E-11	9.02E-12	LE	8.12E-11
RCVSEQ1TR-6AL-001	LE	6.46E-09	6.46E-10	LE	5.81E-09
RCVSEQ1TR-6AL-003	LE	6.20E-08	6.20E-09	LE	5.58E-08
RCVSEQ1TR-6AL-005	LE	4.48E-10	4.48E-11	LE	4.03E-10
RCVSEQ1TR-6AL-007	LE	5.03E-10	5.03E-11	LE	4.53E-10
RCVSEQ1TR-8-027	LI	3.04E-10	3.04E-11	LLI	2.74E-10
RCVSEQ1TR-8-031	MI	4.69E-11	4.69E-12	LLI	4.22E-11

Unit 2 Sequence Changes (Pre-EPU)

Sequence Name	Original Release Category	Original Sequence Frequency (/yr)	Contribution to Original Release Category After Crediting Venting (/yr)	Release Category with WW Vent	Contribution to Release Category With Wetwell Vent (/yr)
RCVSEQ2LT-2-012	LLL	2.46E-11	2.46E-12	LLL	2.21E-11
RCVSEQ2LT-2-016	LL	9.57E-10	9.57E-11	LLL	8.61E-10
RCVSEQ2LT-3-017	ML	6.54E-12	6.54E-13	LLL	5.89E-12
RCVSEQ2LT-3-030	LLL	1.72E-13	1.72E-14	LLL	1.55E-13
RCVSEQ2LT-3-032	LLL	5.31E-14	5.31E-15	LLL	4.78E-14
RCVSEQ2LT-3-034	LL	1.83E-11	1.83E-12	LLL	1.65E-11
RCVSEQ2LT-3-035	HL	8.93E-12	8.93E-13	LLL	8.04E-12
RCVSEQ2LT-3-040	LLL	1.27E-11	1.27E-12	LLL	1.14E-11
RCVSEQ2LT-3-042	LLL	7.17E-10	7.17E-11	LLL	6.45E-10
RCVSEQ2LT-3-046	LLL	2.03E-08	2.03E-09	LLL	1.83E-08
RCVSEQ2LT-6-014	LE	2.85E-09	2.85E-10	LE	2.57E-09
RCVSEQ2LT-6-033	LE	1.04E-10	1.04E-11	LE	9.36E-11
RCVSEQ2LT-6-040	LE	9.14E-10	9.14E-11	LE	8.23E-10
RCVSEQ2LT-6-047	LE	1.03E-09	1.03E-10	LE	9.27E-10
RCVSEQ2TR-2-017	LLL	6.87E-10	6.87E-11	LLL	6.18E-10
RCVSEQ2TR-2-021	LL	1.95E-08	1.95E-09	LLL	1.76E-08
RCVSEQ2TR-2-022	ML	1.53E-10	1.53E-11	LLL	1.38E-10
RCVSEQ2TR-3-040	LLL	8.25E-14	8.25E-15	LLL	7.43E-14
RCVSEQ2TR-3-042	LL	1.67E-09	1.67E-10	LLL	1.50E-09
RCVSEQ2TR-5-087	LL	4.00E-10	4.00E-11	LL	3.60E-10
RCVSEQ2TR-5-091	ML	4.00E-15	4.00E-16	LL	3.60E-15
RCVSEQ2TR-5-101	LL	4.00E-11	4.00E-12	LLL	3.60E-11
RCVSEQ2TR-6AH-001	HE	9.02E-11	9.02E-12	LE	8.12E-11
RCVSEQ2TR-6AL-001	LE	6.46E-09	6.46E-10	LE	5.81E-09
RCVSEQ2TR-6AL-003	LE	6.20E-08	6.20E-09	LE	5.58E-08
RCVSEQ2TR-6AL-005	LE	4.48E-10	4.48E-11	LE	4.03E-10
RCVSEQ2TR-6AL-007	LE	5.03E-10	5.03E-11	LE	4.53E-10
RCVSEQ2TR-7-008	LI	4.11E-13	4.11E-14	LLI	3.70E-13
RCVSEQ2TR-8-027	LI	2.69E-10	2.69E-11	LLI	2.42E-10
RCVSEQ2TR-8-031	MI	4.64E-11	4.64E-12	LLI	4.18E-11

Unit 1 Sequence Changes (Post-EPU)

Sequence Name	Original Release Category	Original Sequence Frequency (/yr)	Contribution to Original Release Category After Crediting Venting (/yr)	Release Category with WW Vent	Contribution to Release Category With Wetwell Vent (/yr)
RCVSEQ1LT-2-012	LLL	1.97E-10	1.97E-11	LLL	1.77E-10
RCVSEQ1LT-2-016	LL	6.65E-09	6.65E-10	LLL	5.99E-09
RCVSEQ1LT-3-017	ML	1.40E-11	1.40E-12	LLL	1.26E-11
RCVSEQ1LT-3-030	LLL	3.67E-13	3.67E-14	LLL	3.30E-13
RCVSEQ1LT-3-032	LLL	1.13E-13	1.13E-14	LLL	1.02E-13
RCVSEQ1LT-3-034	LL	3.95E-11	3.95E-12	LLL	3.56E-11
RCVSEQ1LT-3-035	HL	1.91E-11	1.91E-12	LLL	1.72E-11
RCVSEQ1LT-3-040	LLL	1.27E-11	1.27E-12	LLL	1.14E-11
RCVSEQ1LT-3-042	LLL	7.29E-10	7.29E-11	LLL	6.56E-10
RCVSEQ1LT-3-046	LLL	2.12E-08	2.12E-09	LLL	1.91E-08
RCVSEQ1LT-6-014	LE	3.01E-09	3.01E-10	LE	2.71E-09
RCVSEQ1LT-6-033	LE	1.23E-10	1.23E-11	LE	1.11E-10
RCVSEQ1LT-6-040	LE	1.15E-09	1.15E-10	LE	1.04E-09
RCVSEQ1LT-6-047	LE	1.03E-09	1.03E-10	LE	9.27E-10
RCVSEQ1TR-2-017	LLI	1.56E-09	1.56E-10	LLI	1.40E-09
RCVSEQ1TR-2-021	LI	4.66E-08	4.66E-09	LLI	4.19E-08
RCVSEQ1TR-2-022	MI	1.53E-10	1.53E-11	LLI	1.38E-10
RCVSEQ1TR-3-040	LLL	4.15E-13	4.15E-14	LLL	3.74E-13
RCVSEQ1TR-3-042	LL	1.85E-09	1.85E-10	LLL	1.67E-09
RCVSEQ1TR-5-087	LL	7.30E-10	7.30E-11	LL	6.57E-10
RCVSEQ1TR-5-101	LL	4.00E-11	4.00E-12	LLL	3.60E-11
RCVSEQ1TR-6AH-001	HE	1.61E-10	1.61E-11	LE	1.45E-10
RCVSEQ1TR-6AL-001	LE	9.53E-09	9.53E-10	LE	8.58E-09
RCVSEQ1TR-6AL-003	LE	9.01E-08	9.01E-09	LE	8.11E-08
RCVSEQ1TR-6AL-005	LE	6.69E-10	6.69E-11	LE	6.02E-10
RCVSEQ1TR-6AL-007	LE	7.51E-10	7.51E-11	LE	6.76E-10
RCVSEQ1TR-8-027	LI	3.20E-10	3.20E-11	LLI	2.88E-10
RCVSEQ1TR-8-031	MI	4.75E-11	4.75E-12	LLI	4.28E-11

Unit 2 Sequence Changes (Post-EPU)

Sequence Name	Original Release Category	Original Sequence Frequency (/yr)	Contribution to Original Release Category After Crediting Venting (/yr)	Release Category with WW Vent	Contribution to Release Category With Wetwell Vent (/yr)
RCVSEQ2LT-2-012	LLL	2.46E-11	2.46E-12	LLL	2.21E-11
RCVSEQ2LT-2-016	LL	9.57E-10	9.57E-11	LLL	8.61E-10
RCVSEQ2LT-3-017	ML	1.40E-11	1.40E-12	LLL	1.26E-11
RCVSEQ2LT-3-030	LLL	3.67E-13	3.67E-14	LLL	3.30E-13
RCVSEQ2LT-3-032	LLL	1.13E-13	1.13E-14	LLL	1.02E-13
RCVSEQ2LT-3-034	LL	3.90E-11	3.90E-12	LLL	3.51E-11
RCVSEQ2LT-3-035	HL	1.91E-11	1.91E-12	LLL	1.72E-11
RCVSEQ2LT-3-040	LLL	1.27E-11	1.27E-12	LLL	1.14E-11
RCVSEQ2LT-3-042	LLL	7.17E-10	7.17E-11	LLL	6.45E-10
RCVSEQ2LT-3-046	LLL	2.03E-08	2.03E-09	LLL	1.83E-08
RCVSEQ2LT-6-014	LE	3.01E-09	3.01E-10	LE	2.71E-09
RCVSEQ2LT-6-033	LE	1.23E-10	1.23E-11	LE	1.11E-10
RCVSEQ2LT-6-040	LE	1.15E-09	1.15E-10	LE	1.04E-09
RCVSEQ2LT-6-047	LE	1.03E-09	1.03E-10	LE	9.27E-10
RCVSEQ2TR-2-017	LLI	6.87E-10	6.87E-11	LLI	6.18E-10
RCVSEQ2TR-2-021	LI	1.95E-08	1.95E-09	LLI	1.76E-08
RCVSEQ2TR-2-022	MI	1.53E-10	1.53E-11	LLI	1.38E-10
RCVSEQ2TR-3-040	LLL	4.15E-13	4.15E-14	LLL	3.74E-13
RCVSEQ2TR-3-042	LL	1.84E-09	1.84E-10	LLL	1.66E-09
RCVSEQ2TR-5-087	LL	4.14E-10	4.14E-11	LL	3.73E-10
RCVSEQ2TR-5-091	ML	1.18E-14	1.18E-15	LLL	1.06E-14
RCVSEQ2TR-5-101	LL	4.00E-11	4.00E-12	LLL	3.60E-11
RCVSEQ2TR-6AH-001	HE	1.61E-10	1.61E-11	LE	1.45E-10
RCVSEQ2TR-6AL-001	LE	9.53E-09	9.53E-10	LE	8.58E-09
RCVSEQ2TR-6AL-003	LE	9.02E-08	9.02E-09	LE	8.12E-08
RCVSEQ2TR-6AL-005	LE	6.69E-10	6.69E-11	LE	6.02E-10
RCVSEQ2TR-6AL-007	LE	7.51E-10	7.51E-11	LE	6.76E-10
RCVSEQ2TR-7-008	LI	6.74E-13	6.74E-14	LLI	6.07E-13

Unit 2 Sequence Changes (Post-EPU)

Sequence Name	Original Release Category	Original Sequence Frequency (/yr)	Contribution to Original Release Category After Crediting Venting (/yr)	Release Category with WW Vent	Contribution to Release Category With Wetwell Vent (/yr)
RCVSEQ2TR-8-027	LI	2.81E-10	2.81E-11	LLI	2.53E-10
RCVSEQ2TR-8-031	MI	4.67E-11	4.67E-12	LLI	4.20E-11

The following tables provide the release category frequencies along with the corresponding dose-risk and offsite economic cost-risk resulting from the changes identified above.

PRE-EPU UNIT 1

Release Category	H/E	H/I	H/L	M/E	M/I	M/L	L/E	L/I	L/L	LL/I	LL/L	Total
$Freq_{S12\ Base}$	1.71E-07	1.47E-07	1.13E-10	0.00E+00	5.05E-07	1.32E-07	7.44E-08	4.20E-07	6.94E-09	3.16E-10	7.33E-08	**1.53E-06**
$Dose\text{-}Risk_{S12\ Base}$	0.45	0.22	0.00	0.00	0.69	0.15	0.01	0.13	0.00	0.00	0.01	**1.66**
$OECR_{S12\ Base}$	$2,495	$1,764	$3	$0	$4,338	$752	$10	$252	$6	$0	$1	**$9,621**

PRE-EPU UNIT 2

Release Category	H/E	H/I	H/L	M/E	M/I	M/L	L/E	L/I	L/L	LL/I	LL/L	Total
$Freq_{S12\ Base}$	1.72E-07	1.30E-07	9.90E-11	0.00E+00	5.14E-07	1.13E-07	7.47E-08	4.31E-07	2.73E-09	2.84E-10	4.19E-08	**1.48E-06**
$Dose\text{-}Risk_{S12\ Base}$	0.45	0.20	0.00	0.00	0.70	0.13	0.01	0.13	0.00	0.00	0.00	**1.62**
$OECR_{S12\ Base}$	$2,510	$1,560	$3	$0	$4,415	$642	$10	$259	$2	$0	$1	**$9,402**

POST-EPU UNIT 1

Release Category	H/E	H/I	H/L	M/E	M/I	M/L	L/E	L/I	L/L	LL/I	LL/L	Total
$Freq_{S12\ Base}$	1.73E-07	1.59E-07	1.14E-10	0.00E+00	5.38E-07	1.51E-07	1.08E-07	4.45E-07	1.74E-09	4.40E-08	3.00E-08	**1.65E-06**
$Dose\text{-}Risk_{S12\ Base}$	0.51	0.25	0.00	0.00	0.79	0.18	0.02	0.15	0.00	0.01	0.00	**1.91**
$OECR_{S12\ Base}$	$2,645	$2,099	$3	$0	$5,056	$995	$18	$308	$2	$2	$1	**$11,129**

POST-EPU UNIT 2

Release Category	H/E	H/I	H/L	M/E	M/I	M/L	L/E	L/I	L/L	LL/I	LL/L	Total
$Freq_{S12\ Base}$	1.73E-07	1.39E-07	9.98E-11	0.00E+00	5.49E-07	1.30E-07	1.08E-07	4.55E-07	8.32E-10	1.84E-08	2.37E-08	**1.60E-06**
$Dose\text{-}Risk_{S12\ Base}$	0.51	0.22	0.00	0.00	0.80	0.16	0.02	0.15	0.00	0.00	0.00	**1.86**
$OECR_{S12\ Base}$	$2,645	$1,835	$3	$0	$5,159	$857	$18	$315	$1	$1	$0	**$10,834**

The impact of this SAMA's suggested improvement to existing SSES procedures for venting after core damage is quantified by assuming that the failure probability of venting is 0.0 rather than 1.0. The changes to the release category frequencies were calculated in a manner similar to what was used to obtain the revised baseline frequencies above. The difference is that the entire sequence frequency is reclassified as a scrubbed release instead of 90 percent of the release, as shown in the following tables.

Unit 1 Sequence Changes (Pre-EPU)

Sequence Name	Original Release Category	Original Sequence Frequency (/yr)	Release Category with WW Vent	Contribution to Release Category With Wetwell Vent (/yr)
RCVSEQ1LT-2-012	LLL	1.97E-10	LLL	1.97E-10
RCVSEQ1LT-2-016	LL	6.65E-09	LLL	6.65E-09
RCVSEQ1LT-3-017	ML	6.54E-12	LLL	6.54E-12
RCVSEQ1LT-3-030	LLL	1.72E-13	LLL	1.72E-13
RCVSEQ1LT-3-032	LLL	5.31E-14	LLL	5.31E-14
RCVSEQ1LT-3-034	LL	1.85E-11	LLL	1.85E-11
RCVSEQ1LT-3-035	HL	8.93E-12	LLL	8.93E-12
RCVSEQ1LT-3-040	LLL	1.27E-11	LLL	1.27E-11
RCVSEQ1LT-3-042	LLL	7.29E-10	LLL	7.29E-10
RCVSEQ1LT-3-046	LLL	2.12E-08	LLL	2.12E-08
RCVSEQ1LT-6-014	LE	2.85E-09	LE	2.85E-09
RCVSEQ1LT-6-033	LE	1.04E-10	LE	1.04E-10
RCVSEQ1LT-6-040	LE	9.14E-10	LE	9.14E-10
RCVSEQ1LT-6-047	LE	1.03E-09	LE	1.03E-09
RCVSEQ1TR-2-017	LLL	1.56E-09	LLL	1.56E-09
RCVSEQ1TR-2-021	LL	4.66E-08	LLL	4.66E-08
RCVSEQ1TR-2-022	ML	1.53E-10	LLL	1.53E-10
RCVSEQ1TR-3-040	LLL	8.25E-14	LLL	8.25E-14
RCVSEQ1TR-3-042	LL	1.67E-09	LLL	1.67E-09
RCVSEQ1TR-5-087	ML	6.92E-10	LL	6.92E-10
RCVSEQ1TR-5-101	LL	4.00E-11	LLL	4.00E-11
RCVSEQ1TR-6AH-001	HE	9.02E-11	LE	9.02E-11
RCVSEQ1TR-6AL-001	LE	6.46E-09	LE	6.46E-09
RCVSEQ1TR-6AL-003	LE	6.20E-08	LE	6.20E-08
RCVSEQ1TR-6AL-005	LE	4.48E-10	LE	4.48E-10
RCVSEQ1TR-6AL-007	LE	5.03E-10	LE	5.03E-10
RCVSEQ1TR-8-027	LI	3.04E-10	LLI	3.04E-10
RCVSEQ1TR-8-031	MI	4.69E-11	LLI	4.69E-11

Unit 2 Sequence Changes (Pre-EPU)

Sequence Name	Original Release Category	Original Sequence Frequency (/yr)	Release Category with WW Vent	Contribution to Release Category With Wetwell Vent (/yr)
RCVSEQ2LT-2-012	LLL	2.46E-11	LLL	2.21E-11
RCVSEQ2LT-2-016	LL	9.57E-10	LLL	8.61E-10
RCVSEQ2LT-3-017	ML	6.54E-12	LLL	5.89E-12
RCVSEQ2LT-3-030	LLL	1.72E-13	LLL	1.55E-13
RCVSEQ2LT-3-032	LLL	5.31E-14	LLL	4.78E-14
RCVSEQ2LT-3-034	LL	1.83E-11	LLL	1.65E-11
RCVSEQ2LT-3-035	HL	8.93E-12	LLL	8.04E-12
RCVSEQ2LT-3-040	LLL	1.27E-11	LLL	1.14E-11
RCVSEQ2LT-3-042	LLL	7.17E-10	LLL	6.45E-10
RCVSEQ2LT-3-046	LLL	2.03E-08	LLL	1.83E-08
RCVSEQ2LT-6-014	LE	2.85E-09	LE	2.57E-09
RCVSEQ2LT-6-033	LE	1.04E-10	LE	9.36E-11
RCVSEQ2LT-6-040	LE	9.14E-10	LE	8.23E-10
RCVSEQ2LT-6-047	LE	1.03E-09	LE	9.27E-10
RCVSEQ2TR-2-017	LLL	6.87E-10	LLL	6.18E-10
RCVSEQ2TR-2-021	LL	1.95E-08	LLL	1.76E-08
RCVSEQ2TR-2-022	ML	1.53E-10	LLL	1.38E-10
RCVSEQ2TR-3-040	LLL	8.25E-14	LLL	7.43E-14
RCVSEQ2TR-3-042	LL	1.67E-09	LLL	1.50E-09
RCVSEQ2TR-5-087	LL	4.00E-10	LL	3.60E-10
RCVSEQ2TR-5-091	ML	4.00E-15	LL	3.60E-15
RCVSEQ2TR-5-101	LL	4.00E-11	LLL	3.60E-11
RCVSEQ2TR-6AH-001	HE	9.02E-11	LE	8.12E-11
RCVSEQ2TR-6AL-001	LE	6.46E-09	LE	5.81E-09
RCVSEQ2TR-6AL-003	LE	6.20E-08	LE	5.58E-08
RCVSEQ2TR-6AL-005	LE	4.48E-10	LE	4.03E-10
RCVSEQ2TR-6AL-007	LE	5.03E-10	LE	4.53E-10
RCVSEQ2TR-7-008	LI	4.11E-13	LLI	3.70E-13
RCVSEQ2TR-8-027	LI	2.69E-10	LLI	2.42E-10
RCVSEQ2TR-8-031	MI	4.64E-11	LLI	4.18E-11

Unit 1 Sequence Changes (Post-EPU)

Sequence Name	Original Release Category	Original Sequence Frequency (/yr)	Release Category with WW Vent	Contribution to Release Category With Wetwell Vent (/yr)
RCVSEQ1LT-2-012	LLL	1.97E-10	LLL	1.77E-10
RCVSEQ1LT-2-016	LL	6.65E-09	LLL	5.99E-09
RCVSEQ1LT-3-017	ML	1.40E-11	LLL	1.26E-11
RCVSEQ1LT-3-030	LLL	3.67E-13	LLL	3.30E-13
RCVSEQ1LT-3-032	LLL	1.13E-13	LLL	1.02E-13
RCVSEQ1LT-3-034	LL	3.95E-11	LLL	3.56E-11
RCVSEQ1LT-3-035	HL	1.91E-11	LLL	1.72E-11
RCVSEQ1LT-3-040	LLL	1.27E-11	LLL	1.14E-11
RCVSEQ1LT-3-042	LLL	7.29E-10	LLL	6.56E-10
RCVSEQ1LT-3-046	LLL	2.12E-08	LLL	1.91E-08
RCVSEQ1LT-6-014	LE	3.01E-09	LE	2.71E-09
RCVSEQ1LT-6-033	LE	1.23E-10	LE	1.11E-10
RCVSEQ1LT-6-040	LE	1.15E-09	LE	1.04E-09
RCVSEQ1LT-6-047	LE	1.03E-09	LE	9.27E-10
RCVSEQ1TR-2-017	LLI	1.56E-09	LLI	1.40E-09
RCVSEQ1TR-2-021	LI	4.66E-08	LLI	4.19E-08
RCVSEQ1TR-2-022	MI	1.53E-10	LLI	1.38E-10
RCVSEQ1TR-3-040	LLL	4.15E-13	LLL	3.74E-13
RCVSEQ1TR-3-042	LL	1.85E-09	LLL	1.67E-09
RCVSEQ1TR-5-087	LL	7.30E-10	LL	6.57E-10
RCVSEQ1TR-5-101	LL	4.00E-11	LLL	3.60E-11
RCVSEQ1TR-6AH-001	HE	1.61E-10	LE	1.45E-10
RCVSEQ1TR-6AL-001	LE	9.53E-09	LE	8.58E-09
RCVSEQ1TR-6AL-003	LE	9.01E-08	LE	8.11E-08
RCVSEQ1TR-6AL-005	LE	6.69E-10	LE	6.02E-10
RCVSEQ1TR-6AL-007	LE	7.51E-10	LE	6.76E-10
RCVSEQ1TR-8-027	LI	3.20E-10	LLI	2.88E-10
RCVSEQ1TR-8-031	MI	4.75E-11	LLI	4.28E-11

Unit 2 Sequence Changes (Post-EPU)

Sequence Name	Original Release Category	Original Sequence Frequency (/yr)	Release Category with WW Vent	Contribution to Release Category With Wetwell Vent (/yr)
RCVSEQ2LT-2-012	LLL	2.46E-11	LLL	2.21E-11
RCVSEQ2LT-2-016	LL	9.57E-10	LLL	8.61E-10
RCVSEQ2LT-3-017	ML	1.40E-11	LLL	1.26E-11
RCVSEQ2LT-3-030	LLL	3.67E-13	LLL	3.30E-13
RCVSEQ2LT-3-032	LLL	1.13E-13	LLL	1.02E-13
RCVSEQ2LT-3-034	LL	3.90E-11	LLL	3.51E-11
RCVSEQ2LT-3-035	HL	1.91E-11	LLL	1.72E-11
RCVSEQ2LT-3-040	LLL	1.27E-11	LLL	1.14E-11
RCVSEQ2LT-3-042	LLL	7.17E-10	LLL	6.45E-10
RCVSEQ2LT-3-046	LLL	2.03E-08	LLL	1.83E-08
RCVSEQ2LT-6-014	LE	3.01E-09	LE	2.71E-09
RCVSEQ2LT-6-033	LE	1.23E-10	LE	1.11E-10
RCVSEQ2LT-6-040	LE	1.15E-09	LE	1.04E-09
RCVSEQ2LT-6-047	LE	1.03E-09	LE	9.27E-10
RCVSEQ2TR-2-017	LLI	6.87E-10	LLI	6.18E-10
RCVSEQ2TR-2-021	LI	1.95E-08	LLI	1.76E-08
RCVSEQ2TR-2-022	MI	1.53E-10	LLI	1.38E-10
RCVSEQ2TR-3-040	LLL	4.15E-13	LLL	3.74E-13
RCVSEQ2TR-3-042	LL	1.84E-09	LLL	1.66E-09
RCVSEQ2TR-5-087	LL	4.14E-10	LL	3.73E-10
RCVSEQ2TR-5-091	ML	1.18E-14	LLL	1.06E-14
RCVSEQ2TR-5-101	LL	4.00E-11	LLL	3.60E-11
RCVSEQ2TR-6AH-001	HE	1.61E-10	LE	1.45E-10
RCVSEQ2TR-6AL-001	LE	9.53E-09	LE	8.58E-09
RCVSEQ2TR-6AL-003	LE	9.02E-08	LE	8.12E-08
RCVSEQ2TR-6AL-005	LE	6.69E-10	LE	6.02E-10
RCVSEQ2TR-6AL-007	LE	7.51E-10	LE	6.76E-10
RCVSEQ2TR-7-008	LI	6.74E-13	LLI	6.07E-13
RCVSEQ2TR-8-027	LI	2.81E-10	LLI	2.53E-10
RCVSEQ2TR-8-031	MI	4.67E-11	LLI	4.20E-11

The changes in the release category frequencies are summarized in the "Results" section below. The cost benefit for this SAMA is performed according to the methodology presented in Sections E.4 and E.6 using the revised base model described above in place of the baseline SAMA model.

Results

Implementation of this SAMA yields a reduction in the Dose-risk and Offsite Economic cost-risk (no CDF impact). The results are summarized in the following table for Units 1 and 2 for both pre-EPU and post-EPU conditions:

	Pre-EPU			Post-EPU		
	CDF	Dose-Risk	OECR	CDF	Dose-Risk	OECR
Unit $1_{S12\ Base}$	1.86E-06	1.66	$9,621	1.97E-06	1.91	$11,129
Unit 1_{SAMA}	1.86E-06	1.66	$9,616	1.97E-06	1.91	$11,124
Unit 1 Percent Change	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%
Unit $2_{S12\ Base}$	1.83E-06	1.62	$9,402	1.94E-06	1.86	$10,834
Unit 2_{SAMA}	1.83E-06	1.62	$9,400	1.94E-06	1.86	$10,831
Unit 2 Percent Change	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

A further breakdown of the Dose-risk and OECR information is provided below according to release category.

SAMA 12, Unit 1 Results By Release Category (Pre-EPU)

Release Category	H/E	H/I	H/L	M/E	M/I	M/L	L/E	L/I	L/L	LL/I	LL/L	Total
$Frequency_{S12\ Base}$	1.71E-07	1.47E-07	1.13E-10	0.00E+00	5.05E-07	1.32E-07	7.44E-08	4.20E-07	6.94E-09	3.16E-10	7.33E-08	**1.53E-06**
$Frequency_{SAMA}$	1.71E-07	1.47E-07	1.12E-10	0.00E+00	5.05E-07	1.32E-07	7.44E-08	4.20E-07	1.51E-09	3.51E-10	7.88E-08	**1.53E-06**
$Dose\text{-}Risk_{S12\ Base}$	0.45	0.22	0.00	0.00	0.69	0.15	0.01	0.13	0.00	0.00	0.01	**1.66**
$Dose\text{-}Risk_{SAMA}$	0.45	0.22	0.00	0.00	0.69	0.15	0.01	0.13	0.00	0.00	0.01	**1.66**
$OECR_{S12\ Base}$	$2,495	$1,764	$3	$0	$4,338	$752	$10	$252	$6	$0	$1	**$9,621**
$OECR_{SAMA}$	$2,495	$1,764	$3	$0	$4,338	$752	$10	$252	$1	$0	$1	**$9,616**

SAMA 12, Unit 2 Results By Release Category (Pre-EPU)

Release Category	H/E	H/I	H/L	M/E	M/I	M/L	L/E	L/I	L/L	LL/I	LL/L	Total
Frequency$_{\text{S12 Base}}$	1.72E-07	1.30E-07	9.90E-11	0.00E+00	5.14E-07	1.13E-07	7.47E-08	4.31E-07	2.73E-09	2.84E-10	4.19E-08	**1.48E-06**
Frequency$_{\text{SAMA}}$	1.72E-07	1.30E-07	9.81E-11	0.00E+00	5.14E-07	1.13E-07	7.47E-08	4.31E-07	5.15E-10	3.16E-10	4.42E-08	**1.48E-06**
Dose-Risk$_{\text{S12 Base}}$	0.45	0.20	0.00	0.00	0.70	0.13	0.01	0.13	0.00	0.00	0.00	**1.62**
Dose-Risk$_{\text{SAMA}}$	0.45	0.20	0.00	0.00	0.70	0.13	0.01	0.13	0.00	0.00	0.00	**1.62**
OECR$_{\text{S12 Base}}$	$2,510	$1,560	$3	$0	$4,415	$642	$10	$259	$2	$0	$1	**$9,402**
OECR$_{\text{SAMA}}$	$2,510	$1,560	$3	$0	$4,415	$642	$10	$259	$0	$0	$1	**$9,400**

SAMA 12, Unit 1 Results By Release Category (Post-EPU)

Release Category	H/E	H/I	H/L	M/E	M/I	M/L	L/E	L/I	L/L	LL/I	LL/L	Total
Frequency$_{\text{S12 Base}}$	1.73E-07	1.59E-07	1.14E-10	0.00E+00	5.38E-07	1.51E-07	1.08E-07	4.45E-07	1.74E-09	4.40E-08	3.00E-08	**1.65E-06**
Frequency$_{\text{SAMA}}$	1.73E-07	1.59E-07	1.12E-10	0.00E+00	5.38E-07	1.51E-07	1.08E-07	4.40E-07	8.80E-10	4.87E-08	3.08E-08	**1.65E-06**
Dose-Risk$_{\text{S12 Base}}$	0.51	0.25	0.00	0.00	0.79	0.18	0.02	0.15	0.00	0.01	0.00	**1.91**
Dose-Risk$_{\text{SAMA}}$	0.51	0.25	0.00	0.00	0.79	0.18	0.02	0.15	0.00	0.01	0.00	**1.91**
OECR$_{\text{S12 Base}}$	$2,645	$2,099	$3	$0	$5,056	$995	$18	$308	$2	$2	$1	**$11,129**
OECR$_{\text{SAMA}}$	$2,644	$2,099	$3	$0	$5,055	$995	$18	$305	$1	$3	$1	**$11,124**

SAMA 12, Unit 2 Results By Release Category (Post-EPU)

Release Category	H/E	H/I	H/L	M/E	M/I	M/L	L/E	L/I	L/L	LL/I	LL/L	Total
Frequency$_{\text{S12 Base}}$	1.73E-07	1.39E-07	9.98E-11	0.00E+00	5.49E-07	1.30E-07	1.08E-07	4.55E-07	8.32E-10	1.84E-08	2.37E-08	**1.60E-06**
Frequency$_{\text{SAMA}}$	1.73E-07	1.39E-07	9.79E-11	0.00E+00	5.49E-07	1.30E-07	1.08E-07	4.53E-07	5.44E-10	2.07E-08	2.40E-08	**1.60E-06**
Dose-Risk$_{\text{S12 Base}}$	0.51	0.22	0.00	0.00	0.80	0.16	0.02	0.15	0.00	0.00	0.00	**1.86**
Dose-Risk$_{\text{SAMA}}$	0.51	0.22	0.00	0.00	0.80	0.16	0.02	0.15	0.00	0.00	0.00	**1.86**
OECR$_{\text{S12 Base}}$	$2,645	$1,835	$3	$0	$5,159	$857	$18	$315	$1	$1	$0	**$10,834**
OECR$_{\text{SAMA}}$	$2,644	$1,835	$3	$0	$5,159	$857	$18	$314	$0	$1	$0	**$10,831**

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

SAMA Number 12 Net Value

Unit	SAMA 12 Base Case Cost-Risk (Pre-EPU)	Revised Cost-Risk (Pre-EPU)	Averted Cost-Risk (Pre-EPU)	SAMA 12 Base Case Cost-Risk (Post-EPU)	Revised Cost-Risk (Post-EPU)	Averted Cost-Risk (Post-EPU)
Unit 1	$480,296	$480,145	$151	$548,471	$548,321	$150
Unit 2	$469,945	$469,884	$61	$535,132	$535,042	$90
Total	$950,241	$950,029	$212	$1,083,603	$1,083,363	$240

Based on the assumed minimum cost of implementation for a SAMA of $50,000 (procedure change), the Pre-EPU net value for this SAMA is -$49,788 ($212 - $50,000 = -$49,788), which implies that this SAMA could not be cost beneficial.

For Post-EPU conditions, the net value for this SAMA is -$49,760 ($240 - $50,000 = -$49,760), which implies that this SAMA could not be cost beneficial.

E.6.11 SAMA Number 14: Enhance Fire Main Connection to RHR

SAMA 14 was identified based on the Level 2 importance of the event “013-N-N-EARLY-O”, which represents alignment of the fire protection (FP) or RHRSW system to RHR for injection to the RPV or to containment through the RPV. Review of this HEP reveals that the action’s failure probability is driven by the more limiting conditions associated with FP alignment. This conservative approach prevents undue credit from being taken for FP injection under certain conditions, but it also prevents appropriate credit from being taken for RHRSW injection under other conditions.

The initial strategy conceived to reduce the risk of sequences including these cross-tie failures was to improve the reliability of the cross-tie alignment by simplifying the nature of the cross-tie through the installation of a hard pipe connection. Other methods of addressing the importance of this action through the addition of alternate AC power sources could have been suggested; however, common cause failure and human dependence issues would likely limit the credit that could be taken for these types of enhancements unless costly measures were taken to procure automated, diverse equipment. Ultimately, it was concluded that the existing SSES configuration is adequate to mitigate the sequences highlighted by the importance of the “013-N-N-

EARLY-O" event and that modeling assumptions have artificially inflated the importance of the cross-tie alignment action.

Review of the pre-EPU and post-EPU Level 2 cutsets that were used to generate the importance list revealed that over 88 percent of the cutsets that include the event "013-N-N-EARLY-O" are late injection sequences. There are two main reasons that no SAMAs are required to address the late sequences at SSES:

1. For the relevant late injection scenarios, the 60 minute alignment time of the FP cross-tie is not a limiting issue given that injection is not required until 20 hours (post-EPU conditions) after the initiating event (and many hours after any relevant action cue). Given that the HEP for "013-N-N-EARLY-O" is based on early injection requirements, the most important application of the action does not take credit for the long time that is available to align the FP cross-tie.

2. Discussions with SSES staff revealed that a proceduralized, low flow, hard pipe connection already exists at SSES that is not credited in the PRA model. This connection is capable of providing an injection flow rate of approximately 200 gpm and can be aligned by simple valve manipulations in about 10 minutes. While the low flow rate of the existing hard pipe connection precludes its use early in accident sequences, the connection could be used for makeup late in transient sequences when the decay heat levels are lower. Implementation of a SAMA to install another hard pipe connection between the RHR and FP systems would not reduce the risk of the late sequences further as a functional hard pipe connection already exists.

The remaining 10 to 12 percent of the cases involving the failure of the "013-N-N-EARLY-O" action are early injection scenarios with makeup requirements that exceed the capability of the existing FP to RHR hard pipe connection. While this precludes crediting that connection, the RHRSW to RHR cross-tie connection can be used as this alignment requires only about 2 minutes (based on discussions with Ops personnel). As indicated above, the HEP used to model the alignment of the RHRSW system for early injection is based on the characteristics of the FP system. If a revised HEP were developed to specifically address the alignment of RHRSW for early injection, the importance of the cross-tie action would be reduced below the review cutoff and no SAMAs would be required to address this issue.

Rather than develop a new HEP to demonstrate the impact of crediting the RHRSW cross-tie application, a bounding calculation has been performed using the early injection sequences with the existing cross-tie HEP. This was done by manipulating the composite Level 2 results that were used to generate the original importance list:

1. All cutsets from the Level 2 composite file containing the action “013-N-N-EARLY-O” were extracted and saved in a unique file.

2. The early injection contribution was estimated by eliminating all cutsets from the unique “013-N-N-EARLY-O” file containing the sequence tag for the important late injection sequence (RCVSEQ1TR-7-010B). The frequency of remaining cutsets is the “early injection” frequency for “013-N-N-EARLY-O”.

3. The RRW value for the early injection component of “013-N-N-EARLY-O” is the factor by which the composite Level 2 frequency is reduced by eliminating the early injection frequency for “013-N-N-EARLY-O”. For Unit 1 pre-EPU, the result is 1.005 (9.56E-7 / [9.56E-7 – 4.51E-9] = 1.005) and for Unit 2 the result is 1.004 (9.28E-7 / [9.28E-7 – 4.07E-9] = 1.004). For post-EPU conditions, the result for Unit 1 is 1.004 (1.02E-6 / [1.02E-6 – 4.56E-9] = 1.004) and for Unit 2 the result is 1.004 (9.91E-7 / [9.91E-7 – 4.19E-9] = 1.004).

Based on this calculation, the segment of the Level 2 results related to early injection through the RHRSW cross-tie is small. Even if it was determined that the existing RHRSW cross-tie was in some way inadequate, no SAMAs would be suggested given that the RRW of the cross-tie action for early injection is only 1.005, which is well below the 1.02 cutoff that is used to identify potentially cost beneficial SAMAs.

In summary, no SAMAs are considered to be required to address the importance of the “013-N-N-EARLY-O” action for the following reasons:

1. The CDF based RRW of “013-N-N-EARLY-O” is below the review cutoff limit of 1.02.

2. Over 88 percent of the Level 2 contribution from “013-N-N-EARLY-O” is based on long term scenarios while the HEP used to represent the alignment is based on early injection requirements.

3. An easily aligned hard pipe connection already exists between the FP system and RHR that can be used for 88 percent of the “013-N-N-EARLY-O” cases.

4. For the early injection component of the Level 2 results, the RHRSW alignment is assigned the HEP based on the characteristics of the FP system cross-tie requirements.

5. The Level 2 based RRW for the early injection component of “013-N-N-EARLY-O” is only 1.005, which falls below the review cutoff limit of 1.02. No further analysis is considered to be required.

E.7 UNCERTAINTY ANALYSIS

The following three uncertainties were further investigated as to their impact on the overall SAMA evaluation:

- Use a discount rate of 7 percent, instead of 3 percent used in the base case analysis.
- Use the 95th percentile PRA results in place of the mean PRA results.
- Selected MACCS2 input variables.

While results could be provided for both pre-EPU and post-EPU conditions, the post EPU results are more limiting and are used throughout the sensitivity analyses.

E.7.1 Real Discount Rate

A sensitivity study has been performed in order to identify how the conclusions of the SAMA analysis might change based on the value assigned to the real discount rate (RDR). The original RDR of 3 percent, which could be viewed as conservative, has been changed to 7 percent and the modified maximum averted cost-risk was re-calculated using the methodology outlined in Section E.4. The Phase 1 screening against the MMACR was re-examined using the revised MMACR to identify any SAMA candidates that could be screened from further analysis based on the premise that their costs of implementation exceeded all possible benefit. In addition, the Phase 2 analysis was re-performed using the 7 percent RDR.

Implementation of the 7 percent RDR reduced the MMACR by 24.4 percent compared with the case where a 3 percent RDR was used. This corresponds to a decrease in the MMACR from $1,088,000 to $822,000. The Phase 1 SAMA list was reviewed to determine if such a decrease in the MMACR would impact the disposition of any SAMAs. It was determined that SAMA 7 could have been screened in the Phase 1 analysis based on this reduction in the MMACR. While this is true, it should be noted that a detailed analysis would still have been performed for SAMA 7 in the 95th percentile sensitivity study.

The Phase 2 SAMAs are dispositioned based on PRA insights or detailed analysis. All of the PRA insights used to screen the SAMAs are still applicable given the use of the 7 percent real discount rate as the change only strengthens the factors used to screen them. The SAMA candidates screened based on these insights are considered to be addressed and are not investigated further.

The remaining Phase 2 SAMAs were dispositioned based on the results of a SAMA specific cost-benefit analysis. This step has been re-performed using the 7 percent real discount rate to calculate the net values for the SAMAs.

As shown below, the determination of cost effectiveness changed for two Phase 2 SAMAs when the 7 percent RDR was used in lieu of 3 percent. The margin by which SAMA 2a becomes “not cost beneficial” is large; however, this does not mean that this SAMA would be screened from consideration if a 7 percent real discount rate were applied in the SAMA analysis as other factors influence the decision making process, such as the 95th percentile sensitivity analysis.

Summary of the Impact of the RDR Value on the Detailed SAMA Analyses (Post EPU)

SAMA ID	Cost of Implementation	Averted Cost- Risk (3 percent RDR)	Net Value (3 percent RDR)	Averted Cost- Risk (7 percent RDR)	Net Value (7 percent RDR)	Change in Cost Effective-ness?
1	$2,798,000	$749,073	-$2,048,927	$562,622	-$2,235,378	No
2a	$656,000	$694,331	$38,331	$521,124	-$134,876	Yes
3	$150,000	$137,758	-$12,242	$107,402	-$42,598	No
5	$398,000	$368,403	-$29,597	$274,582	-$123,418	No
6	$203,000	$266,665	$63,665	$198,759	-$4,241	Yes
7	$970,000	$75,890	-$894,110	$58,884	-$911,116	No
8	$600,000	$9,896	-$590,104	$8,865	-$591,135	No
9	$346,000	$34,521	-$311,479	$28,144	-$317,856	No
10	$386,000	$18,612	-$367,388	$15,884	-$370,116	No
12	$50,000	$240	-$49,760	$171	-$49,829	No

E.7.2 95th Percentile PRA Results

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.

For SSES, the UNCERT32 software code was used to perform the Level 1 internal events model uncertainty analysis for Unit 1 (considered to be representative of both Units). The results of the calculation are provided below:

PARAMETER	Unit 1 Pre-EPU	Unit 1 Post EPU
Mean	2.19E-06	2.88E-06
5 percent	1.28E-06	1.38E-06
50 percent	1.76E-06	1.84E-06
95 percent	3.82E-06	4.16E-06
Standard Deviation	2.68E-06	1.49E-05

For Pre-EPU conditions, the PRA uncertainty calculation identifies the 95th percentile CDF as 3.82E-06 per year. This is a factor of 2.0 greater than the CDF point estimate produced by the SSES PRA (1.86E-06). For Post-EPU conditions, the PRA uncertainty calculation identifies the 95th percentile CDF as 4.16E-06 per year, which is a factor of 2.1 greater than the SSES point estimate CDF (1.97E-06). For this analysis, the post-EPU results are used as they bound the Pre-EPU results.

E.7.2.1 Phase 1 Impact

For Phase 1 screening, use of the 95th percentile PRA results will increase the modified maximum averted cost-risk and may prevent the screening of some of the higher cost modifications. There are cases where the SAMAs retained from this process may be cost beneficial using the 95th percentile results, but it is not common for this to occur. This is due to the fact that the benefit gleaned from the implementation of those SAMAs must be extremely large in order to be cost beneficial.

The impact of uncertainty in the PRA results on the Phase 1 SAMA analysis has been examined. The modified maximum averted cost-risk is the primary Phase 1 criteria affected by PRA uncertainty. Thus, this portion of this sensitivity is focused on recalculating the MMACR using the 95th percentile PRA results and re-performing the Phase 1 screening process.

As discussed above, the 95th PRA results are approximately a factor of 2.1 greater than point estimate CDF. The uncertainty analyses that are 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, the same scaling factor calculated for the Level 1 results was assumed to apply to the Level 2 and 3 models. Because the MMACR calculations scale linearly with the CDF, dose-risk, and offsite economic cost-risk, the 95th percentile MMACR can be calculated by multiplying the base case MMACR by 2.1. This results in a revised MMACR of $2,284,800.

The initial SAMA list has been re-examined using the revised MMACR to identify SAMAs that would be retained for the Phase 2 analysis. Those SAMAs that were previously screened due to costs of implementation that exceeded $1,088,000 are now retained if the costs of implementation are less than $2.28 million. In this case, two additional SAMAs would be retained for Phase 2 analysis that were initially screened based on the point estimate results (SAMAs 2b and 4).

E.7.2.2 Phase 2 Impact

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 Phase 2 SAMA analysis, the same process used to calculate the revised MMACR was applied to each of the Phase 2 SAMAs (the averted cost-risk for each SAMA was increased by a factor of 2.1 over the base case).

In addition, it was determined that SAMAs 2b and 4 should be included in the Phase 2 analysis when the 95th percentile PRA results are used. The detailed assessments of these SAMAs are documented below as part of this sensitivity.

E.7.2.2.1 SAMA 2b: Improve Cross-Tie Capability Between 4kV AC Emergency Buses (A-B-C-D)

Failure of an EDG combined with the failure of the “E” diesel in conjunction with non-diesel equipment failure in an alternate division results in the unavailability of both divisions of equipment. However, if power could be cross-tied between divisions, the non-failed equipment could be operated. SSES currently relies on the presence of the spare diesel (the “E” EDG) to mitigate EDG failures. While the “E” EDG is a valuable plant asset, emergency 4kV AC cross-tie capability would further reduce plant risk.

This SAMA is similar to SAMA 2a, but it provides the additional capability of providing the ability to cross-tie trains “A” or “D” to trains “B” or “C”. These additional alignments require the operators to backfeed power through one of the Emergency Safeguards transformers to the 13.8kV AC 10 or 20 bus and then back to the 4kV emergency buses through another Emergency Safeguards transformer. This alignment requires the operators to strip off all unnecessary 13.8kV loads and ensure the 10 and/or 20 buses are isolated from the grid.

The impact of implementing this SAMA has been estimated through the changes summarized in the following table:

SAMA Number 2b Model Changes

Gate and / or Basic Event ID and Description	Description of Change
SAMMA2B-A	This is a new “AND” gate including: • Gate 124-II-D-DGPWRU1 • Gate 224-II-D-DGPWRU2 • Gate 124-II-B-DGPWRU1 • Gate 224-II-B-DGPWRU2 • Gate 124-I-C-DGPWRU1 • Gate 224-I-C-DGPWRU2 The gate represents the ability to power the “A” bus from the other EDGs.
SAMMA2B-D	This is a new “AND” gate including: • Gate 124-I-A-DGPWRU1 • Gate 224-I-A-DGPWRU2 • Gate 124-II-B-DGPWRU1 • Gate 224-II-B-DGPWRU2 • Gate 124-I-C-DGPWRU1 • Gate 224-I-C-DGPWRU2 The gate represents the ability to power the “D” bus from the other EDGs.
SAMMA2B-C	This is a new “AND” gate including: • Gate 124-I-A-DGPWRU1 • Gate 224-I-A-DGPWRU2 • Gate 124-II-B-DGPWRU1 • Gate 224-II-B-DGPWRU2 • Gate 124-II-D-DGPWRU1 • Gate 224-II-D-DGPWRU2 The gate represents the ability to power the “C” bus from the other EDGs.
SAMMA2B-B	This is a new “AND” gate including: • Gate 124-I-A-DGPWRU1 • Gate 224-I-A-DGPWRU2 • Gate 124-I-C-DGPWRU1 • Gate 224-I-C-DGPWRU2 • Gate 124-II-D-DGPWRU1 • Gate 224-II-D-DGPWRU2 The gate represents the ability to power the “B” bus from the other EDGs.
104-I-A-PWR-EDGBU: FAILURE OF 4KV POWER TO THE UNIT 1 BUS 1A201 CREDITING THE E DG	Added gate SAMA2B-A

SAMA Number 2b Model Changes

Gate and / or Basic Event ID and Description	Description of Change
104-II-D-PWR-EDGBU: FAILURE OF 4KV POWER TO THE UNIT 1 BUS 1A204 CREDITING THE E DG IF A B C DG HA	Added gate SAMA2B-D
104-I-C-PWR-EDGBU: FAILURE OF 4KV POWER TO THE UNIT 1 BUS 1A202 CREDITING THE E DG IF A B DG HAS	Added gate SAMA2B-C
104-II-B-PWR-EDGBU: FAILURE OF 4KV POWER TO THE UNIT 1 BUS 1A202 CREDITING THE E DG IF A DG HAS NO	Added gate SAMA2B-B
204-I-A-PWR-EDGBU: FAILURE OF 4KV POWER TO THE UNIT 2 BUS 2A201 CREDITING THE E DG	Added gate SAMMA2B-A
204-II-D-PWR-EDGBU: FAILURE OF 4KV POWER TO THE UNIT 2 BUS 2A204 CREDITING THE E DG IF A B C DG HA	Added gate SAMMA2B-D
204-I-C-PWR-EDGBU: FAILURE OF 4KV POWER TO THE UNIT 2 BUS 2A203 CREDITING THE E DG IF A B DG HAS	Added gate SAMMA2B-C
204-II-B-PWR-EDGBU: FAILURE OF 4KV POWER TO THE UNIT 2 BUS 2A202 CREDITING THE E DG IF A DG HAS NO	Added gate SAMMA2B-B

The cross-tie action for this SAMA was conservatively assumed to be 100 percent reliable.

The cost of enhancing the 4kV AC emergency bus cross-tie capability so that any emergency 4kV AC bus can power any other emergency 4kV AC bus has been estimated to be approximately $1,384,000 (PPL 2005h).

Results

Implementation of this SAMA yields a reduction in the CDF, Dose-risk, and Offsite Economic cost-risk. The results are summarized in the following table for Units 1 and 2 for post-EPU conditions (pre-EPU conditions are not addressed in this sensitivity):

	Post-EPU		
	CDF	**Dose-Risk**	**OECR**
Unit 1_{Base}	1.97E-06	1.90	$11,151
Unit 1_{SAMA}	8.57E-07	0.73	$3,738
Unit 1 Percent Change	56.5%	62.1%	66.5%
Unit 2_{Base}	1.94E-06	1.86	$10,845
Unit 2_{SAMA}	8.38E-07	0.67	$3,322
Unit 2 Percent Change	56.8%	64.0%	69.4%

A further breakdown of the Dose-risk and OECR information is provided below according to release category.

SAMA 2b, Unit 1 Results By Release Category (Post-EPU)

Release Category	H/E	H/I	H/L	M/E	M/I	M/L	L/E	L/I	L/L	LL/I	LL/L	Total
$Frequency_{BASE}$	1.72E-07	1.59E-07	1.31E-10	0.00E+00	5.38E-07	1.51E-07	1.08E-07	4.87E-07	9.46E-09	1.56E-09	2.22E-08	**1.65E-06**
$Frequency_{SAMA}$	1.51E-07	5.65E-08	1.12E-10	0.00E+00	8.83E-09	5.33E-08	1.07E-07	3.16E-07	8.36E-09	1.56E-09	2.22E-08	**7.25E-07**
$Dose\text{-}Risk_{BASE}$	0.50	0.25	0.00	0.00	0.79	0.18	0.02	0.16	0.00	0.00	0.00	**1.90**
$Dose\text{-}Risk_{SAMA}$	0.44	0.09	0.00	0.00	0.01	0.06	0.02	0.10	0.00	0.00	0.00	**0.72**
$OECR_{BASE}$	$2,632	$2,099	$4	$0	$5,057	$995	$18	$337	$9	$0	$0	**$11,151**
$OECR_{SAMA}$	$2,310	$746	$3	$0	$83	$351	$18	$219	$8	$0	$0	**$3,738**

SAMA 2b, Unit 2 Results By Release Category (Post-EPU)

Release Category	H/E	H/I	H/L	M/E	M/I	M/L	L/E	L/I	L/L	LL/I	LL/L	Total
$Frequency_{BASE}$	1.72E-07	1.39E-07	1.17E-10	0.00E+00	5.50E-07	1.30E-07	1.08E-07	4.73E-07	3.42E-09	6.87E-10	2.11E-08	**1.60E-06**
$Frequency_{SAMA}$	1.51E-07	3.36E-08	9.79E-11	0.00E+00	8.52E-09	3.93E-08	1.07E-07	2.98E-07	2.33E-09	6.87E-10	2.11E-08	**6.62E-07**
$Dose\text{-}Risk_{BASE}$	0.50	0.22	0.00	0.00	0.80	0.16	0.02	0.16	0.00	0.00	0.00	**1.86**
$Dose\text{-}Risk_{SAMA}$	0.44	0.05	0.00	0.00	0.01	0.05	0.02	0.10	0.00	0.00	0.00	**0.67**
$OECR_{BASE}$	$2,632	$1,835	$3	$0	$5,170	$857	$18	$327	$3	$0	$0	**$10,845**
$OECR_{SAMA}$	$2,310	$444	$3	$0	$80	$259	$18	$206	$2	$0	$0	**$3,322**

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

SAMA Number 2b Net Value

Unit	Base Case Cost-Risk (Post-EPU)	Revised Cost-Risk (Post-EPU)	Averted Cost-Risk (Post-EPU)
Unit 1	$550,000	$200,204	$349,796
Unit 2	$538,000	$184,821	$353,179
Total	$1,088,000	$385,025	$702,975

In order to obtain the averted cost-risk based on the 95th percentile PRA results, the baseline averted cost-risk is multiplied by a factor of 2.1 to yield $1,476,248. This results in a net value of $92,248 ($1,476,248 - $1,384,000 = $92,248), which implies that this SAMA is cost beneficial.

E.7.2.2.2 SAMA 4: Install 100 Percent Capacity Battery Chargers

Currently, the SSES 125V DC chargers cannot support the full DC load requirements early in LOOP or LOCA sequences. In the event that the 125V batteries fail early in these accident scenarios, DC power is assumed to be unavailable to support injection system operation, which results in core damage even though the 125V DC battery chargers may still be available. For these cases, the DC loads could be supported the existing chargers were replaced with higher capacity units and procedures were developed to remove the failed batteries from the circuit. For LOOP events with concurrent battery failures, changes to the EDGs would be required to allow the EDGs to start and load without DC power.

The impact of implementing this SAMA has been estimated by removing the model logic that dictates 125V DC system failure when the 125V batteries are lost in conjunction with a LOOP or LOCA initiating event. The specific changes are provided below:

- Deleted 102-I-A-BATLOOPLOCA from 102-I-A-D613C.
- Deleted 102-I-C-BATLOOPLOCA from 102-I-C-D633C.
- Deleted 102-II-B-BATLOOPLOCA from 102-II-B-D623C.
- Deleted 102-II-D-BATLOOPLOCA from 102-II-D-D643C.

- Deleted 188-II-N-BATLOOPLOCA from 188-II-N-D663.
- Deleted 188-I-N-BATLOOPLOCA from 188-II-N-D663 and 188-I-B-D653.
- Deleted 202-I-A-BATLOOPLOCA from 202-I-A-D613C.
- Deleted 202-I-C-BATLOOPLOCA from 202-I-C-D633C.
- Deleted 202-II-B-BATLOOPLOCA from 202-II-B-D623C
- Deleted 202-II-D-BATLOOPLOCA from 202-II-D-D643C.
- Deleted 288-II-N-BATLOOPLOCA from 288-II-N-D663.
- Deleted 288-I-N-BATLOOPLOCA from 288-I-A-D653 and 288-I-B-D653

The cost of replacing the current battery chargers with new chargers that can supply 100 percent of the DC loads under all conditions has been estimated to be approximately $1,619,000 (PPL 2005f). This estimate does not address the changes that would be required to allow the EDGs to start without DC power in the event of a LOOP with concurrent battery failures.

Results

Implementation of this SAMA yields a reduction in the CDF, Dose-risk, and Offsite Economic cost-risk. The results are summarized in the following table for Units 1 and 2 for post-EPU conditions (pre-EPU conditions are not addressed in this sensitivity):

	Post-EPU		
	CDF	Dose-Risk	OECR
Unit 1_{Base}	1.97E-06	1.90	$11,151
Unit 1_{SAMA}	1.92E-06	1.86	$10,897
Unit 1 Percent Change	2.5%	2.1%	2.3%
Unit 2_{Base}	1.94E-06	1.86	$10,845
Unit 2_{SAMA}	1.84E-06	1.81	$10,505
Unit 2 Percent Change	5.2%	2.7%	3.1%

A further breakdown of the Dose-risk and OECR information is provided below according to release category.

SAMA 4, Unit 1 Results By Release Category (Post-EPU)

Release Category	H/E	H/I	H/L	M/E	M/I	M/L	L/E	L/I	L/L	LL/I	LL/L	Total
$Frequency_{BASE}$	1.72E-07	1.59E-07	1.31E-10	0.00E+00	5.38E-07	1.51E-07	1.08E-07	4.87E-07	9.46E-09	1.56E-09	2.22E-08	**1.65E-06**
$Frequency_{SAMA}$	1.71E-07	1.58E-07	1.31E-10	0.00E+00	5.30E-07	1.28E-07	1.08E-07	4.97E-07	2.93E-09	1.56E-09	2.08E-08	**1.62E-06**
$Dose\text{-}Risk_{BASE}$	0.50	0.25	0.00	0.00	0.79	0.18	0.02	0.16	0.00	0.00	0.00	**1.90**
$Dose\text{-}Risk_{SAMA}$	0.50	0.25	0.00	0.00	0.77	0.15	0.02	0.17	0.00	0.00	0.00	**1.86**
$OECR_{BASE}$	$2,632	$2,099	$4	$0	$5,057	$995	$18	$337	$9	$0	$0	**$11,151**
$OECR_{SAMA}$	$2,616	$2,086	$4	$0	$4,982	$844	$18	$344	$3	$0	$0	**$10,897**

SAMA 4, Unit 2 Results By Release Category (Post-EPU)

Release Category	H/E	H/I	H/L	M/E	M/I	M/L	L/E	L/I	L/L	LL/I	LL/L	Total
$Frequency_{BASE}$	1.72E-07	1.39E-07	1.17E-10	0.00E+00	5.50E-07	1.30E-07	1.08E-07	4.73E-07	3.42E-09	6.87E-10	2.11E-08	**1.60E-06**
$Frequency_{SAMA}$	1.70E-07	1.32E-07	1.17E-10	0.00E+00	5.30E-07	1.26E-07	1.08E-07	4.73E-07	2.52E-09	6.87E-10	2.09E-08	**1.56E-06**
$Dose\text{-}Risk_{BASE}$	0.50	0.22	0.00	0.00	0.80	0.16	0.02	0.16	0.00	0.00	0.00	**1.86**
$Dose\text{-}Risk_{SAMA}$	0.50	0.21	0.00	0.00	0.77	0.15	0.02	0.16	0.00	0.00	0.00	**1.81**
$OECR_{BASE}$	$2,632	$1,835	$3	$0	$5,170	$857	$18	$327	$3	$0	$0	**$10,845**
$OECR_{SAMA}$	$2,601	$1,742	$3	$0	$4,982	$830	$18	$327	$2	$0	$0	**$10,505**

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

SAMA Number 4 Net Value

Unit	Base Case Cost-Risk (Post-EPU)	Revised Cost-Risk (Post-EPU)	Averted Cost-Risk (Post-EPU)
Unit 1	$550,000	$537,443	$12,557
Unit 2	$538,000	$519,746	$18,254
Total	$1,088,000	$1,057,189	$30,811

In order to obtain the averted cost-risk based on the 95th percentile PRA results, the baseline averted cost-risk is multiplied by a factor of 2.1 to yield $64,703. This results in a net value of -$1,554,297 ($64,703 - $1,619,000 = -$1,554,297), which implies that this SAMA is not cost beneficial.

E.7.2.2.3 SAMA 14: Enhance Fire Main Connection to RHR

In the baseline analysis, SAMA 14 was screened given that the relevant RRW value was below the 1.02 SAMA review cutoff limit. Normally, the RRW review cutoff limit is set to correlate to the lowest expected SAMA implementation cost, which is typically a procedure change of about $50,000. Because the SSES review cutoff limit was artificially lowered to allow a more robust review of the importance list, even when the 95th percentile results are used, the cutoff RRW review value of 1.02 corresponds to an averted cost-risk of only $50,000 (compared with about $21,000 in the base case). Assuming that the RRW values for the events remain constant with the use of the 95th percentile results, it is expected that SAMA 14 would still be screened based on the 1.005 RRW that was calculated for event “013-N-N-EARLY-O”. The importance rankings may actually vary somewhat depending on the failure probability distributions for the basic events, but these values are not calculated as part of the uncertainty analysis and are not available for this sensitivity.

E.7.2.2.4 Summary

The following table provides a summary of the impact of using the 95th percentile PRA results in the detailed cost-benefit calculations that have been performed.

Summary of the Impact of Using the 95th Percentile PRA Results (Post EPU)

SAMA ID	Cost of Implementation	Averted Cost- Risk (Base)	Net Value (Base)	Averted Cost- Risk (95th Percentile)	Net Value (95th Percentile)	Change in Cost Effective-ness?
1	$2,798,000	$749,073	-$2,048,927	$1,573,053	-$1,224,947	No
2a	$656,000	$694,331	$38,331	$1,458,095	$802,095	No
2b	$1,384,000	NA	NA	$1,476,248	$92,248	Yes
3	$150,000	$137,758	-$12,242	$289,292	$139,292	Yes
4	$1,619,000	NA	NA	$64,703	-$1,554,297	No
5	$398,000	$368,403	-$29,597	$773,646	$375,646	Yes
6	$203,000	$266,665	$63,665	$559,997	$356,997	No
7	$970,000	$75,890	-$894,110	$159,369	-$810,631	No
8	$600,000	$9,896	-$590,104	$20,782	-$579,218	No
9	$346,000	$34,521	-$311,479	$38,222	-$307,778	No
10	$386,000	$18,612	-$367,388	$39,085	-$346,915	No
12	$50,000	$240	-$49,760	$504	-$49,496	No

When the 95th percentile PRA results are used, three of the SAMAs that were previously classified as not cost effective are determined to be cost effective, including SAMA 2b, which was initially screened in Phase 1. The use of the 95th percentile PRA results is not considered to provide the most realistic assessment of the cost effectiveness of a SAMA; however, these three additional SAMAs could be considered for implementation to address the uncertainties inherent in the SAMA analysis.

E.7.3 MACCS2 Input variations

The MACC2 model was developed using the best information available for the SSES site; however, reasonable changes to modeling assumptions can lead to variations in the Level 3 results. In order to determine how certain assumptions could impact the SAMA results, a sensitivity analysis was performed on a group of parameters that has previously been shown to impact the Level 3 results. These parameters include:

- Meteorological data (ESSQ2002; ESSQ2003)
- Population estimates(ESS30INC; ESSSIT00)
- Evacuation effectiveness (ESSQSLOW; ESSDELAY)

- Radionuclide release characteristics (ESSQATM1; ESSQATM2)
- Food production factors (ESSQCROP)
- Recovery, decontamination, and resettlement factors (Intermediate Phase) (ESSQCHR, ESSQCHR1)

The risk metrics produced by MACCS2 that are evaluated in the sensitivity analyses are the 50 mile population dose and the 50 mile offsite economic cost. The subsections below discuss the changes in these results for each of the sensitivity cases that are shown below. The final subsection, E.7.3.7, correlates the worst case changes identified in the sensitivity runs to a change in the site's averted cost-risk and discusses the implications of the sensitivity analysis on the SAMA analysis.

Case	Description	Pop. Dose Risk Δ Base (%)	Cost Risk Δ Base (%)
Base Case	Base Case (Year 2001 MET data)	--	--
ESSQ2002	Year 2002 MET data	-6.7%	-8.6%
ESSQ2003	Year 2003 MET data	-8.2%	-7.8%
ESS30INC	Year 2044 population values increased uniformly 30% over base case.	27.9%	28.7%
ESSSit00	Year 2000 population based on SECPOP2000	-8.5%	-9.0%
ESSQSlow	Evacuation speed decreased 50% to 1.1 mph, 0.485 m/sec (Base Case is 2.2 mph).	11.2%	0%
ESSDelay	Evacuation begins 90 minutes after declaration of General Emergency (Base Case is 60 minutes).	2.1%	0%
ESSQATM1	Release height set to ground level	-6.0%	-10.4%
ESSQATM2	Plume thermal heat content set to ambient (i.e., buoyant plume rise not modeled)	-8.0%	-12.1%
ESSQCrop	Site specific crop production values used	-2.5%	0%
ESSQCHR1	Long Term Phase starts immediately after the Early Phase is over	31.4%	-50.41%
ESSQCHR	1/2 Year Intermediate Phase following the Early Phase	14.7%	-25.9%

E.7.3.1 Meteorological Sensitivity

In addition to the base case meteorological data (year 2001), data were also available for the years 2002 and 2003. Analysis of these alternate data sets yielded population dose-risks and offsite economic cost-risks that were lower than the 2001 data by at least 6.5 percent and by as much as 8.5 percent. These are relatively small perturbations.

As no particular criteria have been defined by the industry related to determining which meteorological data set should be used as a base case for a site, the year 2001 data was conservatively chosen for SSES given that it yielded the largest results.

E.7.3.2 Population Sensitivity

The population sensitivity cases (ESS30INC, ESSSIT00) demonstrate a significant dependence on population estimates. This was expected given that the population dose and offsite economic costs are primarily driven by the regional population.

In case ESS30INC, the baseline 2044 population was uniformly increased by 30 percent in all sectors of the 50-mile radius. This change increased the estimated population dose-risk and offsite economic cost by over 27 percent each.

A second population based sensitivity was performed to determine the impact of scaling the year 2000 SECPOP data to account for the expected changes in the site’s 50-mile population. The baseline SAMA case assumes that the population around the site has changed by the end of the license renewal period based on the trends shown between the years 1990 and 2000. In summary, the trends show that many areas around the plant have experienced decreases in population while the areas farther from the plant have shown increases over time. When these population projections are removed from the analysis, the overall dose-risk and OECR decrease. Specifically, the dose-risk decreased by about 8.5 percent and the OECR decreased by about 9 percent.

E.7.3.3 Evacuation sensitivity

The evacuation sensitivity cases (ESSQSLOW and ESSDELAY) demonstrate minor population dose-risk impacts associated with evacuation assumptions due to the relatively slow base case Susquehanna evacuation. While evacuation assumptions do impact the population dose-risk estimates, they do not impact MACCS2 offsite economic cost-risk estimates because MACCS2 calculated cost-risks are based on land contamination levels which remain unaffected by evacuation assumptions and the number of people evacuating.

For Susquehanna, evacuation assumptions have a relatively minor impact on dose-risk. A 50 percent decrease in the evacuation speed increased the dose-risk by only 11 percent while increasing the delay between declaration of a general emergency and the start of evacuation increased the dose-risk by only 2 percent.

E.7.3.4 Radioactive release sensitivity

The sensitivity cases ESSQATM1 and ESSQATM2 quantify the impact of the assumptions related to the height of the release and thermal energy of the plume, respectively. ESSQATM1 assumes that the release occurs at ground level rather than at an elevation that could correspond to a release through the stack or a break high in the reactor building. The lower release height shows a decrease in dose-risk of 6 percent and a reduction in OECR of over 10 percent. Reducing the thermal plume heat content to ambient conditions has a similar impact. ESSQATM2 shows an 8 percent decrease in the dose-risk and a decrease of about 10 percent in the OECR.

E.7.3.5 Food production sensitivity

The food production sensitivity case (ESSQROP) investigates the impact of food contamination and ingestion rates for the 50-mile population. The sensitivity case utilized food production data developed for the counties surrounding the Susquehanna site in lieu of the national averages used in the COMIDA base case modeling. Use of the site specific data resulted in minor changes to the dose-risk (-2.5 percent) and OECR (0.0%). These small changes are consistent with low contribution of the food ingestion pathway to overall population dose (e.g., only about 5% of the total population dose is due to food ingestion).

E.7.3.6 Intermediate Phase Duration Sensitivity

The Intermediate Phase, as modeled by MACCS2, is the time period beginning after the early phase (one week emergency phase) and extends to the time when recovery actions such as decontamination and resettlement are started (long term phase). MACCS2 allows the habitation of land during the intermediate phase unless the projected dose criterion is exceeded. If the projected dose criterion is exceeded during the intermediate phase, the individual is relocated. MACCS2 allows an intermediate phase ranging from no intermediate phase to one (1) year. The Intermediate Phase related sensitivity cases (ESSQCHR and ESSQCHR1) show significant dependence in relation to economic impact, and are therefore discussed further:

- The No Intermediate Phase case (ESSQCHR1) was developed based on the NUREG-1150 modeling approach. However, the 50 percent reduction in economic cost estimates based on the approach are judged too optimistic in that the land decontamination efforts are modeled as starting one week after the accident (i.e., directly after the early phase ends) such that a significant portion of population relocation costs are omitted. For example, the costs associated with temporary housing while decontamination strategies are developed and decontamination teams are contracted are not accounted for without an intermediate phase. It is believed that NUREG-1150 studies omitted the intermediate phase because the MACCS2 intermediate phase coding was not validated at that time. A competing factor is that the population dose increases because people are allowed to re-occupy the land sooner (31 percent increase over the base case).

- The 1 Year Intermediate Phase case (base case) was developed based on the maximum length of time allowed by MACCS2 for the intermediate phase. A long intermediate phase can be unrealistic in that re-occupation of the contaminated land is not performed during this phase even if contamination levels decrease (by natural radioactive decay) to levels which would allow it (i.e., resettlement is evaluated as part of the long term phase, not the intermediate phase). Therefore, population relocation costs may be over estimated using a long (i.e., one year) intermediate phase. Reducing the Intermediate Phase to six months in sensitivity case ESSQCHR showed a 26 percent decrease in the OECR estimates compared with the 1 year Intermediate phase. However, the population dose increased by 15 percent with a shorter Intermediate Phase due to earlier resettlement of contaminated land.

The six month intermediate phase (ESSQCHR) is judged to be a best estimate approach in that it provides a reasonable time for both decontamination efforts and resettlement to begin. The sensitivity cases demonstrate that this six month modeling approach is mid-range of the modeling choices available; however, the one year intermediate phase is used as the base case as it is more conservative for economic cost risk.

E.7.3.7 Impact on SAMA Analysis

Several different Level 3 input parameters have been examined as part of the SSES MACCS2 sensitivity analysis. The primary reason for performing these sensitivity runs was to identify any reasonable changes that could be made to the Level 3 input parameters that would impact the conclusions of the SAMA analysis. While the table in Section E.7.3 summarizes the changes to the dose-risk and OECR estimates for each sensitivity case, it was necessary to determine if any of these changes would result in the retention of the SAMAs that were screened using the baseline results.

Of all the MACCS2 sensitivity cases, the largest increase in the dose-risk was 31 percent in case ESSQCHR1 while the largest increase in OECR was 29 percent in case ESS30INC. While these are separate cases, the SSES MMACR was recalculated using these results to determine the impact of using the worst case for each parameter simultaneously. The resulting MMACR was $1,349,940, which is less than $2,284,800 calculated in Section E.7.2 for the 95th percentile PRA results. The 95th percentile PRA results sensitivity is considered to bound this case and no SAMAs would be retained based on this sensitivity that were not already identified in Section E.7.2.

E.8 CONCLUSIONS

The benefits of revising the operational strategies in place at SSES and/or implementing hardware modifications can be evaluated without the insight from a risk-based analysis. Use of the PRA in conjunction with cost-benefit analysis methodologies has, however, provided an enhanced understanding of the effects of the proposed changes relative to the cost of implementation and projected impact on a larger future population. The results of this study indicate that of the identified potential improvements that can be made at SSES, a few are cost beneficial based on the methodology applied in this analysis and warrant further review for potential implementation.

The base case analysis shows that implementation of the following two SAMAs would be cost beneficial:

- SAMA 2a: Improve Cross-Tie Capability Between 4kV AC Emergency Buses (A-D, B-C)
- SAMA 6: Procure Spare 480V AC Portable Station Generator

The 4kV AC emergency bus cross-tie between the “A” and “D” or “B” and “C” buses (SAMA 2a) is a cost beneficial enhancement at Susquehanna. While SSES already has the “E” EDG to compensate for primary EDG failures, the largest contributor to site risk is still the LOOP initiating event. For a moderate cost of implementation, a means of further reducing LOOP risk could be added to the site.

SAMA 6 is also identified as a cost beneficial change; however, common cause failure of the additional generator is not currently included in the analysis. If common cause failures are included and if SAMA 2a is implemented, the benefit of this SAMA would be reduced. Because of these mitigating factors, this SAMA is not recommended for implementation.

The 95th percentile PRA results show that the following additional SAMAs are cost beneficial:

- SAMA 2b: Improve Cross-Tie Capability Between 4kV AC Emergency Buses (A-B-C-D)
- SAMA 3: Proceduralize Staggered RPV Depressurization When Fire Protection System Injection is the Only Available Makeup Source
- SAMA 5: Auto Align 480V AC Portable Station Generator

The expanded 4kV AC cross-tie (SAMA 2b) could also be considered to be a cost-effective change for SSES. This SAMA would allow any given EDG the capability to power any particular 4kV AC emergency bus. While the cost of implementation is greater than the monetary equivalent of the associated risk reduction based on the best estimate results, the sensitivity case shows that SAMA 2b is a borderline case and that it could be considered as a possible means of reducing plant risk. However, if lower cost SAMA 2a is implemented, most of the cross-tie benefit would be obtained and the further changes required to implement SAMA 2b would not be cost beneficial. This judgement is based on the difference in averted cost risk-shown for the two SAMAs in Section E.7.2. SAMA 2b yields an additional benefit of only $20,000 for an additional cost input of $728,000. This SAMA is not recommended for consideration.

SAMA 3 provides a means of ensuring that injection with the Fire Main can prevent core damage when it is the only available injection source. As this SAMA only requires procedure changes and supporting analysis to support the use of an existing injection system, this low cost SAMA should be considered for implementation.

SAMA 5 only becomes cost effective by about 7.5 percent of its cost of implementation when the 95^{th} percentile PRA results are used. While this SAMA could be considered cost beneficial, SAMAs 2a and 3 yield larger cost benefit margins and should be considered for implementation before SAMA 5.

E.9 TABLES

Table E.2-1 Release Severity and Timing Classification Scheme (Severity, Timing)

Release Severity		Release Timing	
Classification Category	**Cs Iodide % in Release**	**Classification Category**	**Time of Initial Release Relative to Time for General Emergency Declaration**
High (H)	Greater than 10	Late (L)	Greater than 24 hours
Medium or Moderate (M)	1 to 10	Intermediate (I)	Greater than 6 hours but less than 24 hours
Low (L)	0.1 to 1	Early (E)	Less than 6 hours
Low-low (LL)	Less than 0.1		
Intact (OK)	Leakage		

Table E.2-2 RELEASE SEVERITY AND TIMING CLASSIFICATION MATRIX

Time of Release	Magnitude of Release			
	H	**M**	**L**	**LL**
E	H/E	M/E	L/E	LL/E
I	H/I	M/I	L/I	LL/I
L	H/L	M/L	L/L	LL/L

Table E.2-3 Summary of Containment Evaluation (SAMA Model)

Release Bin[a]	Pre-EPU Unit 1 Release Frequency (Per Year)	Pre-EPU Unit 2 Release Frequency (Per Year)	Post-EPU Unit 1 Release Frequency (Per Year)	Post-EPU Unit 2 Release Frequency (Per Year)
H/E	1.71E-07	1.71E-07	1.72E-07	1.72E-07
H/I	1.47E-07	1.30E-07	1.59E-07	1.39E-07
H/L	1.21E-10	1.07E-10	1.31E-10	1.17E-10
M/E	0.0	0.0	0.0	0.0
M/I	5.05E-07	5.14-E07	5.38E-07	5.50-E07
M/L	1.33E-07	1.13E-07	1.51E-07	1.30E-07
L/E	7.43E-08	7.43E-08	1.08E-07	1.08E-07
L/I	4.20E-07	4.31E-07	4.87E-07	4.73E-07
L/L	5.58E-08	2.28E-08	9.46E-09	3.42E-09
LL/I	0.0	0.0	1.56E-09	6.87E-10
LL/L	2.37E-08	2.18E-08	2.22E-08	2.11E-08

(a) The LL/E bin is not included here as the frequency is always zero and does not contribute to the Level 3 results. For post-EPU, release timing changes moved some of the LL/L results from the pre-EPU model to the LL/I release category.

Table E.2-4a SSES Source Term Summary (Pre-EPU)

	Release Category[1,2]										
	H/E	H/I	H/L	M/E	M/I	M/L	L/E	L/I	L/L	LL/E	LL/L
MAAP Run	SU0516	SU0500	SU0514	SU0515	SU0500a	SU0505	SU0515a	SU0511	SU0550	SU0516a	SU0556a
Description	IVA-L2-14A-NED-DW	IA-L2-1A-NSPR	IIID-L2-12C-DW	IVA-L2-14A-ED-DW	IIA-L2-9A-DW	ID-L2-7B-NSPR	IVA-L2-14A-ED-WWA	IIA-L2-9A-WWA	IIIB-L2-1A-NSPR	IVA-L2-14A-NED-WWA	IIIC-L2-7BA-SPRY
Time after Scram when General Emergency is declared	.5 hr	1.5 hr	.5 hr	2 hr	1.5 hr	1.0 hr	2.0 hr	18 hr	.5 hr	.75 hr	.1 hr
Fission Product Group:											
1) Noble											
Total Release **Fraction** at 48 Hours	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Start of Release (hr)	0.75	21.40	29.00	2.00	21.00	33.50	2.00	30.70	34.00	1.00	27.70
End of Release (hr)	3.00	21.40	34.00	4.00	22.00	33.50	4.00	30.70	34.00	4.00	27.20
2) CsI											
Total Release Fraction at 48 Hours	5.90E-01	2.40E-01	3.40E-01	6.00E-02	3.80E-02	2.50E-02	1.00E-03	2.00E-03	7.00E-03	7.80E-04	4.00E-06
Start of Release (hr)	3.80	21.40	30.00	2.00	21.00	33.50	2.00	30.70	34.00	1.00	27.70
End of Release (hr)	5.00	48.00	40.00	16.00	48.00	48.00	4.00	34.00	48.00	4.00	48.00
3) TeO2											
Total Release Fraction at 48 Hours	5.00E-01	4.00E-02	3.50E-01	1.70E-01	2.40E-02	4.50E-03	8.00E-04	1.00E-03	2.00E-02	4.00E-04	5.00E-06
Start of Release (hr)	4.00	21.40	30.00	8.00	21.00	33.50	2.00	30.70	38.00	1.00	27.70
End of Release (hr)	4.00	48.00	48.00	10.00	48.00	48.00	4.00	40.00	48.00	4.00	48.00
4) SrO											
Total Release Fraction at 48 Hours	3.00E-04	6.00E-09	3.00E-03	8.50E-04	6.00E-09	1.50E-07	7.00E-06	4.00E-06	8.50E-07	1.00E-06	1.50E-08
Start of Release (hr)	3.80	4.50	30.00	8.00	21.00	6.00	2.00	30.70	2.00	1.00	2.00
End of Release (hr)	3.80	4.50	36.00	8.00	21.00	6.00	4.00	40.00	2.00	4.00	2.00
5) MoO2											
Total Release Fraction at 48 Hours	2.00E-04	5.50E-09	1.30E-02	5.50E-05	6.00E-09	2.00E-08	2.00E-05	9.00E-06	1.00E-06	5.00E-05	1.00E-07
Start of Release (hr)	3.80	4.50	30.00	2.00	21.00	33.50	2.00	30.70	2.00	2.00	2.00
End of Release (hr)	3.80	4.50	36.00	8.00	21.00	33.50	4.00	34.00	2.00	2.00	2.00

Table E.2-4a SSES Source Term Summary (Pre-EPU) (continued)

	Release Category[1]										
	H/E	H/I	H/L	M/E	M/I	M/L	L/E	L/I	L/L	LL/E	LL/L
6) CsOH											
Total Release Fraction at 48 Hours	4.00E-01	4.00E-02	2.80E-01	1.90E-01	2.30E-02	7.50E-03	7.00E-04	1.00E-03	5.50E-02	4.00E-04	1.00E-04
Start of Release (hr)	4.00	21.40	30.00	8.00	21.00	33.50	2.00	30.70	34.00	1.00	27.70
End of Release (hr)	5.00	48.00	48.00	12.00	48.00	48.00	4.00	48.00	48.00	6.00	48.00
7) BaO											
Total Release Fraction at 48 Hours	4.00E-04	1.50E-08	2.00E-02	4.00E-04	2.00E-08	1.00E-07	4.00E-05	2.00E-05	2.00E-06	8.30E-06	1.00E-07
Start of Release (hr)	3.80	4.50	30.00	8.00	21.00	33.50	2.00	30.70	2.00	1.00	2.00
End of Release (hr)	3.80	4.50	36.00	8.00	21.00	33.50	4.00	34.00	2.00	4.00	2.00
8) La2O3											
Total Release Fraction at 48 Hours	1.00E-05	4.00E-10	2.50E-04	5.00E-06	4.00E-10	1.00E-09	7.00E-07	5.00E-07	8.00E-08	2.00E-07	2.00E-09
Start of Release (hr)	3.80	4.50	30.00	8.00	21.00	33.50	2.00	34.00	2.00	2.00	2.00
End of Release (hr)	3.80	4.50	36.00	8.00	21.00	33.50	4.00	34.00	2.00	4.00	2.00
9) CeO2											
Total Release Fraction at 48 Hours	7.50E-04	2.50E-09	3.00E-04	1.00E-04	2.50E-09	2.00E-08	1.00E-05	9.00E-07	3.50E-07	9.00E-07	2.00E-09
Start of Release (hr)	3.80	4.50	30.00	8.00	21.00	6.00	2.00	30.70	2.00	1.00	2.00
End of Release (hr)	3.80	4.50	36.00	8.00	21.00	6.00	4.00	34.00	6.00	4.00	2.00
10) Sb											
Total Release Fraction at 48 Hours	2.80E-02	1.80E-02	4.00E-01	8.00E-02	5.00E-03	3.00E-02	1.00E-03	4.00E-03	2.00E-02	3.00E-03	7.00E-05
Start of Release (hr)	3.80	21.40	30.00	8.00	21.00	33.50	2.00	30.70	34.00	2.00	27.70
End of Release (hr)	3.80	48.00	40.00	10.00	21.00	48.00	4.00	30.70	48.00	20.00	48.00
11) Te2											
Total Release Fraction at 48 Hours	0.00E+00	8.50E-05	6.80E-09	3.00E-04	9.00E-05	5.00E-05	2.00E-05	5.00E-05	2.00E-04	1.00E-04	1.00E-07
Start of Release (hr)	0.00	21.40	40.00	8.00	21.00	33.50	26.00	37.00	34.00	6.00	27.70
End of Release (hr)	0.00	21.40	40.00	8.00	21.00	48.00	44.00	48.00	34.00	20.00	27.70
12) UO2											
Total Release Fraction at 48 Hours	1.50E-07	1.00E-12	2.00E-12	3.00E-07	1.00E-12	4.00E-11	3.00E-10	2.00E-10	1.00E-09	7.20E-12	2.00E-14
Start of Release (hr)	4.00	4.50	40.00	8.00	4.00	6.00	8.00	37.00	4.00	4.00	4.00
End of Release (hr)	4.00	4.50	40.00	8.00	4.00	6.00	8.00	37.00	4.00	4.00	4.00

(1) Puff releases are denoted in the table by those entries with equivalent start and end times.
(2) Neither the LL/E nor the LL/I Release Categories contribute to the Pre-EPU results, but the LL/E source term is provided for reference purposes.

Table E.2-4b SSES Source Term Summary (Post-EPU)

	Release Category[1,2]										
	H/E	H/I	H/L	M/E	M/I	M/L	L/E	L/I	L/L	LL/I	LL/L
MAAP Run	ESU0516	ESU0500	ESU0514	ESU0515	ESU0500a	ESU505	ESU0515a	ESE0131	ESE0117	ESE0127	ESU556a
Description	IVA-L2-14A-NED-DW	IA-L2-1A-NSPR	IIID-L2-12C-DW	IVA-L2-14A-ED-DW	IIA-L2-9A-DW	ID-L2-7B-NSPR	IVA-L2-14A-ED-WWA	IIA-L2-9A-WWA	IIIB-L2-1A-NSPR	MSIV Closure	IIIC-L2-7BA-SPRY
Time after Scram when General Emergency is declared	.5 hr	1.5 hr	.5 hr	1.3 hr	1.5 hr	1.0 hr	2.0 hr	13 hr	13 hr	15 hr	0.1 hr
Fission Product Group:											
1) Noble											
Total Release **Fraction** at 48 Hours	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Start of Release (hr)	0.8	17.3	22.9	1.3	17.3	27.2	1.3	20.6	39.6	33.0	23.2
End of Release (hr)	3.8	17.3	29.1	4.7	17.3	27.2	7.7	39.8	47.4	36.7	23.2
2) CsI											
Total Release Fraction at 48 Hours	5.82E-01	3.55E-01	4.75E-01	5.64E-02	6.13E-02	2.85E-02	1.05E-03	3.76E-03	7.42E-03	7.46E-04	1.35E-05
Start of Release (hr)	3.4	17.3	23.8	1.3	17.3	32.5	1.3	21.0	40.0	34.1	23.8
End of Release (hr)	48.0	48.0	48.0	48.0	48.0	48.0	48.0	31.1	58.6	42.5	48.0
3) TeO2											
Total Release Fraction at 48 Hours	5.27E-01	5.42E-02	2.39E-01	1.57E-01	4.77E-02	8.45E-03	8.74E-04	1.16E-03	9.43E-04	4.01E-05	1.40E-05
Start of Release (hr)	3.4	17.3	23.5	2.7	17.3	27.2	1.3	21.2	40.2	34.1	27.7
End of Release (hr)	17.3	48.0	48.0	48.0	48.0	48.0	48.0	48.0	65.5	43.0	48.0
4) SrO											
Total Release Fraction at 48 Hours	3.13E-04	8.47E-09	3.39E-03	9.38E-04	8.47E-09	2.04E-07	8.96E-06	1.75E-05	1.10E-05	3.36E-07	1.32E-08
Start of Release (hr)	3.4	3.0; 17.3	23.5	5.8	3.0; 17.3	4.1	1.3	21.0	40.1	34.1	4.3
End of Release (hr)	3.9	3.0; 17.3	30.2	6.6	3.0; 17.3	8.1	8.6	32.3	51.5	37.2	4.3
5) MoO2											
Total Release Fraction at 48 Hours	2.17E-04	1.07E-08	1.50E-02	2.08E-04	1.07E-08	6.95E-08	4.41E-05	1.11E-04	3.16E-05	1.74E-06	8.25E-08
Start of Release (hr)	2.1	3.0; 17.3	24.2	1.3	3.0; 17.3	1.5	1.3	21.2	40.3	34.1	3.5
End of Release (hr)	3.7	3.0; 17.3	29.2	6.0	3.0;17.3	27.6	6.2	27.8	48.7	36.7	3.5

Table E.2-4b SSES Source Term Summary (Post-EPU) (continued)

	Release Category[1]										
	H/E	H/I	H/L	M/E	M/I	M/L	L/E	L/I	L/L	LL/I	LL/L
6) CsOH											
Total Release Fraction at 48 Hours	4.06E-01	6.80E-02	2.97E-01	1.63E-01	4.23E-02	1.30E-02	7.64E-04	1.45E-03	2.00E-03	1.91E-04	2.73E-04
Start of Release (hr)	3.4	17.3	23.6	1.3	17.3	27.2	1.3	21.0	40.0	34.1	23.7
End of Release (hr)	48.0	48.0	48.0	48.0	17.3	48.0	48.0	48.0	69.5	43.9	48.0
7) BaO											
Total Release Fraction at 48 Hours	5.25E-04	2.61E-08	1.32E-02	6.20E-04	2.54E-08	1.72E-07	5.21E-05	1.06E-05	6.28E-05	2.09E-06	8.73E-08
Start of Release (hr)	2.3	3.0; 17.3	24.1	1.3	3.0; 17.3	1.5	1.3	21.0	40.0	34.1	4.4
End of Release (hr)	3.9	3.0; 17.3	30.1	6.5	3.0; 17.3	27.4	6.8	27.9	49.9	36.5	4.4
8) La2O3											
Total Release Fraction at 48 Hours	8.20E-06	7.00E-10	1.24E-04	8.28E-06	7.00E-10	5.45E-09	1.06E-06	2.34E-06	7.92E-07	3.09E-08	1.21E-09
Start of Release (hr)	2.4	3.0; 17.3	24.2	1.3	3.0; 17.3	1.5	1.3	21.2	40.3	34.1	4.1
End of Release (hr)	3.9	3.0; 17.3	29.6	6.4	3.0; 17.3	27.4	7.0	28.1	50.3	36.5	4.1
9) CeO2											
Total Release Fraction at 48 Hours	6.27E-05	4.92E-09	2.52E-04	1.29E-04	4.92E-09	4.55E-08	1.68E-06	3.33E-06	1.34E-06	3.05E-07	1.59E-09
Start of Release (hr)	2.5	3.0; 17.3	24.0	1.8	3.0; 17.3	4.1	1.3	21.0	40.2	34.1	4.2
End of Release (hr)	3.9	3.0; 17.3	30.1	6.3	3.0; 17.3	27.4	7.5	31.6	52.0	37.5	4.2
10) Sb											
Total Release Fraction at 48 Hours	4.49E-02	2.38E-02	4.80E-01	1.00E-01	1.49E-02	4.64E-02	8.89E-04	4.65E-02	6.25E-02	3.63E-04	1.99E-05
Start of Release (hr)	2.4	17.3	24.1	5.8	17.3	27.2	1.3	21.3	40.4	33.8	22.8
End of Release (hr)	48.0	48.0	44.2	48.0	48.0	48.0	48.0	33.5	49.9	44.1	48.0
11) Te2											
Total Release Fraction at 48 Hours	0.00E+00	2.96E-05	1.09E-09	3.56E-04	2.95E-05	2.18E-04	5.51E-05	1.25E-05	6.80E-05	3.58E-04	5.87E-08
Start of Release (hr)	0.00	17.3	29.2	6.1	17.3	27.2	6.3	29.7	49.1	37.7	22.9
End of Release (hr)	0.00	17.3	40.4	6.5	17.3	48.0	48.0	48.0	72.0	37.7	39.8
12) UO2											
Total Release Fraction at 48 Hours	8.28E-08	1.30E-12	2.77E-07	3.22E-07	1.3E-12	2.20E-10	6.35E-10	1.19E-10	1.18E-10	5.29E-13	1.10E-12
Start of Release (hr)	3.5	3.0	29.2	6.1	3.0	4.3	6.3	29.6	48.9	36.9	3.3
End of Release (hr)	4.0	3.0	30.1	6.4	3.0	8.0	10.1	39.1	52.0	36.9	3.3

(1) Puff releases are denoted in the table by those entries with equivalent start and end times.
(2) LL/E does not contribute to the post-EPU results, but some of the pre-EPU LL/L sequences have been binned into the LL/I category based on the impact of EPU.

Table E.2-5 Open 'B' Peer Review Certification Resolution Prior to Issuance of the FEB06pre/postEPU PRA Model

F&O Identifier	Description	Prior PPL Disposition	Disposition for FEB06pre/postEPU Model
AS-7-4	Conservative RPV Rupture Frequency	Frequency documented in the Initiating Events Notebook.	Since this directly influences the LERF frequency, the initiating event (IE) frequency value was adjusted to 1.0E-8 consistent with many other industry BWRs. (Now closed).
HR-4-1	Missing Pre-Initiator HEPs	Adding more pre-initiators is not expected to affect the insights presently realized.	Acceptable to proceed as is.
IE-13-1	LOOP Frequency Pedigree	Future update to consider using INEEL/EXT-04-02326 LOOP frequency and recovery data.	Incorporated new data directly into the FEB06preEPU and FEB06EPU models. (Now closed).
IE-5-2	Reconsider IE exclusion for loss of service water (LOSW), etc.	Future update to consider LOSW. Others adequately addressed.	Acceptable to proceed as is. Consider sensitivity studies.
IE-6-1	Consider including loss of instrument air (LOIA)	Future update to consider LOIA.	Acceptable to proceed as is. Consider sensitivity studies.
IE-7-1	Consider including break outside containment (BOC)	Future update to consider BOC.	Included in updated models since will influence LERF. (Now closed).
IE-7-2	Consider including LOIA and BOC	Future update to consider LOIA and BOC.	See resolution above for IE-6-1 and IE-7-1.
IE-13-2	Compare IE frequencies with other similar sites.	Results indicate reasonableness of chosen values.	Values are reasonable based on comparison with other similar sites. (Now closed).
L2-5-1	Reconsider timing of containment overtemperature failure (COTF) scenarios	Being evaluated as part of the Level 2 update.	Addressed by updated detailed Level 2 analysis included in the FEB06preEPU and FEB06EPU models. (Now closed).
L2-8-2	Adjust CI node placement in event trees	Being evaluated as part of the Level 2 update.	Addressed by updated detailed Level 2 analysis included in the FEB06preEPU and FEB06EPU models. (Now closed).
L2-10-1	Reconsider COTF w/o drywell sprays	Being evaluated as part of the Level 2 update.	Addressed by updated detailed Level 2 analysis included in the FEB06preEPU and FEB06EPU models. (Now closed).

Table E.2-5 Open ‘B’ Peer Review Certification Resolution Prior to Issuance of the FEB06pre/postEPU PRA Model

F&O Identifier	Description	Prior PPL Disposition	Disposition for FEB06pre/postEPU Model
L2-15-1	Refine ATWS CF assumptions	Being evaluated as part of the Level 2 update.	Addressed by updated detailed Level 2 analysis included in the FEB06preEPU and FEB06EPU models. (Now closed).
L2-22-3	Conservative LERF Timing	Being evaluated as part of the Level 2 update.	Addressed by updated detailed Level 2 analysis included in the FEB06preEPU and FEB06EPU models. (Now closed).
MU-1	Formalize PRA Model Update Process	Although overall PRA update procedure would be beneficial, the current model is documented and controlled under PPL QA procedures.	Continue existing calculation review and approval processes. No impact on SAMA results.
QU-19-1	Formalize PRA Model Assembly Process	Although overall PRA model assembly procedure would be beneficial, the current model is documented and controlled under PPL QA procedures.	Continue existing calculation review and approval processes. No impact on SAMA results.
ST-5-2	Reconsider COTF Assumptions	Being evaluated as part of the Level 2 update.	Addressed by updated detailed Level 2 analysis included in the FEB06preEPU and FEB06EPU models. (Now closed).
ST-5-3	Refine ATWS CF assumptions	Being evaluated as part of the Level 2 update.	Addressed by updated detailed Level 2 analysis included in the FEB06preEPU and FEB06EPU models. (Now closed).
SY-4-1	Complete System Notebooks	10 remaining system notebooks to be completed.	Deferred. No significant model impacts are foreseen from the remaining low risk significant systems.
SY-8-2	Missing Pre-Initiator HEPs	Adding more pre-initiators is not expected to affect the insights presently realized.	Acceptable to proceed as is.

Table E.3-1 Estimated Population Distribution Within a 50-Mile Radius of Susquehanna, Year 2044

Sector	0-1 mile (1.00) [1]	1-2 miles (1.45) [1]	2-3 miles (1.14) [1]	3-4 miles (1.00) [1]	4-5 miles (1.05) [1]	5-10 miles (1.11) [1]	10-mile total
N	0	66	6	695	980	1582	3329
NNE	33	33	0	37	56	2669	2828
NE	0	0	130	169	147	3770	4216
ENE	0	0	0	68	48	2284	2400
E	23	79	83	142	77	1476	1880
ESE	4	0	233	118	214	1801	2370
SE	27	127	0	216	133	4348	4851
SSE	0	20	0	107	67	3329	3523
S	76	82	117	193	47	776	1292
SSW	0	231	106	107	133	867	1444
SW	0	249	148	116	1619	886	3017
WSW	0	397	59	549	4865	12722	18592
W	0	74	179	51	318	1926	2548
WNW	0	51	52	36	31	772	941
NW	0	194	208	0	159	1229	1790
NNW	0	0	0	0	139	1887	2027
Total	163	1604	1320	2604	9034	42323	57048

[1] Radial population multiplier applied to year 2000 census data to develop year 2044 estimate.

Table E.3-2 Estimated Population Distribution Within a 50-Mile Radius of Susquehanna, Year 2044

Sector	0-10 miles	10-20 miles (0.85) [1]	20-30 miles (0.98) [1]	30-40 miles (1.14) [1]	40-50 miles (1.49) [1]	50-mile total
N	3329	4004	553	7385	9802	25074
NNE	2828	14507	10048	19295	14299	60977
NE	4216	98506	77412	166222	58059	404414
ENE	2400	15422	4618	15462	28695	66596
E	1880	5968	3453	19566	74949	105816
ESE	2370	11399	5320	29261	78321	126673
SE	4851	32097	27749	44007	342273	450977
SSE	3523	6319	15523	16634	95795	137795
S	1292	13246	36295	29859	43455	124148
SSW	1444	2815	25562	15624	26349	71794
SW	3017	2195	26829	18247	22680	72968
WSW	18592	21763	16812	43275	49917	150359
W	2548	5075	5694	34197	22368	69882
WNW	941	3133	3706	20566	97495	125842
NW	1790	1867	1253	1601	1846	8357
NNW	2027	1355	880	4909	14656	23828
Total	57048	239670	261710	486111	980961	2025499

(1) Radial population multiplier applied to year 2000 census data to develop year 2044 estimate.

Table E.3-3 MACCS2 Release Categories vs. Susquehanna Release Categories

MACCS Release Categories	Susquehanna Release Categories
1-Xe/Kr	noble gases
2-I	CsI
3-Cs	CsOH
4-Te	TeO2 (Sb[1] & Te2[2] fractions are included)
5-Sr	SrO
6-Ru	MoO2 (Mo is in Ru MACCS category)
7-La	La2O3
8-Ce	CeO2 (included UO2[2] in this category)
9-Ba	BaO

(1) Sb release fractions are not added into the Te category based on the large difference in total mass in the core (97% TeO2 and 3% Sb).

(2) These release fractions are negligible and are not added into the appropriate MACCS radionuclide category

Table E.3-4a MACCS2 Base Case Mean Results (Pre-EPU)

Release Category	SSQ MAAP Run	Dose (sv)	Offsite Economic Cost ($)	Unit 1 Freq. (/yr)	Unit 1 Dose-Risk (p-rem/yr)	Unit 1 OECR ($/yr)	Unit 2 Freq. (/yr)	Unit 2 Dose-Risk (p-rem/yr)	Unit 2 OECR ($/yr)
L2-1 (H/E)	SU0516	2.63E+04	1.46E+10	1.71E-07	0.45	2,497	1.71E-07	0.45	2,497
L2-2 (H/I)	SU0500	1.51E+04	1.20E+10	1.47E-07	0.22	1,764	1.30E-07	0.20	1,560
L2-3 (H/L)	SU0514	3.10E+04	2.68E+10	1.21E-10	0.00	3	1.07E-10	0.00	3
L2-4 (M/E)	SU0515	1.64E+04	1.61E+10	0.0	0.00	0	0.0	0.00	0
L2-5 (M/I)	SU0500a	1.37E+04	8.59E+09	5.05E-07	0.69	4,338	5.14E-07	0.70	4,415
L2-6 (M/L)	SU0505	1.16E+04	5.69E+09	1.33E-07	0.15	757	1.13E-07	0.13	643
L2-7 (L/E)	SU0515a	1.61E+03	1.38E+08	7.43E-08	0.01	10	7.43E-08	0.01	10
L2-8 (L/I)	SU0511	3.02E+03	6.01E+08	4.20E-07	0.13	252	4.31E-07	0.13	259
L2-9 (L/L)	ESE0117	3.52E+03	7.95E+08	5.58E-08	0.02	44	2.28E-08	0.01	18
L2-10 (LL/I)	SU0516a	1.39E+03	4.37E+07	0.0	0.00	0	0.0	0.00	0
L2-11 (LL/L)	SU0556a	7.18E+02	1.47E+07	2.37E-08	0.00	0	2.18E-08	0.00	0
FREQUENCY WEIGHTED TOTALS				1.53E-06	1.67	9,665	1.48E-06	1.63	9,405

Table E.3-4b MACCS2 Base Case Mean Results (Post-EPU)

Release Category	SSQ MAAP Run	Dose (sv)	Offsite Economic Cost ($)	Unit 1 Freq. (/yr)	Unit 1 Dose-Risk (p-rem/yr)	Unit 1 OECR ($/yr)	Unit 2 Freq. (/yr)	Unit 2 Dose-Risk (p-rem/ yr)	Unit 2 OECR ($/yr)
L2-1 (H/E)	ESU0516	2.93E+04	1.53E+10	1.72E-07	0.50	2,632	1.72E-07	0.50	2,632
L2-2 (H/I)	ESU0500	1.57E+04	1.32E+10	1.59E-07	0.25	2,099	1.39E-07	0.22	1,835
L2-3 (H/L)	ESU0514	3.35E+04	2.82E+10	1.31E-10	0.00	4	1.17E-10	0.00	3
L2-4 (M/E)	ESU0515	1.73E+04	1.70E+10	0.0	0.00	0	0.0	0.00	0
L2-5 (M/I)	ESU0500a	1.46E+04	9.40E+09	5.38E-07	0.79	5,057	5.50E-07	0.80	5,170
L2-6 (M/L)	ESU0505	1.21E+04	6.59E+09	1.51E-07	0.18	995	1.30E-07	0.16	857
L2-7 (L/E)	ESU0515a	1.80E+03	1.69E+08	1.08E-07	0.02	18	1.08E-07	0.02	18
L2-8 (L/I)	ESE0131	3.32E+03	6.92E+08	4.87E-07	0.16	337	4.73E-07	0.16	327
L2-9 (L/L)	ESE0117	3.89E+03	9.07E+08	9.46E-09	0.00	9	3.42E-09	0.00	3
L2-10 (LL/I)	ESU0516a	1.58E+03	5.63E+07	1.56E-09	0.00	0	6.87E-10	0.00	0
L2-11 (LL/L)	ESU556	8.28E+02	1.97E+07	2.22E-08	0.00	0	2.11E-08	0.00	0
FREQUENCY WEIGHTED TOTALS				1.65E-06	1.90	11,151	1.60E-06	1.86	10,845

Table E.5-1a Unit 1 Level 1 Importance List Review (Pre-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
1CDFNEW-FLAG	1.00E+00	1.00E+30	UNIT 1 CORE DAMAGE FREQUENCY FLAG	N/A – This flag marks all sequences for the Unit 1 CDF model and does not provide any risk based insights. No SAMAs suggested.
LOOP-FLAG	1.00E+00	4.265	FLAG TO BE USED FOR ANY CONDITIONAL OR NON CONDITIONAL LOOP	The importance of the LOOP flag provides limited information about plant risk given that the LOOP category is broad and includes several different contributors. These contributors are represented by other events in this importance list that better define specific failures that can be investigated to identify means of reducing plant risk. No credible means of reducing the SSES LOOP frequency have been identified. Implementation of the Maintenance Rule is considered to address equipment reliability issues such that no measurable improvement is likely available based on enhancing maintenance practices. It may be possible to improve switchyard work planning and/or practices, but a reliable means of quantifying the impact of these types of changes is not available. No SAMAs suggested.
%LOOP-FLAG	1.00E+00	3.629	LOOP FLAG FOR INITIATING EVENT	The importance of the LOOP initiator flag provides limited information about plant risk given that the LOOP category is broad and includes several different contributors. These contributors are represented by other events in this importance list that better define specific failures that can be investigated to identify means of reducing plant risk. No credible means of reducing the SSES LOOP frequency have been identified. Implementation of the Maintenance Rule is considered to address equipment reliability issues such that no measurable improvement is likely available based on enhancing maintenance practices. It may be possible to improve switchyard work planning and/or practices, but a reliable means of quantifying the impact of these types of changes is not available. No SAMAs suggested.

Table E.5-1a Unit 1 Level 1 Importance List Review (Pre-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
RCVSEQ1TR-7-001CD	1.00E+00	1.942	SEQUENCE FLAG FOR 1TR-7-001CD	The primary contributors to these sequences are LOOP events with failure of on-site AC power to support the DC power requirements for HPI and ADS in conjunction with the failure to recover off-site power. Restoration of AC power is clearly an important priority for this sequence; however, additional onsite AC sources are not likely to provide much benefit given the large impact of common cause EDG failure. A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of this sequence by prolonging the time the plant can operate under SBO or degraded AC/DC conditions (SAMA 1). Alternatively, the ability to cross-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed (SAMA 2). The FP System is currently available as a low pressure injection source, but the need for AC power to support long term depressurization limits its benefit and flow limitations preclude its success when both units require makeup simultaneously.

Table E.5-1a Unit 1 Level 1 Importance List Review (Pre-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
EXTSEVWEATHER	2.32E-03	1.610	LOSS OF OFF SITE POWER DUE TO EXTREMELY SEVERE WEATHER	LOOP due to severe weather, as represented by this event, is grid related and no means are available to the plant to reduce its frequency. While there are many important cutsets that include this event, the largest contributors include failures of the support systems that provide DC power to HPI and ADS. For this general event, an HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Alternatively, the ability to X-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed (SAMA 2). Finally, the Fire Protection System is not credited due to flow limitations even in the very late time frames in some LOOP evolutions. Procedure changes to stagger depressurization between units will allow FPS to be used as a viable makeup source (SAMA 3).
024-N-E-DSL-P	3.29E-01	1.424	PREVENTATIVE MAINTENANCE 0.328542094	There are multiple important contributors that include this event and for clarity reasons, they are addressed by the more specific events in the importance list below. However, two general SAMAs have been identified in association with this event. A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Alternatively, the ability to cross-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed (SAMA 2).

Table E.5-1a Unit 1 Level 1 Importance List Review (Pre-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
002-N-N-BMS-FLAG	1.00E+00	1.329		This flag is used to identify operator errors related to aligning the station portable diesel generator, including: 002-N-N-BMS-O, Z-BMAX-EDG-O, and Z-BMS-IACIG-O. The events 002-N-N-BMS-O and Z-BMAX-EDG-O are specifically addressed in this table. The event Z-BMS-IACIG-O has a RRW value of 1.001 and does not require further review.
GRIDCENTERED	1.38E-02	1.287	LOSS OF OFF SITE POWER DUE TO GRID FAILURE	A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Alternatively, the ability to cross-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed (SAMA 2).
024DGS0G501B	2.40E-02	1.270	DIESEL GENERATOR 'B' 0G501B D.G. FAIL WITHIN THE FIRST HOUR	A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Alternatively, the ability to cross-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed (SAMA 2).
024DGS0G501A	2.40E-02	1.254	DIESEL GENERATOR 'A' 0G501A DIESEL GENERATOR FAILS TO START	A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Alternatively, the ability to cross-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed (SAMA 2).

Table E.5-1a Unit 1 Level 1 Importance List Review (Pre-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
RCVLOOPEW5.6	9.78E-01	1.224	PROBABILITY OF NONRECOVERY FROM A EXTREME WEATHER RELATED LOOP IN 5.6 HOURS	A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Alternatively, the ability to cross-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed (SAMA 2).
RCVLOOPGR5.6	1.38E-01	1.223	PROBABILITY OF NONRECOVERY FROM A GRID RELATED LOOP IN 5.6 HOURS	A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Alternatively, the ability to cross-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed (SAMA 2).
RCVSEQ1TR-1-005CD	1.00E+00	1.205	SEQUENCE FLAG FOR 1TR-1-005CD	The importance of this sequence is tied to LOOP with multiple diesel failures and SPC not available. A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Currently, the Fire Protection System is not credited due to flow limitations even in the very late time frames in some LOOP evolutions. Procedure changes to stagger depressurization between units will allow FPS to be used as a viable makeup source (SAMA 3).

Table E.5-1a Unit 1 Level 1 Importance List Review (Pre-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
RCVSBOWEDG	1.00E+00	1.188	STATION BLACKOUT WITH E DG	A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Currently, the Fire Protection System is not credited due to flow limitations even in the very late time frames in some LOOP evolutions. Procedure changes to stagger depressurization between units will allow FPS to be used as a viable makeup source (SAMA 3). Battery failures that result in the loss of DC for HPI and ADS are also minor contributors. These cases could be addressed by providing battery chargers that can provide 100% of the load without the batteries (SAMA 4).
RCVLOOPEW30.6	7.89E-01	1.182	PROBABILITY OF NONRECOVERY FROM A EXTREME WEATHER RELATED LOOP IN 30.6 HOURS	LOOP due to severe weather, as represented by this event, is grid related and no means are available to the plant to reduce its frequency. A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolong the time the plant can operate without offsite AC power (SAMA 1). Currently, the Fire Protection System is not credited due to flow limitations even in the very late time frames in some LOOP evolutions. Procedure changes to stagger depressurization between units will allow FPS to be used as a viable makeup source (SAMA 3).

Table E.5-1a Unit 1 Level 1 Importance List Review (Pre-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
Z-BMAX-EDG-O	1.63E-02	1.170	DEPENDENT HEP FOR BLUE MAX AND E DG	A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Permanently installing the existing 480V AC generator and add hardware to allow it to automatically align to supply power to the required 480V AC buses directly addresses the importance of the HEP (SAMA 5). In addition, cutset review shows that major contributors including the HEP are cases where the "C" and "D" EDGs are typically available. The ability to cross-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed (SAMA 2).
024DGR0G501B	1.57E-02	1.158	DIESEL GENERATOR 'B' 0G501B D.G. FAIL AFTER FIRST HOUR FAILS TO OPERATE	A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Alternatively, the ability to cross-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed (SAMA 2).
024DGR0G501A	1.57E-02	1.149	DIESEL GENERATOR 'A' 0G501A D.G. FAIL AFTER FIRST HOUR FAILS TO OPERATE	A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Alternatively, the ability to cross-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed (SAMA 2).

Table E.5-1a Unit 1 Level 1 Importance List Review (Pre-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
002DGS0G503	2.40E-02	1.132	STATION PORTABLE DIESEL GEN - BLUE MAX 0G503 DIESEL GENERATOR FAILS TO START	A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Providing an additional portable 480V AC generator could also potentially provide benefit (SAMA 6). In addition, cutset review shows that major contributors including the 0G503 failure are cases where the "C" and "D" EDGs are typically available. The ability to cross-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed (SAMA 2).
002-N-N-BMS-O	2.93E-02	1.124	OPERATOR ERROR FOR ALIGNING THE STATION PORTABLE DIESEL GENERATOR	A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Permanently install the existing 480V AC generator and add hardware to allow it to automatically align to supply power to the required 480V AC buses (SAMA 5).
151-N-N-F005-O	1.00E+00	1.104	OPERATOR FAILS TO OPEN HV152F005A/B MANUALLY	This action is important when HPI fails and Core Spray injection is required for inventory makeup. In these cases, loss of off-site AC power and specific EDG failures result in the loss of "D" RHR due to the Division I ESW cooling dependence for lube oil cooling (ESW pumps A and C cool RHR pump D). The core spray injection valve cannot be opened remotely because it is powered by the "B" EDG, which has failed. A potential means of mitigating these types of accidents is to change RHR pump cooling such that the "B" and "D" ESW pumps provide cooling flow to the "B" and "D" RHR pumps (SAMA 7). This issue could also be addressed through the use of an AC cross-tie (SAMA 2).
RCVSEQ1TR-8-023CD	1.00E+00	1.104	SEQUENCE FLAG FOR 1TR-8-023CD	About 83 percent of this sequence is linked to event 151-N-N-F005-O above and the same SAMAs are considered to be applicable.

Table E.5-1a Unit 1 Level 1 Importance List Review (Pre-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
%1NONISO	8.94E-01	1.087	TRIP W/O MSIV CLOSURE	About 50 percent of the contribution from this initiator is related to mechanical scram failure ATWS scenarios with subsequent operator failure to run back Feedwater and initiate SLC. Due to operator dependence issues, credit for any enhancements that would require further operator actions would be difficult to justify. Installation of logic to automate Feedwater runback may be a means of reducing the risk of ATWS sequences (SAMA 8). Additional major contributors include sequences RCVSEQ1TR-7-001CD (31%) and RCVSEQ1TR-2-001CD (12%). The RCVSEQ1TR-7-001CD sequence is a conditional LOOP case with subsequent SBO or degraded AC/DC conditions. This sequence is addressed by SAMAs 1, 5, and 6. No SAMAs are suggested for the remaining contributors.
002DGR0G503	1.57E-02	1.082	STATION PORTABLE DIESEL GEN - BLUE MAX 0G503 DIESEL GENERATOR FAILS TO OPERATE	A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Providing an additional portable 480V AC generator could also potentially provide benefit (SAMA 6). In addition, cutset review shows that major contributors including the 0G503 failure are cases where the "C" and "D" EDGs are typically available. The ability to cross-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed (SAMA 2).

Table E.5-1a Unit 1 Level 1 Importance List Review (Pre-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
024-N-N-DGE-O	1.15E-01	1.078	OPERATOR FAILS TO ALIGN	Failure to align the "E" DG is important for SBO sequences. Due to human dependence issues, further enhancements related to alternate power alignment requiring operator action would provide limited benefit. For this general event, an HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Alternatively, the ability to X-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed (SAMA 2). Finally, the Fire Protection System is not credited due to flow limitations even in the very late time frames in some LOOP evolutions. Procedure changes to stagger depressurization between units will allow FPS to be used as a viable makeup source (SAMA 3).
SEVEREWEATHER	2.87E-03	1.077	LOSS OF OFF SITE POWER DUE TO SEVERE WEATHER	LOOP due to severe weather, as represented by this event, is grid related and no means are available to the plant to reduce its frequency. A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolong the time the plant can operate without offsite AC power (SAMA 1). In addition, the contributing sequences including EDG A, B, and E failures could be addressed through the use of an AC cross-tie (SAMA 2).

Table E.5-1a Unit 1 Level 1 Importance List Review (Pre-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
RCVSEQ1TR-2-001CD	1.00E+00	1.069	SEQUENCE FLAG FOR 1TR-2-001CD	These sequences include failures of high pressure injection systems and subsequent failures of depressurization. The primary contributors to these sequences are DC failures that fail both functions. Battery failure and DC bus failures preclude credit from the station portable diesel generator. SAMA 1 could provide a means of mitigating these accidents assuming that the pump could be operated without DC power. SAMA 4 can be used to mitigate battery failures by providing all DC power from the "100%" chargers. Failures of the DC buses or panels could be mitigated by providing direct feeds from the chargers to critical loads (SAMA 9). In addition, this sequence contains may cutsets that include event 125-N-N-FXTIACIGO-FLAG, which is addressed separately in the list.
125-N-N-FXTIACIGO-FLAG	1.00E+00	1.066	FLAG FOR IA TO CIG OPERATOR ACTION FAILURE	This flag is linked to the operator action to cross-tie IA to CIG. The importance of this action is primarily based on sequences in which loss of DC power fails HPI and depressurization capability through power and air dependencies. In order to recover to a safe, stable endstate from these sequences, injection and heat removal must be restored. Installing a pressure control valve between the IA and CIG systems would automate the cross-tie and remove the primary dependence on human action (SAMA 10).
CCFDG4DGS_ALL	7.41E-05	1.065	CCF 4 OF 4 DGs FAIL TO START AND RUN (8)	A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Currently, the Fire Protection System is not credited due to flow limitations even in the very late time frames in some LOOP evolutions. Procedure changes to stagger depressurization between units will allow FPS to be used as a viable makeup source (SAMA 3).

Table E.5-1a Unit 1 Level 1 Importance List Review (Pre-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
CCFDG3DGS_123	9.39E-05	1.060	CCF 3 OF 4 EDGs (A, B, C) TO START AND RUN (8)	A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Currently, the Fire Protection System is not credited due to flow limitations even in the very late time frames in some LOOP evolutions. Procedure changes to stagger depressurization between units will allow FPS to be used as a viable makeup source (SAMA 3). Alternatively, the ability to cross-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed (SAMA 2). In addition, SAMA 7 addresses the sequences in which RHR the "C" or "D" RHR pump cooling function is failed by the cross-divisionalized ESW cooling.
CCFDG3DGS_124	9.39E-05	1.060	CCF 3 OF 4 EDGs (A, B, D) TO START AND RUN (8)	A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Currently, the Fire Protection System is not credited due to flow limitations even in the very late time frames in some LOOP evolutions. Procedure changes to stagger depressurization between units will allow FPS to be used as a viable makeup source (SAMA 3). Alternatively, the ability to cross-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed (SAMA 2). In addition, SAMA 7 addresses the sequences in which RHR the "C" or "D" RHR pump cooling function is failed by the cross-divisionalized ESW cooling.

Table E.5-1a Unit 1 Level 1 Importance List Review (Pre-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
%1ISLOCA_RHR_S	1.02E-07	1.058	INTERFACING SYSTEM LOCA FOR RHR PUMP SUCTION (F008-F009) BREAK	A high pressure core spray pump that could use an inexhaustible, high flow, cold suction source would reduce the risk of ISLOCAs by providing an alternate means of injection and precluding pump failures due to room flooding provided the pump is not located in the lower floors of the reactor building (SAMA 11). The engine driven HPI pump from SAMA 1 is not sized to provide the required makeup flow and is not considered to be capable of mitigating an ISLOCA.
RCVSEQ1IS-2-001CD	1.00E+00	1.058	SEQUENCE FLAG FOR 1IS-2-001CD	This sequence is directly tied to %1ISLOCA_RHR_S and is addressed by SAMA 11.
125-N-N-FXTIACIG-O	2.20E-01	1.058	OPERATOR FAILS TO OPEN IA-CIG CROSSTIE VALVES	The importance of this action is primarily based on sequences in which loss of DC power fails HPI and depressurization capability through power and air dependencies. In order to recover to a safe, stable endstate from these sequences, injection and heat removal must be restored. Installing a pressure control valve between the IA and CIG systems would automate the cross-tie and remove the primary dependence on human action (SAMA 10).
024-II-B-DSL-P	7.13E-03	1.054	PREVENTATIVE MAINTENANCE 7.13E-03	A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Currently, the Fire Protection System is not credited due to flow limitations even in the very late time frames in some LOOP evolutions. Procedure changes to stagger depressurization between units will allow FPS to be used as a viable makeup source (SAMA 3). Alternatively, the ability to cross-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed (SAMA 2).

Table E.5-1a Unit 1 Level 1 Importance List Review (Pre-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
RCV1ATWS	1.00E+00	1.054		Over 57 percent of the contributors with this flag are related to mechanical scram failure ATWS scenarios with subsequent operator failure to run back Feedwater and initiate SLC. Due to dependence issues, credit for any enhancements that would require further operator actions would be difficult to justify. Installation of logic to automate Feedwater runback may be a means of reducing the risk of ATWS sequences (SAMA 8). The remainder of the contributions are spread among the following types of initiators: - SLC initiation/level control operator errors (29%) - Other failures (14%) Auto SLC initiation could be installed to address the SLC initiation failures, the cost of which is likely comparable to auto Feedwater runback. No changes to the ADS/inhibit logic are suggested. As Feedwater runback failures are the largest contributors, the SAMA analysis focuses on that issue. No SAMAs are suggested for the remaining contributors.

Table E.5-1a Unit 1 Level 1 Importance List Review (Pre-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
CCFMEATWS-PE	2.10E-06	1.054	CCF RPS MECHANICAL SCRAM FAILURE - UNIT 1	Over 57 percent of the contributors with mechanical scram failure ATWS scenarios also contain subsequent operator failure to run back Feedwater. Due to the limited time for response and dependence issues, credit for any enhancements that would require further operator actions would be difficult to justify. Installation of logic to automate Feedwater runback may be a means of reducing the risk of ATWS sequences (SAMA 8). The remainder of the contributions are spread among the following types of initiators: - SLC initiation/level control operator errors (29%) - Other failures (14%) Auto SLC initiation could be installed to address the SLC initiation failures, the cost of which is likely comparable to auto Feedwater runback. No changes to the ADS/inhibit logic are suggested. As Feedwater runback failures are the largest contributors, the SAMA analysis focuses on that issue. No SAMAs are suggested for the remaining contributors.
024-I-A-DSL-P	7.13E-03	1.052	PREVENTATIVE MAINTENANCE 7.13E-03	A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Currently, the Fire Protection System is not credited due to flow limitations even in the very late time frames in some LOOP evolutions. Procedure changes to stagger depressurization between units will allow FPS to be used as a viable makeup source (SAMA 3). Alternatively, the ability to cross-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed (SAMA 2).

Table E.5-1a Unit 1 Level 1 Importance List Review (Pre-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
CCFDE3DGS_5	4.45E-01	1.051	CCF DG E W/ FAILURE OF 3 OF 4 OTHER DGS (11)	A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Currently, the Fire Protection System is not credited due to flow limitations even in the very late time frames in some LOOP evolutions. Procedure changes to stagger depressurization between units will allow FPS to be used as a viable makeup source (SAMA 3). Alternatively, the ability to cross-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed (SAMA 2). In addition, SAMA X addresses the sequences in which RHR the "C" or "D" RHR pump cooling function is failed by the cross-divisionalized ESW cooling.
RCVLOOPSW5.6	2.04E-01	1.050	PROBABILITY OF NONRECOVERY FROM A SEVERE WEATHER RELATED LOOP IN 5.6 HOURS	A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Alternatively, the ability to cross-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed (SAMA 2).

Table E.5-1a Unit 1 Level 1 Importance List Review (Pre-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
SWITCHYARDCENTERED	7.87E-03	1.049	LOOP DUE TO SWITCHYARD CENTERED FAILURES	The LOOP frequency due to switchyard centered failures could theoretically be reduced through preventative strategies or recovery actions; however, given the existence of maintenance review practices and operator training programs, no reliable means of measuring the improvement from any such enhancements has been identified. While the LOOP frequency is not considered to be easily influenced, there are other recovery mitigative options. A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Alternatively, the ability to cross-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed (SAMA 2). Contributors that include battery failures could be mitigated by installing 100% battery chargers and ensuring that the DC system can operate without the batteries (SAMA 4).
CCFDG2DGS_12	1.85E-04	1.048	CCF 2 OF 4 EDGs (A, B) TO START AND RUN (8)	A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Alternatively, the ability to cross-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed (SAMA 2).

Table E.5-1a Unit 1 Level 1 Importance List Review (Pre-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
RCVSPC_INJ_L-O	6.00E-04	1.046	OPERATOR FAILS TO REPOSITION VALVE MANUALLY	This event represents operator failure to perform local, manual action to open valves to recover DHR in long term Class II accidents. In these scenarios, onsite AC power is available through the "E" diesel or another diesel, but valve failures prevent successful operation of DHR other than containment vent. Due to human dependence issues, further operator actions related to DHR recovery will offer limited benefit. While containment venting is a successful heat removal option, its use fails the initially operating injection system. For the relevant scenarios, late containment injection systems also fail. Currently, the Fire Protection System is not credited due to flow limitations even in the very late time frames in some LOOP evolutions. Procedure changes to stagger depressurization between units will allow FPS to be used as a viable makeup source (SAMA 3).
%1LODCBUS_622	1.50E-03	1.045	LOSS OF 1D622	The importance of this event is primarily based on sequences in which loss of DC power fails HPI and depressurization capability through direct and indirect dependencies. In order to recover to a safe, stable endstate from these sequences, injection and heat removal must be restored. Installing a pressure control valve between the IA and CIG systems would automate the cross-tie and remove the primary dependence on human action (SAMA 10).
RCVLOOPGR5.4	1.46E-01	1.044	PROBABILITY OF NONRECOVERY FROM A GRID RELATED LOOP IN 5.4 HOURS	A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Alternatively, the ability to cross-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed (SAMA 2). This initiator also includes the same sequences as for event 151-N-N-F005-O, which is addressed by SAMA 7.

Table E.5-1a Unit 1 Level 1 Importance List Review (Pre-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
024DGS0G501D	2.40E-02	1.039	DIESEL GENERATOR 'D' 0G501D D.G. FAIL AFTER FIRST HOUR FAILS TO START	A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Currently, the Fire Protection System is not credited due to flow limitations even in the very late time frames in some LOOP evolutions. Procedure changes to stagger depressurization between units will allow FPS to be used as a viable makeup source (SAMA 3). In addition, SAMA 7 addresses the sequences in which RHR the "C" or "D" RHR pump cooling function is failed by the cross-divisionalized ESW cooling.
COND-LOOP-TRANS	2.40E-03	1.039	CONDITIONAL LOOP PROBABILITY GIVEN TRANSIENT	A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Alternatively, the ability to cross-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed (SAMA 2). Contributors that include battery failures could be mitigated by installing 100% battery chargers and ensuring that the DC system can operate without the batteries (SAMA 4).
102BCR1D613	1.68E-04	1.038	125VDC BATTERY CHARGER 1D613 BATTERY CHARGER FAILS TO OPERATE	Failure of this battery charger in conjunction with the failure of 125V DC bus 622 results in the loss of both divisions of 125V DC power in the long term (after battery depletion). Providing the ability to power required loads directly from the available DC charger would allow for recovery on one DC division's essential equipment (SAMA 9). In addition, a large majority of the cutsets including this event include the failure of the IA to CIG cross tie (125-N-N-FXTIACIG-O). These contributors are addressed by SAMA 10.

Table E.5-1a Unit 1 Level 1 Importance List Review (Pre-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
RCVLOOPEW5.4	9.79E-01	1.037	PROBABILITY OF NONRECOVERY FROM A EXTREME WEATHER RELATED LOOP IN 5.4 HOURS	The cutsets including this recovery event are dominated by cases where either the "C" or "D" EDG is the only source of AC power and the RHR pumps are failed due to the lack of ESW cooling. SAMA 7 addresses these conditions.
024DGS0G501C	2.40E-02	1.036	DIESEL GENERATOR 'C' 0G501C D.G. FAIL AFTER FIRST HOUR FAILS TO START	A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Currently, the Fire Protection System is not credited due to flow limitations even in the very late time frames in some LOOP evolutions. Procedure changes to stagger depressurization between units will allow FPS to be used as a viable makeup source (SAMA 3). In addition, SAMA 7 addresses the sequences in which RHR the "C" or "D" RHR pump cooling function is failed by the cross-divisionalized ESW cooling.
102BTS1D610	5.00E-04	1.035	125VDC BATTERY BANK A FAILS TO START	The contributors that include battery failures could be mitigated by installing 100% battery chargers and ensuring that the DC system can operate without the batteries (SAMA 4).
150PTS1P203	2.00E-02	1.033	1P203 TURBINE-DRIVEN PUMP STAND-BY FAILS TO START	Over 93% of the cutsets including this event are related to the failure of RHR due to the non-divisionalized ESW cooling alignment. This is addressed by SAMA 7.
145-N-N-REDFW-O	1.00E+00	1.030	OPERATOR FAILS TO RUN BACK FEEDWATER IN 3.5 MINUTES FOLLOWING AN ATWS .15	Installation of logic to automate Feedwater runback is a potential means of reducing the risk of ATWS sequences (SAMA 8).
145-N-N-REDFWO-FLAG	1.00E+00	1.030	FLAG FOR OPERATOR FAILS TO RUN BACK FEEDWATER IN 3.5 MINUTES FOLLOWING AN ATWS	Installation of logic to automate Feedwater runback is a potential means of reducing the risk of ATWS sequences (SAMA 8).

Table E.5-1a Unit 1 Level 1 Importance List Review (Pre-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
CCFDE2DGS_5	3.84E-01	1.026	CCF DG E W/ FAILURE OF 2 OF 4 OTHER DGS (11)	A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Alternatively, the ability to cross-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed (SAMA 2).
1CLPIA-O	1.60E-01	1.025	OPERATOR FAILS TO CONTROL LOW PRESSURE INJECTION DURING ATWS	Over 70% of the cutset contributions including this event include failures of 145-N-N-REDFW-O. As CLPIA-O is also a level/power control event, there is a dependence between the actions. Automating the Feedwater runback function would remove this dependence (SAMA 8).
RCVSEQ1TR-3-038CD	1.00E+00	1.025	SEQUENCE FLAG FOR 1TR-3-038CD	about 70% of the cutsets including this event are related to the failure of RHR due to the non-divisionalized ESW cooling alignment. This is addressed by SAMA 7.
RCVLOOPSY5.6	3.85E-02	1.025	PROBABILITY OF NONRECOVERY FROM A SWITCHYARD RELATED LOOP IN 5.6 HOURS	A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Alternatively, the ability to cross-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed (SAMA 2).

Table E.5-1a Unit 1 Level 1 Importance List Review (Pre-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
%1LOCA-SM-LQD	2.32E-03	1.024	SMALL LIQUID LINE BREAK LOCA	There are several different types of contributors to the CDF give this initiating event. These are either addressed by the SSES SAMAs identified for other contributors or have contributions below the RRW review cutoff for this analysis: • 30.0%: ESW failures result in long term loss of HPI and LPI due to lack of SPC and equipment cooling. After initial success of HPI and subsequent depressurization, SAMA 1 would be capable of providing core cooling. • 4.6%: Consequential LOOP events result in conditions similar to the ESW failures and are addressed by SAMA 1. • 27.1%: Vapor suppression failures are addressed by SAMA 13. • 38.3%: The remaining contributors represent an RRW of only 1.009, which is well below the review cutoff of 1.02 for the SAMA list development and no SAMAs are required to address this contribution.

Table E.5-1a Unit 1 Level 1 Importance List Review (Pre-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
024DGR0G501D	1.57E-02	1.023	DIESEL GENERATOR 'D' 0G501D D.G. FAIL AFTER FIRST HOUR FAILS TO OPERATE	A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Currently, the Fire Protection System is not credited due to flow limitations even in the very late time frames in some LOOP evolutions. Procedure changes to stagger depressurization between units will allow FPS to be used as a viable makeup source (SAMA 3). In addition, SAMA 7 addresses the sequences in which RHR the "C" or "D" RHR pump cooling function is failed by the cross-divisionalized ESW cooling. Finally, the ability to cross-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed (SAMA 2).
1RWST-FLAG	1.00E+00	1.023	FLAG FOR OPERATOR FAILING TO CROSSTIE RWST TO CST	The cutsets including this flag require replenishment of the CST for extended high pressure makeup success. These contributors could potentially be reduced by automating the cross-tie between the RWST and the CST, but this would introduce the potential to drain both the CST and the RWST in the event of a CST rupture or pumpdown. This is not considered to be a desirable option. Another possibility is providing automated makeup from the Fire Protection system. However, the dominate contributors including 1RWST-FLAG are evolutions that could be mitigated by divisionalizing the ESW cooling to the RHR pumps (SAMA 7). This is considered to be the most appropriate approach for SSES.
%1ISO	1.36E-01	1.021	INADVERTENT ISOLATION - MSIV	There are no dominant contributors for this initiating event and no viable method has been identified that could be implemented to reduce the initiating event frequency. Some of the contribution could be eliminated by providing a means of providing power directly to critical loads given DC bus or distribution panel failures (SAMA 9).

Table E.5-1a Unit 1 Level 1 Importance List Review (Pre-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
024DGR0G501C	1.57E-02	1.021	DIESEL GENERATOR 'C' 0G501C D.G. FAIL AFTER FIRST HOUR FAILS TO OPERATE	A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Currently, the Fire Protection System is not credited due to flow limitations even in the very late time frames in some LOOP evolutions. Procedure changes to stagger depressurization between units will allow FPS to be used as a viable makeup source (SAMA 3). In addition, SAMA 7 addresses the sequences in which RHR the "C" or "D" RHR pump cooling function is failed by the cross-divisionalized ESW cooling. Finally, the ability to cross-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed (SAMA 2).
016-N-N-VENT-O	9.90E-03	1.020	OPERATOR FAILS TO OPEN DOORS AND DAMPERS IN ESW PUMP HOUSE 9.9E-3	This event is important due to its role in SBO sequences in which the station portable diesel generator is available. A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Currently, the Fire Protection System is not credited due to flow limitations even in the very late time frames in some LOOP evolutions. Procedure changes to stagger depressurization between units will allow FPS to be used as a viable makeup source (SAMA 3).

Table E.5-1a Unit 1 Level 1 Importance List Review (Pre-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
116-F073/075-O	1.00E+00	1.020	OPERATOR FAILS TO OPEN HV112F073A/B OR HV112F075A/B MANUALLY	This event is important due to its role in SBO sequences in which the station portable diesel generator is available. A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Currently, the Fire Protection System is not credited due to flow limitations even in the very late time frames in some LOOP evolutions. Procedure changes to stagger depressurization between units will allow FPS to be used as a viable makeup source (SAMA 3).

Table E.5-1b Unit 2 Level 1 Importance List Review (Pre-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
2CDFNEW-FLAG	1.00E+00	1.00E+30	UNIT 2 CORE DAMAGE FREQUENCY FLAG	Addressed in the Unit 1 Level 1 Importance List Review
LOOP-FLAG	1.00E+00	4.252	FLAG TO BE USED FOR ANY CONDITIONAL OR NON CONDITIONAL LOOP	Addressed in the Unit 1 Level 1 Importance List Review
%LOOP-FLAG	1.00E+00	3.617	LOOP FLAG FOR INITIATING EVENT	Addressed in the Unit 1 Level 1 Importance List Review
RCVSEQ2TR-7-001CD	1.00E+00	1.971	SEQUENCE FLAG FOR 2TR-7-001CD	Addressed in the Unit 1 Level 1 Importance List Review
EXTSEVWEATHER	2.32E-03	1.621	LOSS OF OFF SITE POWER DUE TO EXTREMELY SEVERE WEATHER	Addressed in the Unit 1 Level 1 Importance List Review
024-N-E-DSL-P	3.29E-01	1.438	PREVENTATIVE MAINTENANCE 0.328542094	Addressed in the Unit 1 Level 1 Importance List Review
002-N-N-BMS-FLAG	1.00E+00	1.338		Addressed in the Unit 1 Level 1 Importance List Review
GRIDCENTERED	1.38E-02	1.280	LOSS OF OFF SITE POWER DUE TO GRID FAILURE	Addressed in the Unit 1 Level 1 Importance List Review
024DGS0G501B	2.40E-02	1.262	DIESEL GENERATOR 'B' 0G501B D.G. FAIL WITHIN THE FIRST HOUR	Addressed in the Unit 1 Level 1 Importance List Review
024DGS0G501A	2.40E-02	1.262	DIESEL GENERATOR 'A' 0G501A DIESEL GENERATOR FAILS TO START	Addressed in the Unit 1 Level 1 Importance List Review

Table E.5-1b Unit 2 Level 1 Importance List Review (Pre-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
RCVLOOPEW5.6	9.78E-01	1.229	PROBABILITY OF NONRECOVERY FROM A EXTREME WEATHER RELATED LOOP IN 5.6 HOURS	Addressed in the Unit 1 Level 1 Importance List Review
RCVLOOPGR5.6	1.38E-01	1.228	PROBABILITY OF NONRECOVERY FROM A GRID RELATED LOOP IN 5.6 HOURS	Addressed in the Unit 1 Level 1 Importance List Review
RCVSEQ2TR-1-005CD	1.00E+00	1.216	SEQUENCE FLAG FOR 2TR-1-005CD	Addressed in the Unit 1 Level 1 Importance List Review
RCVLOOPEW30.6	7.89E-01	1.193	PROBABILITY OF NONRECOVERY FROM A EXTREME WEATHER RELATED LOOP IN 30.6 HOURS	Addressed in the Unit 1 Level 1 Importance List Review
Z-BMAX-EDG-O	1.63E-02	1.176	DEPENDENT HEP FOR BLUE MAX AND E DG	Addressed in the Unit 1 Level 1 Importance List Review
024DGR0G501B	1.57E-02	1.154	DIESEL GENERATOR 'B' 0G501B D.G. FAIL AFTER FIRST HOUR FAILS TO OPERATE	Addressed in the Unit 1 Level 1 Importance List Review
024DGR0G501A	1.57E-02	1.154	DIESEL GENERATOR 'A' 0G501A D.G. FAIL AFTER FIRST HOUR FAILS TO OPERATE	Addressed in the Unit 1 Level 1 Importance List Review

Table E.5-1b Unit 2 Level 1 Importance List Review (Pre-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
002DGS0G503	2.40E-02	1.133	STATION PORTABLE DIESEL GEN - BLUE MAX 0G503 DIESEL GENERATOR FAILS TO START	Addressed in the Unit 1 Level 1 Importance List Review
RCVSBOWEDG	1.00E+00	1.130	STATION BLACKOUT WITH E DG	Addressed in the Unit 1 Level 1 Importance List Review
002-N-N-BMS-O	2.93E-02	1.125	OPERATOR ERROR FOR ALIGNING THE STATION PORTABLE DIESEL GENERATOR	Addressed in the Unit 1 Level 1 Importance List Review
251-N-N-F005-O	1.00E+00	1.099	OPERATOR FAILS TO OPEN HV252F005A/B MANUALLY	Addressed in the Unit 1 Level 1 Importance List Review
%2NONISO	8.94E-01	1.088	UNIT 2 TRIP W/O MSIV CLOSURE 2	Addressed in the Unit 1 Level 1 Importance List Review
RCVSEQ2TR-8-023CD	1.00E+00	1.085	SEQUENCE FLAG FOR 2TR-8-023CD	Addressed in the Unit 1 Level 1 Importance List Review
002DGR0G503	1.57E-02	1.083	STATION PORTABLE DIESEL GEN - BLUE MAX 0G503 DIESEL GENERATOR FAILS TO OPERATE	Addressed in the Unit 1 Level 1 Importance List Review
024-N-N-DGE-O	1.15E-01	1.080	OPERATOR FAILS TO ALIGN	Addressed in the Unit 1 Level 1 Importance List Review
SEVEREWEATHER	2.87E-03	1.077	LOSS OF OFF SITE POWER DUE TO SEVERE WEATHER	Addressed in the Unit 1 Level 1 Importance List Review

Table E.5-1b Unit 2 Level 1 Importance List Review (Pre-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
RCVSEQ2TR-2-001CD	1.00E+00	1.071	SEQUENCE FLAG FOR 2TR-2-001CD	Addressed in the Unit 1 Level 1 Importance List Review
CCFDG4DGS_ALL	7.41E-05	1.067	CCF 4 OF 4 DGs FAIL TO START AND RUN (8)	Addressed in the Unit 1 Level 1 Importance List Review
225-N-N-FXTIACIGO-FLAG	1.00E+00	1.066	FLAG FOR IA TO CIG OPERATOR ACTION FAILURE	Addressed in the Unit 1 Level 1 Importance List Review
CCFDG3DGS_124	9.39E-05	1.061	CCF 3 OF 4 EDGs (A, B, D) TO START AND RUN (8)	Addressed in the Unit 1 Level 1 Importance List Review
CCFDG3DGS_123	9.39E-05	1.061	CCF 3 OF 4 EDGs (A, B, C) TO START AND RUN (8)	Addressed in the Unit 1 Level 1 Importance List Review
%2ISLOCA_RHR_S	1.02E-07	1.059	INTERFACING SYSTEM LOCA FOR RHR PUMP SUCTION (F008-F009) BREAK	Addressed in the Unit 1 Level 1 Importance List Review
RCVSEQ2IS-2-001CD	1.00E+00	1.059	SEQUENCE FLAG FOR 2IS-2-001CD	Addressed in the Unit 1 Level 1 Importance List Review
225-N-N-FXTIACIG-O	2.20E-01	1.059	OPERATOR FAILS TO OPEN IA-CIG CROSSTIE VALVES	Addressed in the Unit 1 Level 1 Importance List Review
RCV2ATWS	1.00E+00	1.055		Addressed in the Unit 1 Level 1 Importance List Review
CCFMEATWS-PE-UNIT2	2.10E-06	1.055	CCF RPS MECHANICAL SCRAM FAILURE - UNIT 2	Addressed in the Unit 1 Level 1 Importance List Review
024-I-A-DSL-P	7.13E-03	1.053	PREVENTATIVE MAINTENANCE 7.13E-03	Addressed in the Unit 1 Level 1 Importance List Review

Table E.5-1b Unit 2 Level 1 Importance List Review (Pre-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
024-II-B-DSL-P	7.13E-03	1.053	PREVENTATIVE MAINTENANCE 7.13E-03	Addressed in the Unit 1 Level 1 Importance List Review
CCFDE3DGS_5	4.45E-01	1.052	CCF DG E W/ FAILURE OF 3 OF 4 OTHER DGS (11)	Addressed in the Unit 1 Level 1 Importance List Review
RCVLOOPSW5.6	2.04E-01	1.051	PROBABILITY OF NONRECOVERY FROM A SEVERE WEATHER RELATED LOOP IN 5.6 HOURS	Addressed in the Unit 1 Level 1 Importance List Review
CCFDG2DGS_12	1.85E-04	1.049	CCF 2 OF 4 EDGs (A, B) TO START AND RUN (8)	Addressed in the Unit 1 Level 1 Importance List Review
SWITCHYARDCENTERED	7.87E-03	1.048	LOOP DUE TO SWITCHYARD CENTERED FAILURES	Addressed in the Unit 1 Level 1 Importance List Review
%2LODCBUS_622	1.50E-03	1.046	LOSS OF 2D622	Addressed in the Unit 1 Level 1 Importance List Review
RCVSPC_INJ_L-O	6.00E-04	1.046	OPERATOR FAILS TO REPOSITION VALVE MANUALLY	Addressed in the Unit 1 Level 1 Importance List Review
COND-LOOP-TRANS	2.40E-03	1.039	CONDITIONAL LOOP PROBABILITY GIVEN TRANSIENT	Addressed in the Unit 1 Level 1 Importance List Review
024DGS0G501D	2.40E-02	1.038	DIESEL GENERATOR 'D' 0G501D D.G. FAIL AFTER FIRST HOUR FAILS TO START	Addressed in the Unit 1 Level 1 Importance List Review

Table E.5-1b Unit 2 Level 1 Importance List Review (Pre-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
RCVLOOPGR5.4	1.46E-01	1.037	PROBABILITY OF NONRECOVERY FROM A GRID RELATED LOOP IN 5.4 HOURS	Addressed in the Unit 1 Level 1 Importance List Review
202BCR2D613	1.68E-04	1.037	125VDC BATTERY CHARGER 2D613 BATTERY CHARGER FAILS TO OPERATE	Addressed in the Unit 1 Level 1 Importance List Review
024DGS0G501C	2.40E-02	1.033	DIESEL GENERATOR 'C' 0G501C D.G. FAIL AFTER FIRST HOUR FAILS TO START	Addressed in the Unit 1 Level 1 Importance List Review
250PTS2P203	2.00E-02	1.033	2P203 TURBINE-DRIVEN PUMP STAND-BY FAILS TO START	Addressed in the Unit 1 Level 1 Importance List Review
245-N-N-REDFW-O	1.00E+00	1.031	OPERATOR FAILS TO RUN BACK FEEDWATER IN 3.5 MINUTES FOLLOWING AN ATWS	Addressed in the Unit 1 Level 1 Importance List Review
245-N-N-REDFWO-FLAG	1.00E+00	1.031	FLAG FOR OPERATOR FAILS TO RUN BACK FEEDWATER IN 3.5 MINUTES FOLLOWING AN ATWS	Addressed in the Unit 1 Level 1 Importance List Review
RCVLOOPEW5.4	9.79E-01	1.031	PROBABILITY OF NONRECOVERY FROM A EXTREME WEATHER RELATED LOOP IN 5.4 HOURS	Addressed in the Unit 1 Level 1 Importance List Review
CCFDE2DGS_5	3.84E-01	1.027	CCF DG E W/ FAILURE OF 2 OF 4 OTHER DGS (11)	Addressed in the Unit 1 Level 1 Importance List Review

Table E.5-1b Unit 2 Level 1 Importance List Review (Pre-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
2CLPIA-O	1.60E-01	1.026	OPERATOR FAILS TO CONTROL LOW PRESSURE INJECTION DURING ATWS	Addressed in the Unit 1 Level 1 Importance List Review
RCVLOOPSY5.6	3.85E-02	1.026	PROBABILITY OF NONRECOVERY FROM A SWITCHYARD RELATED LOOP IN 5.6 HOURS	Addressed in the Unit 1 Level 1 Importance List Review
RCVSEQ2TR-3-038CD	1.00E+00	1.024	SEQUENCE FLAG FOR 2TR-3-038CD	Addressed in the Unit 1 Level 1 Importance List Review
%2LOCA-SM-LQD	2.32E-03	1.024	SMALL LIQUID LINE BREAK LOCA	Addressed in the Unit 1 Level 1 Importance List Review
2RWST-FLAG	1.00E+00	1.023	FLAG FOR OPERATOR FAILING TO CROSSTIE RWST TO CST	Addressed in the Unit 1 Level 1 Importance List Review
024DGR0G501D	1.57E-02	1.022	DIESEL GENERATOR 'D' 0G501D D.G. FAIL AFTER FIRST HOUR FAILS TO OPERATE	Addressed in the Unit 1 Level 1 Importance List Review
%2ISO	1.36E-01	1.021	UNIT 2 INADVERTENT ISOLATION	Addressed in the Unit 1 Level 1 Importance List Review

Table E.5-1b Unit 2 Level 1 Importance List Review (Pre-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
024DGS0G501E	2.40E-02	1.020	DIESEL GENERATOR 'E' 0G501E FAILS TO START	Failure to align the "E" DG is important for SBO sequences. Due to human dependence issues, further enhancements related to alt power alignment requiring operator action would provide limited benefit. For this general event, an HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Alternatively, the ability to X-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed (SAMA 2). Finally, the Fire Protection System is not credited due to flow limitations even in the very late time frames in some LOOP evolutions. Procedure changes to stagger depressurization between units will allow FPS to be used as a viable makeup source (SAMA 3).
216-F073/075-O	1.00E+00	1.020	OPERATOR FAILS TO OPEN HV212F073A/B OR HV212F075A/B MANUALLY	Addressed in the Unit 1 Level 1 Importance List Review

Table E.5-1c Unit 1 Level 1 Importance List Review (Post-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
1CDFNEW-FLAG	1.00E+00	1.00E+30	UNIT 1 CORE DAMAGE FREQUENCY FLAG	N/A – This flag marks all sequences for the Unit 1 CDF model and does not provide any risk based insights. No SAMAs suggested.
LOOP-FLAG	1.00E+00	4.128	FLAG TO BE USED FOR ANY CONDITIONAL OR NON CONDITIONAL LOOP	The importance of the LOOP flag provides limited information about plant risk given that the LOOP category is broad and includes several different contributors. These contributors are represented by other events in this importance list that better define specific failures that can be investigated to identify means of reducing plant risk. No credible means of reducing the SSES LOOP frequency have been identified. Implementation of the Maintenance Rule is considered to address equipment reliability issues such that no measurable improvement is likely available based on enhancing maintenance practices. It may be possible to improve switchyard work planning and/or practices, but a reliable means of quantifying the impact of these types of changes is not available. No SAMAs suggested.

Table E.5-1c Unit 1 Level 1 Importance List Review (Post-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
%LOOP-FLAG	1.00E+00	3.533	LOOP FLAG FOR INITIATING EVENT	The importance of the LOOP initiator flag provides limited information about plant risk given that the LOOP category is broad and includes several different contributors. These contributors are represented by other events in this importance list that better define specific failures that can be investigated to identify means of reducing plant risk. No credible means of reducing the SSES LOOP frequency have been identified. Implementation of the Maintenance Rule is considered to address equipment reliability issues such that no measurable improvement is likely available based on enhancing maintenance practices. It may be possible to improve switchyard work planning and/or practices, but a reliable means of quantifying the impact of these types of changes is not available. No SAMAs suggested.
RCVSEQ1TR-7-001CD	1.00E+00	1.892	SEQUENCE FLAG FOR 1TR-7-001CD	The primary contributors to these sequences are LOOP events with failure of on-site AC power to support the DC power requirements for HPI and ADS in conjunction with the failure to recover off-site power. Restoration of AC power is clearly an important priority for this sequence; however, additional onsite AC sources are not likely to provide much benefit given the large impact of common cause EDG failure. A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of this sequence by prolonging the time the plant can operate under SBO or degraded AC/DC conditions (SAMA 1). Alternatively, the ability to cross-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed (SAMA 2). The FP System is currently available as a low pressure injection source, but the need for AC power to support long term depressurization limits its benefit and flow limitations preclude its success when both units require makeup simultaneously.

Table E.5-1c Unit 1 Level 1 Importance List Review (Post-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
EXTSEVWEATHER	2.32E-03	1.583	LOSS OF OFF SITE POWER DUE TO EXTREMELY SEVERE WEATHER	LOOP due to severe weather, as represented by this event, is grid related and no means are available to the plant to reduce its frequency. While there are multiple important contributors that include this event, the primary types of events include failures of on-site AC power to support the DC power requirements for HPI and ADS in conjunction with the failure to recover off-site power and SBO sequences with the station portable generator available. For this general event, a HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolong the time the plant can operate without offsite AC power (SAMA 1). Alternatively, the ability to cross-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed (SAMA 2). Finally, the Fire Protection System is not credited due to flow limitations even in the very late time frames in some LOOP evolutions. Procedure changes to stagger depressurization between units will allow FPS to be used as a viable makeup source (SAMA 3).
024-N-E-DSL-P	3.29E-01	1.421	PREVENTATIVE MAINTENANCE 0.328542094	There are multiple important contributors that include this event and for clarity reasons, they are addressed by the more specific events in the importance list below. However, two general SAMAs have been identified in association with this event. A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Alternatively, the ability to cross-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed (SAMA 2).

Table E.5-1c Unit 1 Level 1 Importance List Review (Post-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
002-N-N-BMS-FLAG	1.00E+00	1.318		This flag is used to identify operator errors related to aligning the station portable diesel generator, including: 002-N-N-BMS-O, Z-BMAX-EDG-O, and Z-BMS-IACIG-O. The events 002-N-N-BMS-O and Z-BMAX-EDG-O are specifically addressed in this table. The event Z-BMS-IACIG-O has a RRW value of 1.001 and does not require further review.
GRIDCENTERED	1.38E-02	1.290	LOSS OF OFF SITE POWER DUE TO GRID FAILURE	A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Alternatively, the ability to cross-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed (SAMA 2).
024DGS0G501B	2.40E-02	1.264	DIESEL GENERATOR 'B' 0G501B D.G. FAIL WITHIN THE FIRST HOUR	A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Alternatively, the ability to cross-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed (SAMA 2).
024DGS0G501A	2.40E-02	1.249	DIESEL GENERATOR 'A' 0G501A DIESEL GENERATOR FAILS TO START	A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Alternatively, the ability to cross-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed (SAMA 2).

Table E.5-1c Unit 1 Level 1 Importance List Review (Post-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
RCVLOOPGR5.4	1.46E-01	1.223	PROBABILITY OF NONRECOVERY FROM A GRID RELATED LOOP IN 5.4 HOURS	The primary contributors to the cutsets including this recovery are LOOP events with failure of on-site AC power to support the DC power requirements for HPI and ADS. Restoration of AC power is clearly an important priority for this sequence; however, additional onsite AC sources are not likely to provide much benefit given the large impact of common cause EDG failure. A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of this sequence by prolonging the time the plant can operate under SBO conditions (SAMA 1). Alternatively, the ability to cross-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed (SAMA 2)
RCVLOOPEW5.4	9.79E-01	1.209	PROBABILITY OF NONRECOVERY FROM A EXTREME WEATHER RELATED LOOP IN 5.4 HOURS	A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Alternatively, the ability to cross-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed (SAMA 2).
RCVSEQ1TR-1-005CD	1.00E+00	1.209	SEQUENCE FLAG FOR 1TR-1-005CD	The importance of this sequence is tied to SBO and LOOP without SPC (portable station diesel generator available). A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Currently, the Fire Protection System is not credited due to flow limitations even in the very late time frames in some LOOP evolutions. Procedure changes to stagger depressurization between units will allow FPS to be used as a viable makeup source (SAMA 3).

Table E.5-1c Unit 1 Level 1 Importance List Review (Post-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
RCVSBOWEDG	1.00E+00	1.186	STATION BLACKOUT WITH E DG	A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Currently, the Fire Protection System is not credited due to flow limitations even in the very late time frames in some LOOP evolutions. Procedure changes to stagger depressurization between units will allow FPS to be used as a viable makeup source (SAMA 3). Battery failure that result in the loss of DC for HPI and ADS are also minor contributors. These cases could be addressed by providing battery chargers that can provide 100% of the load without the batteries (SAMA 4).
RCVLOOPEW25.4	8.33E-01	1.181	PROBABILITY OF NONRECOVERY FROM A EXTREME WEATHER RELATED LOOP IN 25.4 HOURS	LOOP due to severe weather, as represented by this event, is grid related and no means are available to the plant to reduce its frequency. A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolong the time the plant can operate without offsite AC power (SAMA 1). Currently, the Fire Protection System is not credited due to flow limitations even in the very late time frames in some LOOP evolutions. Procedure changes to stagger depressurization between units will allow FPS to be used as a viable makeup source (SAMA 3).

Table E.5-1c Unit 1 Level 1 Importance List Review (Post-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
Z-BMAX-EDG-O	1.63E-02	1.165	DEPENDENT HEP FOR BLUE MAX AND E DG	A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Permanently installing the existing 480V AC generator and add hardware to allow it to automatically align to supply power to the required 480V AC buses directly addresses the importance of the HEP (SAMA 5). In addition, cutset review shows that major contributors including the HEP are cases where the "C" and "D" EDGs are typically available. The ability to cross-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed (SAMA 2).
024DGR0G501B	1.57E-02	1.155	DIESEL GENERATOR 'B' 0G501B D.G. FAIL AFTER FIRST HOUR FAILS TO OPERATE	A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Alternatively, the ability to cross-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed (SAMA 2).
024DGR0G501A	1.57E-02	1.147	DIESEL GENERATOR 'A' 0G501A D.G. FAIL AFTER FIRST HOUR FAILS TO OPERATE	A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Alternatively, the ability to cross-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed (SAMA 2).

Table E.5-1c Unit 1 Level 1 Importance List Review (Post-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
002DGS0G503	2.40E-02	1.128	STATION PORTABLE DIESEL GEN - BLUE MAX 0G503 DIESEL GENERATOR FAILS TO START	A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Providing an additional portable 480V AC generator could also potentially provide benefit (SAMA 6). In addition, cutset review shows that major contributors including the 0G503 failure are cases where the "C" and "D" EDGs are typically available. The ability to cross-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed (SAMA 2).
002-N-N-BMS-O	2.93E-02	1.120	OPERATOR ERROR FOR ALIGNING THE STATION PORTABLE DIESEL GENERATOR	A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Providing an additional portable 480V AC generator could also potentially provide benefit (SAMA 6). In addition, cutset review shows that major contributors including the HEP are cases where the "C" and "D" EDGs are typically available. The ability to cross-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed (SAMA 2).

Table E.5-1c Unit 1 Level 1 Importance List Review (Post-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
RCVSEQ1TR-8-023CD	1.00E+00	1.108	SEQUENCE FLAG FOR 1TR-8-023CD	This sequence is dominated by loss of HPI due to support system failures and subsequent Core Spray injection alignment difficulties. For example, in these cases, loss of off-site AC power and specific EDG failures result in the loss of "D" RHR due to the Division I ESW cooling dependence for lube oil cooling (ESW pumps A and C cool RHR pump D). The core spray injection valve cannot be opened remotely because it is powered by the "B" EDG, which has failed. A potential means of mitigating these types of accidents is to change RHR pump cooling such that the "B" and "D" ESW pumps provide cooling flow to the "B" and "D" RHR pumps (SAMA 7). This issue could also be addressed through the use of an AC cross-tie (SAMA 2).
151-N-N-F005-O	1.00E+00	1.107	OPERATOR FAILS TO OPEN HV152F005A/B MANUALLY	This action is important when HPI fails and Core Spray injection is required for inventory makeup. For example, in these cases, loss of off-site AC power and specific EDG failures result in the loss of "D" RHR due to the Division I ESW cooling dependence for lube oil cooling (ESW pumps A and C cool RHR pump D). The core spray injection valve cannot be opened remotely because it is powered by the "B" EDG, which has failed. A potential means of mitigating these types of accidents is to change RHR pump cooling such that the "B" and "D" ESW pumps provide cooling flow to the "B" and "D" RHR pumps (SAMA 7). This issue could also be addressed through the use of an AC cross-tie (SAMA 2).

Table E.5-1c Unit 1 Level 1 Importance List Review (Post-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
%1NONISO	8.94E-01	1.104	TRIP W/O MSIV CLOSURE	Over 58 percent of the contribution from this initiator is related to mechanical scram failure ATWS scenarios with subsequent operator failure to run back Feedwater and initiate SLC. Due to operator dependence issues, credit for any enhancements that would require further operator actions would be difficult to justify. Installation of logic to automate Feedwater runback may be a means of reducing the risk of ATWS sequences (SAMA 8). Additional major contributors include sequences RCVSEQ1TR-7-001CD (27%) and RCVSEQ1TR-2-001CD (10%). The RCVSEQ1TR-7-001CD sequence is a conditional LOOP with subsequent SBO or degraded AC/DC conditions. This sequence is addressed by SAMAs 1, 5, and 6. No SAMAs are suggested for the remaining contributors.
002DGR0G503	1.57E-02	1.080	STATION PORTABLE DIESEL GEN - BLUE MAX 0G503 DIESEL GENERATOR FAILS TO OPERATE	A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Provide an additional portable 480V AC generator (SAMA 6). In addition, cutset review shows that major contributors including the 0G503 failure are cases where the "C" and "D" EDGs are typically available. The ability to cross-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed (SAMA 2).

Table E.5-1c Unit 1 Level 1 Importance List Review (Post-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
024-N-N-DGE-O	1.15E-01	1.079	OPERATOR FAILS TO ALIGN	Failure to align the alternate 4kV AC DG is important for SBO sequences. Due to human dependence issues, further plant enhancements related to alternate power alignment requiring operator action would provide limited benefit. In general, a diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). For cases in which the 0G503 diesel is available, Fire Protection could be used for injection. The Fire Protection System is not credited due to flow limitations even in the very late time frames in some LOOP evolutions. Procedure changes to stagger depressurization between units will allow FPS to be used as a viable makeup source (SAMA 3). Finally, the contributing sequences including EDG A, B, and E failures could be addressed through the use of an AC cross-tie (SAMA 2).
SEVEREWEATHER	2.87E-03	1.078	LOSS OF OFF SITE POWER DUE TO SEVERE WEATHER	LOOP due to severe weather, as represented by this event, is grid related and no means are available to the plant to reduce its frequency. In general, a diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolong the time the plant can operate without offsite AC power (SAMA 1). In addition, the contributing sequences including EDG A, B, and E failures could be addressed through the use of an AC cross-tie (SAMA 2).

Table E.5-1c Unit 1 Level 1 Importance List Review (Post-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
RCV1ATWS	1.00E+00	1.074		Over 59 percent of the contributors with this flag are related to mechanical scram failure ATWS scenarios with subsequent operator failure to run back Feedwater. Due to the limited time for response and dependence issues, credit for any enhancements that would require further operator actions would be difficult to justify. Installation of logic to automate Feedwater runback may be a means of reducing the risk of ATWS sequences (SAMA 8). The remainder of the contributions are spread among the following types of initiators: - SLC initiation/level control operator errors (29%) - Other failures (>12%) Auto SLC initiation could be installed to address the SLC initiation failures, the cost of which is likely comparable to auto Feedwater runback. No changes to the ADS/inhibit logic are suggested. As Feedwater runback failures are the largest contributors, the SAMA analysis focuses on that issue. No SAMAs are suggested for the remaining contributors.

Table E.5-1c Unit 1 Level 1 Importance List Review (Post-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
CCFMEATWS-PE	2.10E-06	1.074	CCF RPS MECHANICAL SCRAM FAILURE - UNIT 1	Over 59 percent of the contributors with mechanical scram failure ATWS scenarios also contain subsequent operator failure to run back Feedwater. Due to the limited time for response and dependence issues, credit for any enhancements that would require further operator actions would be difficult to justify. Installation of logic to automate Feedwater runback may be a means of reducing the risk of ATWS sequences (SAMA 8). The remainder of the contributions are spread among the following types of initiators: - SLC initiation/level control operator errors (30%) - Other failures (11%) Auto SLC initiation could be installed to address the SLC initiation failures, the cost of which is likely comparable to auto Feedwater runback. As Feedwater runback failures are the largest contributors, the SAMA analysis focuses on that issue. No SAMAs are suggested for the remaining contributors.
CCFDG4DGS_ALL	7.41E-05	1.066	CCF 4 OF 4 DGs FAIL TO START AND RUN (8)	A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). The Fire Protection System is not credited due to flow limitations even in the very late time frames in some LOOP evolutions. Procedure changes to stagger depressurization between units will allow FPS to be used as a viable makeup source (SAMA 3).

Table E.5-1c Unit 1 Level 1 Importance List Review (Post-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
RCVSEQ1TR-2-001CD	1.00E+00	1.065	SEQUENCE FLAG FOR 1TR-2-001CD	These sequences include failures of high pressure injection systems and subsequent failures of depressurization. The primary contributors to these sequences are DC failures that fail both functions. Battery failure and DC bus failures preclude credit from the station portable diesel generator. SAMA 1 could provide a means of mitigating these accidents assuming that the pump could be operated without DC power. In addition, many FW failures are linked to event flag 125-N-N-FXTIACIGO-FLAG, which is addressed separately in the list.
125-N-N-FXTIACIGO-FLAG	1.00E+00	1.063	FLAG FOR IA TO CIG OPERATOR ACTION FAILURE	This flag is linked to the operator action to cross-tie IA to CIG. The importance of this action is primarily based on sequences in which loss of DC power fails HPI and depressurization capability through power and air dependencies. In order to recover to a safe, stable endstate from these sequences, injection and heat removal must be restored. Installing a pressure control valve between the IA and CIG systems would automate the cross-tie and remove the primary dependence on human action (SAMA 10).

Table E.5-1c Unit 1 Level 1 Importance List Review (Post-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
CCFDG3DGS_123	9.39E-05	1.060	CCF 3 OF 4 EDGs (A, B, C) TO START AND RUN (8)	A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Currently, the Fire Protection System is not credited due to flow limitations even in the very late time frames in some LOOP evolutions. Procedure changes to stagger depressurization between units will allow FPS to be used as a viable makeup source (SAMA 3). Alternatively, the ability to cross-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed (SAMA 2). In addition, SAMA 7 addresses the sequences in which RHR the "C" or "D" RHR pump cooling function is failed by the cross-divisionalized ESW cooling.
CCFDG3DGS_124	9.39E-05	1.060	CCF 3 OF 4 EDGs (A, B, D) TO START AND RUN (8)	A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Currently, the Fire Protection System is not credited due to flow limitations even in the very late time frames in some LOOP evolutions. Procedure changes to stagger depressurization between units will allow FPS to be used as a viable makeup source (SAMA 3). Alternatively, the ability to cross-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed (SAMA 2). In addition, SAMA 7 addresses the sequences in which RHR the "C" or "D" RHR pump cooling function is failed by the cross-divisionalized ESW cooling.

Table E.5-1c Unit 1 Level 1 Importance List Review (Post-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
125-N-N-FXTIACIG-O	2.20E-01	1.055	OPERATOR FAILS TO OPEN IA-CIG CROSSTIE VALVES	The importance of this action is primarily based on sequences in which loss of DC power fails HPI and depressurization capability through power and air dependencies. In order to recover to a safe, stable endstate from these sequences, injection and heat removal must be restored. Installing a pressure control valve between the IA and CIG systems would automate the cross-tie and remove the primary dependence on human action (SAMA 10).
%1ISLOCA_RHR_S	1.02E-07	1.055	INTERFACING SYSTEM LOCA FOR RHR PUMP SUCTION (F008-F009) BREAK	A high pressure core spray pump that could use an inexhaustible, high flow, cold suction source would reduce the risk of ISLOCAs by providing an alternate means of injection and precluding pump failures due to room flooding provided the pump is not located in the lower floors of the reactor building (SAMA 11). The engine driven HPI pump from SAMA 1 is not sized to provide the required makeup flow and is not considered to be capable of mitigating an ISLOCA.
RCVSEQ1IS-2-001CD	1.00E+00	1.055	SEQUENCE FLAG FOR 1IS-2-001CD	This sequence is directly tied to %1ISLOCA_RHR_S and is addressed by SAMA 11.
024-II-B-DSL-P	7.13E-03	1.053	PREVENTATIVE MAINTENANCE 7.13E-03	A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Currently, the Fire Protection System is not credited due to flow limitations even in the very late time frames in some LOOP evolutions. Procedure changes to stagger depressurization between units will allow FPS to be used as a viable makeup source (SAMA 3). Alternatively, the ability to cross-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed (SAMA 2).

Table E.5-1c Unit 1 Level 1 Importance List Review (Post-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
CCFDE3DGS_5	4.45E-01	1.052	CCF DG E W/ FAILURE OF 3 OF 4 OTHER DGS (11)	A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Currently, the Fire Protection System is not credited due to flow limitations even in the very late time frames in some LOOP evolutions. Procedure changes to stagger depressurization between units will allow FPS to be used as a viable makeup source (SAMA 3). Alternatively, the ability to cross-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed (SAMA 2). In addition, SAMA 7 addresses the sequences in which RHR the "C" or "D" RHR pump cooling function is failed by the cross-divisionalized ESW cooling.
024-I-A-DSL-P	7.13E-03	1.051	PREVENTATIVE MAINTENANCE 7.13E-03	A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Currently, the Fire Protection System is not credited due to flow limitations even in the very late time frames in some LOOP evolutions. Procedure changes to stagger depressurization between units will allow FPS to be used as a viable makeup source (SAMA 3). Alternatively, the ability to cross-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed (SAMA 2).

Table E.5-1c Unit 1 Level 1 Importance List Review (Post-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
SWITCHYARDCENTERED	7.87E-03	1.049	LOOP DUE TO SWITCHYARD CENTERED FAILURES	The LOOP frequency due to switchyard centered failures could theoretically be reduced through preventative strategies or recovery actions; however, given the existence of maintenance review practices and operator training programs, no reliable means of measuring the improvement from any such enhancements has been identified. While the LOOP frequency is not considered to be easily influenced, there are other recovery mitigative options. A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Alternatively, the ability to cross-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed (SAMA 2). Contributors that include battery failures could be mitigated by installing 100% battery chargers and ensuring that the DC system can operate without the batteries (SAMA 4).
RCVLOOPSW5.4	2.09E-01	1.048	PROBABILITY OF NONRECOVERY FROM A SEVERE WEATHER RELATED LOOP IN 5.4 HOURS	A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Alternatively, the ability to cross-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed (SAMA 2).
CCFDG2DGS_12	1.85E-04	1.047	CCF 2 OF 4 EDGs (A, B) TO START AND RUN (8)	The cutsets including this recovery event are dominated by cases where either the "C" or "D" EDG is the only source of AC power and the RHR pumps are failed due to the lack of ESW cooling. SAMA 7 addresses these conditions.

Table E.5-1c Unit 1 Level 1 Importance List Review (Post-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
RCVLOOPGR5.2	1.55E-01	1.047	PROBABILITY OF NONRECOVERY FROM A GRID RELATED LOOP IN 5.2 HOURS	This recovery is important when HPI fails due to loss of AC power and Core Spray injection is required for inventory makeup. In these cases, loss of off-site AC power and specific EDG failures result in the loss of "D" RHR due to the Division I ESW cooling dependence for lube oil cooling (ESW pumps A and C cool RHR pump D). The core spray injection valve cannot be opened remotely because it is powered by the "B" EDG, which has failed. A potential means of mitigating these types of accidents is to change RHR pump cooling such that the "B" and "D" ESW pumps provide cooling flow to the "B" and "D" RHR pumps (SAMA 7). This issue could also be addressed through the use of an AC cross-tie (SAMA 2).
RCVSPC_INJ_L-O	6.00E-04	1.046	OPERATOR FAILS TO REPOSITION VALVE MANUALLY	This event represents Op failure to perform local, manual action to open valves to recover DHR in Class II accidents. In these scenarios, onsite AC power is available through the “E” EDG or another EDG, but valve failures prevent successful operation of DHR other than containment vent. Due to human dependence issues, further operator actions related to DHR recovery will offer limited benefit. While venting is a successful DHR option, its use fails the initially operating injection system. For the relevant scenarios, injection systems fail after containment failure as well. Currently, the Fire Protection System is not credited due to flow limitations even in the very late time frames in some LOOP evolutions. Procedure changes to stagger depressurization between units will allow FPS to be used as a viable makeup source (SAMA 3).
145-N-N-REDFW-O	1.00E+00	1.043	OPERATOR FAILS TO RUN BACK FEEDWATER IN 3.5 MINUTES FOLLOWING AN ATWS .15	Installation of logic to automate Feedwater runback is a potential means of reducing the risk of ATWS sequences (SAMA 8).

Table E.5-1c Unit 1 Level 1 Importance List Review (Post-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
145-N-N-REDFWO-FLAG	1.00E+00	1.043	FLAG FOR OPERATOR FAILS TO RUN BACK FEEDWATER IN 3.5 MINUTES FOLLOWING AN ATWS	Installation of logic to automate Feedwater runback is a potential means of reducing the risk of ATWS sequences (SAMA 8).
%1LODCBUS_622	1.50E-03	1.043	LOSS OF 1D622	The importance of this event is primarily based on sequences in which loss of DC power fails HPI and depressurization capability through direct and indirect dependencies. In order to recover to a safe, stable endstate from these sequences, injection and heat removal must be restored. Installing a pressure control valve between the IA and CIG systems would automate the cross-tie and remove the primary dependence on human action (SAMA 10).
024DGS0G501D	2.40E-02	1.040	DIESEL GENERATOR 'D' 0G501D D.G. FAIL AFTER FIRST HOUR FAILS TO START	A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Currently, the Fire Protection System is not credited due to flow limitations even in the very late time frames in some LOOP evolutions. Procedure changes to stagger depressurization between units will allow FPS to be used as a viable makeup source (SAMA 3). In addition, SAMA 7 addresses the sequences in which RHR the "C" or "D" RHR pump cooling function is failed by the cross-divisionalized ESW cooling.
1CLPIA-O	2.30E-01	1.039	OPERATOR FAILS TO CONTROL LOW PRESSURE INJECTION DURING ATWS	Over 70% of the cutset contributions including this event include failures of 145-N-N-REDFW-O. As CLPIA-O is also a level/power control event, there is a dependence between the actions. Automating the Feedwater runback function would remove this dependence (SAMA 8).

Table E.5-1c Unit 1 Level 1 Importance List Review (Post-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
COND-LOOP-TRANS	2.40E-03	1.039	CONDITIONAL LOOP PROBABILITY GIVEN TRANSIENT	A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Alternatively, the ability to cross-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed (SAMA 2). Contributors that include battery failures could be mitigated by installing 100% battery chargers and ensuring that the DC system can operate without the batteries (SAMA 4).
RCVLOOPEW5.2	9.80E-01	1.037	PROBABILITY OF NONRECOVERY FROM A EXTREME WEATHER RELATED LOOP IN 5.2 HOURS	The cutsets including this recovery event are dominated by cases where either the "C" or "D" EDG is the only source of AC power and the RHR pumps are failed due to the lack of ESW cooling. SAMA 7 addresses these conditions.
024DGS0G501C	2.40E-02	1.037	DIESEL GENERATOR 'C' 0G501C D.G. FAIL AFTER FIRST HOUR FAILS TO START	A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Currently, the Fire Protection System is not credited due to flow limitations even in the very late time frames in some LOOP evolutions. Procedure changes to stagger depressurization between units will allow FPS to be used as a viable makeup source (SAMA 3). In addition, SAMA 7 addresses the sequences in which RHR the "C" or "D" RHR pump cooling function is failed by the cross-divisionalized ESW cooling.

Table E.5-1c Unit 1 Level 1 Importance List Review (Post-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
102BCR1D613	1.68E-04	1.035	125VDC BATTERY CHARGER 1D613 BATTERY CHARGER FAILS TO OPERATE	Failure of this battery charger in conjunction with the failure of 125V DC bus 622 results in the loss of both divisions of 125V DC power in the long term (after battery depletion). Providing the ability to power required loads directly from the available DC charger would allow for recovery on one DC division's essential equipment (SAMA 9). In addition, a large majority of the cutsets including this event include the failure of the IA to CIG cross tie (125-N-N-FXTIACIG-O). These contributors are addressed by SAMA 10.
102BTS1D610	5.00E-04	1.034	125VDC BATTERY BANK A FAILS TO START	The contributors that include battery failures could be mitigated by installing 100% battery chargers and ensuring that the DC system can operate without the batteries (SAMA 4).
150PTS1P203	2.00E-02	1.032	1P203 TURBINE-DRIVEN PUMP STAND-BY FAILS TO START	Over 86% of the cutsets including this event are related to the failure of RHR due to the non-divisionalized ESW cooling alignment. This is addressed by SAMA 7.
RCVSEQ1TR-6-011CD	1.00E+00	1.028	SEQUENCE FLAG FOR 1TR-6-011CD	This sequence includes the failure of 145-N-N-REDFW-O. Automating the Feedwater runback function would remove the need for this action (SAMA 8).
CCFDE2DGS_5	3.84E-01	1.026	CCF DG E W/ FAILURE OF 2 OF 4 OTHER DGS (11)	A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Alternatively, the ability to cross-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed (SAMA 2).

Table E.5-1c Unit 1 Level 1 Importance List Review (Post-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
RCVLOOPSY5.4	4.17E-02	1.026	PROBABILITY OF NONRECOVERY FROM A SWITCHYARD RELATED LOOP IN 5.4 HOURS	A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Alternatively, the ability to cross-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed (SAMA 2).
RCVSEQ1TR-3-038CD	1.00E+00	1.024	SEQUENCE FLAG FOR 1TR-3-038CD	Over 66% of the cutsets including this event are related to the failure of RHR due to the non-divisionalized ESW cooling alignment. This is addressed by SAMA 7.
024DGR0G501D	1.57E-02	1.023	DIESEL GENERATOR 'D' 0G501D D.G. FAIL AFTER FIRST HOUR FAILS TO OPERATE	A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Currently, the Fire Protection System is not credited due to flow limitations even in the very late time frames in some LOOP evolutions. Procedure changes to stagger depressurization between units will allow FPS to be used as a viable makeup source (SAMA 3). In addition, SAMA 7 addresses the sequences in which RHR the "C" or "D" RHR pump cooling function is failed by the cross-divisionalized ESW cooling. Finally, the ability to cross-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed (SAMA 2).

Table E.5-1c Unit 1 Level 1 Importance List Review (Post-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
%1ISO	1.36E-01	1.023	INADVERTENT ISOLATION - MSIV	There are no dominant contributors for this initiating event and no viable method has been identified that could be implemented to reduce the initiating event frequency. Some of the contribution could be eliminated by providing a means of providing power directly to critical loads given DC bus or distribution panel failures (SAMA 9). The ATWS contributors (about 38%) include multiple different failure paths including failures of level control, SLC injection, ADS inhibit failures. No SAMAs have been identified to address these events, especially given the low RRW value of this initiating event.
%1LOCA-SM-LQD	2.32E-03	1.022	SMALL LIQUID LINE BREAK LOCA	There are several different types of contributors to the CDF give this initiating event. These are either addressed by the SSES SAMAs identified for other contributors or have contributions below the RRW review cutoff for this analysis: • 29.5%: ESW failures result in long term loss of HPI and LPI due to lack of SPC and equipment cooling. After initial success of HPI and subsequent depressurization, SAMA 1 would be capable of providing core cooling. • 4.5%: Consequential LOOP events result in conditions similar to the ESW failures and are addressed by SAMA 1. • 26.8%: Vapor suppression failures are addressed by SAMA 13. 39.2%: The remaining contributors represent an RRW of only 1.009, which is well below the review cutoff of 1.02 for the SAMA list development and no SAMAs are required to address this contribution.

Table E.5-1c Unit 1 Level 1 Importance List Review (Post-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
1RWST-FLAG	1.00E+00	1.022	FLAG FOR OPERATOR FAILING TO XTIE RWST	The cutsets including this flag require of the CST for extended high pressure makeup success. These contributors could potentially be reduced by automating the cross-tie between the RWST and the CST, but this would introduce the potential to drain both the CST and the RWST in the event of a CST rupture or pumpdown. This is not considered to be a desirable option. Another possibility is providing automated makeup from the Fire Protection system. However, the dominate contributors including 1RWST-FLAG are evolutions that could be mitigated by divisionalizing the ESW cooling to the RHR pumps (SAMA 7). This is considered to be the most appropriate approach for SSES.
024DGR0G501C	1.57E-02	1.022	DIESEL GENERATOR 'C' 0G501C D.G. FAIL AFTER FIRST HOUR FAILS TO OPERATE	A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Currently, the Fire Protection System is not credited due to flow limitations even in the very late time frames in some LOOP evolutions. Procedure changes to stagger depressurization between units will allow FPS to be used as a viable makeup source (SAMA 3). In addition, SAMA 7 addresses the sequences in which RHR the "C" or "D" RHR pump cooling function is failed by the cross-divisionalized ESW cooling. Finally, the ability to cross-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed (SAMA 2).

Table E.5-1c Unit 1 Level 1 Importance List Review (Post-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
183-N-N-ADS_INH_10-O	4.70E-02	1.020	OPERATOR FAILS TO INHIBIT ADS WITHIN 9 MINUTES DURING ATWS	Over 70 percent of the contribution from this initiator is related to mechanical scram failure ATWS scenarios with subsequent operator failure to run back Feedwater and initiate SLC. Due to operator dependence issues, credit for any enhancements that would require further operator actions would be difficult to justify. Installation of logic to automate Feedwater runback may be a means of reducing the risk of ATWS sequences (SAMA 8).
016-N-N-VENT-O	9.90E-03	1.020	OPERATOR FAILS TO OPEN DOORS AND DAMPERS IN ESW PUMP HOUSE 9.9E-3	"A", "B", and "E" EDG failures dominate the cutsets including 016-N-N-VENT-O. The ability to cross-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed (SAMA 2).
116-F073/075-O	1.00E+00	1.020	OPERATOR FAILS TO OPEN HV112F073A/B OR HV112F075A/B MANUALLY	This event is completely tied to event "RCVSPC_INJ_L" which is addressed above.

Table E.5-1d Unit 2 Level 1 Importance List Review (Post-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
2CDFNEW-FLAG	1.00E+00	1.00E+30	UNIT 2 CORE DAMAGE FREQUENCY FLAG	Addressed in the Unit 1 Level 1 Importance List Review
LOOP-FLAG	1.00E+00	4.116	FLAG TO BE USED FOR ANY CONDITIONAL OR NON CONDITIONAL LOOP	Addressed in the Unit 1 Level 1 Importance List Review
%LOOP-FLAG	1.00E+00	3.518	LOOP FLAG FOR INITIATING EVENT	Addressed in the Unit 1 Level 1 Importance List Review
RCVSEQ2TR-7-001CD	1.00E+00	1.917	SEQUENCE FLAG FOR 2TR-7-001CD	Addressed in the Unit 1 Level 1 Importance List Review
EXTSEVWEATHER	2.32E-03	1.593	LOSS OF OFF SITE POWER DUE TO EXTREMELY SEVERE WEATHER	Addressed in the Unit 1 Level 1 Importance List Review
024-N-E-DSL-P	3.29E-01	1.434	PREVENTATIVE MAINTENANCE 0.328542094	Addressed in the Unit 1 Level 1 Importance List Review
002-N-N-BMS-FLAG	1.00E+00	1.326	BLUE MAX FAILS DUE TO OPERATOR ERROR	Addressed in the Unit 1 Level 1 Importance List Review
GRIDCENTERED	1.38E-02	1.283	LOSS OF OFF SITE POWER DUE TO GRID FAILURE	Addressed in the Unit 1 Level 1 Importance List Review
024DGS0G501B	2.40E-02	1.256	DIESEL GENERATOR 'B' 0G501B D.G. FAIL WITHIN THE FIRST HOUR	Addressed in the Unit 1 Level 1 Importance List Review

Table E.5-1d Unit 2 Level 1 Importance List Review (Post-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
024DGS0G501A	2.40E-02	1.256	DIESEL GENERATOR 'A' 0G501A DIESEL GENERATOR FAILS TO START	Addressed in the Unit 1 Level 1 Importance List Review
RCVLOOPGR5.4	1.46E-01	1.228	PROBABILITY OF NONRECOVERY FROM A GRID RELATED LOOP IN 5.4 HOURS	Addressed in the Unit 1 Level 1 Importance List Review
RCVSEQ2TR-1-005CD	1.00E+00	1.219	SEQUENCE FLAG FOR 2TR-1-005CD	Addressed in the Unit 1 Level 1 Importance List Review
RCVLOOPEW5.4	9.79E-01	1.213	PROBABILITY OF NONRECOVERY FROM A EXTREME WEATHER RELATED LOOP IN 5.4 HOURS	Addressed in the Unit 1 Level 1 Importance List Review
RCVLOOPEW25.4	8.33E-01	1.192	PROBABILITY OF NONRECOVERY FROM A EXTREME WEATHER RELATED LOOP IN 25.4 HOURS	Addressed in the Unit 1 Level 1 Importance List Review
Z-BMAX-EDG-O	1.63E-02	1.171	DEPENDENT HEP FOR BLUE MAX AND E DG	Addressed in the Unit 1 Level 1 Importance List Review
024DGR0G501B	1.57E-02	1.151	DIESEL GENERATOR 'B' 0G501B D.G. FAIL AFTER FIRST HOUR FAILS TO OPERATE	Addressed in the Unit 1 Level 1 Importance List Review
024DGR0G501A	1.57E-02	1.150	DIESEL GENERATOR 'A' 0G501A D.G. FAIL AFTER FIRST HOUR FAILS TO OPERATE	Addressed in the Unit 1 Level 1 Importance List Review

Table E.5-1d Unit 2 Level 1 Importance List Review (Post-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
RCVSBOWEDG	1.00E+00	1.132	STATION BLACKOUT WITH E DG	Addressed in the Unit 1 Level 1 Importance List Review
002DGS0G503	2.40E-02	1.130	STATION PORTABLE DIESEL GEN - BLUE MAX 0G503 DIESEL GENERATOR FAILS TO START	Addressed in the Unit 1 Level 1 Importance List Review
002-N-N-BMS-O	2.93E-02	1.121	OPERATOR ERROR FOR ALIGNING THE STATION PORTABLE DIESEL GENERATOR	Addressed in the Unit 1 Level 1 Importance List Review
%2NONISO	8.94E-01	1.105	UNIT 2 TRIP W/O MSIV CLOSURE 2	Addressed in the Unit 1 Level 1 Importance List Review
251-N-N-F005-O	1.00E+00	1.103	OPERATOR FAILS TO OPEN HV252F005A/B MANUALLY	Addressed in the Unit 1 Level 1 Importance List Review
RCVSEQ2TR-8-023CD	1.00E+00	1.090	SEQUENCE FLAG FOR 2TR-8-023CD	Addressed in the Unit 1 Level 1 Importance List Review
002DGR0G503	1.57E-02	1.081	STATION PORTABLE DIESEL GEN - BLUE MAX 0G503 DIESEL GENERATOR FAILS TO OPERATE	Addressed in the Unit 1 Level 1 Importance List Review
024-N-N-DGE-O	1.15E-01	1.080	OPERATOR FAILS TO ALIGN	Addressed in the Unit 1 Level 1 Importance List Review
SEVEREWEATHER	2.87E-03	1.077	LOSS OF OFF SITE POWER DUE TO SEVERE WEATHER	Addressed in the Unit 1 Level 1 Importance List Review
RCV2ATWS	1.00E+00	1.075		Addressed in the Unit 1 Level 1 Importance List Review

Table E.5-1d Unit 2 Level 1 Importance List Review (Post-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
CCFMEATWS-PE-UNIT2	2.10E-06	1.075	CCF RPS MECHANICAL SCRAM FAILURE - UNIT 2	Addressed in the Unit 1 Level 1 Importance List Review
CCFDG4DGS_ALL	7.41E-05	1.067	CCF 4 OF 4 DGs FAIL TO START AND RUN (8)	Addressed in the Unit 1 Level 1 Importance List Review
RCVSEQ2TR-2-001CD	1.00E+00	1.066	SEQUENCE FLAG FOR 2TR-2-001CD	Addressed in the Unit 1 Level 1 Importance List Review
225-N-N-FXTIACIGO-FLAG	1.00E+00	1.062	FLAG FOR IA TO CIG OPERATOR ACTION FAILURE	Addressed in the Unit 1 Level 1 Importance List Review
CCFDG3DGS_124	9.39E-05	1.062	CCF 3 OF 4 EDGs (A, B, D) TO START AND RUN (8)	Addressed in the Unit 1 Level 1 Importance List Review
CCFDG3DGS_123	9.39E-05	1.061	CCF 3 OF 4 EDGs (A, B, C) TO START AND RUN (8)	Addressed in the Unit 1 Level 1 Importance List Review
%2ISLOCA_RHR_S	1.02E-07	1.055	INTERFACING SYSTEM LOCA FOR RHR PUMP SUCTION (F008-F009) BREAK	Addressed in the Unit 1 Level 1 Importance List Review
RCVSEQ2IS-2-001CD	1.00E+00	1.055	SEQUENCE FLAG FOR 2IS-2-001CD	Addressed in the Unit 1 Level 1 Importance List Review
225-N-N-FXTIACIG-O	2.20E-01	1.055	OPERATOR FAILS TO OPEN IA-CIG CROSSTIE VALVES	Addressed in the Unit 1 Level 1 Importance List Review
CCFDE3DGS_5	4.45E-01	1.053	CCF DG E W/ FAILURE OF 3 OF 4 OTHER DGS (11)	Addressed in the Unit 1 Level 1 Importance List Review
024-I-A-DSL-P	7.13E-03	1.052	PREVENTATIVE MAINTENANCE 7.13E-03	Addressed in the Unit 1 Level 1 Importance List Review
024-II-B-DSL-P	7.13E-03	1.052	PREVENTATIVE MAINTENANCE 7.13E-03	Addressed in the Unit 1 Level 1 Importance List Review

Table E.5-1d Unit 2 Level 1 Importance List Review (Post-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
RCVLOOPSW5.4	2.09E-01	1.049	PROBABILITY OF NONRECOVERY FROM A SEVERE WEATHER RELATED LOOP IN 5.4 HOURS	Addressed in the Unit 1 Level 1 Importance List Review
SWITCHYARDCENTERED	7.87E-03	1.048	LOOP DUE TO SWITCHYARD CENTERED FAILURES	Addressed in the Unit 1 Level 1 Importance List Review
CCFDG2DGS_12	1.85E-04	1.048	CCF 2 OF 4 EDGs (A, B) TO START AND RUN (8)	Addressed in the Unit 1 Level 1 Importance List Review
RCVSPC_INJ_L-O	6.00E-04	1.047	OPERATOR FAILS TO REPOSITION VALVE MANUALLY	Addressed in the Unit 1 Level 1 Importance List Review
245-N-N-REDFW-O	1.00E+00	1.044	OPERATOR FAILS TO RUN BACK FEEDWATER IN 3.5 MINUTES FOLLOWING AN ATWS	Addressed in the Unit 1 Level 1 Importance List Review
245-N-N-REDFWO-FLAG	1.00E+00	1.044	FLAG FOR OPERATOR FAILS TO RUN BACK FEEDWATER IN 3.5 MINUTES FOLLOWING AN ATWS	Addressed in the Unit 1 Level 1 Importance List Review
%2LODCBUS_622	1.50E-03	1.043	LOSS OF 2D622	Addressed in the Unit 1 Level 1 Importance List Review
RCVLOOPGR5.2	1.55E-01	1.040	PROBABILITY OF NONRECOVERY FROM A GRID RELATED LOOP IN 5.2 HOURS	Addressed in the Unit 1 Level 1 Importance List Review

Table E.5-1d Unit 2 Level 1 Importance List Review (Post-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
2CLPIA-O	2.30E-01	1.040	OPERATOR FAILS TO CONTROL LOW PRESSURE INJECTION DURING ATWS	Addressed in the Unit 1 Level 1 Importance List Review
COND-LOOP-TRANS	2.40E-03	1.039	CONDITIONAL LOOP PROBABILITY GIVEN TRANSIENT	Addressed in the Unit 1 Level 1 Importance List Review
024DGS0G501D	2.40E-02	1.038	DIESEL GENERATOR 'D' 0G501D D.G. FAIL AFTER FIRST HOUR FAILS TO START	Addressed in the Unit 1 Level 1 Importance List Review
202BCR2D613	1.68E-04	1.035	125VDC BATTERY CHARGER 2D613 BATTERY CHARGER FAILS TO OPERATE	Addressed in the Unit 1 Level 1 Importance List Review
024DGS0G501C	2.40E-02	1.034	DIESEL GENERATOR 'C' 0G501C D.G. FAIL AFTER FIRST HOUR FAILS TO START	Addressed in the Unit 1 Level 1 Importance List Review
250PTS2P203	2.00E-02	1.032	2P203 TURBINE-DRIVEN PUMP STAND-BY FAILS TO START	Addressed in the Unit 1 Level 1 Importance List Review
RCVLOOPEW5.2	9.80E-01	1.031	PROBABILITY OF NONRECOVERY FROM A EXTREME WEATHER RELATED LOOP IN 5.2 HOURS	Addressed in the Unit 1 Level 1 Importance List Review
RCVSEQ2TR-6-011CD	1.00E+00	1.028	SEQUENCE FLAG FOR 2TR-6-011CD	Addressed in the Unit 1 Level 1 Importance List Review
CCFDE2DGS_5	3.84E-01	1.026	CCF DG E W/ FAILURE OF 2 OF 4 OTHER DGS (11)	Addressed in the Unit 1 Level 1 Importance List Review

Table E.5-1d Unit 2 Level 1 Importance List Review (Post-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
RCVLOOPSY5.4	4.17E-02	1.026	PROBABILITY OF NONRECOVERY FROM A SWITCHYARD RELATED LOOP IN 5.4 HOURS	Addressed in the Unit 1 Level 1 Importance List Review
RCVSEQ2TR-3-038CD	1.00E+00	1.023	SEQUENCE FLAG FOR 2TR-3-038CD	Addressed in the Unit 1 Level 1 Importance List Review
%2ISO	1.36E-01	1.023	UNIT 2 INADVERTENT ISOLATION	Addressed in the Unit 1 Level 1 Importance List Review
%2LOCA-SM-LQD	2.32E-03	1.023	SMALL LIQUID LINE BREAK LOCA	Addressed in the Unit 1 Level 1 Importance List Review
2RWST-FLAG	1.00E+00	1.022	FLAG FOR OPERATOR FAILS TO XTIE CST	Addressed in the Unit 1 Level 1 Importance List Review
024DGR0G501D	1.57E-02	1.022	DIESEL GENERATOR 'D' 0G501D D.G. FAIL AFTER FIRST HOUR FAILS TO OPERATE	Addressed in the Unit 1 Level 1 Importance List Review
283-N-N-ADS_INH_10-O	4.70E-02	1.021	OPERATOR FAILS TO INHIBIT ADS WITHIN 10 MINUTES DURING ATWS	Addressed in the Unit 1 Level 1 Importance List Review
216-F073/075-O	1.00E+00	1.020	OPERATOR FAILS TO OPEN HV212F073A/B OR HV212F075A/B MANUALLY	Addressed in the Unit 1 Level 1 Importance List Review
024DGR0G501C	1.57E-02	1.020	DIESEL GENERATOR 'C' 0G501C D.G. FAIL AFTER FIRST HOUR FAILS TO OPERATE	Addressed in the Unit 1 Level 1 Importance List Review

Table E.5-1d Unit 2 Level 1 Importance List Review (Post-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
024DGS0G501E	2.40E-02	1.020	DIESEL GENERATOR 'E' 0G501E FAILS TO START	A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolong the time the plant can operate without offsite AC power (SAMA 1). Currently, the Fire Protection System is not credited due to flow limitations even in the very late time frames in some LOOP evolutions. Procedure changes to stagger depressurization between units will allow FPS to be used as a viable makeup source (SAMA 3). In addition, the ability to cross-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed (SAMA 2).

Table E.5-2a Unit 1 Level 2 Importance List Review (Based on Level 2 Results) (Pre-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
1LEVEL2-FLAG	1.00E+00	1.07E+07	FLAG FOR UNIT 1 LEVEL 2	N/A - This flag marks all sequences for the Unit 1 Level 2 model and does not provide any risk based insights. No SAMAs suggested.
LOOP-FLAG	1.00E+00	5.915	FLAG TO BE USED FOR ANY CONDITIONAL OR NON CONDITIONAL LOOP	Addressed in the Unit 1 Level 1 Importance List Review.
%LOOP-FLAG	1.00E+00	4.964	LOOP FLAG FOR INITIATING EVENT	Addressed in the Unit 1 Level 1 List Review.
1MI-FLAG	1.00E+00	2.119	FLAG FOR UNIT 1 MEDIUM INTERMEDIATE RELEASE	The M/I release category is primarily comprised of LOOP events with EDGs A, B, and E failed combined with the failure of the station portable diesel generator. A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Alternatively, the ability to cross-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed (SAMA 2). In addition, this release category contains sequences that include containment failure after core damage when venting is not credited. Clarifying the procedures to direct wetwell venting to protect the containment is assumed to improve the reliability of venting after core damage (SAMA 12). While this modeling strategy is not limited to sequences binned into the M/I release category, this release category has been used to identify the issue for the SSES model.

Table E.5-2a Unit 1 Level 2 Importance List Review (Based on Level 2 Results) (Pre-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
RCVREL-1MI	1.00E+00	2.119	FLAG FOR MEDIMUM INTERMEDIATE RELEASE	The M/I release category is primarily comprised of LOOP events with EDGs A, B, and E failed combined with the failure of the station portable diesel generator. A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Alternatively, the ability to cross-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed (SAMA 2). In addition, this release category contains sequences that include containment failure after core damage when venting is not credited. Clarifying the procedures to direct wetwell venting to protect the containment is assumed to improve the reliability of venting after core damage (SAMA 12). While this modeling strategy is not limited to sequences binned into the M/I release category, this release category has been used to identify the issue for the SSES model.
RCVSEQ1TR-7-010A	1.00E+00	2.081	SEQUENCE FLAG FOR 1TR-7-010A	SAMA 1 is a means of reducing the frequency of this high pressure core melt sequence by providing an alternate means of high pressure injection. In addition, these sequences are predominantly long term SBO scenarios, which would be mitigated by SAMA 13.
EXTSEVWEATHER	2.32E-03	2.032	LOSS OF OFF SITE POWER DUE TO EXTREMELY SEVERE WEATHER	Addressed in the Unit 1 Level 1 enlist Review.

Table E.5-2a Unit 1 Level 2 Importance List Review (Based on Level 2 Results) (Pre-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
RCVLOOPEW9.2	9.57E-01	1.679	PROBABILITY OF NONRECOVERY FROM A EXTREME WEATHER RELATED LOOP IN 9.2 HOURS	The cutsets that include RCVLOOPEW9.2 are dominated by the M/I release category, which is primarily comprised of LOOP events with EDGs A, B, and E failed combined with the failure of the station portable diesel generator. A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Alternatively, the ability to cross-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed (SAMA 2).
002-N-N-BMS-FLAG	1.00E+00	1.614		Addressed in the Unit 1 Level 1 Importance List Review.
024-N-E-DSL-P	3.29E-01	1.507	PREVENTATIVE MAINTENANCE 0.328542094	Addressed in the Unit 1 Level 1 Importance List Review.
024DGS0G501B	2.40E-02	1.403	DIESEL GENERATOR 'B' 0G501B D.G. FAIL WITHIN THE FIRST HOUR	Addressed in the Unit 1 Level 1 Importance List Review.
024DGS0G501A	2.40E-02	1.379	DIESEL GENERATOR 'A' 0G501A DIESEL GENERATOR FAILS TO START	Addressed in the Unit 1 Level 1 Importance List Review.
Z-BMAX-EDG-O	1.63E-02	1.281	DEPENDENT HEP FOR BLUE MAX AND E DG	Addressed in the Unit 1 Level 1 Importance List Review.

Table E.5-2a Unit 1 Level 2 Importance List Review (Based on Level 2 Results) (Pre-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
024DGR0G501B	1.57E-02	1.227	DIESEL GENERATOR 'B' 0G501B D.G. FAIL AFTER FIRST HOUR FAILS TO OPERATE	Addressed in the Unit 1 Level 1 Importance List Review.
1HE-FLAG	1.00E+00	1.218	FLAG FOR HIGH EARLY RELEASE	About 70% of the H/E release category contributors are ISLOCA events, which are addressed by SAMA 11. Most of the remaining contributors are LOCA events that would also be mitigated by the high pressure core spray system.
RCVREL-1HE	1.00E+00	1.218	FLAG FOR HIGH EARLY RELEASE	About 70% of the H/E release contributors are ISLOCA events, which are addressed by SAMA 11. Most of the remaining contributors are LOCA events that would also be mitigated by the high pressure core spray system.
002DGS0G503	2.40E-02	1.215	STATION PORTABLE DIESEL GEN - BLUE MAX 0G503 DIESEL GENERATOR FAILS TO START	Addressed in the Unit 1 Level 1 Importance List Review.
024DGR0G501A	1.57E-02	1.215	DIESEL GENERATOR 'A' 0G501A D.G. FAIL AFTER FIRST HOUR FAILS TO OPERATE	Addressed in the Unit 1 Level 1 Importance List Review.
GRIDCENTERED	1.38E-02	1.212	LOSS OF OFF SITE POWER DUE TO GRID FAILURE	Addressed in the Unit 1 Level 1 Importance List Review.

Table E.5-2a Unit 1 Level 2 Importance List Review (Based on Level 2 Results) (Pre-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
002-N-N-BMS-O	2.93E-02	1.204	OPERATOR ERROR FOR ALIGNING THE STATION PORTABLE DIESEL GENERATOR	Addressed in the Unit 1 Level 1 Importance List Review.
RCVLOOPGR9.2	5.11E-02	1.182	PROBABILITY OF NONRECOVERY FROM A GRID RELATED LOOP IN 9.2 HOURS	The cutsets that include RCVLOOPEW9.2 are dominated by the M/I release category, which is primarily comprised of LOOP events with EDGs A, B, and E failed combined with the failure of the station portable diesel generator. A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Alternatively, the ability to cross-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed (SAMA 2).
1HI-FLAG	1.00E+00	1.182	FLAG FOR UNIT 1 HIGH INTERMEDIATE RELEASE	The H/I release category includes many different contributors. LOOP initiating events, however, are responsible for about 65 percent of the release category's frequency, much of which includes failure of the station portable diesel generator. Potential SAMAs that could reduce the H/I frequency include SAMAs 1, 5, 6, and 2.

Table E.5-2a Unit 1 Level 2 Importance List Review (Based on Level 2 Results) (Pre-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
RCVREL-1HI	1.00E+00	1.182	FLAG FOR HIGH INTERMEDIATE RELEASE	The H/I release category includes many different contributors. LOOP initiating events, however, are responsible for about 65 percent of the release category's frequency, much of which includes failure of the station portable diesel generator. Potential SAMAs that could reduce the H/I frequency include SAMAs 1, 5, 6, and 2.
1ML-FLAG	1.00E+00	1.162	FLAG FOR UNIT 1 MEDIUM LATE RELEASE	Over 60% of the M/L release category is related to the failure to provide injection due to the dependence of RHR pump cooling on non-divisionalized ESW flow. This is addressed in the Unit 1 Level 1 importance list by event 151-N-N-F005-O. The remaining contributors in this release category include a mixture of SBO sequences that could be addressed by SAMA 3 and other initiating events.
RCVREL-1ML	1.00E+00	1.162	FLAG FOR MEDIMUM LATE RELEASE	Over 60% of the M/L release category is related to the failure to provide injection due to the dependence of RHR pump cooling on non-divisionalized ESW flow. This is addressed in the Unit 1 Level 1 importance list by event 151-N-N-F005-O. The remaining contributors in this release category include a mixture of SBO sequences that could be addressed by SAMA 3 and other initiating events.

Table E.5-2a Unit 1 Level 2 Importance List Review (Based on Level 2 Results) (Pre-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
RCVSEQ1TR-7-010B	1.00E+00	1.148	SEQUENCE FLAG FOR 1TR-7-010B	All of the RCVSEQ1TR-7-010B sequences belong to the H/I release category. All of these sequences include failure of the station portable diesel generator. Potential SAMAs that could reduce the H/I frequency include SAMAs 1, 5, 6, and 2.
RCVSEQ1TR-8-032	1.00E+00	1.132	SEQUENCE FLAG FOR 1TR-8-032	This sequence is completely comprised of M/L contributors. About 80% of the contributors to this sequence are related to the failure to provide injection due to the dependence of RHR pump cooling on non-divisionalized ESW flow. This is addressed in the Unit 1 Level 1 importance list by event 151-N-N-F005-O. The remaining contributors in this release category include cutsets with failure of all on-site 4kV AC power to operate (portable station generator is available), which could be mitigated by SAMA 3.
002DGR0G503	1.57E-02	1.129	STATION PORTABLE DIESEL GEN - BLUE MAX 0G503 DIESEL GENERATOR FAILS TO OPERATE	Addressed in the Unit 1 Level 1 Importance List Review.
%1ISLOCA_RHR_S	1.02E-07	1.119	INTERFACING SYSTEM LOCA FOR RHR PUMP SUCTION (F008-F009) BREAK	Addressed in the Unit 1 Level 1 Importance List Review.
RCVSEQ1IS-2-001	1.00E+00	1.119	SEQUENCE FLAG FOR 1IS-2-001	Addressed in the Unit 1 Level 1 Importance List Review.
SEVEREWEATHER	2.87E-03	1.102	LOSS OF OFF SITE POWER DUE TO SEVERE WEATHER	Addressed in the Unit 1 Level 1 Importance List Review.

Table E.5-2a Unit 1 Level 2 Importance List Review (Based on Level 2 Results) (Pre-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
RCVSBOWEDG	1.00E+00	1.099	STATION BLACKOUT WITH E DG	Addressed in the Unit 1 Level 1 Importance List Review.
151-N-N-F005-O	1.00E+00	1.097	OPERATOR FAILS TO OPEN HV152F005A/B MANUALLY	Addressed in the Unit 1 Level 1 Importance List Review.
RCVLOOPEW11	9.45E-01	1.087	PROBABILITY OF NONRECOVERY FROM A EXTREME WEATHER RELATED LOOP IN 11 HOURS	About 80% of the cutsets including this recovery are related to the failure to provide injection due to the dependence of RHR pump cooling on non-divisionalized ESW flow. This is addressed in the Unit 1 Level 1 importance list by event 151-N-N-F005-O. The remaining contributors in this release category mostly include cutsets with failure of all 4kV AC EDGs to operate (portable station generator is available), which could be mitigated by SAMA 3.
RCVLOOPSW9.2	1.41E-01	1.080	PROBABILITY OF NONRECOVERY FROM A SEVERE WEATHER RELATED LOOP IN 9.2 HOURS	All of the cutsets containing this recovery event include the failure of the station portable diesel generator in conjunction with 4kV EDG failures. Potential SAMAs that could reduce the frequency of these cutsets include SAMAs 1, 5, 6, and 2.
024-N-N-DGE-O	1.15E-01	1.076	OPERATOR FAILS TO ALIGN	Addressed in the Unit 1 Level 1 Importance List Review.
024-II-B-DSL-P	7.13E-03	1.075	PREVENTATIVE MAINTENANCE 7.13E-03	Addressed in the Unit 1 Level 1 Importance List Review.
024-I-A-DSL-P	7.13E-03	1.072	PREVENTATIVE MAINTENANCE 7.13E-03	Addressed in the Unit 1 Level 1 Importance List Review.

Table E.5-2a Unit 1 Level 2 Importance List Review (Based on Level 2 Results) (Pre-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
CCFDG2DGS_12	1.85E-04	1.069	CCF 2 OF 4 EDGs (A, B) TO START AND RUN (8)	Addressed in the Unit 1 Level 1 Importance List Review.
CCFDG3DGS_123	9.39E-05	1.061	CCF 3 OF 4 EDGs (A, B, C) TO START AND RUN (8)	Addressed in the Unit 1 Level 1 Importance List Review.
CCFDG3DGS_124	9.39E-05	1.059	CCF 3 OF 4 EDGs (A, B, D) TO START AND RUN (8)	Addressed in the Unit 1 Level 1 Importance List Review.
CCFDE3DGS_5	4.45E-01	1.049	CCF DG E W/ FAILURE OF 3 OF 4 OTHER DGS (11)	Addressed in the Unit 1 Level 1 Importance List Review.
013-N-N-EARLY-O	7.50E-02	1.044	OPERATOR FAILS TO TIE IN FIRE MAIN OR RHRSW FOR EARLY SEQUENCES 1 HOUR	The reliability of injection with the fire main could be improved by installing a permanent connection to the RHR system. The hard pipe connection would reduce the alignment time, improve man machine interface, and increase the injection flow rate (SAMA 14).
102BTS1D610	5.00E-04	1.036	125VDC BATTERY BANK A FAILS TO START	Addressed in the Unit 1 Level 1 List Review.
CCFDG4DGS_ALL	7.41E-05	1.035	CCF 4 OF 4 DGs FAIL TO START AND RUN (8)	Addressed in the Unit 1 Level 1 Importance List Review.
150PTS1P203	2.00E-02	1.034	1P203 TURBINE-DRIVEN PUMP STAND-BY FAILS TO START	Addressed in the Unit 1 Level 1 Importance List Review.
COND-LOOP-TRANS	2.40E-03	1.031	CONDITIONAL LOOP PROBABILITY GIVEN TRANSIENT	Addressed in the Unit 1 Level 1 Importance List Review.
CCFDE2DGS_5	3.84E-01	1.031	CCF DG E W/ FAILURE OF 2 OF 4 OTHER DGS (11)	Addressed in the Unit 1 Level 1 Importance List Review.

Table E.5-2a Unit 1 Level 2 Importance List Review (Based on Level 2 Results) (Pre-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
1RWST-FLAG	1.00E+00	1.031	FLAG FOR OPERATOR FAILING TO CROSSTIE RWST TO CST	Addressed in the Unit 1 Level 1 Importance List Review.
1DCH	2.70E-02	1.028	DIRECT CONTAINMENT HEATING PROBABILITY	The majority of the contributors including direct containment heating are high pressure core melt sequences with failure of the portable station generator to supply power for depressurization. If the RPV could be depressurized, the contribution of DCH would be reduced. SAMAs 5 and 6 provide means of addressing portable diesel generator failures. Alternatively, SAMA 1 would mitigate these scenarios by providing a high pressure injection source.
%1NONISO	8.94E-01	1.027	TRIP W/O MSIV CLOSURE	Addressed in the Unit 1 Level 1 Importance List Review.
024DGS0G501D	2.40E-02	1.026	DIESEL GENERATOR 'D' 0G501D D.G. FAIL AFTER FIRST HOUR FAILS TO START	Addressed in the Unit 1 Level 1 enlist Review.
RCVSEQ1TR-2-023B	1.00E+00	1.025	SEQUENCE FLAG FOR 1TR-2-023B	This sequence is dominated by battery failures that could be mitigated by installing 100% battery chargers and ensuring that the DC system can operate without the batteries (SAMA 4). In order to mitigate battery failures concurrent with LOOP events, changes would also be required to ensure the EDGs could be started without DC power.

Table E.5-2a Unit 1 Level 2 Importance List Review (Based on Level 2 Results) (Pre-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
024-II-B-DSL-H	2.30E-03	1.025	DGB FAILS DUE TO HUMAN ERROR IN MAINTENANCE	A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Alternatively, the ability to cross-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed (SAMA 2).
RCVSEQ1TR-7-013	1.00E+00	1.025	SEQUENCE FLAG FOR 1TR-7-013	This sequence is dominated by EDG "A" and "B" failures in combination with failures of the portable station EDG. A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Alternatively, the ability to cross-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed (SAMA 2).
024-I-A-DSL-H	2.30E-03	1.024	DGA FAILS DUE TO HUMAN ERROR IN MAINTENANCE	A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Alternatively, the ability to cross-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed (SAMA 2).
SWITCHYARDCENTERED	7.87E-03	1.023	LOOP DUE TO SWITCHYARD	Addressed in the Unit 1 Level 1 Importance List

Table E.5-2a Unit 1 Level 2 Importance List Review (Based on Level 2 Results) (Pre-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
			CENTERED FAILURES	Review.
RCVLOOPGR11	3.20E-02	1.022	PROBABILITY OF NONRECOVERY FROM A GRID RELATED LOOP IN 11 HOURS	About 80% of the cutsets including this recovery are related to the failure to provide injection due to the dependence of RHR pump cooling on non-divisionalized ESW flow. This is addressed in the Unit 1 Level 1 importance list by event 151-N-N-F005-O. The remaining contributors in this release category mostly include cutsets with failure of all 4kV AC EDGs to operate (portable station generator is available), which could be mitigated by SAMA 3.
024DGS0G501E	2.40E-02	1.022	DIESEL GENERATOR 'E' 0G501E FAILS TO START	As with the maintenance event for this EDG in the Level 1 list, a diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Alternatively, the ability to cross-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed (SAMA 2).

Table E.5-2a Unit 1 Level 2 Importance List Review (Based on Level 2 Results) (Pre-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
Z-EARLY-RWST-O	1.08E-02	1.021	JHEP OPERATOR FAILS TO ALIGN FIRE MAIN OR RHRSW AND XTIE RWST	Over 50% of the contributors requiring these operator actions result in the need for alternate low pressure injection because the RHR pumps are unavailable to provide SPC for HPCI operation or ECCS injection. This is due to the non-divisionalized nature of the RHR pump cooling alignment with ESW. SAMA 7 addresses this issue. Many of the remaining cutsets include loss of long term DC through portable station generator and EDG failures. These scenarios are addressed by SAMAs 1 and 2.

Table E.5-2b Unit 2 Level 2 Importance List Review (Based on Level 2 Results) (Pre-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
2LEVEL2-FLAG	1.00E+00	1.09E+07	FLAG FOR UNIT 2 LEVEL 2	N/A - This flag marks all sequences for the Unit 1 Level 2 model and does not provide any risk based insights. No SAMAs suggested.
LOOP-FLAG	1.00E+00	5.836	FLAG TO BE USED FOR ANY CONDITIONAL OR NON CONDITIONAL LOOP	Addressed in the Unit 1 Level 2 Importance List Review.
%LOOP-FLAG	1.00E+00	4.911	LOOP FLAG FOR INITIATING EVENT	Addressed in the Unit 1 Level 2 Importance List Review.
2MI-FLAG	1.00E+00	2.243	FALAG FOR 2MI	Addressed in the Unit 1 Level 2 Importance List Review.
RCVREL-2MI	1.00E+00	2.243	FLAG FOR MEDIMUM INTERMEDIATE RELEASE	Addressed in the Unit 1 Level 2 Importance List Review.
RCVSEQ2TR-7-010A	1.00E+00	2.159	SEQUENCE FLAG FOR 2TR-7-010A	Addressed in the Unit 1 Level 2 Importance List Review.
EXTSEVWEATHER	2.32E-03	2.034	LOSS OF OFF SITE POWER DUE TO EXTREMELY SEVERE WEATHER	Addressed in the Unit 1 Level 2 Importance List Review.
RCVLOOPEW9.2	9.57E-01	1.718	PROBABILITY OF NONRECOVERY FROM A EXTREME WEATHER RELATED LOOP IN 9.2 HOURS	Addressed in the Unit 1 Level 2 Importance List Review.
002-N-N-BMS-FLAG	1.00E+00	1.652		Addressed in the Unit 1 Level 2 Importance List Review.

Table E.5-2b Unit 2 Level 2 Importance List Review (Based on Level 2 Results) (Pre-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
024-N-E-DSL-P	3.29E-01	1.555	PREVENTATIVE MAINTENANCE 0.328542094	Addressed in the Unit 1 Level 2 Importance List Review.
024DGS0G501B	2.40E-02	1.400	DIESEL GENERATOR 'B' 0G501B D.G. FAIL WITHIN THE FIRST HOUR	Addressed in the Unit 1 Level 2 Importance List Review.
024DGS0G501A	2.40E-02	1.400	DIESEL GENERATOR 'A' 0G501A DIESEL GENERATOR FAILS TO START	Addressed in the Unit 1 Level 2 Importance List Review.
Z-BMAX-EDG-O	1.63E-02	1.299	DEPENDENT HEP FOR BLUE MAX AND E DG	Addressed in the Unit 1 Level 2 Importance List Review.
024DGR0G501B	1.57E-02	1.226	DIESEL GENERATOR 'B' 0G501B D.G. FAIL AFTER FIRST HOUR FAILS TO OPERATE	
2HE-FLAG	1.00E+00	1.226	FLAG FOR 2HE	Addressed in the Unit 1 Level 2 Importance List Review.
RCVREL-2HE	1.00E+00	1.226	FLAG FOR HIGH EARLY RELEASE	Addressed in the Unit 1 Level 2 Importance List Review.
024DGR0G501A	1.57E-02	1.226	DIESEL GENERATOR 'A' 0G501A D.G. FAIL AFTER FIRST HOUR FAILS TO OPERATE	Addressed in the Unit 1 Level 2 Importance List Review.
002DGS0G503	2.40E-02	1.223	STATION PORTABLE DIESEL GEN - BLUE MAX 0G503 DIESEL GENERATOR FAILS TO START	Addressed in the Unit 1 Level 2 Importance List Review.

Table E.5-2b Unit 2 Level 2 Importance List Review (Based on Level 2 Results) (Pre-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
002-N-N-BMS-O	2.93E-02	1.209	OPERATOR ERROR FOR ALIGNING THE STATION PORTABLE DIESEL GENERATOR	
GRIDCENTERED	1.38E-02	1.209	LOSS OF OFF SITE POWER DUE TO GRID FAILURE	Addressed in the Unit 1 Level 2 Importance List Review.
RCVLOOPGR9.2	5.11E-02	1.190	PROBABILITY OF NONRECOVERY FROM A GRID RELATED LOOP IN 9.2 HOURS	Addressed in the Unit 1 Level 2 Importance List Review.
2HI-FLAG	1.00E+00	1.163	FLAG FOR 2HI	Addressed in the Unit 1 Level 2 Importance List Review.
RCVREL-2HI	1.00E+00	1.163	FLAG FOR HIGH INTERMEDIATE RELEASE	Addressed in the Unit 1 Level 2 Importance List Review.
RCVSEQ2TR-7-010B	1.00E+00	1.154	SEQUENCE FLAG FOR 2TR-7-010B	Addressed in the Unit 1 Level 2 Importance List Review.
2ML-FLAG	1.00E+00	1.139	FLAG FOR 2ML	Addressed in the Unit 1 Level 2 Importance List Review.
RCVREL-2ML	1.00E+00	1.139	FLAG FOR MEDIMUM LATE RELEASE	Addressed in the Unit 1 Level 2 Importance List Review.
002DGR0G503	1.57E-02	1.133	STATION PORTABLE DIESEL GEN - BLUE MAX 0G503 DIESEL GENERATOR FAILS TO OPERATE	Addressed in the Unit 1 Level 2 Importance List Review.
%2ISLOCA_RHR_S	1.02E-07	1.123	INTERFACING SYSTEM LOCA FOR RHR PUMP SUCTION (F008-F009) BREAK	Addressed in the Unit 1 Level 2 Importance List Review.

Table E.5-2b Unit 2 Level 2 Importance List Review (Based on Level 2 Results) (Pre-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
RCVSEQ2IS-2-001	1.00E+00	1.123	SEQUENCE FLAG FOR 2IS-2-001	Addressed in the Unit 1 Level 2 Importance List Review.
RCVSEQ2TR-8-032	1.00E+00	1.114	SEQUENCE FLAG FOR 2TR-8-032	Addressed in the Unit 1 Level 2 Importance List Review.
SEVEREWEATHER	2.87E-03	1.102	LOSS OF OFF SITE POWER DUE TO SEVERE WEATHER	Addressed in the Unit 1 Level 2 Importance List Review.
251-N-N-F005-O	1.00E+00	1.092	OPERATOR FAILS TO OPEN HV252F005A/B MANUALLY	Addressed in the Unit 1 Level 2 Importance List Review.
RCVLOOPSW9.2	1.41E-01	1.083	PROBABILITY OF NONRECOVERY FROM A SEVERE WEATHER RELATED LOOP IN 9.2 HOURS	Addressed in the Unit 1 Level 2 Importance List Review.
024-N-N-DGE-O	1.15E-01	1.081	OPERATOR FAILS TO ALIGN	Addressed in the Unit 1 Level 2 Importance List Review.
RCVLOOPEW11	9.45E-01	1.075	PROBABILITY OF NONRECOVERY FROM A EXTREME WEATHER RELATED LOOP IN 11 HOURS	Addressed in the Unit 1 Level 2 Importance List Review.
024-II-B-DSL-P	7.13E-03	1.075	PREVENTATIVE MAINTENANCE 7.13E-03	Addressed in the Unit 1 Level 2 Importance List Review.
024-I-A-DSL-P	7.13E-03	1.075	PREVENTATIVE MAINTENANCE 7.13E-03	Addressed in the Unit 1 Level 2 Importance List Review.
CCFDG2DGS_12	1.85E-04	1.071	CCF 2 OF 4 EDGs (A, B) TO START AND RUN (8)	Addressed in the Unit 1 Level 2 Importance List Review.
CCFDG3DGS_123	9.39E-05	1.062	CCF 3 OF 4 EDGs (A, B, C) TO	Addressed in the Unit 1 Level 2 Importance List

Table E.5-2b Unit 2 Level 2 Importance List Review (Based on Level 2 Results) (Pre-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
			START AND RUN (8)	Review.
CCFDG3DGS_124	9.39E-05	1.060	CCF 3 OF 4 EDGs (A, B, D) TO START AND RUN (8)	Addressed in the Unit 1 Level 2 Importance List Review.
RCVSBOWEDG	1.00E+00	1.057	STATION BLACKOUT WITH E DG	Addressed in the Unit 1 Level 2 Importance List Review.
CCFDE3DGS_5	4.45E-01	1.050	CCF DG E W/ FAILURE OF 3 OF 4 OTHER DGS (11)	Addressed in the Unit 1 Level 2 Importance List Review.
013-N-N-EARLY-O	7.50E-02	1.045	OPERATOR FAILS TO TIE IN FIRE MAIN OR RHRSW FOR EARLY SEQUENCES 1 HOUR	Addressed in the Unit 1 Level 2 Importance List Review.
CCFDG4DGS_ALL	7.41E-05	1.036	CCF 4 OF 4 DGs FAIL TO START AND RUN (8)	Addressed in the Unit 1 Level 2 Importance List Review.
250PTS2P203	2.00E-02	1.034	2P203 TURBINE-DRIVEN PUMP STAND-BY FAILS TO START	Addressed in the Unit 1 Level 2 Importance List Review.
CCFDE2DGS_5	3.84E-01	1.032	CCF DG E W/ FAILURE OF 2 OF 4 OTHER DGS (11)	Addressed in the Unit 1 Level 2 Importance List Review.
2RWST-FLAG	1.00E+00	1.031	FLAG FOR OPERATOR FAILING TO CROSSTIE RWST TO CST	Addressed in the Unit 1 Level 2 Importance List Review.
COND-LOOP-TRANS	2.40E-03	1.031	CONDITIONAL LOOP PROBABILITY GIVEN TRANSIENT	Addressed in the Unit 1 Level 2 Importance List Review.
2DCH	2.70E-02	1.029	DIRECT CONTAINMENT HEATING PROBABILITY	Addressed in the Unit 1 Level 2 Importance List Review.

Table E.5-2b Unit 2 Level 2 Importance List Review (Based on Level 2 Results) (Pre-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
%2NONISO	8.94E-01	1.027	UNIT 2 TRIP W/O MSIV CLOSURE 2	Addressed in the Unit 1 Level 2 Importance List Review.
RCVSEQ2TR-7-013	1.00E+00	1.025	SEQUENCE FLAG FOR 2TR-7-013	Addressed in the Unit 1 Level 2 Importance List Review.
024-II-B-DSL-H	2.30E-03	1.025	DGB FAILS DUE TO HUMAN ERROR IN MAINTENANCE	Addressed in the Unit 1 Level 2 Importance List Review.
024-I-A-DSL-H	2.30E-03	1.025	DGA FAILS DUE TO HUMAN ERROR IN MAINTENANCE	Addressed in the Unit 1 Level 2 Importance List Review.
024DGS0G501D	2.40E-02	1.023	DIESEL GENERATOR 'D' 0G501D D.G. FAIL AFTER FIRST HOUR FAILS TO START	Addressed in the Unit 1 Level 2 Importance List Review.
024DGS0G501E	2.40E-02	1.023	DIESEL GENERATOR 'E' 0G501E FAILS TO START	Addressed in the Unit 1 Level 2 Importance List Review.
SWITCHYARDCENTERED	7.87E-03	1.022	LOOP DUE TO SWITCHYARD CENTERED FAILURES	Addressed in the Unit 1 Level 2 Importance List Review.
Z-EARLY-RWST-O	1.08E-02	1.021	JHEP OPERATOR FAILS TO ALIGN FIRE MAIN OR RHRSW AND XTIE RWST	Addressed in the Unit 1 Level 2 Importance List Review.

Table E.5-2b Unit 2 Level 2 Importance List Review (Based on Level 2 Results) (Pre-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
RCVSEQ2LT-7-001	1.00E+00	1.020	SEQUENCE FLAG FOR 2LT-7-001	This sequence corresponds to LOCA events combined with the SP to DW vacuum breakers failed open such that vapor suppression is failed. Depressurizing the RPV before the containment can overpressurize is a means of mitigating this accident; however, the time available to prevent containment failure is short. Decreasing the response time of the ADS system is not suggested as it may result in premature blowdowns in circumstances when emergency depressurization is not desired. Operators are trained to deal with these scenarios and existing procedures guide them toward depressurization as soon as is practical. No credible means of providing a method of ensuring depressurization before containment failure has been identified. An alternate method of preventing drywell failure could be to install a passive vent path that is forced through a pool of water (SAMA 13). Including a vent path below the SP water line is not suggested as it introduced an additional drain path in the pool.
RCVLOOPGR11	3.20E-02	1.020	PROBABILITY OF NONRECOVERY FROM A GRID RELATED LOOP IN 11 HOURS	Addressed in the Unit 1 Level 2 Importance List Review.

Table E.5-2c Unit 1 Level 2 Importance List Review (Based on Level 2 Results) (Post-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
1LEVEL2-FLAG	1.00E+00	9.53E+06	FLAG FOR UNIT 1 LEVEL 2	N/A - This flag marks all sequences for the Unit 1 Level 2 model and does not provide any risk based insights. No SAMAs suggested.
LOOP-FLAG	1.00E+00	6.253	FLAG TO BE USED FOR ANY CONDITIONAL OR NON CONDITIONAL LOOP	Addressed in the Unit 1 Level 1 Importance List Review
%LOOP-FLAG	1.00E+00	5.093	LOOP FLAG FOR INITIATING EVENT	Addressed in the Unit 1 Level 1 Importance List Review
1MI-FLAG	1.00E+00	2.114	FLAG FOR UNIT 1 MEDIUM INTERMEDIATE RELEASE	The M/I release category is primarily comprised of LOOP events with EDGs A, B, and E failed combined with the failure of the station portable diesel generator. A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Alternatively, the ability to cross-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed (SAMA 2). In addition, this release category contains sequences that include containment failure after core damage when venting is not credited. Clarifying the procedures to direct wetwell venting to protect the containment is assumed to improve the reliability of venting after core damage (SAMA 12). While this modeling strategy is not limited to sequences binned into the M/I release category, this release category has been used to identify the issue for the SSES model.

Table E.5-2c Unit 1 Level 2 Importance List Review (Based on Level 2 Results) (Post-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
RCVREL-1MI	1.00E+00	2.114	FLAG FOR MEDIMUM INTERMEDIATE RELEASE	The M/I release category is primarily comprised of LOOP events with EDGs A, B, and E failed combined with the failure of the station portable diesel generator. A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Alternatively, the ability to cross-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed (SAMA 2). In addition, this release category contains sequences that include containment failure after core damage when venting is not credited. Clarifying the procedures to direct wetwell venting to protect the containment is assumed to improve the reliability of venting after core damage (SAMA 12). While this modeling strategy is not limited to sequences binned into the M/I release category, this release category has been used to identify the issue for the SSES model.
RCVSEQ1TR-7-010A	1.00E+00	2.074	SEQUENCE FLAG FOR 1TR-7-010A	Addressed in the Unit 1 Level 1 Importance List Review
EXTSEVWEATHER	2.32E-03	1.937	LOSS OF OFF SITE POWER DUE TO EXTREMELY SEVERE WEATHER	Addressed in the Unit 1 Level 1 Importance List Review

Table E.5-2c Unit 1 Level 2 Importance List Review (Based on Level 2 Results) (Post-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
RCVLOOPEW8.5	9.61E-01	1.614	PROBABILITY OF NONRECOVERY FROM A EXTREME WEATHER RELATED LOOP IN 8.5 HOURS	The cutsets that include RCVLOOPEW8.5 are dominated by the M/I release category, which is primarily comprised of LOOP events with EDGs A, B, and E failed combined with the failure of the station portable diesel generator. A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Alternatively, the ability to cross-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed (SAMA 2).
002-N-N-BMS-FLAG	1.00E+00	1.610		Addressed in the Unit 1 Level 1 Importance List Review
024-N-E-DSL-P	3.29E-01	1.514	PREVENTATIVE MAINTENANCE 0.328542094	Addressed in the Unit 1 Level 1 Importance List Review
024DGS0G501B	2.40E-02	1.404	DIESEL GENERATOR 'B' 0G501B D.G. FAIL WITHIN THE FIRST HOUR	Addressed in the Unit 1 Level 1 Importance List Review
024DGS0G501A	2.40E-02	1.380	DIESEL GENERATOR 'A' 0G501A DIESEL GENERATOR FAILS TO START	Addressed in the Unit 1 Level 1 Importance List Review
Z-BMAX-EDG-O	1.63E-02	1.280	DEPENDENT HEP FOR BLUE MAX AND E DG	Addressed in the Unit 1 Level 1 Importance List Review
GRIDCENTERED	1.38E-02	1.248	LOSS OF OFF SITE POWER DUE TO GRID FAILURE	Addressed in the Unit 1 Level 1 Importance List Review

Table E.5-2c Unit 1 Level 2 Importance List Review (Based on Level 2 Results) (Post-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
024DGR0G501B	1.57E-02	1.228	DIESEL GENERATOR 'B' 0G501B D.G. FAIL AFTER FIRST HOUR FAILS TO OPERATE	Addressed in the Unit 1 Level 1 Importance List Review
024DGR0G501A	1.57E-02	1.216	DIESEL GENERATOR 'A' 0G501A D.G. FAIL AFTER FIRST HOUR FAILS TO OPERATE	Addressed in the Unit 1 Level 1 Importance List Review
002DGS0G503	2.40E-02	1.214	STATION PORTABLE DIESEL GEN - BLUE MAX 0G503 DIESEL GENERATOR FAILS TO START	Addressed in the Unit 1 Level 1 Importance List Review
RCVLOOPGR8.5	6.16E-02	1.210	PROBABILITY OF NONRECOVERY FROM A GRID RELATED LOOP IN 8.5 HOURS	The cutsets that include RCVLOOPEW8.5 are dominated by the M/I release category, which is primarily comprised of LOOP events with EDGs A, B, and E failed combined with the failure of the station portable diesel generator. A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Alternatively, the ability to cross-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed (SAMA 2).
002-N-N-BMS-O	2.93E-02	1.203	OPERATOR ERROR FOR ALIGNING THE STATION PORTABLE DIESEL GENERATOR	Addressed in the Unit 1 Level 1 Importance List Review

Table E.5-2c Unit 1 Level 2 Importance List Review (Based on Level 2 Results) (Post-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
1HE-FLAG	1.00E+00	1.202	FLAG FOR HIGH EARLY RELEASE	About 70% of the HE release category contributors are ISLOCA events, which are addressed by SAMA 11. Most of the remaining contributors are LOCA events that would also be mitigated by the high pressure core spray system.
RCVREL-1HE	1.00E+00	1.202	FLAG FOR HIGH EARLY RELEASE	About 70% of the HE release category contributors are ISLOCA events, which are addressed by SAMA 11. Most of the remaining contributors are LOCA events that would also be mitigated by the high pressure core spray system.
1HI-FLAG	1.00E+00	1.185	FLAG FOR UNIT 1 HIGH INTERMEDIATE RELEASE	The H/I release category includes many different contributors. LOOP initiating events, however, are responsible for about 95 percent of the release category's frequency, much of which includes failure of the station portable diesel generator. Potential SAMAs that could reduce the H/I frequency include SAMAs 1, 5, 6, and 2.
RCVREL-1HI	1.00E+00	1.185	FLAG FOR HIGH INTERMEDIATE RELEASE	The H/I release category includes many different contributors. LOOP initiating events, however, are responsible for about 95 percent of the release category's frequency, much of which includes failure of the station portable diesel generator. Potential SAMAs that could reduce the H/I frequency include SAMAs 1, 5, 6, and 2.

Table E.5-2c Unit 1 Level 2 Importance List Review (Based on Level 2 Results) (Post-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
1ML-FLAG	1.00E+00	1.173	FLAG FOR UNIT 1 MEDIUM LATE RELEASE	Over 60% of the M/L release category is related to the failure to provide injection dud to the dependence of RHR pump cooling on non-divisionalized ESW flow. This is addressed in the Unit 1 Level 1 importance list by event 151-N-N-F005-O. The remaining contributors in this release category include a mixture of sequences including 4kV AC EDG failures that could be addressed by SAMA 3 and other low contribution, initiating events.
RCVREL-1ML	1.00E+00	1.173	FLAG FOR MEDIMUM LATE RELEASE	Over 60% of the M/L release category is related to the failure to provide injection dud to the dependence of RHR pump cooling on non-divisionalized ESW flow. This is addressed in the Unit 1 Level 1 importance list by event 151-N-N-F005-O. The remaining contributors in this release category include a mixture of sequences including 4kV AC EDG failures that could be addressed by SAMA 3 and other low contribution, initiating events.
RCVSEQ1TR-7-010B	1.00E+00	1.148	SEQUENCE FLAG FOR 1TR-7-010B	All of the RCVSEQ1TR-7-010B sequences belong to the H/I release category. All of these sequences include failure of the station portable diesel generator. Potential SAMAs that could reduce the H/I frequency include SAMAs 1, 5, 6, and 2.

Table E.5-2c Unit 1 Level 2 Importance List Review (Based on Level 2 Results) (Post-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
RCVSEQ1TR-8-032	1.00E+00	1.144	SEQUENCE FLAG FOR 1TR-8-032	This sequence is completely comprised of M/L contributors. About 80% of the contributors to this sequence are related to the failure to provide injection due to the dependence of RHR pump cooling on non-divisionalized ESW flow. This is addressed in the Unit 1 Level 1 importance list by event 151-N-N-F005-O. The remaining contributors in this release category include cutsets with failure of all on-site 4kV AC power to operate (portable station generator is available), which could be mitigated by SAMA 3.
002DGR0G503	1.57E-02	1.129	STATION PORTABLE DIESEL GEN - BLUE MAX 0G503 DIESEL GENERATOR FAILS TO OPERATE	Addressed in the Unit 1 Level 1 Importance List Review
%1ISLOCA_RHR_S	1.02E-07	1.111	INTERFACING SYSTEM LOCA FOR RHR PUMP SUCTION (F008-F009) BREAK	Addressed in the Unit 1 Level 1 Importance List Review
RCVSEQ1IS-2-001	1.00E+00	1.111	SEQUENCE FLAG FOR 1IS-2-001	Addressed in the Unit 1 Level 1 Importance List Review
151-N-N-F005-O	1.00E+00	1.105	OPERATOR FAILS TO OPEN HV152F005A/B MANUALLY	Addressed in the Unit 1 Level 1 Importance List Review
RCVSBOWEDG	1.00E+00	1.104	STATION BLACKOUT WITH E DG	Addressed in the Unit 1 Level 1 Importance List Review
SEVEREWEATHER	2.87E-03	1.103	LOSS OF OFF SITE POWER DUE TO SEVERE WEATHER	Addressed in the Unit 1 Level 1 Importance List Review

Table E.5-2c Unit 1 Level 2 Importance List Review (Based on Level 2 Results) (Post-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
RCVLOOPEW10	9.52E-01	1.088	PROBABILITY OF NONRECOVERY FROM A EXTREME WEATHER RELATED LOOP IN 10 HOURS	This sequence is completely comprised of M/L contributors. About 80% of the contributors to this sequence are related to the failure to provide injection due to the dependence of RHR pump cooling on non-divisionalized ESW flow. This is addressed in the Unit 1 Level 1 importance list by event 151-N-N-F005-O. The remaining contributors in this release category include cutsets with failure of all on-site 4kV AC power to operate (portable station generator is available), which could be mitigated by SAMA 3.
RCVLOOPSW8.5	1.51E-01	1.080	PROBABILITY OF NONRECOVERY FROM A SEVERE WEATHER RELATED LOOP IN 8.5 HOURS	All of the cutsets containing this recovery event include the failure of the station portable diesel generator in conjunction with 4kV EDG failures. Potential SAMAs that could reduce the frequency of these cutsets include SAMAs 1, 5, 6, and 2.
024-N-N-DGE-O	1.15E-01	1.077	OPERATOR FAILS TO ALIGN	Addressed in the Unit 1 Level 1 Importance List Review
024-II-B-DSL-P	7.13E-03	1.076	PREVENTATIVE MAINTENANCE 7.13E-03	Addressed in the Unit 1 Level 1 Importance List Review
024-I-A-DSL-P	7.13E-03	1.072	PREVENTATIVE MAINTENANCE 7.13E-03	Addressed in the Unit 1 Level 1 Importance List Review
CCFDG2DGS_12	1.85E-04	1.069	CCF 2 OF 4 EDGs (A, B) TO START AND RUN (8)	Addressed in the Unit 1 Level 1 Importance List Review
CCFDG3DGS_123	9.39E-05	1.063	CCF 3 OF 4 EDGs (A, B, C) TO START AND RUN (8)	Addressed in the Unit 1 Level 1 Importance List Review
CCFDG3DGS_124	9.39E-05	1.061	CCF 3 OF 4 EDGs (A, B, D) TO START AND RUN (8)	Addressed in the Unit 1 Level 1 Importance List Review

Table E.5-2c Unit 1 Level 2 Importance List Review (Based on Level 2 Results) (Post-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
CCFDE3DGS_5	4.45E-01	1.051	CCF DG E W/ FAILURE OF 3 OF 4 OTHER DGS (11)	Addressed in the Unit 1 Level 1 Importance List Review
013-N-N-EARLY-O	7.50E-02	1.044	OPERATOR FAILS TO TIE IN FIRE MAIN OR RHRSW FOR EARLY SEQUENCES 1 HOUR	The reliability of injection with the fire main could be improved by installing a permanent connection to the RHR system. The hard pipe connection would reduce the alignment time, improve man machine interface, and increase the injection flow rate (SAMA 14).
102BTS1D610	5.00E-04	1.037	125VDC BATTERY BANK A FAILS TO START	Addressed in the Unit 1 Level 1 Importance List Review
CCFDG4DGS_ALL	7.41E-05	1.037	CCF 4 OF 4 DGs FAIL TO START AND RUN (8)	Addressed in the Unit 1 Level 1 Importance List Review
COND-LOOP-TRANS	2.40E-03	1.035	CONDITIONAL LOOP PROBABILITY GIVEN TRANSIENT	Addressed in the Unit 1 Level 1 Importance List Review
150PTS1P203	2.00E-02	1.034	1P203 TURBINE-DRIVEN PUMP STAND-BY FAILS TO START	Addressed in the Unit 1 Level 1 Importance List Review
CCFDE2DGS_5	3.84E-01	1.031	CCF DG E W/ FAILURE OF 2 OF 4 OTHER DGS (11)	Addressed in the Unit 1 Level 1 Importance List Review
%1NONISO	8.94E-01	1.031	TRIP W/O MSIV CLOSURE	Addressed in the Unit 1 Level 1 Importance List Review
1RWST-FLAG	1.00E+00	1.031	FLAG FOR OPERATOR FAILING TO XTIE RWST	Addressed in the Unit 1 Level 1 Importance List Review

Table E.5-2c Unit 1 Level 2 Importance List Review (Based on Level 2 Results) (Post-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
RCVLOOPGR10	4.14E-02	1.029	PROBABILITY OF NONRECOVERY FROM A GRID RELATED LOOP IN 10 HOURS	This sequence is completely comprised of M/L contributors. About 80% of the contributors to this sequence are related to the failure to provide injection due to the dependence of RHR pump cooling on non-divisionalized ESW flow. This is addressed in the Unit 1 Level 1 importance list by event 151-N-N-F005-O. The remaining contributors in this release category include cutsets with failure of all on-site 4kV AC power to operate (portable station generator is available), which could be mitigated by SAMA 3.
SWITCHYARDCENTERED	7.87E-03	1.027	LOOP DUE TO SWITCHYARD CENTERED FAILURES	Addressed in the Unit 1 Level 1 Importance List Review
RCVSEQ1TR-2-023B	1.00E+00	1.027	SEQUENCE FLAG FOR 1TR-2-023B	This sequence is dominated (over 80%) by battery failures that could be mitigated by installing 100% battery chargers and ensuring that the DC system can operate without the batteries (SAMA 4). In order to mitigate battery failures concurrent with LOOP events, changes would also be required to ensure the EDGs could be started without DC power.
1DCH	2.70E-02	1.027	DIRECT CONTAINMENT HEATING PROBABILITY	The majority of the contributors including direct containment heating are high pressure core melt sequences with failure of the portable station generator to supply power for depressurization. If the RPV could be depressurized, the contribution of DCH would be reduced. SAMAs 5 and 6 provide means of addressing portable diesel generator failures. Alternatively, SAMA 1 would mitigate these scenarios by providing a high pressure injection source.

Table E.5-2c Unit 1 Level 2 Importance List Review (Based on Level 2 Results) (Post-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
024DGS0G501D	2.40E-02	1.027	DIESEL GENERATOR 'D' 0G501D D.G. FAIL AFTER FIRST HOUR FAILS TO START	Addressed in the Unit 1 Level 1 Importance List Review
150-152RXLEVELCTRL-FLAG	1.00E+00	1.025	FLAG FOR OPERATOR FAILURE TO CONTROL LEVEL	This cutsets including this event are dominated by loss of HPI due to support system failures and subsequent Core Spray injection alignment difficulties. For example, in these cases, loss of off-site AC power and specific EDG failures result in the loss of "D" RHR due to the Division I ESW cooling dependence for lube oil cooling (ESW pumps A and C cool RHR pump D). The core spray injection valve cannot be opened remotely because it is powered by the "B" EDG, which has failed. A potential means of mitigating these types of accidents is to change RHR pump cooling such that the "B" and "D" ESW pumps provide cooling flow to the "B" and "D" RHR pumps (SAMA 7). This issue could also be addressed through the use of an AC cross-tie (SAMA 2).
024-II-B-DSL-H	2.30E-03	1.025	DGB FAILS DUE TO HUMAN ERROR IN MAINTENANCE	A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Alternatively, the ability to cross-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed (SAMA 2).

Table E.5-2c Unit 1 Level 2 Importance List Review (Based on Level 2 Results) (Post-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
024-I-A-DSL-H	2.30E-03	1.024	DGA FAILS DUE TO HUMAN ERROR IN MAINTENANCE	A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Alternatively, the ability to cross-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed (SAMA 2).
RCVSEQ1TR-7-013	1.00E+00	1.024	SEQUENCE FLAG FOR 1TR-7-013	This sequence is dominated by LOOP with failure of HPI and ADS due to failures that result in loss of DC power. A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power (SAMA 1). Alternatively, the ability to cross-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed (SAMA 2).
024DGS0G501E	2.40E-02	1.022	DIESEL GENERATOR 'E' 0G501E FAILS TO START	Addressed in the Unit 2 Level 1 Importance List Review
150-152RXLEVELCTRL-O	1.50E-02	1.021	OPERATOR FAILS TO CONTROL REACTOR WATER LEVEL	This event is completely tied to flag 150-152RXLEVELCTRL-FLAG, which is addressed above.

Table E.5-2c Unit 1 Level 2 Importance List Review (Based on Level 2 Results) (Post-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
Z-EARLY-RWST-O	1.08E-02	1.021	JHEP OPERATOR FAILS TO ALIGN FIRE MAIN OR RHRSW AND XTIE RWST	Over 50% of the contributors requiring these operator actions result in the need for alternate low pressure injection because the RHR pumps are unavailable to provide SPC for HPCI operation or ECCS injection. This is due to the non-divisionalized nature of the RHR pump cooling alignment with ESW. SAMA 7 addresses this issue. Many of the remaining cutsets include loss of long term DC through portable station generator and EDG failures. These scenarios are addressed by SAMAs 1 and 2.

Table E.5-2d Unit 2 Level 2 Importance List Review (Based on Level 2 Results) (Post-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
2LEVEL2-FLAG	1.00E+00	9.68E+06	FLAG FOR UNIT 2 LEVEL 2	N/A - This flag marks all sequences for the Unit 1 Level 2 model and does not provide any risk based insights. No SAMAs suggested.
LOOP-FLAG	1.00E+00	6.199	FLAG TO BE USED FOR ANY CONDITIONAL OR NON CONDITIONAL LOOP	Addressed in the Unit 1 Level 1 Importance List Review
%LOOP-FLAG	1.00E+00	5.056	LOOP FLAG FOR INITIATING EVENT	Addressed in the Unit 1 Level 1 Importance List Review
2MI-FLAG	1.00E+00	2.245	FALAG FOR 2MI	Addressed in the Unit 1 Level 2 Importance List Review
RCVREL-2MI	1.00E+00	2.245	FLAG FOR MEDIMUM INTERMEDIATE RELEASE	Addressed in the Unit 1 Level 2 Importance List Review
RCVSEQ2TR-7-010A	1.00E+00	2.154	SEQUENCE FLAG FOR 2TR-7-010A	Addressed in the Unit 1 Level 1 Importance List Review
EXTSEVWEATHER	2.32E-03	1.942	LOSS OF OFF SITE POWER DUE TO EXTREMELY SEVERE WEATHER	Addressed in the Unit 1 Level 1 Importance List Review
002-N-N-BMS-FLAG	1.00E+00	1.649		Addressed in the Unit 1 Level 1 Importance List Review
RCVLOOPEW8.5	9.61E-01	1.649	PROBABILITY OF NONRECOVERY FROM A EXTREME WEATHER RELATED LOOP IN 8.5 HOURS	Addressed in the Unit 1 Level 2 Importance List Review

Table E.5-2d Unit 2 Level 2 Importance List Review (Based on Level 2 Results) (Post-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
024-N-E-DSL-P	3.29E-01	1.565	PREVENTATIVE MAINTENANCE 0.328542094	Addressed in the Unit 1 Level 1 Importance List Review
024DGS0G501B	2.40E-02	1.403	DIESEL GENERATOR 'B' 0G501B D.G. FAIL WITHIN THE FIRST HOUR	Addressed in the Unit 1 Level 1 Importance List Review
024DGS0G501A	2.40E-02	1.402	DIESEL GENERATOR 'A' 0G501A DIESEL GENERATOR FAILS TO START	Addressed in the Unit 1 Level 1 Importance List Review
Z-BMAX-EDG-O	1.63E-02	1.299	DEPENDENT HEP FOR BLUE MAX AND E DG	Addressed in the Unit 1 Level 1 Importance List Review
GRIDCENTERED	1.38E-02	1.245	LOSS OF OFF SITE POWER DUE TO GRID FAILURE	Addressed in the Unit 1 Level 1 Importance List Review
024DGR0G501B	1.57E-02	1.227	DIESEL GENERATOR 'B' 0G501B D.G. FAIL AFTER FIRST HOUR FAILS TO OPERATE	Addressed in the Unit 1 Level 1 Importance List Review
024DGR0G501A	1.57E-02	1.227	DIESEL GENERATOR 'A' 0G501A D.G. FAIL AFTER FIRST HOUR FAILS TO OPERATE	Addressed in the Unit 1 Level 1 Importance List Review
002DGS0G503	2.40E-02	1.222	STATION PORTABLE DIESEL GEN - BLUE MAX 0G503 DIESEL GENERATOR FAILS TO START	Addressed in the Unit 1 Level 1 Importance List Review

Table E.5-2d Unit 2 Level 2 Importance List Review (Based on Level 2 Results) (Post-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
RCVLOOPGR8.5	6.16E-02	1.220	PROBABILITY OF NONRECOVERY FROM A GRID RELATED LOOP IN 8.5 HOURS	Addressed in the Unit 1 Level 2 Importance List Review
2HE-FLAG	1.00E+00	1.210	FLAG FOR 2HE	Addressed in the Unit 1 Level 2 Importance List Review
RCVREL-2HE	1.00E+00	1.210	FLAG FOR HIGH EARLY RELEASE	Addressed in the Unit 1 Level 2 Importance List Review
002-N-N-BMS-O	2.93E-02	1.209	OPERATOR ERROR FOR ALIGNING THE STATION PORTABLE DIESEL GENERATOR	Addressed in the Unit 1 Level 1 Importance List Review
2HI-FLAG	1.00E+00	1.164	FLAG FOR 2HI	Addressed in the Unit 1 Level 2 Importance List Review
RCVREL-2HI	1.00E+00	1.164	FLAG FOR HIGH INTERMEDIATE RELEASE	Addressed in the Unit 1 Level 2 Importance List Review
RCVSEQ2TR-7-010B	1.00E+00	1.154	SEQUENCE FLAG FOR 2TR-7-010B	Addressed in the Unit 1 Level 2 Importance List Review
2ML-FLAG	1.00E+00	1.151	FLAG FOR 2ML	Addressed in the Unit 1 Level 2 Importance List Review
RCVREL-2ML	1.00E+00	1.151	FLAG FOR MEDIMUM LATE RELEASE	Addressed in the Unit 1 Level 2 Importance List Review
002DGR0G503	1.57E-02	1.133	STATION PORTABLE DIESEL GEN - BLUE MAX 0G503 DIESEL GENERATOR FAILS TO OPERATE	Addressed in the Unit 1 Level 1 Importance List Review

Table E.5-2d Unit 2 Level 2 Importance List Review (Based on Level 2 Results) (Post-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
RCVSEQ2TR-8-032	1.00E+00	1.126	SEQUENCE FLAG FOR 2TR-8-032	Addressed in the Unit 1 Level 2 Importance List Review
%2ISLOCA_RHR_S	1.02E-07	1.115	INTERFACING SYSTEM LOCA FOR RHR PUMP SUCTION (F008-F009) BREAK	Addressed in the Unit 1 Level 1 Importance List Review
RCVSEQ2IS-2-001	1.00E+00	1.115	SEQUENCE FLAG FOR 2IS-2-001	Addressed in the Unit 1 Level 1 Importance List Review
SEVEREWEATHER	2.87E-03	1.104	LOSS OF OFF SITE POWER DUE TO SEVERE WEATHER	Addressed in the Unit 1 Level 1 Importance List Review
251-N-N-F005-O	1.00E+00	1.101	OPERATOR FAILS TO OPEN HV252F005A/B MANUALLY	Addressed in the Unit 1 Level 1 Importance List Review
024-N-N-DGE-O	1.15E-01	1.083	OPERATOR FAILS TO ALIGN	Addressed in the Unit 1 Level 1 Importance List Review
RCVLOOPSW8.5	1.51E-01	1.083	PROBABILITY OF NONRECOVERY FROM A SEVERE WEATHER RELATED LOOP IN 8.5 HOURS	Addressed in the Unit 1 Level 2 Importance List Review
RCVLOOPEW10	9.52E-01	1.077	PROBABILITY OF NONRECOVERY FROM A EXTREME WEATHER RELATED LOOP IN 10 HOURS	Addressed in the Unit 1 Level 2 Importance List Review
024-II-B-DSL-P	7.13E-03	1.075	PREVENTATIVE MAINTENANCE 7.13E-03	Addressed in the Unit 1 Level 1 Importance List Review
024-I-A-DSL-P	7.13E-03	1.075	PREVENTATIVE MAINTENANCE 7.13E-03	Addressed in the Unit 1 Level 1 Importance List Review

Table E.5-2d Unit 2 Level 2 Importance List Review (Based on Level 2 Results) (Post-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
CCFDG2DGS_12	1.85E-04	1.071	CCF 2 OF 4 EDGs (A, B) TO START AND RUN (8)	Addressed in the Unit 1 Level 1 Importance List Review
CCFDG3DGS_123	9.39E-05	1.065	CCF 3 OF 4 EDGs (A, B, C) TO START AND RUN (8)	Addressed in the Unit 1 Level 1 Importance List Review
CCFDG3DGS_124	9.39E-05	1.063	CCF 3 OF 4 EDGs (A, B, D) TO START AND RUN (8)	Addressed in the Unit 1 Level 1 Importance List Review
RCVSBOWEDG	1.00E+00	1.060	STATION BLACKOUT WITH E DG	Addressed in the Unit 1 Level 1 Importance List Review
CCFDE3DGS_5	4.45E-01	1.053	CCF DG E W/ FAILURE OF 3 OF 4 OTHER DGS (11)	Addressed in the Unit 1 Level 1 Importance List Review
013-N-N-EARLY-O	7.50E-02	1.045	OPERATOR FAILS TO TIE IN FIRE MAIN OR RHRSW FOR EARLY SEQUENCES 1 HOUR	Addressed in the Unit 1 Level 2 Importance List Review
CCFDG4DGS_ALL	7.41E-05	1.038	CCF 4 OF 4 DGs FAIL TO START AND RUN (8)	Addressed in the Unit 1 Level 1 Importance List Review
COND-LOOP-TRANS	2.40E-03	1.035	CONDITIONAL LOOP PROBABILITY GIVEN TRANSIENT	Addressed in the Unit 1 Level 1 Importance List Review
250PTS2P203	2.00E-02	1.035	2P203 TURBINE-DRIVEN PUMP STAND-BY FAILS TO START	Addressed in the Unit 1 Level 1 Importance List Review
CCFDE2DGS_5	3.84E-01	1.032	CCF DG E W/ FAILURE OF 2 OF 4 OTHER DGS (11)	Addressed in the Unit 1 Level 1 Importance List Review
2RWST-FLAG	1.00E+00	1.031	FLAG FOR OPERATOR FAILS TO XTIE CST	Addressed in the Unit 1 Level 1 Importance List Review

Table E.5-2d Unit 2 Level 2 Importance List Review (Based on Level 2 Results) (Post-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
%2NONISO	8.94E-01	1.031	UNIT 2 TRIP W/O MSIV CLOSURE 2	Addressed in the Unit 1 Level 1 Importance List Review
2DCH	2.70E-02	1.028	DIRECT CONTAINMENT HEATING PROBABILITY	Addressed in the Unit 1 Level 2 Importance List Review
SWITCHYARDCENTERED	7.87E-03	1.026	LOOP DUE TO SWITCHYARD CENTERED FAILURES	Addressed in the Unit 1 Level 1 Importance List Review
RCVLOOPGR10	4.14E-02	1.026	PROBABILITY OF NONRECOVERY FROM A GRID RELATED LOOP IN 10 HOURS	Addressed in the Unit 1 Level 2 Importance List Review
250-252RXLEVELCTRL-FLAG	1.00E+00	1.026	FLAG FOR OPERATOR FAILURE TO CONTROL LEVEL	Addressed in the Unit 1 Level 2 Importance List Review
024-II-B-DSL-H	2.30E-03	1.025	DGB FAILS DUE TO HUMAN ERROR IN MAINTENANCE	Addressed in the Unit 1 Level 2 Importance List Review
024-I-A-DSL-H	2.30E-03	1.025	DGA FAILS DUE TO HUMAN ERROR IN MAINTENANCE	Addressed in the Unit 1 Level 2 Importance List Review
RCVSEQ2TR-7-013	1.00E+00	1.025	SEQUENCE FLAG FOR 2TR-7-013	Addressed in the Unit 1 Level 2 Importance List Review
024DGS0G501D	2.40E-02	1.024	DIESEL GENERATOR 'D' 0G501D D.G. FAIL AFTER FIRST HOUR FAILS TO START	Addressed in the Unit 1 Level 1 Importance List Review
024DGS0G501E	2.40E-02	1.023	DIESEL GENERATOR 'E' 0G501E FAILS TO START	Addressed in the Unit 2 Level 1 Importance List Review
250-252RXLEVELCTRL-O	1.50E-02	1.022	OPERATOR FAILS TO CONTROL REACTOR WATER LEVEL	Addressed in the Unit 1 Level 2 Importance List Review

Table E.5-2d Unit 2 Level 2 Importance List Review (Based on Level 2 Results) (Post-EPU)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
Z-EARLY-RWST-O	1.08E-02	1.021	JHEP OPERATOR FAILS TO ALIGN FIRE MAIN OR RHRSW AND XTIE RWST	Addressed in the Unit 1 Level 2 Importance List Review

Table E.5-3 Phase 1 SAMA

SAMA NUMBER	SAMA TITLE	SAMA DESCRIPTION	SOURCE	Cost Estimate	Pre-EPU Phase 1 Baseline Disposition	Post-EPU Phase 1 Baseline Disposition
1	Diesel Driven High Pressure Injection Pump	SBO sequences at SSES result in core damage even with the availability of the low pressure diesel driven fire pump due to unavailability of the SRVs in long term accidents. Given the existence of an alternate 4kV AC diesel generator and a portable 480V AC generator, additional AC power assets are not likely to provide a large benefit due to hardware and human dependence issues. The installation of a diesel driven, high pressure injection pump with a long term, cold, injection source could prolong the time to core damage. This would allow additional time for off-site AC power recovery. While some benefit would be gained even if this pump required DC power for success, the ability to operate the pump without DC support would enhance the benefit of this change.	SSES Level 1 Importance List (pre-EPU, post-EPU), IPEEE Fire Review	The cost of implementation for this SAMA was estimated to be $2,798,000 by PPL (PPL 2006c).	While the cost of this SAMA exceeds the SSES Pre-EPU MMACR, it has been retained for Phase 2 analysis in order to demonstrate the large potential risk reduction that is available through implementation of a SAMA of this type.	While the cost of this SAMA exceeds the SSES Post-EPU MMACR, it has been retained for Phase 2 analysis in order to demonstrate the large potential risk reduction that is available through implementation of a SAMA of this type.
2a	Improve Cross-Tie Capability Between 4kV AC Emergency Buses (A-D, B-C)	At least two strategies are available at SSES to improve the 4kV AC bus cross-tie capability. The strategy for this SAMA includes providing a mechanism to easily bypass the emergency 4kV AC feeder breaker interlocks such that new procedures would allow the operators to cross-tie buses which share a common emergency safeguards transformer. The inter-train cross-ties that would be supported by this SAMA include the "A" to "D" connection and the "B" to "C" connection.	SSES Level 1 Importance List (pre-EPU, post-EPU)	The cost of implementation for this SAMA was estimated to be $656,000 by PPL (PPL 2005g).	As the cost of implementation is less than the SSES Pre-EPU MMACR, it has been retained for Phase 2 analysis	As the cost of implementation is less than the SSES Post-EPU MMACR, it has been retained for Phase 2 analysis

Table E.5-3 Phase 1 SAMA

SAMA NUMBER	SAMA TITLE	SAMA DESCRIPTION	SOURCE	Cost Estimate	Pre-EPU Phase 1 Baseline Disposition	Post-EPU Phase 1 Baseline Disposition
2b	Improve Cross-Tie Capability Between 4kV AC Emergency Buses (A-B-C-D)	At least two strategies are available at SSES to improve the 4kV AC bus cross-tie capability. This strategy includes updating procedures and adding the hardware necessary to provide the ability to tie any 4kV AC emergency bus to any other 4kV AC emergency bus. In addition to the changes required for SAMA 2a, this SAMA would require the operators to have the ability to strip all 13.8kV loads from the startup bus, backfeed power through one Emergency Safeguards transformer, and then energize the opposite train's Emergency Safeguards transformer to power the required bus.	SSES Level 1 Importance List (pre-EPU, post-EPU)	The cost of implementation for this SAMA was estimated to be $1,384,000 by PPL (PPL 2005h).	As the cost of implementation is greater than the SSES Pre-EPU MMACR, it has been precluded from Phase 2 analysis	As the cost of implementation is greater than the SSES Post-EPU MMACR, it has been precluded from Phase 2 analysis
3	Proceduralize Staggered RPV Depressurization When Fire Protection System Injection is the Only Available Makeup Source	Currently, the Fire Protection system is not credited due to flow limitations even in the very late time frames in some LOOP evolutions. During depressurization, the loss of RPV inventory results in a makeup requirement greater than the 50% Fire Protection flow that is assumed to be available to prevent core damage. A potential SAMA for this scenarios is a procedure change that directs staggering RPV depressurization between the units such that 100% flow is available to a given unit level is restored after blowdown. Part of this procedure change would require temporarily valving out injection to the unit that has undergone depressurization after level recovery so that flow is not split when the second unit is depressurized. MAAP must be run to confirm that this is a viable option.	SSES Level 1 Importance List (pre-EPU, post-EPU)	The cost of procedure changes varies depending on the scope of the changes; however, the $50,000 value used in the Brunswick SAMA analysis (CPL 2004) is used here as a rough estimate of the cost for SSES. In addition to the cost of the procedure changes, flow analysis is required to confirm that the proposed changes would be effective. The cost of this analysis is estimated to be $100,000. The total cost of implementation for this SAMA is, therefore, $150,000. This estimate does not account for any changes that would be required for operator training.	As the cost of implementation is less than the SSES Pre-EPU MMACR, it has been retained for Phase 2 analysis	As the cost of implementation is less than the SSES Post-EPU MMACR, it has been retained for Phase 2 analysis

Table E.5-3 Phase 1 SAMA

SAMA NUMBER	SAMA TITLE	SAMA DESCRIPTION	SOURCE	Cost Estimate	Pre-EPU Phase 1 Baseline Disposition	Post-EPU Phase 1 Baseline Disposition
4	Install 100 Percent Capacity Battery Chargers	For cases in which the batteries have failed, the chargers could supply the DC loads if they were replaced with higher capacity units and procedures were developed to remove the failed batteries from the circuit. Currently, the chargers cannot support the full DC load requirements early in LOOP or LOCA sequences.	SSES Level 1 Importance List (pre-EPU, post-EPU), SSES PRA Group	The cost of implementation for this SAMA was estimated to be $1,619,000 by PPL (PPL 2005f).	As the cost of implementation is greater than the SSES Pre-EPU MMACR, it has been precluded from Phase 2 analysis	As the cost of implementation is greater than the SSES Post-EPU MMACR, it has been precluded from Phase 2 analysis
5	Auto Align 480V AC Portable Station Generator	Auto alignment of the portable 480V AC diesel generator would remove the requirement for the operators to perform the alignment action and increase the reliability of the alternate 480V AC supply. This enhancement would require changes to permanently install the portable generator.	SSES Level 1 Importance List (pre-EPU, post-EPU), SSES PRA Group	The cost of implementation for this SAMA was estimated to be $398,000 by PPL (PPL 2005b).	As the cost of implementation is less than the SSES Pre-EPU MMACR, it has been retained for Phase 2 analysis	As the cost of implementation is less than the SSES Post-EPU MMACR, it has been retained for Phase 2 analysis
6	Procure Spare 480V AC Portable Station Generator	An additional portable 480V AC diesel generator would reduce the impact of 480V AC generator hardware failures.	SSES Level 1 Importance List (pre-EPU, post-EPU), SSES PRA Group	The cost of implementation for this SAMA was estimated to be $203,000 by PPL (PPL 2005c).	As the cost of implementation is less than the SSES Pre-EPU MMACR, it has been retained for Phase 2 analysis	As the cost of implementation is less than the SSES Post-EPU MMACR, it has been retained for Phase 2 analysis
7	Re-Divisionalize ESW Cooling to RHR	Due to a previous change that was implemented to address a plant issue, ESW cooling for RHR is not aligned according to divisional groupings: 1) ESW divisions "A" and "C" provide cooling for RHR pumps "A" and "D", and 2) ESW divisions "B" and "D" provide cooling for RHR pumps "B" and "C". This results in the unavailability of RHR when only the "C" or "D" EDGs are available. Re-piping the cooling paths so that each ESW division cools the corresponding RHR division would eliminate this failure mode. The issue which forced the original ESW change is no longer present at SSES.	SSES Level 1 Importance List (pre-EPU, post-EPU), SSES PRA Group	The cost of implementation for this SAMA was estimated to be $970,000 by PPL (PPL 2006a, PPL 2006b).	As the cost of implementation is less than the SSES Pre-EPU MMACR, it has been retained for Phase 2 analysis	As the cost of implementation is less than the SSES Post-EPU MMACR, it has been retained for Phase 2 analysis

Table E.5-3 Phase 1 SAMA

SAMA NUMBER	SAMA TITLE	SAMA DESCRIPTION	SOURCE	Cost Estimate	Pre-EPU Phase 1 Baseline Disposition	Post-EPU Phase 1 Baseline Disposition
8	Automate Feedwater Runback	The largest ATWS contributors for SSES include scenarios in which Feedwater injection is not reduced to lower level. Without Feedwater runback, SLC injection is not credited to prevent core damage. Automating Feedwater flow reduction in ATWS conditions would reduce the failure probability of level control.	SSES Level 1 Importance List (pre-EPU, post-EPU), SSES PRA Group	The cost of installing logic to automate feedwater runback is considered to be similar in scope to the ABWR SAMDA to install computer aided instrumentation. This enhancement was estimated to cost approximately $600,000 for a single unit in the reactor's design phase (GE 1994). While this estimate would likely be larger for SSES to account for installation at both units, the need to retrofit an existing plant, and for inflation from the time the ABWR study was performed in 1994, $600,000 is used as a lower bound cost of implementation for this SAMA.	As the cost of implementation is less than the SSES Pre-EPU MMACR, it has been retained for Phase 2 analysis	As the cost of implementation is less than the SSES Post-EPU MMACR, it has been retained for Phase 2 analysis
9	Direct Feeds From the 125V DC Battery Chargers to Critical Loads	Failure of the DC buses prevents powering required loads even when the batteries or chargers are available. Temporary direct feeds from the batteries or chargers to the required loads could be aligned in emergency conditions if the cables are staged in such a way that the alignment could be performed in a short period of time. While this could not likely be done in ATWS or LOCA accidents, transient initiators with loss of injection would allow about 30 to 40 minutes for power alignment.	SSES Level 1 Importance List (pre-EPU, post-EPU), IPEEE Fire Review	The cost of implementation for this SAMA was estimated to be $346,000 by PPL (PPL 2005e).	As the cost of implementation is less than the SSES Pre-EPU MMACR, it has been retained for Phase 2 analysis	As the cost of implementation is less than the SSES Post-EPU MMACR, it has been retained for Phase 2 analysis

Table E.5-3 Phase 1 SAMA

SAMA NUMBER	SAMA TITLE	SAMA DESCRIPTION	SOURCE	Cost Estimate	Pre-EPU Phase 1 Baseline Disposition	Post-EPU Phase 1 Baseline Disposition
10	Install a Pressure Control Valve Between the IA and CIG Systems	The current requirement for plant operators to perform a manual cross-tie between the IA and CIG system on loss of CIG pressure in order to maintain Feedwater/Condensate injection and prevent a plant trip could be eliminated through the installation of the pressure control valve (PCV). The PCV would operate by opening a flowpath from IA system to the CIG system on low CIG pressure; however, a flow limiting orifice would be required in the cross-tie line to prevent depressurizing the IA system in the event that the CIG system ruptures.	SSES Level 1 Importance List (pre-EPU, post-EPU)	The cost of implementation for this SAMA was estimated to be $386,000 by PPL (PPL 2005d).	As the cost of implementation is less than the SSES Pre-EPU MMACR, it has been retained for Phase 2 analysis	As the cost of implementation is less than the SSES Post-EPU MMACR, it has been retained for Phase 2 analysis
11	Install a High Pressure Core Spray System with an Inexhaustible Suction Source	The HPCS system could provide some protection against an ISLOCA that existing systems can not. HPCI and RCIC will not be available in the short term due to vessel depressurization from the initiator while LPCI and Core Spray could initially function, but would eventually deplete the CST and Suppression Pool suction sources and/or fail due to room flooding. Condensate would also deplete its inventory. RHRSW is a potentially inexhaustible injection supply, but core cooling issues preclude crediting it for success. It should be noted that even with HPCS operating from a long term supply, a steady state will not have been achieved. Continued injection for core cooling may result in turbine building flooding, which could damage the alternate unit.	SSES Level 1 Importance List (pre-EPU, post-EPU)	The cost of installing an engine driven high pressure injection pump capable of mitigating LOCA and ATWS scenarios has been estimated to be $4,000,000 for the Brunswick site (CPL 2004). The type of high pressure system required for SAMA 11 is considered to be comparable to the Brunswick system and the cost of implementation is assumed to be the same.	As the cost of implementation is greater than the SSES Pre-EPU MMACR, it has been precluded from Phase 2 analysis	As the cost of implementation is greater than the SSES Post-EPU MMACR, it has been precluded from Phase 2 analysis

Table E.5-3 Phase 1 SAMA

SAMA NUMBER	SAMA TITLE	SAMA DESCRIPTION	SOURCE	Cost Estimate	Pre-EPU Phase 1 Baseline Disposition	Post-EPU Phase 1 Baseline Disposition
12	Enhance Procedures for Containment Venting After Core Damage When Containment Failure is Imminent	While SSES procedures exist to vent the primary containment irrespective of offsite dose, they are not directly referenced in the EOP flowcharts on high containment pressure given that core damage has occurred. The decision to vent is deferred to the TSC, which may conclude that venting is appropriate even after core damage has occurred and containment failure is imminent. While venting containment would not eliminate a release, it would ensure that the release was scrubbed through the wetwell and reduce the release's impact on the population. The current PRA model does not currently credit venting after core damage, but even if the current procedures were credited, some potential to clarify the EOPs may exist.	SSES Level 2 Importance List (pre-EPU, post-EPU)	N/A - Discussions with SSES operations personnel indicate that plant procedures already support containment venting after core damage. This item is further analyzed in the Phase 2 analysis to demonstrate that when credit is taken for the existing plant capabilities, the potential averted cost-risk that could be claimed for any further venting improvements would be less than any realistic cost of implementation.	Passed to Phase 2 analysis to demonstrate appropriate venting credit reduces the RRW value of the relevant events to a point below the SAMA review cutoff.	Passed to Phase 2 analysis to demonstrate appropriate venting credit reduces the RRW value of the relevant events to a point below the SAMA review cutoff.
13	Passive Overpressure Relief	In order to address in-containment LOCA events with vapor suppression failures, a passive vent path could be installed that would force air from the Suppression Pool air space through a water pool (or some filtering system) and then out of the stack. This would require the installation of a pressure capable water tank or filter and a rupture disk in addition to the new vent path piping.	SSES Level 2 Importance List (pre-EPU)	The cost of a filtered containment vent was estimated to be about $5.7 million in 1989 (PECO 1989). While that vent design required valve manipulation for operation, the cost is considered to be representative of the type of changes required to mitigate the LOCA events identified for SSES. $5.7 million is used for the cost of implementation for this SAMA (not updated to present dollars).	As the cost of implementation is greater than the SSES Pre-EPU MMACR, it has been precluded from Phase 2 analysis	As the cost of implementation is greater than the SSES Post-EPU MMACR, it has been precluded from Phase 2 analysis

Table E.5-3 Phase 1 SAMA

SAMA NUMBER	SAMA TITLE	SAMA DESCRIPTION	SOURCE	Cost Estimate	Pre-EPU Phase 1 Baseline Disposition	Post-EPU Phase 1 Baseline Disposition
14	Enhance Fire Main Connection to RHR	The reliability of injection with the fire main could be improved by installing a permanent connection to the RHR system that would facilitate local alignment and increase the injection flow rate.	SSES Level 2 Importance List	N/A - Review of the PRA model revealed that conservative modeling methods resulted in overestimating the importance of the action to align alternate injection for SSES. This item is further analyzed in the Phase 2 analysis to demonstrate that when credit is taken for the existing plant capabilities, the importance of aligning alternate injection is reduced below the threshold of review for the SAMA analysis.	Passed to Phase 2 analysis to demonstrate appropriate venting credit reduces the RRW value of the relevant events to a point below the SAMA review cutoff.	Passed to Phase 2 analysis to demonstrate appropriate venting credit reduces the RRW value of the relevant events to a point below the SAMA review cutoff.

Table E.6-1 Phase 2 SAMA

SAMA NUMBER	SAMA TITLE	SAMA DESCRIPTION	SOURCE	Pre-EPU Phase 2 Baseline Disposition	Post-EPU Phase 2 Baseline Disposition
1	Diesel Driven High Pressure Injection Pump	SBO sequences at SSES result in core damage even with the availability of the low pressure diesel driven fire pump due to unavailability of the SRVs in long term accidents. Given the existence of an alternate 4kV AC diesel generator and a portable 480V AC generator, additional AC power assets are not likely to provide a large benefit due to hardware and human dependence issues. The installation of a diesel driven, high pressure injection pump with a long term, cold, injection source could prolong the time to core damage. This would allow additional time for off-site AC power recovery. While some benefit would be gained even if this pump required DC power for success, the ability to operate the pump without DC support would enhance the benefit of this change.	SSES Level 1 Importance List (pre-EPU, post-EPU), IPEEE Fire Review	The averted cost-risk for this SAMA is less than the cost of implementation and the SAMA is not cost beneficial.	The averted cost-risk for this SAMA is less than the cost of implementation and the SAMA is not cost beneficial.
2a	Improve Cross-Tie Capability Between 4kV AC Emergency Buses (A-D, B-C)	At least two strategies are available at SSES to improve the 4kV AC bus cross-tie capability. The strategy for this SAMA includes providing a mechanism to easily bypass the emergency 4kV AC feeder breaker interlocks such that new procedures would allow the operators to cross-tie buses which share a common emergency safeguards transformer. The inter-train cross-ties that would be supported by this SAMA include the "A" to "D" connection and the "B" to "C" connection.	SSES Level 1 Importance List (pre-EPU, post-EPU)	The averted cost-risk for this SAMA is less than the cost of implementation and the SAMA is not cost beneficial.	The averted cost-risk for this SAMA is greater than the cost of implementation and the SAMA is cost beneficial.

Table E.6-1 Phase 2 SAMA

SAMA NUMBER	SAMA TITLE	SAMA DESCRIPTION	SOURCE	Pre-EPU Phase 2 Baseline Disposition	Post-EPU Phase 2 Baseline Disposition
3	Proceduralize Staggered RPV Depressurization When Fire Protection System Injection is the Only Available Makeup Source	Currently, the Fire Protection system is not credited due to flow limitations even in the very late time frames in some LOOP evolutions. During depressurization, the loss of RPV inventory results in a makeup requirement greater than the 50% Fire Protection flow that is assumed to be available to prevent core damage. A potential SAMA for this scenarios is a procedure change that directs staggering RPV depressurization between the units such that 100% flow is available to a given unit level is restored after blowdown. Part of this procedure change would require temporarily valving out injection to the unit that has undergone depressurization after level recovery so that flow is not split when the second unit is depressurized. MAAP must be run to confirm that this is a viable option.	SSES Level 1 Importance List (pre-EPU, post-EPU)	The averted cost-risk for this SAMA is less than the cost of implementation and the SAMA is not cost beneficial.	The averted cost-risk for this SAMA is less than the cost of implementation and the SAMA is not cost beneficial.
5	Auto Align 480V AC Portable Station Generator	Auto alignment of the portable 480V AC diesel generator would remove the requirement for the operators to perform the alignment action and increase the reliability of the alternate 480V AC supply. This enhancement would require changes to permanently install the portable generator.	SSES Level 1 Importance List (pre-EPU, post-EPU), SSES PRA Group	The averted cost-risk for this SAMA is less than the cost of implementation and the SAMA is not cost beneficial.	The averted cost-risk for this SAMA is less than the cost of implementation and the SAMA is not cost beneficial.
6	Procure Spare 480V AC Portable Station Generator	An additional portable 480V AC diesel generator would reduce the impact of 480V AC generator hardware failures.	SSES Level 1 Importance List (pre-EPU, post-EPU), SSES PRA Group	The averted cost-risk for this SAMA is greater than the cost of implementation and the SAMA is cost beneficial.	The averted cost-risk for this SAMA is greater than the cost of implementation and the SAMA is cost beneficial.
7	Re-Divisionalize ESW Cooling to RHR	Due to a previous change that was implemented to address a plant issue, ESW cooling for RHR is not aligned according to divisional groupings: 1) ESW divisions "A" and "C" provide cooling for RHR pumps "A" and "D", and 2) ESW divisions "B" and "D" provide cooling for RHR pumps "B" and "C". This results in the unavailability of RHR when only the "C" or "D" EDGs are available. Re-piping the cooling paths so that each ESW division cools the corresponding RHR division would eliminate this failure mode. The issue which forced the original ESW change is no longer present at SSES.	SSES Level 1 Importance List (pre-EPU, post-EPU), SSES PRA Group	The averted cost-risk for this SAMA is less than the cost of implementation and the SAMA is not cost beneficial.	The averted cost-risk for this SAMA is less than the cost of implementation and the SAMA is not cost beneficial.

Table E.6-1 Phase 2 SAMA

SAMA NUMBER	SAMA TITLE	SAMA DESCRIPTION	SOURCE	Pre-EPU Phase 2 Baseline Disposition	Post-EPU Phase 2 Baseline Disposition
8	Automate Feedwater Runback	The largest ATWS contributors for SSES include scenarios in which Feedwater injection is not reduced to lower level. Without Feedwater runback, SLC injection is not credited to prevent core damage. Automating Feedwater flow reduction in ATWS conditions would reduce the failure probability of level control.	SSES Level 1 Importance List (pre-EPU, post-EPU), SSES PRA Group	The averted cost-risk for this SAMA is less than the cost of implementation and the SAMA is not cost beneficial.	The averted cost-risk for this SAMA is less than the cost of implementation and the SAMA is not cost beneficial.
9	Direct Feeds From the 125V DC Battery Chargers to Critical Loads	Failure of the DC buses prevents powering required loads even when the batteries or chargers are available. Temporary direct feeds from the batteries or chargers to the required loads could be aligned in emergency conditions if the cables are staged in such a way that the alignment could be performed in a short period of time. While this could not likely be done in ATWS or LOCA accidents, transient initiators with loss of injection would allow about 30 to 40 minutes for power alignment.	SSES Level 1 Importance List (pre-EPU, post-EPU), IPEEE Fire Review	The averted cost-risk for this SAMA is less than the cost of implementation and the SAMA is not cost beneficial.	The averted cost-risk for this SAMA is less than the cost of implementation and the SAMA is not cost beneficial.
10	Install a Pressure Control Valve Between the IA and CIG Systems	The current requirement for plant operators to perform a manual cross-tie between the IA and CIG system on loss of CIG pressure in order to maintain Feedwater/Condensate injection and prevent a plant trip could be eliminated through the installation of the pressure control valve (PCV). The PCV would operate by opening a flowpath from IA system to the CIG system on low CIG pressure; however, a flow limiting orifice would be required in the cross-tie line to prevent depressurizing the IA system in the event that the CIG system ruptures.	SSES Level 1 Importance List (pre-EPU, post-EPU)	The averted cost-risk for this SAMA is less than the cost of implementation and the SAMA is not cost beneficial.	The averted cost-risk for this SAMA is less than the cost of implementation and the SAMA is not cost beneficial.

Table E.6-1 Phase 2 SAMA

SAMA NUMBER	SAMA TITLE	SAMA DESCRIPTION	SOURCE	Pre-EPU Phase 2 Baseline Disposition	Post-EPU Phase 2 Baseline Disposition
12	Enhance Procedures for Containment Venting After Core Damage When Containment Failure is Imminent	While SSES procedures exist to vent the primary containment irrespective of offsite dose, they are not directly referenced in the EOP flowcharts on high containment pressure given that core damage has occurred. The decision to vent is deferred to the TSC, which may conclude that venting is appropriate even after core damage has occurred and containment failure is imminent. While venting containment would not eliminate a release, it would ensure that the release was scrubbed through the wetwell and reduce the release's impact on the population. The current PRA model does not currently credit venting after core damage, but even if the current procedures were credited, some potential to clarify the EOPs may exist.	SSES Level 2 Importance List (pre-EPU, post-EPU)	The averted cost-risk for this SAMA is less than the cost of implementation and the SAMA is not cost beneficial.	The averted cost-risk for this SAMA is less than the cost of implementation and the SAMA is not cost beneficial.
14	Enhance Fire Main Connection to RHR	The reliability of injection with the fire main could be improved by installing a permanent connection to the RHR system that would facilitate local alignment and increase the injection flow rate.	SSES Level 2 Importance List	When credit is taken for the available alternate injection credit, the risk reduction worth value related to Fire Main injection is 1.005 or less, which is well below the 1.02 cutoff value used for SAMA. This SAMA would not be cost beneficial.	When credit is taken for the available alternate injection credit, the risk reduction worth value related to Fire Main injection is 1.005 or less, which is well below the 1.02 cutoff value used for SAMA. This SAMA would not be cost beneficial.

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Addendum 1 Selected Previous Industry SAMAs

SAMA ID Number	SAMA Title	Result of Potential Enhancement
	Improvements Related to RCP Seal LOCAs (Loss of CC or SW)	
1	Cap downstream piping of normally closed component cooling water drain and vent valves.	SAMA would reduce the frequency of a loss of component cooling event, a large portion of which was derived from catastrophic failure of one of the many single isolation valves.
2	Enhance loss of component cooling procedure to facilitate stopping reactor coolant pumps.	SAMA would reduce the potential for reactor coolant pump (RCP) seal damage due to pump bearing failure.
3	Enhance loss of component cooling procedure to present desirability of cooling down reactor coolant system (RCS) prior to seal LOCA.	SAMA would reduce the potential for RCP seal failure.
4	Provide additional training on the loss of component cooling.	SAMA would potentially improve the success rate of operator actions after a loss of component cooling (to restore RCP seal damage).
5	Provide hardware connections to allow another essential raw cooling water system to cool charging pump seals.	SAMA would reduce effect of loss of component cooling by providing a means to maintain the centrifugal charging pump seal injection after a loss of component cooling.
6	Procedure changes to allow cross connection of motor cooling for RHRSW pumps.	SAMA would allow continued operation of both RHRSW pumps on a failure of one train of PSW.
7	Proceduralize shedding component cooling water loads to extend component cooling heatup on loss of essential raw cooling water.	SAMA would increase time before the loss of component cooling (and reactor coolant pump seal failure) in the loss of essential raw cooling water sequences.
8	Increase charging pump lube oil capacity.	SAMA would lengthen the time before centrifugal charging pump failure due to lube oil overheating in loss of CC sequences.

Addendum 1 Selected Previous Industry SAMAs

SAMA ID Number	SAMA Title	Result of Potential Enhancement
9	Eliminate the RCP thermal barrier dependence on component cooling such that loss of component cooling does not result directly in core damage.	SAMA would prevent the loss of recirculation pump seal integrity after a loss of component cooling. Watts Bar Nuclear Plant IPE said that they could do this with essential raw cooling water connection to RCP seals.

Addendum 1 SELECTED PREVIOUS INDUSTRY SAMAs (continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
10	Add redundant DC control power for PSW pumps C & D.	SAMA would increase reliability of PSW and decrease core damage frequency due to a loss of SW.
11	Create an independent RCP seal injection system, with a dedicated diesel.	SAMA would add redundancy to RCP seal cooling alternatives, reducing CDF from loss of component cooling or service water or from a station blackout event.
12	Use existing hydro-test pump for RCP seal injection.	SAMA would provide an independent seal injection source, without the cost of a new system.
13	Replace ECCS pump motor with air-cooled motors.	SAMA would eliminate ECCS dependency on component cooling system (but not on room cooling).
14	Install improved RCS pumps seals.	SAMA would reduce probability of RCP seal LOCA by installing RCP seal O-ring constructed of improved materials
15	Install additional component cooling water pump.	SAMA would reduce probability of loss of component cooling leading to RCP seal LOCA.
16	Prevent centrifugal charging pump flow diversion from the relief valves.	SAMA modification would reduce the frequency of the loss of RCP seal cooling if relief valve opening causes a flow diversion large enough to prevent RCP seal injection.
17	Change procedures to isolate RCP seal letdown flow on loss of component cooling, and guidance on loss of injection during seal LOCA.	SAMA would reduce CDF from loss of seal cooling.
18	Implement procedures to stagger high pressure safety injection (HPSI) pump use after a loss of service water.	SAMA would allow HPSI to be extended after a loss of service water.

Addendum 1 SELECTED PREVIOUS INDUSTRY SAMAs (continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
19	Use FP system pumps as a backup seal injection and high pressure makeup.	SAMA would reduce the frequency of the RCP seal LOCA and the SBO CDF.
20	Enhance procedural guidance for use of cross-tied component cooling or service water pumps.	SAMA would reduce the frequency of the loss of component cooling water and service water.
21	Procedure enhancements and operator training in support system failure sequences, with emphasis on anticipating problems and coping.	SAMA would potentially improve the success rate of operator actions subsequent to support system failures.
22	Improved ability to cool the residual heat removal heat exchangers.	SAMA would reduce the probability of a loss of decay heat removal by implementing procedure and hardware modifications to allow manual alignment of the FP system or by installing a component cooling water cross-tie.
23	8.a. Additional Service Water Pump	SAMA would conceivably reduce common cause dependencies from SW system and thus reduce plant risk through system reliability improvement.
24	Create an independent RCP seal injection system, without dedicated diesel	This SAMA would add redundancy to RCP seal cooling alternatives, reducing the CDF from loss of CC or SW, but not SBO.
	Improvements Related to Heating, Ventilation, and Air Conditioning	
25	Provide reliable power to control building fans.	SAMA would increase availability of control room ventilation on a loss of power.
26	Provide a redundant train of ventilation.	SAMA would increase the availability of components dependent on room cooling.

Addendum 1 SELECTED PREVIOUS INDUSTRY SAMAs (continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
27	Procedures for actions on loss of HVAC.	SAMA would provide for improved credit to be taken for loss of HVAC sequences (improved affected electrical equipment reliability upon a loss of control building HVAC).
28	Add a diesel building switchgear room high temperature alarm.	SAMA would improve diagnosis of a loss of switchgear room HVAC. Option 1: Install high temp alarm. Option 2: Redundant louver and thermostat
29	Create ability to switch fan power supply to DC in an SBO event.	SAMA would allow continued operation in an SBO event. This SAMA was created for reactor core isolation cooling system room at Fitzpatrick Nuclear Power Plant.
30	Enhance procedure to instruct operators to trip unneeded RHR/CS pumps on loss of room ventilation.	SAMA increases availability of required RHR/CS pumps. Reduction in room heat load allows continued operation of required RHR/CS pumps, when room cooling is lost.
31	Stage backup fans in switchgear (SWGR) rooms	This SAMA would provide alternate ventilation in the event of a loss of SWGR Room ventilation
	Improvements Related to Ex-Vessel Accident Mitigation/Containment Phenomena	
32	Delay containment spray actuation after large LOCA.	SAMA would lengthen time of RWST availability.
33	Install containment spray pump header automatic throttle valves.	SAMA would extend the time over which water remains in the RWST, when full Containment Spray flow is not needed
34	Install an independent method of suppression pool cooling.	SAMA would decrease the probability of loss of containment heat removal. For PWRs, a potential similar enhancement would be to install an independent cooling system for sump water.

Addendum 1 SELECTED PREVIOUS INDUSTRY SAMAs (continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
35	Develop an enhanced drywell spray system.	SAMA would provide a redundant source of water to the containment to control containment pressure, when used in conjunction with containment heat removal.
36	Provide dedicated existing drywell spray system.	SAMA would provide a source of water to the containment to control containment pressure, when used in conjunction with containment heat removal. This would use an existing spray loop instead of developing a new spray system.
37	Install an unfiltered hardened containment vent.	SAMA would provide an alternate decay heat removal method for non-ATWS events, with the released fission products not being scrubbed.
38	Install a filtered containment vent to remove decay heat.	SAMA would provide an alternate decay heat removal method for non-ATWS events, with the released fission products being scrubbed. Option 1: Gravel Bed Filter Option 2: Multiple Venturi Scrubber
39	Install a containment vent large enough to remove ATWS decay heat.	Assuming that injection is available, this SAMA would provide alternate decay heat removal in an ATWS event.
40	Create/enhance hydrogen recombiners with independent power supply.	SAMA would reduce hydrogen detonation at lower cost, Use either 1) a new independent power supply 2) a nonsafety-grade portable generator 3) existing station batteries 4) existing AC/DC independent power supplies.
41	Install hydrogen recombiners.	SAMA would provide a means to reduce the chance of hydrogen detonation.

Addendum 1 SELECTED PREVIOUS INDUSTRY SAMAs (continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
42	Create a passive design hydrogen ignition system.	SAMA would reduce hydrogen denotation system without requiring electric power.
43	Create a large concrete crucible with heat removal potential under the basemat to contain molten core debris.	SAMA would ensure that molten core debris escaping from the vessel would be contained within the crucible. The water cooling mechanism would cool the molten core, preventing a melt-through of the basemat.
44	Create a water-cooled rubble bed on the pedestal.	SAMA would contain molten core debris dropping on to the pedestal and would allow the debris to be cooled.
45	Provide modification for flooding the drywell head.	SAMA would help mitigate accidents that result in the leakage through the drywell head seal.
46	Enhance FP system and/or standby gas treatment system hardware and procedures.	SAMA would improve fission product scrubbing in severe accidents.
47	Create a reactor cavity flooding system.	SAMA would enhance debris coolability, reduce core concrete interaction, and provide fission product scrubbing.
48	Create other options for reactor cavity flooding.	SAMA would enhance debris coolability, reduce core concrete interaction, and provide fission product scrubbing.
49	Enhance air return fans (ice condenser plants).	SAMA would provide an independent power supply for the air return fans, reducing containment failure in SBO sequences.

Addendum 1 SELECTED PREVIOUS INDUSTRY SAMAs (continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
50	Create a core melt source reduction system.	SAMA would provide cooling and containment of molten core debris. Refractory material would be placed underneath the reactor vessel such that a molten core falling on the material would melt and combine with the material. Subsequent spreading and heat removal form the vitrified compound would be facilitated, and concrete attack would not occur
51	Provide a containment inerting capability.	SAMA would prevent combustion of hydrogen and carbon monoxide gases.
52	Use the FP system as a backup source for the containment spray system.	SAMA would provide redundant containment spray function without the cost of installing a new system.
53	Install a secondary containment filtered vent.	SAMA would filter fission products released from primary containment.
54	Install a passive containment spray system.	SAMA would provide redundant containment spray method without high cost.
55	Strengthen primary/secondary containment.	SAMA would reduce the probability of containment overpressurization to failure.
56	Increase the depth of the concrete basemat or use an alternative concrete material to ensure melt-through does not occur.	SAMA would prevent basemat melt-through.
57	Provide a reactor vessel exterior cooling system.	SAMA would provide the potential to cool a molten core before it causes vessel failure, if the lower head could be submerged in water.

Addendum 1 SELECTED PREVIOUS INDUSTRY SAMAs (continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
58	Construct a building to be connected to primary/secondary containment that is maintained at a vacuum.	SAMA would provide a method to depressurize containment and reduce fission product release.
59	Refill CST	SAMA would reduce the risk of core damage during events such as extended station blackouts or LOCAs which render the suppression pool unavailable as an injection source due to heat up.
60	Maintain ECCS suction on CST	SAMA would maintain suction on the CST as long as possible to avoid pump failure as a result of high suppression pool temperature
61	Modify containment flooding procedure to restrict flooding to below Top of Active Fuel	SAMA would avoid forcing containment venting
62	Enhance containment venting procedures with respect to timing, path selection and technique.	SAMA would improve likelihood of successful venting strategies.
63	1.a. Severe Accident EPGs/Accident Management Guidelines	SAMA would lead to improved arrest of core melt progress and prevention of containment failure
64	1.h. Simulator Training for Severe Accident	SAMA would lead to improved arrest of core melt progress and prevention of containment failure
65	2.g. Dedicated Suppression Pool Cooling	SAMA would decrease the probability of loss of containment heat removal. While PWRs do not have suppression pools, a similar modification may be applied to the sump. Installation of a dedicated sump cooling system would provide an alternate method of cooling injection water.

Addendum 1 SELECTED PREVIOUS INDUSTRY SAMAs (continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
66	3.a. Larger Volume Containment	SAMA increases time before containment failure and increases time for recovery
67	3.b. Increased Containment Pressure Capability (sufficient pressure to withstand severe accidents)	SAMA minimizes likelihood of large releases
68	3.c. Improved Vacuum Breakers (redundant valves in each line)	SAMA reduces the probability of a stuck open vacuum breaker.
69	3.d. Increased Temperature Margin for Seals	This SAMA would reduce containment failure due to drywell head seal failure caused by elevated temperature and pressure.
70	3.e. Improved Leak Detection	This SAMA would help prevent LOCA events by identifying pipes which have begun to leak. These pipes can be replaced before they break.
71	3.f. Suppression Pool Scrubbing	Directing releases through the suppression pool will reduce the radionuclides allowed to escape to the environment.
72	3.g. Improved Bottom Penetration Design	SAMA reduces failure likelihood of RPV bottom head penetrations
73	4.a. Larger Volume Suppression Pool (double effective liquid volume)	SAMA would increase the size of the suppression pool so that heatup rate is reduced, allowing more time for recovery of a heat removal system
74	5.a/d. Unfiltered Vent	SAMA would provide an alternate decay heat removal method with the released fission products not being scrubbed.
75	5.b/c. Filtered Vent	SAMA would provide an alternate decay heat removal method with the released fission products being scrubbed.

Addendum 1 SELECTED PREVIOUS INDUSTRY SAMAs (continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
76	6.a. Post Accident Inerting System	SAMA would reduce likelihood of gas combustion inside containment
77	6.b. Hydrogen Control by Venting	Prevents hydrogen detonation by venting the containment before combustible levels are reached.
78	6.c. Pre-inerting	SAMA would reduce likelihood of gas combustion inside containment
79	6.d. Ignition Systems	Burning combustible gases before they reach a level which could cause a harmful detonation is a method of preventing containment failure.
80	6.e. Fire Suppression System Inerting	Use of the FP system as a back up containment inerting system would reduce the probability of combustible gas accumulation. This would reduce the containment failure probability for small containments (e.g. BWR MKI).
81	7.a. Drywell Head Flooding	SAMA would provide intentional flooding of the upper drywell head such that if high drywell temperatures occurred, the drywell head seal would not fail.
82	7.b. Containment Spray Augmentation	This SAMA would provide additional means of providing flow to the containment spray system.
83	12.b. Integral Basemat	This SAMA would improve containment and system survivability for seismic events.

Addendum 1 SELECTED PREVIOUS INDUSTRY SAMAs (continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
84	13.a. Reactor Building Sprays	This SAMA provides the capability to use firewater sprays in the reactor building to mitigate release of fission products into the Rx Bldg following an accident.
85	14.a. Flooded Rubble Bed	SAMA would contain molten core debris dropping on to the pedestal and would allow the debris to be cooled.
86	14.b. Reactor Cavity Flooder	SAMA would enhance debris coolability, reduce core concrete interaction, and provide fission product scrubbing.
87	14.c. Basaltic Cements	SAMA minimizes carbon dioxide production during core concrete interaction.
88	Provide a core debris control system	(Intended for ice condenser plants): This SAMA would prevent the direct core debris attack of the primary containment steel shell by erecting a barrier between the seal table and the containment shell.
89	Add ribbing to the containment shell	This SAMA would reduce the risk of buckling of containment under reverse pressure loading.
	Improvements Related to Enhanced AC/DC Reliability/Availability	
90	Proceduralize alignment of spare diesel to shutdown board after loss of offsite power and failure of the diesel normally supplying it.	SAMA would reduce the SBO frequency.
91	Provide an additional diesel generator.	SAMA would increase the reliability and availability of onsite emergency AC power sources.

Addendum 1 SELECTED PREVIOUS INDUSTRY SAMAs (continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
92	Provide additional DC battery capacity.	SAMA would ensure longer battery capability during an SBO, reducing the frequency of long-term SBO sequences.
93	Use fuel cells instead of lead-acid batteries.	SAMA would extend DC power availability in an SBO.
94	Procedure to cross-tie high pressure core spray diesel.	SAMA would improve core injection availability by providing a more reliable power supply for the high pressure core spray pumps.
95	Improve 4.16-kV bus cross-tie ability.	SAMA would improve AC power reliability.
96	Incorporate an alternate battery charging capability.	SAMA would improve DC power reliability by either cross-tying the AC busses, or installing a portable diesel-driven battery charger.
97	Increase/improve DC bus load shedding.	SAMA would extend battery life in an SBO event.
98	Replace existing batteries with more reliable ones.	SAMA would improve DC power reliability and thus increase available SBO recovery time.
99	Mod for DC Bus A reliability.	SAMA would increase the reliability of AC power and injection capability. Loss of DC Bus A causes a loss of main condenser prevents transfer from the main transformer to offsite power, and defeats one half of the low vessel pressure permissive for LPCI/CS injection valves.
100	Create AC power cross-tie capability with other unit.	SAMA would improve AC power reliability.
101	Create a cross-tie for diesel fuel oil.	SAMA would increase diesel fuel oil supply and thus diesel generator, reliability.

Addendum 1 SELECTED PREVIOUS INDUSTRY SAMAs (continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
102	Develop procedures to repair or replace failed 4-kV breakers.	SAMA would offer a recovery path from a failure of the breakers that perform transfer of 4.16-kV non-emergency busses from unit station service transformers, leading to loss of emergency AC power.
103	Emphasize steps in recovery of offsite power after an SBO.	SAMA would reduce human error probability during offsite power recovery.
104	Develop a severe weather conditions procedure.	For plants that do not already have one, this SAMA would reduce the CDF for external weather-related events.
105	Develop procedures for replenishing diesel fuel oil.	SAMA would allow for long-term diesel operation.
106	Install gas turbine generator.	SAMA would improve onsite AC power reliability by providing a redundant and diverse emergency power system.
107	Create a backup source for diesel cooling. (Not from existing system)	This SAMA would provide a redundant and diverse source of cooling for the diesel generators, which would contribute to enhanced diesel reliability.
108	Use FP system as a backup source for diesel cooling.	This SAMA would provide a redundant and diverse source of cooling for the diesel generators, which would contribute to enhanced diesel reliability.
109	Provide a connection to an alternate source of offsite power.	SAMA would reduce the probability of a loss of offsite power event.
110	Bury offsite power lines.	SAMA could improve offsite power reliability, particularly during severe weather.

Addendum 1 SELECTED PREVIOUS INDUSTRY SAMAs (continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
111	Replace anchor bolts on diesel generator oil cooler.	Millstone Nuclear Power Station found a high seismic SBO risk due to failure of the diesel oil cooler anchor bolts. For plants with a similar problem, this would reduce seismic risk. Note that these were Fairbanks Morse DGs.
112	Change undervoltage (UV), auxiliary feedwater actuation signal (AFAS) block and high pressurizer pressure actuation signals to 3-out-of-4, instead of 2-out-of-4 logic.	SAMA would reduce risk of 2/4 inverter failure.
113	Provide DC power to the 120/240-V vital AC system from the Class 1E station service battery system instead of its own battery.	SAMA would increase the reliability of the 120-VAC Bus.
114	Bypass Diesel Generator Trips	SAMA would allow D/Gs to operate for longer.
115	2.i. 16 hour Station Blackout Injection	SAMA includes improved capability to cope with longer station blackout scenarios.
116	9.a. Steam Driven Turbine Generator	This SAMA would provide a steam driven turbine generator which uses reactor steam and exhausts to the suppression pool. If large enough, it could provide power to additional equipment.
117	9.b. Alternate Pump Power Source	This SAMA would provide a small dedicated power source such as a dedicated diesel or gas turbine for the feedwater or condensate pumps, so that they do not rely on offsite power.
118	9.d. Additional Diesel Generator	SAMA would reduce the SBO frequency.

Addendum 1 SELECTED PREVIOUS INDUSTRY SAMAs (continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
119	9.e. Increased Electrical Divisions	SAMA would provide increased reliability of AC power system to reduce core damage and release frequencies.
120	9.f. Improved Uninterruptable Power Supplies	SAMA would provide increased reliability of power supplies supporting front-line equipment, thus reducing core damage and release frequencies.
121	9.g. AC Bus Cross-Ties	SAMA would provide increased reliability of AC power system to reduce core damage and release frequencies.
122	9.h. Gas Turbine	SAMA would improve onsite AC power reliability by providing a redundant and diverse emergency power system.
123	9.i. Dedicated RHR (bunkered) Power Supply	SAMA would provide RHR with more reliable AC power.
124	10.a. Dedicated DC Power Supply	This SAMA addresses the use of a diverse DC power system such as an additional battery or fuel cell for the purpose of providing motive power to certain components (e.g., RCIC).
125	10.b. Additional Batteries/Divisions	This SAMA addresses the use of a diverse DC power system such as an additional battery or fuel cell for the purpose of providing motive power to certain components (e.g., RCIC).
126	10.c. Fuel Cells	SAMA would extend DC power availability in an SBO.
127	10.d. DC Cross-ties	This SAMA would improve DC power reliability.
128	10.e. Extended Station Blackout Provisions	SAMA would provide reduction in SBO sequence frequencies.

Addendum 1 SELECTED PREVIOUS INDUSTRY SAMAs (continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
129	Add an automatic bus transfer feature to allow the automatic transfer of the 120V vital AC bus from the on-line unit to the standby unit	Plants are typically sensitive to the loss of one or more 120V vital AC buses. Manual transfers to alternate power supplies could be enhanced to transfer automatically.
	Improvements in Identifying and Mitigating Containment Bypass	
130	Install a redundant spray system to depressurize the primary system during a steam generator tube rupture (SGTR).	SAMA would enhance depressurization during a SGTR.
131	Improve SGTR coping abilities.	SAMA would improve instrumentation to detect SGTR, or additional system to scrub fission product releases.
132	Add other SGTR coping abilities.	SAMA would decrease the consequences of an SGTR.
133	Increase secondary side pressure capacity such that an SGTR would not cause the relief valves to lift.	SAMA would eliminate direct release pathway for SGTR sequences.
134	Replace steam generators (SG) with a new design.	SAMA would lower the frequency of an SGTR.
135	Revise EOPs to direct that a faulted SG be isolated.	SAMA would reduce the consequences of an SGTR.
136	Direct SG flooding after a SGTR, prior to core damage.	SAMA would provide for improved scrubbing of SGTR releases.
137	Implement a maintenance practice that inspects 100% of the tubes in a SG.	SAMA would reduce the potential for an SGTR.
138	Locate residual heat removal (RHR) inside of containment.	SAMA would prevent intersystem LOCA (ISLOCA) out the RHR pathway.

Addendum 1 SELECTED PREVIOUS INDUSTRY SAMAs (continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
139	Install additional instrumentation for ISLOCAs.	SAMA would decrease ISLOCA frequency by installing pressure of leak monitoring instruments in between the first two pressure isolation valves on low-pressure inject lines, RHR suction lines, and HPSI lines.
140	Increase frequency for valve leak testing.	SAMA could reduce ISLOCA frequency.
141	Improve operator training on ISLOCA coping.	SAMA would decrease ISLOCA effects.
142	Install relief valves in the CC System.	SAMA would relieve pressure buildup from an RCP thermal barrier tube rupture, preventing an ISLOCA.
143	Provide leak testing of valves in ISLOCA paths.	SAMA would help reduce ISLOCA frequency. At Kewaunee Nuclear Power Plant, four MOVs isolating RHR from the RCS were not leak tested.
144	Revise EOPs to improve ISLOCA identification.	SAMA would ensure LOCA outside containment could be identified as such. Salem Nuclear Power Plant had a scenario where an RHR ISLOCA could direct initial leakage back to the pressurizer relief tank, giving indication that the LOCA was inside containment.
145	Ensure all ISLOCA releases are scrubbed.	SAMA would scrub all ISLOCA releases. One example is to plug drains in the break area so that the break point would be covered with water.
146	Add redundant and diverse limit switches to each containment isolation valve.	SAMA could reduce the frequency of containment isolation failure and ISLOCAs through enhanced isolation valve position indication.
147	Early detection and mitigation of ISLOCA	SAMA would limit the effects of ISLOCA accidents by early detection and isolation

Addendum 1 SELECTED PREVIOUS INDUSTRY SAMAs (continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
148	8.e. Improved MSIV Design	This SAMA would improve isolation reliability and reduce spurious actuations that could be initiating events.
149	Proceduralize use of pressurizer vent valves during steam generator tube rupture (SGTR) sequences	Some plants may have procedures to direct the use of pressurizer sprays to reduce RCS pressure after an SGTR. Use of the vent valves would provide a back-up method.
150	Implement a maintenance practice that inspects 100% of the tubes in an SG	This SAMA would reduce the potential for a tube rupture.
151	Locate RHR inside of containment	This SAMA would prevent ISLOCA out the RHR pathway.
152	Install self-actuating containment isolation valves	For plants that do not have this, it would reduce the frequency of isolation failure.
	Improvements in Reducing Internal Flooding Frequency	
153	Modify swing direction of doors separating turbine building basement from areas containing safeguards equipment.	SAMA would prevent flood propagation, for a plant where internal flooding from turbine building to safeguards areas is a concern.
154	Improve inspection of rubber expansion joints on main condenser.	SAMA would reduce the frequency of internal flooding, for a plant where internal flooding due to a failure of circulating water system expansion joints is a concern.
155	Implement internal flood prevention and mitigation enhancements.	This SAMA would reduce the consequences of internal flooding.

Addendum 1 SELECTED PREVIOUS INDUSTRY SAMAs (continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
156	Implement internal flooding improvements such as those implemented at Fort Calhoun.	This SAMA would reduce flooding risk by preventing or mitigating rupture in the RCP seal cooler of the component cooling system and ISLOCA in a shutdown cooling line, an auxiliary feedwater (AFW) flood involving the need to remove a watertight door.
157	Shield electrical equipment from potential water spray	SAMA would decrease risk associated with seismically induced internal flooding
158	13.c. Reduction in Reactor Building Flooding	This SAMA reduces the Reactor Building Flood Scenarios contribution to core damage and release.
	Improvements Related to Feedwater/Feed and Bleed Reliability/Availability	
159	Install a digital feedwater upgrade.	This SAMA would reduce the chance of a loss of main feedwater following a plant trip.
160	Perform surveillances on manual valves used for backup AFW pump suction.	This SAMA would improve success probability for providing alternative water supply to the AFW pumps.
161	Install manual isolation valves around AFW turbine-driven steam admission valves.	This SAMA would reduce the dual turbine-driven AFW pump maintenance unavailability.
162	Install accumulators for turbine-driven AFW pump flow control valves (CVs).	This SAMA would provide control air accumulators for the turbine-driven AFW flow CVs, the motor-driven AFW pressure CVs and SG power-operated relief valves (PORVs). This would eliminate the need for local manual action to align nitrogen bottles for control air during a LOOP.
163	Install separate accumulators for the AFW cross-connect and block valves	This SAMA would enhance the operator's ability to operate the AFW cross-connect and block valves following loss of air support.

Addendum 1 SELECTED PREVIOUS INDUSTRY SAMAs (continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
164	Install a new condensate storage tank (CST)	Either replace the existing tank with a larger one, or install a back-up tank.
165	Provide cooling of the steam-driven AFW pump in an SBO event	This SAMA would improve success probability in an SBO by: (1) using the FP system to cool the pump, or (2) making the pump self cooled.
166	Proceduralize local manual operation of AFW when control power is lost.	This SAMA would lengthen AFW availability in an SBO. Also provides a success path should AFW control power be lost in non-SBO sequences.
167	Provide portable generators to be hooked into the turbine driven AFW, after battery depletion.	This SAMA would extend AFW availability in an SBO (assuming the turbine driven AFW requires DC power)
168	Add a motor train of AFW to the Steam trains	For PWRs that do not have any motor trains of AFW, this would increase reliability in non-SBO sequences.
169	Create ability for emergency connections of existing or alternate water sources to feedwater/condensate	This SAMA would be a back-up water supply for the feedwater/condensate systems.
170	Use FP system as a back-up for SG inventory	This SAMA would create a back-up to main and AFW for SG water supply.
171	Procure a portable diesel pump for isolation condenser make-up	This SAMA would provide a back-up to the city water supply and diesel FP system pump for isolation condenser make-up.
172	Install an independent diesel generator for the CST make-up pumps	This SAMA would allow continued inventory make-up to the CST during an SBO.

Addendum 1 SELECTED PREVIOUS INDUSTRY SAMAs (continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
173	Change failure position of condenser make-up valve	This SAMA would allow greater inventory for the AFW pumps by preventing CST flow diversion to the condenser if the condenser make-up valve fails open on loss of air or power.
174	Create passive secondary side coolers.	This SAMA would reduce CDF from the loss of Feedwater by providing a passive heat removal loop with a condenser and heat sink.
175	Replace current PORVs with larger ones such that only one is required for successful feed and bleed.	This SAMA would reduce the dependencies required for successful feed and bleed.
176	Install motor-driven feedwater pump.	SAMA would increase the availability of injection subsequent to MSIV closure.
177	Use Main FW pumps for a Loss of Heat Sink Event	This SAMA involves a procedural change that would allow for a faster response to loss of the secondary heat sink. Use of only the feedwater booster pumps for injection to the SGs requires depressurization to about 350 psig; before the time this pressure is reached, conditions would be met for initiating feed and bleed. Using the available turbine driven feedwater pumps to inject water into the SGs at a high pressure rather than using the feedwater booster alone allows injection without the time consuming depressurization.
	Improvements in Core Cooling Systems	
178	Provide the capability for diesel driven, low pressure vessel make-up	This SAMA would provide an extra water source in sequences in which the reactor is depressurized and all other injection is unavailable (e.g., FP system)

Addendum 1 SELECTED PREVIOUS INDUSTRY SAMAs (continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
179	Provide an additional HPSI pump with an independent diesel	This SAMA would reduce the frequency of core melt from small LOCA and SBO sequences
180	Install an independent AC HPSI system	This SAMA would allow make-up and feed and bleed capabilities during an SBO.
181	Create the ability to manually align ECCS recirculation	This SAMA would provide a back-up should automatic or remote operation fail.
182	Implement an RWT make-up procedure	This SAMA would decrease CDF from ISLOCA scenarios, some smaller break LOCA scenarios, and SGTR.
183	Stop low pressure safety injection pumps earlier in medium or large LOCAs.	This SAMA would provide more time to perform recirculation swap over.
184	Emphasize timely swap over in operator training.	This SAMA would reduce human error probability of recirculation failure.
185	Upgrade Chemical and Volume Control System to mitigate small LOCAs.	For a plant like the AP600 where the Chemical and Volume Control System cannot mitigate a Small LOCA, an upgrade would decrease the Small LOCA CDF contribution.
186	Install an active HPSI system.	For a plant like the AP600 where an active HPSI system does not exist, this SAMA would add redundancy in HPSI.
187	Change "in-containment" RWT suction from 4 check valves to 2 check and 2 air operated valves.	This SAMA would remove common mode failure of all four injection paths.

Addendum 1 SELECTED PREVIOUS INDUSTRY SAMAs (continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
188	Replace 2 of the 4 safety injection (SI) pumps with diesel-powered pumps.	This SAMA would reduce the SI system common cause failure probability. This SAMA was intended for the System 80+, which has four trains of SI.
189	Align low pressure core injection or core spray to the CST on loss of suppression pool cooling.	This SAMA would help to ensure low pressure ECCS can be maintained in loss of suppression pool cooling scenarios.
190	Raise high pressure core injection/reactor core isolation cooling backpressure trip setpoints	This SAMA would ensure high pressure core injection/reactor core isolation cooling availability when high suppression pool temperatures exist.
191	Improve the reliability of the automatic depressurization system.	This SAMA would reduce the frequency of high pressure core damage sequences.
192	Disallow automatic vessel depressurization in non-ATWS scenarios	This SAMA would improve operator control of the plant.
193	Create automatic swap over to recirculation on RWT depletion	This SAMA would reduce the human error contribution from recirculation failure.
194	Proceduralize intermittent operation of HPCI.	SAMA would allow for extended duration of HPCI availability.
195	Increase available net positive suction head (NPSH) for injection pumps.	SAMA increases the probability that these pumps will be available to inject coolant into the vessel by increasing the available NPSH for the injection pumps.
196	Modify Reactor Water Cleanup (RWCU) for use as a decay heat removal system and proceduralize use.	SAMA would provide an additional source of decay heat removal.

Addendum 1 SELECTED PREVIOUS INDUSTRY SAMAs (continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
197	CRD Injection	SAMA would supply an additional method of level restoration by using a non-safety system.
198	Condensate Pumps for Injection	SAMA to provide an additional option for coolant injection when other systems are unavailable or inadequate
199	Align EDG to CRD for Injection	SAMA to provide power to an additional injection source during loss of power events
200	Re-open MSIVs	SAMA to regain the main condenser as a heat sink by re-opening the MSIVs.
201	Bypass RCIC Turbine Exhaust Pressure Trip	SAMA would allow RCIC to operate longer.
202	2.a. Passive High Pressure System	SAMA will improve prevention of core melt sequences by providing additional high pressure capability to remove decay heat through an isolation condenser type system
203	2.c. Suppression Pool Jockey Pump	SAMA will improve prevention of core melt sequences by providing a small makeup pump to provide low pressure decay heat removal from the RPV using the suppression pool as a source of water.
204	2.d. Improved High Pressure Systems	SAMA will improve prevention of core melt sequences by improving reliability of high pressure capability to remove decay heat.
205	2.e. Additional Active High Pressure System	SAMA will improve reliability of high pressure decay heat removal by adding an additional system.
206	2.f. Improved Low Pressure System (Firepump)	SAMA would provide FP system pump(s) for use in low pressure scenarios.

Addendum 1 SELECTED PREVIOUS INDUSTRY SAMAs (continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
207	4.b. Clean Up Water Decay Heat Removal	This SAMA provides a means for Alternate Decay Heat Removal.
208	4.c. High Flow Suppression Pool Cooling	SAMA would improve suppression pool cooling.
209	8.c. Diverse Injection System	SAMA will improve prevention of core melt sequences by providing additional injection capabilities.
210	Alternate Charging Pump Cooling	This SAMA will improve the high pressure core flooding capabilities by providing the SI pumps with alternate gear and oil cooling sources. Given a total loss of Chilled Water, abnormal operating procedures would direct alignment of preferred Demineralized Water or the Fire System to the Chilled Water System to provide cooling to the SI pumps' gear and oil box (and the other normal loads).
	Instrument Air/Gas Improvements	
211	Modify EOPs for ability to align diesel power to more air compressors.	For plants that do not have diesel power to all normal and back-up air compressors, this change would increase the reliability of IA after a LOOP.
212	Replace old air compressors with more reliable ones	This SAMA would improve reliability and increase availability of the IA compressors.
213	Install nitrogen bottles as a back-up gas supply for safety relief valves.	This SAMA would extend operation of safety relief valves during an SBO and loss of air events (BWRs).
214	Allow cross connection of uninterruptible compressed air supply to opposite unit.	SAMA would increase the ability to vent containment using the hardened vent.

Addendum 1 SELECTED PREVIOUS INDUSTRY SAMAs (continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
	ATWS Mitigation	
215	Install MG set trip breakers in control room	This SAMA would provide trip breakers for the MG sets in the control room. In some plants, MG set breaker trip requires action to be taken outside of the control room. Adding control capability to the control room would reduce the trip failure probability in sequences where immediate action is required (e.g., ATWS).
216	Add capability to remove power from the bus powering the control rods	This SAMA would decrease the time to insert the control rods if the reactor trip breakers fail (during a loss of FW ATWS which has a rapid pressure excursion)
217	Create cross-connect ability for standby liquid control trains	This SAMA would improve reliability for boron injection during an ATWS event.
218	Create an alternate boron injection capability (back-up to standby liquid control)	This SAMA would improve reliability for boron injection during an ATWS event.
219	Remove or allow override of low pressure core injection during an ATWS	On failure on high pressure core injection and condensate, some plants direct reactor depressurization followed by 5 minutes of low pressure core injection. This SAMA would allow control of low pressure core injection immediately.
220	Install a system of relief valves that prevents any equipment damage from a pressure spike during an ATWS	This SAMA would improve equipment availability after an ATWS.
221	Create a boron injection system to back up the mechanical control rods.	This SAMA would provide a redundant means to shut down the reactor.

Addendum 1 SELECTED PREVIOUS INDUSTRY SAMAs (continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
222	Provide an additional instrument system for ATWS mitigation (e.g., ATWS mitigation scram actuation circuitry).	This SAMA would improve instrument and control redundancy and reduce the ATWS frequency.
223	Increase the safety relief valve (SRV) reseat reliability.	SAMA addresses the risk associated with dilution of boron caused by the failure of the SRVs to reseat after standby liquid control (SBLC) injection.
224	Use control rod drive for alternate boron injection.	SAMA provides an additional system to address ATWS with SBLC failure or unavailability.
225	Bypass MSIV isolation in Turbine Trip ATWS scenarios	SAMA will afford operators more time to perform actions. The 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., SBLC injection, lower water level, depressurize RPV) than if the main condenser was unavailable, resulting in lower human error probabilities
226	Enhance operator actions during ATWS	SAMA will reduce human error probabilities during ATWS
227	Guard against SBLC dilution	SAMA to control vessel injection to prevent boron loss or dilution following SBLC injection.
228	11.a. ATWS Sized Vent	This SAMA would be providing the ability to remove reactor heat from ATWS events.
229	11.b. Improved ATWS Capability	This SAMA includes items which reduce the contribution of ATWS to core damage and release frequencies.
	Other Improvements	

Addendum 1 SELECTED PREVIOUS INDUSTRY SAMAs (continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
230	Provide capability for remote operation of secondary side relief valves in an SBO	Manual operation of these valves is required in an SBO scenario. High area temperatures may be encountered in this case (no ventilation to main steam areas), and remote operation could improve success probability.
231	Create/enhance RCS depressurization ability	With either a new depressurization system, or with existing PORVs, head vents, and secondary side valve, RCS depressurization would allow earlier low pressure ECCS injection. Even if core damage occurs, low RCS pressure would alleviate some concerns about high pressure melt ejection.
232	Make procedural changes only for the RCS depressurization option	This SAMA would reduce RCS pressure without the cost of a new system
233	Defeat 100% load rejection capability.	This SAMA would eliminate the possibility of a stuck open PORV after a LOOP, since PORV opening would not be needed.
234	Change control rod drive flow control valve failure position	Change failure position to the "fail-safest" position.
235	Install secondary side guard pipes up to the MSIVs	This SAMA would prevent secondary side depressurization should a steam line break occur upstream of the main steam isolation valves. This SAMA would also guard against or prevent consequential multiple SGTR following a Main Steam Line Break event.
236	Install digital large break LOCA protection	Upgrade plant instrumentation and logic to improve the capability to identify symptoms/precursors of a large break LOCA (leak before break).

Addendum 1 SELECTED PREVIOUS INDUSTRY SAMAs (continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
237	Increase seismic capacity of the plant to a high confidence, low pressure failure of twice the Safe Shutdown Earthquake.	This SAMA would reduce seismically -induced CDF.
238	Enhance the reliability of the demineralized water (DW) make-up system through the addition of diesel-backed power to one or both of the DW make-up pumps.	Inventory loss due to normal leakage can result in the failure of the CC and the SRW systems. Loss of CC could challenge the RCP seals. Loss of SRW results in the loss of three EDGs and the containment air coolers (CACs).
239	Increase the reliability of safety relief valves by adding signals to open them automatically.	SAMA reduces the probability of a certain type of medium break LOCA. Hatch evaluated medium LOCA initiated by an MSIV closure transient with a failure of SRVs to open. Reducing the likelihood of the failure for SRVs to open, subsequently reduces the occurrence of this medium LOCA.
240	Reduce DC dependency between high pressure injection system and ADS.	SAMA would ensure containment depressurization and high pressure injection upon a DC failure.
241	Increase seismic ruggedness of plant components.	SAMA would increase the availability of necessary plant equipment during and after seismic events.
242	Enhance RPV depressurization capability	SAMA would decrease the likelihood of core damage in loss of high pressure coolant injection scenarios
243	Enhance RPV depressurization procedures	SAMA would decrease the likelihood of core damage in loss of high pressure coolant injection scenarios
244	Replace mercury switches on FP systems	SAMA would decrease probability of spurious fire suppression system actuation given a seismic event+D114

Addendum 1 SELECTED PREVIOUS INDUSTRY SAMAs (continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
245	Provide additional restraints for CO_2 tanks	SAMA would increase availability of FP given a seismic event.
246	Enhance control of transient combustibles	SAMA would minimize risk associated with important fire areas.
247	Enhance fire brigade awareness	SAMA would minimize risk associated with important fire areas.
248	Upgrade fire compartment barriers	SAMA would minimize risk associated with important fire areas.
249	Enhance procedures to allow specific operator actions	SAMA would minimize risk associated with important fire areas.
250	Develop procedures for transportation and nearby facility accidents	SAMA would minimize risk associated with transportation and nearby facility accidents.
251	Enhance procedures to mitigate Large LOCA	SAMA would minimize risk associated with Large LOCA
252	1.b. Computer Aided Instrumentation	SAMA will improve prevention of core melt sequences by making operator actions more reliable.
253	1.c/d. Improved Maintenance Procedures/Manuals	SAMA will improve prevention of core melt sequences by increasing reliability of important equipment
254	1.e. Improved Accident Management Instrumentation	SAMA will improve prevention of core melt sequences by making operator actions more reliable.
255	1.f. Remote Shutdown Station	This SAMA would provide the capability to control the reactor in the event that evacuation of the main control room is required.
256	1.g. Security System	Improvements in the site's security system would decrease the potential for successful sabotage.

Addendum 1 SELECTED PREVIOUS INDUSTRY SAMAs (continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
257	2.b. Improved Depressurization	SAMA will improve depressurization system to allow more reliable access to low pressure systems.
258	2.h. Safety Related Condensate Storage Tank	SAMA will improve availability of CST following a Seismic event
259	4.d. Passive Overpressure Relief	This SAMA would prevent vessel overpressurization.
260	8.b. Improved Operating Response	Improved operator reliability would improve accident mitigation and prevention.
261	8.d. Operation Experience Feedback	This SAMA would identify areas requiring increased attention in plant operation through review of equipment performance.
262	8.e. Improved SRV Design	This SAMA would improve SRV reliability, thus increasing the likelihood that sequences could be mitigated using low pressure heat removal.
263	12.a. Increased Seismic Margins	This SAMA would reduce the risk of core damage and release during seismic events.
264	13.b. System Simplification	This SAMA is intended to address system simplification by the elimination of unnecessary interlocks, automatic initiation of manual actions or redundancy as a means to reduce overall plant risk.
265	Train operations crew for response to inadvertent actuation signals	This SAMA would improve chances of a successful response to the loss of two 120V AC buses, which may cause inadvertent signal generation.
266	Install tornado protection on gas turbine generators	This SAMA would improve onsite AC power reliability.

ATTACHMENT F
NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM PERMIT

Pennsylvania Department of Environmental Protection

2 Public Square
Wilkes-Barre, PA 18711-0790
August 5, 2005

Northeast Regional Office

570-826-2511
Fax 570-830-3016

Mr. Britt T. McKinney
VP-Nuclear Site Operations
PPL Susquehanna, LLC
769 Salem Boulevard
Berwick, PA 18603-0467

Re: Industrial Waste
PPL Susquehanna, LLC
NPDES Permit No. PA-0047325
APS ID No. 542214
Authorization ID No. 578109
Salem Township, Luzerne County

Dear Mr. McKinney:

Your permit is enclosed.

As part of Pennsylvania's effort to prevent localized impairment, help restore impaired waters, and remove the Chesapeake Bay and its tidal tributaries from the list of impaired waters under the Clean Water Act by the year 2010, the Department of Environmental Protection (DEP) has begun to implement a strategy for reducing our nutrient and sediment loads from the Susquehanna and Potomac River watersheds. As such, the Department has placed monitoring requirements for Total Nitrogen (TN) and Total Phosphorus (TP) in your NPDES permit renewal. Monitoring of nutrient loads discharged from each point source facility is critical to documenting our progress in the restoration effort. Monitoring also helps identify the type of effort you may need to undertake to achieve any future nutrient load reductions.

Please be advised that under 25 Pa. Code §92.8a(a) of the Department's Rules and Regulations, we are notifying you that new cap load limits for TN and TP may change your existing treatment requirements. You will be advised once the cap load limits have been developed for your facility, and how those new limits will be incorporated into your NPDES permit.

Any person aggrieved by this action may appeal, pursuant to Section 4 of the Environmental Hearing Board Act, 35 P.S. Section 7514, and the Administrative Agency Law, 2 Pa. C.S., Chapter 5A, to the Environmental Hearing Board, Second Floor, Rachel Carson State Office Building, 400 Market Street, P.O. Box 8457, Harrisburg, PA 17105-8457, 717-787-3483. TDD users may contact the Board through the Pennsylvania Relay Service, 800-654-5984. Appeals must be filed with the Environmental Hearing Board within 30 days of receipt of written notice of this action unless the appropriate statute provides a different time period. Copies of the appeal form and the Board's rules of practice and procedure may be obtained from the Board. The appeal form and the Board's rules of practice and procedure are also available in Braille or on audiotape from the Secretary to the Board at 717-787-3483. This paragraph does not, in and of itself, create any right of appeal beyond that permitted by applicable statutes and decisional law.

IF YOU WANT TO CHALLENGE THIS ACTION, YOUR APPEAL MUST REACH THE BOARD WITHIN 30 DAYS. YOU DO NOT NEED A LAWYER TO FILE AN APPEAL WITH THE BOARD.

Mr. Britt T. McKinney -2- August 5, 2005

IMPORTANT LEGAL RIGHTS ARE AT STAKE, HOWEVER, SO YOU SHOULD SHOW THIS DOCUMENT TO A LAWYER AT ONCE. IF YOU CANNOT AFFORD A LAWYER, YOU MAY QUALIFY FOR FREE PRO BONO REPRESENTATION. CALL THE SECRETARY TO THE BOARD (717-787-3483) FOR MORE INFORMATION.

If you have any questions, please call Brian F. Busher, P.E. at 570-826-2306.

Sincerely

Kate Crowley

Kate Crowley
Program Manager
Water Management Program

Enclosures

cc: U.S. Environmental Protection Agency

3800-PM-WSWM0011 Rev. 4/2005
Permit

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF WATER SUPPLY AND WASTEWATER MANAGEMENT

AUTHORIZATION TO DISCHARGE UNDER THE NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM DISCHARGE REQUIREMENTS FOR INDUSTRIAL WASTEWATER FACILITIES

NPDES PERMIT NO: PA-0047325

In compliance with the provisions of the Clean Water Act, 33 U.S.C. Section 1251 *et seq.* ("the Act") and Pennsylvania's Clean Streams Law, as amended, 35 P.S. Section 691.1 *et seq.*,

PPL Susquehanna, LLC
769 Salem Boulevard
Berwick, PA 18603-0467

is authorized to discharge from a facility known as **Susquehanna Steam Electric Station**, located in **Salem Township, Luzerne County** to the **Susquehanna River** in Watershed **5B** in accordance with effluent limitations, monitoring requirements and other conditions set forth in Parts A, B and C hereof.

THIS PERMIT SHALL BECOME EFFECTIVE ON September 1, 2005

THIS PERMIT SHALL EXPIRE AT MIDNIGHT ON August 31, 2010

The authority granted by this permit is subject to the following further qualifications:

1. If there is a conflict between the application, its supporting documents and/or amendments and the terms and conditions of this permit, the terms and conditions shall apply.

2. Failure to comply with the terms, conditions, or effluent limitations of this permit is grounds for enforcement action; for permit termination, revocation and reissuance, or modification; or for denial of a permit renewal application.

3. A complete application for reissuance of this permit, or notice of intent to cease discharging by the expiration date, must be submitted to DEP at least 180 days prior to the above expiration date (unless permission has been granted by DEP for submission at a later date), using the appropriate NPDES permit application form.

   In the event that a timely and complete application for reissuance has been submitted and DEP is unable, through no fault of the permittee, to reissue the permit before the above expiration date, the terms and conditions of this permit, including submission of the Discharge Monitoring Reports (DMRs), will be automatically continued and will remain fully effective and enforceable against the discharger until DEP takes final action on the pending permit application.

4. This NPDES permit does not constitute authorization to construct or make modifications to wastewater treatment facilities necessary to meet the terms and conditions of this permit.

DATE PERMIT ISSUED August 5, 2005 **ISSUED BY** Kate Crowley
Water Management Program Manager

DATE PERMIT AMENDMENT ISSUED ____________