APPENDIX F

SEVERE ACCIDENT MITIGATION ALTERNATIVES

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ACRONYMS USED IN APPENDIX F

AMSAC	ATWS Mitigating System Actuation Circuitry
AOP	Abnormal Operating Procedure
ATWS	Anticipated Transient Without Scram
BWR	Boiling Water Reactor
CC	Component Cooling
CCW	Component Cooling Water
CDF	Core Damage Frequency
CHR	Containment Heat Removal
EDG	Emergency Diesel Generator
EOP	Emergency Operating Procedure
EPZ	Emergency Planning Zone
GIS	Geographic Information System
HEP	Human Error Probability
IPE	Individual Plant Examination
IPEEE	Individual Plant Examination – External Events
ISLOCA	Interfacing System LOCA
kV	Kilovolt
LERF	Large Early Release Frequency
LOCA	Loss of Coolant Accident
m/sec	Meters per second
MACCS2	MELCOR Accident Consequences Code System, Version 2
MG	Motor Generator
MSIV	Main Steam Isolation Valve
MWe	Megawatts-electrical
MWth	Megawatts-thermal
NPSH	Net Positive Suction Head
NRC	U.S. Nuclear Regulatory Commission
OECR	Off-site economic cost risk
PORV	Power-operated relief valve
PRA	Probabilistic Risk Analysis
PSA	Probabilistic Safety Assessment
PWR	Pressurized Water Reactor
RAI	Request for Additional Information
RCP	Reactor Coolant Pump
RDR	Real Discount Rate
RHR	Residual Heat Removal
RPV	Reactor Pressure Vessel
RWST	Refueling Water Storage Tank

ACRONYMS USED IN APPENDIX F

SAMA	Severe Accident Mitigation Alternative
SGTR	Steam Generator Tube Rupture
VCSNS	V.C. Summer Nuclear Station

F.0 APPENDIX F: SEVERE ACCIDENT MITIGATION ALTERNATIVES (SAMA)

F.1 Methodology

The methodology selected for this analysis involves identifying those Severe Accident Mitigation Alternative (SAMA) candidates that have the highest potential for reducing core damage frequency (CDF) and both radiological and economic risk to determine whether or not the implementation of those candidates is beneficial on a cost-risk reduction basis. This process consists of the following steps:

- Identify potential SAMA candidates based on V.C. Summer Nuclear Station (VCSNS), NRC, and industry documents,
- Screen out Phase 1 SAMA candidates that are not applicable to the VCSNS design or are of low benefit in Pressurized Water Reactors (PWRs),
- Determine the maximum averted cost-risk that is possible based on the VCSNS probabilistic safety assessment (PSA) Level 3 results,
- Screen out Phase 1 SAMA candidates whose estimated cost exceeds the maximum possible averted cost-risk, and
- Perform a more detailed analysis (Phase 2) to determine if the remaining SAMA candidates are desirable modifications or changes. This is based on a comparison of the averted cost-risk associated with implementing the SAMA at the site and the cost required to perform the modification. If the averted cost-risk is greater than the cost of implementation, then the SAMA candidate is considered to be a beneficial modification. PSA insights are also used to screen SAMA candidates in this phase.

The steps outlined above are described in more detail in the subsections of this appendix. Figure F.1-1 provides a graphical representation of the SAMA process.

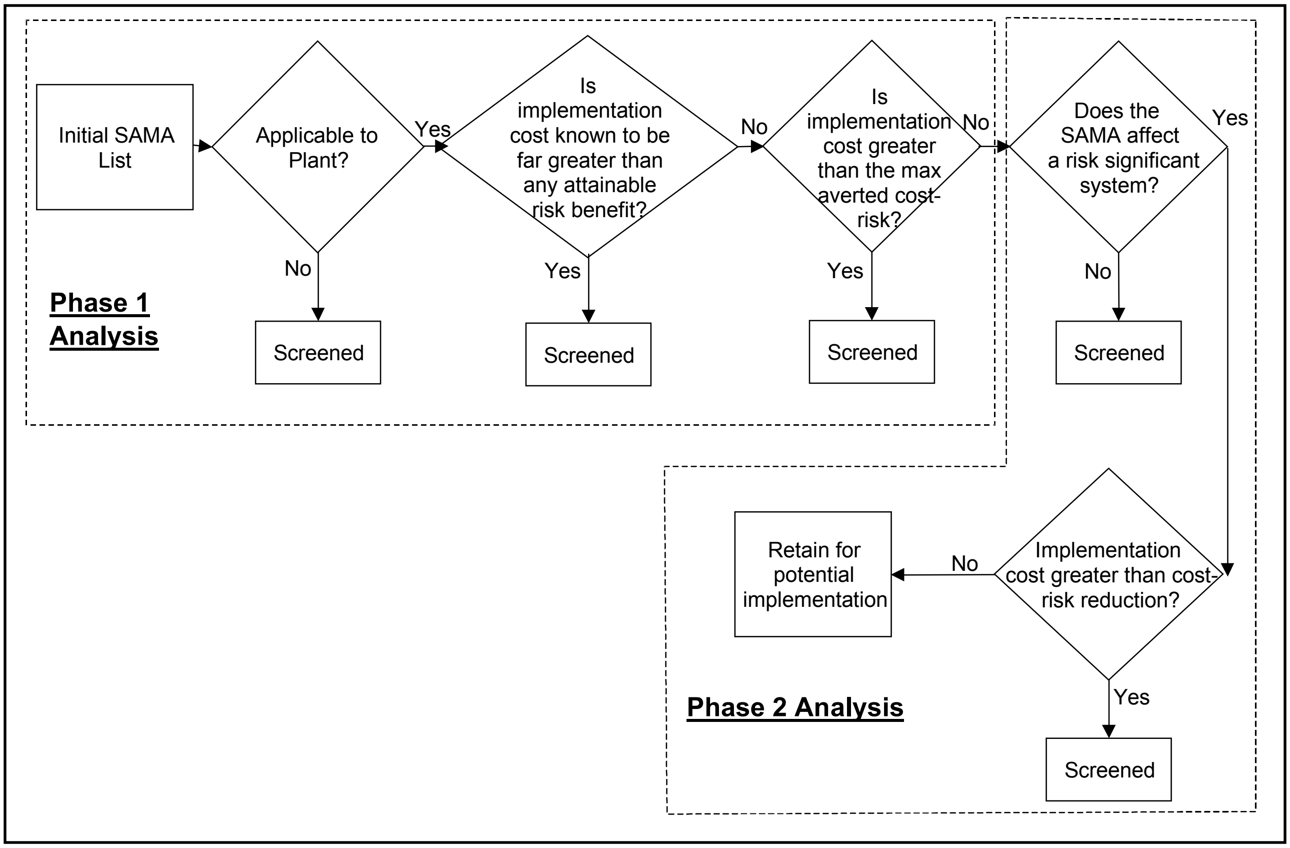

Figure F.1-1. SAMA Screening Process

F.1.1. VCSNS-Specific SAMA

The initial list of SAMA candidates for VCSNS was developed from lists of SAMAs at other nuclear power plants (including References 4, 6, 8, 11, 12, and 31), NRC documents (References 1, 2, 3, 5, 7, 13, 14, and 15), and documents related to advanced power reactor designs (ABWR SAMAs) (including References 9 and 10). In addition, plant-specific analyses (including References 16 and 17) have been used to identify potential SAMAs that address VCSNS vulnerabilities. Eleven SAMA candidates were taken from these plant-specific references and are included in this document. Four of the SAMAs identified in the VCSNS sources were considered to be unique while the other seven were already identified by industry reference sources. This process is considered to adequately address the requirement of identifying significant safety improvements that could be performed at VCSNS. The initial SAMA list, Table F.4-1, includes a column that documents the reference sources for each SAMA.

All of the SAMAs identified originally in the VCSNS Individual Plant Examination (IPE) (Reference 16) have been implemented at the plant. Two SAMAs already identified by industry sources were independently identified in plant initiated programs. These SAMAs were included in and screened in this cost-benefit analysis.

The VCSNS Individual Plant Examination – External Events (IPEEE) and IPEEE Request for Additional Information (RAI) (References 17 and 32, respectively) identified minor opportunities for plant improvements. As a result of the Seismic Analysis, electrical cabinets were bolted together to increase their ruggedness (subsumed by a generic SAMA directed at this type of upgrade). The Fire Analysis in the IPEEE identified the potential for changing plant response procedures, but these changes were judged to have a negligible impact on the results of the Fire Analysis and are not specifically included in this document.

Given the existing assessments of external events and internal fires at VCSNS, the cost-benefit analysis uses the internal events PSA as the basis for measuring the impact of SAMA implementation. No fire or external events models are used in this analysis because the Fire and IPEEE programs are considered to have already addressed potential plant improvements related to those categories.

For the purposes of this SAMA evaluation, the current VCSNS Probabilistic Risk Analysis (PRA) model (model UP3a) is used for the required quantitative assessments. The baseline CDF is 5.59E-5/yr (28,435 cutsets) and the baseline Large Early Release Frequency (LERF) is 6.99E-7/yr (45,837 cutsets). Cost-risk calculations are based on this model and the modifications made to it to represent implementation of the proposed SAMAs.

F.1.2. VCSNS-PRA History

Since the original development of the VCSNS PRA model, several updates have been performed to reflect the changes that have been made to the plant. Modeling techniques have also improved and the PRA has been enhanced to implement some of these techniques. This section summarizes the model changes that have been made since the original IPE submittal.

Section 6.1 of the IPE Submittal (Reference 16) lists the improvements to the plant that were a result of the IPE Program. These improvements address potential vulnerabilities or deficiencies, either directly or indirectly, that improved operator response to accidents or improved system or component performance. In addition to these improvements, the Submittal also discusses the use of the new O-rings in the reactor coolant pumps and also the use of the fire service system for emergency RCP thermal barrier cooling.

Table F.1-1 provides a summary of the plant improvements discussed in the submittal and also the improvement to eliminate the dependency of the component cooling water pumps and charging pumps on the chilled water system for cooling. For each improvement, the following information is provided:

- description of the improvement
- date the improvement was implemented in the plant or status of evaluation
- whether or not the improvement was credited in the IPE
- the impact of the improvement on the core damage frequency (based on the original IPE model)
- the basis for the improvement

As noted on this table, a majority of the improvements have been credited in the IPE. One improvement was evaluated in a sensitivity study and provided in the IPE Submittal Report (plant improvement number 1 from Table F.1-1), and one was evaluated in a study after the IPE results were submitted to the NRC (plant improvement number 11 from Table F.1-1). It is difficult to quantify the benefits of several of the improvements due to the qualitative nature of the changes. The benefits of several of the improvements are qualitatively assessed to be relatively small (plant improvement numbers 2 and 7 from Table F.1-1).

Plant improvement number 11 from Table F.1-1 provides some information on the elimination of the chilled water dependency of the component cooling water (CCW) pumps and charging pumps. This plant modification involved changing the charging pump cooling to the CCW system and using CCW flow to also cool the CCW pump motors. This change was evaluated using the VCSNS IPE through detailed modeling changes. It can be seen that the impact of implementing this change had a significant impact on the plant risk profile. The core damage frequency was reduced to 1.22E-04/yr from the IPE submittal value of 2.04E-04/yr.

Table F.1-2 provides a list of model update tasks which summarize the model changes from the IPE submittal through the present. The CDF and LERF are provided for each model revision, as appropriate.

TABLE F.1-1
SUMMARY AND STATUS OF VCSNS IMPROVEMENTS

Plant Improvement	Improvement Description	Date Implemented In Plant	Credited In IPE	Impact on CDF (1)	Credited in Current PRA (UP3a)	Basis For Improvement
1. Alternate Charging Pump Cooling	Developed Abnormal Operating Procedure "Total Loss of Chilled Water." Use AOP following loss of both trains of chilled water. Alternate cooling for charging pumps is established, using the preferred Demineralized Water System or the Fire Service System, so RCP seal injection can be maintained.	7/93	IPE credit only for LOSP event. Sensitivity credit for all events.	2.04E-04 (2) 1.54E-04	Yes	IPE Vulnerability
2. Chilled Water System Reliability	A "chiller rotation" policy to reduce the time a chiller will be down has been implemented. Data has indicated a correlation between chiller downtime and failure to start probability.	1/93	No	NA	N/A Chilled water removed from model	IPE Vulnerability
3. Diesel Generator Temperature Monitoring	The Fire Service System is a backup to the Service Water System for DG cooling, but the Fire Service System is not sized to maintain the DG at rated load. Steps were added to an Emergency Operating Procedure to monitor DG temperature and reduce load if temperatures increase.	9/92	No credit in IPE for alternate cooling of DG	NA, but will reduce SBO frequency due to failure of service water	No	IPE System Analysis
4. Energizing Pressurizer PORV Block Valves	Revised EOP "Response to Loss of Secondary Heat Sink" to direct operators to re-energize any PZR PORV block valves that were closed and racked out. The steps were moved up in the procedure to allow operators more time to prepare for feed and bleed before complete loss of heat sink.	8/92	Yes	NA, included in IPE Submittal report results(3)	Yes	IPE System Analysis
5. Use of Main Feedwater Pumps for a Loss of Heat Sink Event	Use the turbine-driven Feedwater System pumps to supply feedwater to the SGs if the Emergency Feedwater System fails. Currently, EOPs call for using feedwater booster pumps which require SG depressurization to less than 350 psig (the HRA showed the operator could not complete the required steps in the available time).	1/01	No	NA, but will reduce the CDF due to transients that do not lead to consequential LOCAs	No. However, EOPs direct this action.	IPE System Analysis

TABLE F.1-1
SUMMARY AND STATUS OF VCSNS IMPROVEMENTS (Cont'd)

Plant Improvement	Improvement Description	Date Implemented In Plant	Credited In IPE	Impact on CDF (1)	Credited in Current PRA (UP3a)	Basis For Improvement
6. Bypasses and Inoperable Status Indication (BISI)	The computerized BISI System, which provides a graphic control room indication of critical system operability, was reviewed and updated based on insights gained during the IPE system analyses.	6/91	No	NA, but will improve operator awareness of system problems	Considered in HRA	IPE Related Improvement
7. Reactor Building Instrument Air Supply	Operators are required to re-establish instrument air to the pressurizer PORVs to ensure sufficient air supply is available for multiple openings of the PORVs during feed and bleed. Locally opening of the valve dominating failure to re-establish instrument air was included as an improvement.	12/93	No	NA. but will improve feed and bleed availability	Yes	IPE System Analysis
8. Training and Emergency Planning Input	The IPE results have been used to identify drill scenarios that can be used in training and emergency planning.	2/93	No	NA, but there would be some benefit to HEPs lowering CDF	Considered in HRA	IPE Related Improvement
9. New RCP Seal O-rings	Use of new RCP seal O-ring to provide better performance under loss of thermal barrier cooling and seal injection conditions	RCP A - Refuel 11 (Spring '99) RCP B - Refuel 12 (Fall '00) RCP C - Refuel 10 (Fall '97)	No	NA, but will improve ability of the plant to with-stand SBO	No	IPE Vulnerability
10. Fire Water Connection for RCP Thermal Barrier Cooling	Alternate and diverse cooling source for RCP thermal barrier cooling to address SBO plant vulnerability	Not Planned	No	NA, but will reduce CDF due to SBO events	No	IPE Risk Informed Improvement

TABLE F.1-1
SUMMARY AND STATUS OF VCSNS IMPROVEMENTS (Cont'd)

Plant Improvement	Improvement Description	Date Implemented In Plant	Credited In IPE	Impact on CDF (1)	Credited in Current PRA (UP3a)	Basis For Improvement
11. Elimination of CCW and Charging/SI Pump Chilled Water Dependency	Change the cooling dependency of the CCW pumps and charging pumps from the chilled water system to the CCW system	11/94	No	1.22E-04	Yes	IPE Risk Informed Improvement
12. Installation of key switches to allow use of condensate feed during a loss of EFW.	Key switches have been provided, with the keys kept in the control room, to bypass FW isolation signals during a loss of heat sink accident. (4)	11/94	No	NA, but will reduce CDF due to loss of heat sink events	No	IPE Risk Informed Improvement

Notes:

1 - This column provides the core damage frequency with the improvement implemented based on the original IPE model.

2 - The results presented in the IPE Submittal report credit the "Loss of Chilled Water" AOP during loss of offsite power event only.

3 - The IPE does include the action to re-energize and open a closed pressurizer PORV block valve if closed, in order to initiate feed and bleed cooling. However, based on PSA input, the operator action to re-energize any closed & de-energized block valve has been moved to the front of the Loss of Heat Sink EOP. This will increase the allowed operator action time beyond the original 30 minute assumption, and increase the likelihood of success.

4 - The switches eliminate the need to install jumpers and remove a fuse in order to re-open the FW isolation valves after an SI has occurred. The original HRA analysis of the time available to establish condensate feed and the required actions to enable condensate feed (i.e., jumpers & fuses) led to the conclusion that the required actions could not be completed in time. Therefore, the REP for OAF (Establish Condensate Feed) was set to a value of 1.0 (i.e., assumed to fail). The use of the new switches may be included in a future PRA model update. No impact on CDF is available at this time.

TABLE F.1-2
PRA MODEL CHANGES - IPE SUBMITTAL THROUGH 3RD UPDATE 1/2000

MODEL REVISION	CDF	LERF	CALC NUMBER
IPE Model	2.0E-4	N/A	IPE SUBMITTAL
Data Update	1.8E-4	N/A	DCOO300-033
VU / CCW MOD	1.2E-4	N/A	DCOO300-034
EFW CK VLV MOD, Expand IA Modeling, and Other Modeling Changes	9.6E-5	N/A	DCOO300-035 & DCOO300-037
Conversion to Singletop Model and Removed Excess Conservatism to Singletop Model	8.4E-5	N/A	DCOO300-131
Created Stand Alone LERF Model	N/A	1.7E-6	DCOO300-132
Updated Common Cause Failure Probability	8.6E-5	1.1 E-6	DCOO300-133
Demodulized Special Initiators	8.6E-5	1.1 E-6	DCOO300-136
Human Reliability Analysis Update	1.3E-4	2.2E-6	DCOO300-134
Second Data Update (Changes Primarily Due To LOCA Freq Changes, NUREG 5750 And LOSP)	5.8E-5	8.9E- 7	DCOO300-135
Third Data Update, Common Cause Update And Model Corrections	5.6E-5	7.0E-7	DCOO300-137

F.2 Level 3 PRA Analysis

F.2.1 Analysis

The MACCS2 code (Reference 34) was used to perform the level 3 PRA for VCSNS. The input parameters given with the MACCS2 "Sample Problem A," which included the NUREG-1150 food model (Reference 35), formed the basis for the present analysis. These generic values were supplemented with parameters specific to VCSNS and its surrounding area. Site-specific data included population distribution, economic parameters, and agricultural production. Plant-specific release data included the time-nuclide distribution of releases, release frequencies, and release locations. The behavior of the population during a release (evacuation parameters) was based on plant- and site-specific set points (i.e., declaration of a General Emergency) and the emergency planning zone (EPZ) evacuation table (Reference 36). These data were used in combination with site-specific meteorology to simulate the probability distribution of impact risks (exposure and economic) to the surrounding population (within 50 miles) from the large early release accident sequences at VCSNS.

F.2.2 Population

The population surrounding VCSNS was estimated for the year 2042. The distribution was given in terms of population at distances to 1, 2, 3, 4, 5, 10, 20, 30, 40 and 50 miles from the plant and in the direction of each of the 16 compass points (i.e., N, NNE, NE, NNW). The total population for the 160 sectors (10 distances × 16 directions) in the region was estimated as 2,078,740, the distribution of which is given in Tables F.2-1 and F.2-2.

Population projections within 50 miles of VCSNS were determined using a geographic information system (GIS), U.S. Nuclear Regulatory Commission (NRC) sector population data for 1990, and population growth rates based on 1990 and 2000 county-level U.S. Census Bureau data. Population sectors were created for 16 sectors at an interval of 1 mile from 0 to 5 miles, the interval from 5 to 10 miles and at 10-mile intervals from 10 miles to 50 miles. The counties were combined with the sectors to determine which counties fell within each sector. The area of each county within a given sector was calculated to determine the area fraction of a county or counties that comprise each sector. The decennial growth rate for each county was converted to an equivalent annual growth rate. The annual growth rate in each sector was then calculated by the sum of the products of the annual growth rate of each county within a sector and the fraction of the area in that sector occupied by that county. This weighted-average annual growth rate for each sector is given in Tables F.2-3 and F.2-4.

TABLE F.2-1
ESTIMATED POPULATION DISTRIBUTION WITHIN A 10-MILE RADIUS OF VCSNS, YEAR 2042

Sector	0-1 mile	1-2 miles	2-3 miles	3-4 miles	4-5 miles	5-10 miles	10-mile total
N	0	0	0	16	9	267	292
NNE	0	0	0	20	364	216	600
NE	0	0	7	0	0	207	214
ENE	0	144	89	1	60	420	714
E	0	72	0	8	51	661	792
ESE	0	0	68	0	13	597	678
SE	0	156	83	42	143	339	763
SSE	0	7	0	26	0	1,611	1,644
S	0	0	0	1	138	1,806	1,945
SSW	0	0	3	11	78	2,199	2,291
SW	0	0	33	75	23	1,153	1,284
WSW	0	0	0	16	241	1,181	1,438
W	0	15	15	25	0	465	520
WNW	0	0	0	0	28	1,104	1,132
NW	0	0	0	32	74	367	473
NNW	0	0	12	51	99	323	485
Total	0	394	310	324	1,321	12,916	15,265

TABLE F.2-2
ESTIMATED POPULATION DISTRIBUTION WITHIN A 50-MILE RADIUS OF VCSNS, YEAR 2042

Sector	0-10 miles	10-20 miles	20-30 miles	30-40 miles	40-50 miles	50-mile total
N	292	921	8,291	6,705	49,643	65,852
NNE	600	410	13,351	10,229	206,009	230,599
NE	214	1,838	4,514	15,800	65,188	87,554
ENE	714	11,201	1,029	2,934	20,973	36,851
E	792	2,969	5,432	29,636	50,040	88,869
ESE	678	4,796	58,929	19,997	8,201	92,601
SE	763	22,327	343,898	61,527	15,997	444,512
SSE	1,644	104,555	275,790	49,253	19,112	450,354
S	1,945	24,968	53,003	25,550	13,195	118,661
SSW	2,291	15,496	34,764	21,126	11,351	85,028
SW	1,284	4,316	6,542	15,571	39,729	67,442
WSW	1,438	5,344	3,596	6,349	15,510	32,237
W	520	23,881	3,062	6,881	77,271	111,615
WNW	1,132	1,170	5,509	44,286	52,446	104,543
NW	473	804	3,972	5,308	15,393	25,950
NNW	485	482	2,237	18,414	14,454	36,072
Total	15,265	225,478	823,919	339,566	674,512	2,078,740

TABLE F.2-3
ESTIMATED ANNUAL POPULATION GROWTH RATE WITHIN A 10-MILE RADIUS OF VCSNS

Sector	0-1 mile	1-2 miles	2-3 miles	3-4 miles	4-5 miles	5-10 miles
N	1.0051	1.0051	1.0051	1.0051	1.0051	1.0051
NNE	1.0051	1.0051	1.0051	1.0051	1.0051	1.0051
NE	1.0051	1.0051	1.0051	1.0051	1.0051	1.0051
ENE	1.0051	1.0051	1.0051	1.0051	1.0051	1.0051
E	1.0051	1.0051	1.0051	1.0051	1.0051	1.0051
ESE	1.0051	1.0051	1.0051	1.0051	1.0051	1.0051
SE	1.0051	1.0051	1.0051	1.0051	1.0051	1.0059
SSE	1.0051	1.0051	1.0051	1.0051	1.0066	1.0107
S	1.0051	1.0051	1.0051	1.0059	1.0096	1.0171
SSW	1.0051	1.0051	1.0061	1.0085	1.0085	1.0137
SW	1.0051	1.0053	1.0079	1.0085	1.0085	1.0085
WSW	1.0051	1.0075	1.0085	1.0085	1.0085	1.0085
W	1.0051	1.0065	1.0084	1.0085	1.0085	1.0085
WNW	1.0051	1.0051	1.0065	1.0084	1.0085	1.0085
NW	1.0051	1.0051	1.0051	1.0057	1.0072	1.0083
NNW	1.0051	1.0051	1.0051	1.0051	1.0051	1.0052

The NRC 1990 sector population data for VCSNS provided in NUREG/CR-6525 (Reference 37), was projected to the year 2042 using the county area-weighted-average annual growth rate in each sector. The county populations in 1990 and 2000 are provided in Reference 38. It was assumed that the annual population growth rate would remain constant to that reported between 1990 and 2000. Using the sector-specific population growth rates, projections were made for the year 2042 by multiplying the 1990 sector population data by the annual growth rate raised to the power of 52 (2042-1990 = 52).

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 specifying the data for each of the 22 South Carolina counties surrounding the plant, to a distance of 50 miles. The values used for each of the 160 sectors was then the data corresponding to that county which made up a vast majority of the land in that sector. For 22 sectors, no county encompassed more than two-thirds of the area, so conglomerate data (weighted by the fraction of each county in that sector) was defined.

TABLE F.2-4.
ESTIMATED ANNUAL POPULATION GROWTH RATE WITHIN A 10 TO 50-MILE RADIUS OF VCSNS

Sector	0-10 miles	10-20 miles	20-30 miles	30-40 miles	40-50 miles
N	See Table F.2-3	1.0052	1.0057	1.0125	1.0227
NNE	See Table F.2-3	1.0051	1.0057	1.0081	1.0215
NE	See Table F.2-3	1.0051	1.0054	1.0085	1.0132
ENE	See Table F.2-3	1.0051	1.0068	1.0155	1.0144
E	See Table F.2-3	1.0051	1.0077	1.0186	1.0189
ESE	See Table F.2-3	1.0092	1.0124	1.0154	1.0083
SE	See Table F.2-3	1.0113	1.0122	1.0117	1.0127
SSE	See Table F.2-3	1.0190	1.0256	1.0232	1.0170
S	See Table F.2-3	1.0245	1.0257	1.0254	1.0169
SSW	See Table F.2-3	1.0209	1.0233	1.0195	1.0173
SW	See Table F.2-3	1.0089	1.0160	1.0161	1.0282
WSW	See Table F.2-3	1.0085	1.0127	1.0137	1.0139
W	See Table F.2-3	1.0085	1.0091	1.0153	1.0142
WNW	See Table F.2-3	1.0085	1.0134	1.0181	1.0180
NW	See Table F.2-3	1.0054	1.0031	1.0007	1.0095
NNW	See Table F.2-3	1.0033	0.9998	0.9997	1.0094

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), value of farm and non-farm wealth, and fraction of farm wealth from improvements (e.g., buildings, equipment).

Agriculture

Agricultural production information was taken from the 1997 Agricultural Census (Reference 39). Production within 50 miles of VCSNS was estimated based on those counties within this radius. Production in those counties, which lie partially outside of this area, was multiplied by the fraction of the county within the area of interest. Cotton and tobacco, non-foods, were harvested from 5 percent of the croplands within 50 miles of the site. Of the food crops, stored forage (22 percent of total cropland, consisting of hay) and grain (11 percent of the total cropland, made up of corn and wheat) were harvested from the largest areas. The total food and commercial harvest consumed almost 50 percent of the croplands within 50 miles of VCSNS; pasture made up another 38 percent of this land.

The lengths of the growing seasons for grains, roots, and legumes were obtained from Reference 40. The duration of the growing seasons for the remaining crop categories (pasture, stored forage, green leafy vegetables, and other food crops) were taken to be the same as those used previously at a site in the neighboring state of Georgia (Reference 31).

Nuclide Release

The core inventory at the time of the accident was based on the input supplied in the MACCS2 User's Guide (Reference 34). The core inventory corresponds to the end-of-cycle values for a 3,412-MWth PWR plant. A scaling factor of 0.850 was used to provide a representative core inventory of 2,900-MWth at VCSNS. Table F.2-5 gives the estimated VCSNS core inventory. Release frequencies (1.18×10^{-7}, 1.78×10^{-7}, and 4.04×10^{-7} for sequences SGL16BH, ILM08BH, and TRE13NH, respectively) and nuclide release fractions (of the core inventory) were analyzed to determine the sum of the exposure (50-mile dose) and economic (50-mile economic costs) risks from large early release sequences SGL16BH, ILM08BH, and TRE13NH. VCSNS nuclide release categories were related to the MACCS2 categories, as shown in Table F.2-6.

Where appropriate, multiple release duration periods were defined that represented the duration of each category's releases. Each VCSNS category corresponded with a single release duration (either puff or continuous); MACCS2 categories Te and Ce required multiple releases.

The reactor building has a diameter of 154 feet and a height of 190 feet. All releases were modeled as occurring at ground level. The thermal content of each release was conservatively assumed as to be the same as ambient (i.e., buoyant plume rise was not modeled).

Evacuation

The initiating event for each sequence was taken as time zero relative to the core containment response times. A General Emergency is declared when plant conditions degrade to the point where it is judged that there is a credible risk to the public; for example, for the SGL16BH case a General Emergency will be declared when two of the three fission product barriers have been breached and the third is in jeopardy. A General Emergency is declared at 22.8 hours (after initiating event) for Sequence SGL16BH, at 10 hours for Sequence ILM08BH, and 6.5 hours for Sequence TRE13NH.

TABLE F.2-5
ESTIMATED VCSNS CORE INVENTORY

Nuclide	Core Inventory (Becquerels)	Nuclide	Core Inventory (Becquerels)
Co-58	2.740×10^{16}	Te-131m	3.978×10^{17}
Co-60	2.095×10^{16}	Te-132	3.959×10^{18}
Kr-85	2.104×10^{16}	I-131	2.725×10^{18}
Kr-85m	9.852×10^{17}	I-132	4.016×10^{18}
Kr-87	1.800×10^{18}	I-133	5.762×10^{18}
Kr-88	2.434×10^{18}	I-134	6.324×10^{18}
Rb-86	1.605×10^{15}	I-135	5.433×10^{18}
Sr-89	3.052×10^{18}	Xe-133	5.765×10^{18}
Sr-90	1.647×10^{17}	Xe-135	1.082×10^{18}
Sr-91	3.924×10^{18}	Cs-134	3.675×10^{17}
Sr-92	4.083×10^{18}	Cs-136	1.119×10^{17}
Y-90	1.767×10^{17}	Cs-137	2.054×10^{17}
Y-91	3.718×10^{18}	Ba-139	5.340×10^{18}
Y-92	4.098×10^{18}	Ba-140	5.284×10^{18}
Y-93	4.636×10^{18}	La-140	5.399×10^{18}
Zr-95	4.697×10^{18}	La-141	4.952×10^{18}
Zr-97	4.895×10^{18}	La-142	4.774×10^{18}
Nb-95	4.440×10^{18}	Ce-141	4.803×10^{18}
Mo-99	5.183×10^{18}	Ce-143	4.670×10^{18}
Tc-99m	4.474×10^{18}	Ce-144	2.894×10^{18}
Ru-103	3.861×10^{18}	Pr-143	4.586×10^{18}
Ru-105	2.511×10^{18}	Nd-147	2.050×10^{18}
Ru-106	8.772×10^{17}	Np-239	5.494×10^{19}
Rh-105	1.739×10^{18}	Pu-238	3.114×10^{15}
Sb-127	2.369×10^{17}	Pu-239	7.024×10^{14}
Sb-129	8.391×10^{17}	Pu-240	8.857×10^{14}
Te-127	2.288×10^{17}	Pu-241	1.492×10^{17}
Te-127m	3.029×10^{16}	Am-241	9.852×10^{13}
Te-129	7.877×10^{17}	Cm-242	3.771×10^{16}
Te-129m	2.077×10^{17}	Cm-244	2.207×10^{15}

TABLE F.2-6
MACCS2 RELEASE CATEGORIES VS. VCSNS RELEASE CATEGORIES

MACCS2 Release Categories	VCSNS Release Categories
Xe/Kr	1 – noble gases
I	2 – CsI
Cs	2 & 6 – CsI and CsOH
Te	3 & 11- TeO_2 and Te_2
Sr	4 – SrO
Ru	5 – MoO_2 (Mo is in Ru MACCS2 category)
La	8 – La_2O_3
Ce	9 – CeO_2 & UO_2
Ba	7 – BaO
Sb (supplemental category)	10 – Sb

The MACCS2 User's Guide input parameters of 95 percent of the population within 10 miles of the plant (Emergency Planning Zone) evacuating and 5 percent not evacuating were employed. These values have been used in similar studies (e.g., Hatch and Calvert Cliffs, References 31 and 15, respectively) and are conservative relative to the NUREG-1150 study, which assumed evacuation of 99.5 percent of the population within the EPZ (Reference 35). The evacuees are assumed to evacuate at a radial speed of 0.43 meter/second (Reference 36). This speed is taken from the minimum speed from any evacuation zone under adverse weather conditions.

Meteorology

Annual meteorology data sets from 1996 through 2000 were investigated for use in MACCS2. The 1997 data set was found to result in the largest doses and was subsequently used to create the one-year sequential hourly data set used in MACCS2. Wind speed and direction from the 10-meter sensor were combined with precipitation (hourly cumulative) and atmospheric stability (specified according to the vertical temperature gradient as measured between the 60-meter and 10-meter levels). Hourly stability was classified according to the scheme used by the NRC (Reference 15).

Atmospheric mixing heights were specified for AM and PM hours. These values were taken as 380 and 1,450 meters, respectively (Reference 43).

MACCS2 Results

The resulting annual risks from VCSNS early release sequences SGL16BH, ILM08BH, and TRE13NH (and their sum) are provided in Table F.2-7. The largest risks are from ILM08BH, it having the largest release, especially of Cs, I, and Sr. This sequence contributes two-thirds of the risks from these large early releases.

TABLE F.2-7
RESULTS OF VCSNS LEVEL 3 PRA ANALYSIS

Sequence	SGL16BH	ILM08BH	TRE13NH	Sum of annual risk
Population dose risk (person-rem)				
0-50 miles	0.273	0.628	0.053	0.954
Total economic cost risk ($)				
0-50 miles	741	1,994	4	2,739

Quantification of the base case shows a baseline CDF of 5.59×10^{-5}/yr based on 28,435 cutsets (accident scenarios). The baseline LERF is 6.99×10^{-7}/yr based on 45,837 cutsets. MACCS2 calculated the annual baseline population dose risk within 50 miles at 0.954 person-rem. The total annual economic risk was calculated at $2,739.

F.3 Cost-Benefit Analysis

F.3.1 Offsite Exposure Cost

The baseline annual offsite exposure risk was converted to dollars using the NRC's conversion factor of $2,000 per person-rem (Reference 30, Section 5.7.1.2), and discounting to present value using NRC's standard formula (Reference 30, Section 5.7.1.3):

$$W_{pha} = C * Z_{pha}$$

Where:

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

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

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

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

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

The calculated value for C using 20 years and a 7 percent discount rate is 10.76. Therefore, calculating the discounted monetary equivalent of accident risk involves multiplying the dose risk (0.95 person-rem per year) by $2,000 and by the C value (10.76). The calculated offsite exposure cost is $20,540.

F.3.2 Offsite Economic Cost-Risk

The baseline VCSNS PSA offsite economic cost-risk (OECR) is $2,739. This cost-risk is an annual estimate based on conditions present at the end of the license renewal period. The baseline OECR must also be discounted to present value in order to account for the entire license renewal period. This is performed in the same manner as for public health risks and uses the same C value. The resulting estimate is $29,480.

F.3.3 Onsite Exposure Cost-Risk

Occupational health cost-risk was evaluated using the NRC methodology in Reference 30, Section 5.7.3, which involves separately evaluating "immediate" and long-term doses.

Immediate Dose - For the case in which the plant is in operation, the equation that NRC recommends using (Reference 30, Sections 5.7.3 and 5.7.3.3) is:

Equation 1:

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

Where:

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

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

F = accident frequency (events/yr)

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

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

$_A$ = subscript denoting after implementation of proposed action

r = real discount rate

t_f = years remaining until end of facility life.

The values used in the VCSNS analysis are:

R = $2,000/person-rem

r = 0.07

D_{IO} = 3,300 person-rem/accident (best estimate, from Reference 30, Section 5.7.3.1)

t_f = 20 years (license renewal period)

F = 5.6E-5 (baseline CDF)

For the basis discount rate, assuming F_A is zero, the best estimate of the immediate dose cost is:

$$W_{10} = R\left(FD_{IO}\right)_S * \left\{\frac{\left[1 - \exp(-rt_f)\right]}{r}\right\}$$

$$= \quad 2000 * (5.6E - 5 * 3{,}300) * \left\{\frac{[1 - \exp(-0.07 * 20)]}{0.07}\right\}$$

= $3,978

Long-Term Dose - For the case in which the plant is in operation, the NRC equation (Reference 30, Sections 5.7.3 and 5.7.3.3) is:

Equation 2:

$$W_{LTO} = R\{(FD_{LTO})_S - (FD_{LTO})_A\} * \left\{\frac{[1 - \exp(-rt_f)]}{r}\right\} * \left\{\frac{[1 - \exp(-rm)]}{rm}\right\}$$

Where:

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

m = years over which long-term doses accrue

The values used in the VCSNS analysis are:

R = $2,000/person-rem

r = 0.07

D_{LTO} = 20,000 person-rem/accident (best estimate, Reference 30, Section 5.7.3.1)

m = 10 years (estimate)

t_f = 20 years (license renewal period)

F = 5.6E-5 (baseline CDF)

For the basis discount rate, assuming F_A is zero, the best estimate of the long-term dose is:

$$W_{LTO} = R\ (FD_{LTO})_S * \left\{\frac{[1 - \exp(-rt_f)]}{r}\right\} * \left\{\frac{[1 - \exp(-rm)]}{rm}\right\}$$

$$= 2000 * (5.6E - 5 * 20{,}000) * \left\{\frac{[1 - \exp(-0.07 * 20)]}{0.07}\right\} * \left\{\frac{[1 - \exp(-0.07 * 10)]}{0.07 * 10}\right\}$$

= $17,338

Total Occupational Exposure - Combining Equations 1 and 2 above and using the above numerical values, the total accident related on-site (occupational) exposure avoided (W_O) based on Summer Station's contribution to independent, single-unit core damage is:

$$W_O = W_{IO} + W_{LTO} = (\$3{,}978 + \$17{,}338) = \$21{,}316$$

F.3.4 Onsite Cleanup and Decontamination Cost

The net present value that NRC provides for cleanup and decontamination for a single event is $1.1 billion discounted over a 10-year cleanup period (Reference 30, Section 5.7.6.1). NRC uses the following equation to integrate the net present value over the average number of remaining service years:

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

Where:

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

r = real discount rate

t_f = years remaining until end of facility life.

The values used in the VCSNS analysis are:

PV_{CD} = $1.1E9

r = 0.07

t_f = 20

The resulting net present value of cleanup integrated over the license renewal term, $1.18E10 must be multiplied by the baseline CDF of 5.6E-5 to determine the expected value of cleanup and decontamination costs. The resulting monetary equivalent is $662,995.

F.3.5 Replacement Power Cost

Long-term replacement power cost was determined following NRC methodology in Reference 30, Section 5.7.6.2. The net present value of replacement power for a single event, PV_{RP}, was determined using the following equation:

$$PV_{RP} = \left[\frac{\$1.2E8}{r}\right] * [1 - \exp(-rt_f)]^2$$

Where:

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

r = 0.07

t_f = 20 years (license renewal period)

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

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

Where:

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

After applying a correction factor to account for VCSNS size relative to the "generic" reactor described in NUREG/BR-0184 (i.e., 966 MWe/910 MWe), the replacement power costs are determined to be 8.38E9 ($-year). Multiplying this value by the baseline CDF (5.6E-5) results in a replacement power cost of $469,049.

F.3.6 Baseline Screening

The sum of the baseline costs for a core damage event is as follows:

Offsite exposure cost	=	$20,540
Offsite economic cost	=	$29,480
Onsite exposure cost	=	$21,316
Onsite cleanup cost	=	$662,995
Replacement power cost	=	$469,049
Total cost	=	$1,203,380

This cost estimate was used in screening out SAMAs that are not economically feasible; if the estimated cost of implementing a SAMA exceeded $1.203 million, it was discarded from further analysis. Exceeding this threshold would mean that a SAMA would not have a positive net value even if it could eliminate all severe accident costs. On the other hand, if the cost of implementation is less than this value, then a more detailed examination of the potential fractional risk benefit that can be attributed to the SAMA is performed.

F.4 Phase 1 SAMA Analysis: SAMA Candidates and Screening Process

An initial list of 268 SAMA candidates is presented in Table F.4-1. This list was then screened to remove those candidates that were not applicable to VCSNS due to design differences or high implementation costs. In addition, SAMAs were eliminated if they were related to changes that would be made during the design phase of a plant rather than to an existing plant. These would typically screen on high cost, but they are categorized separately for reference purposes. The SAMA screening process is presented graphically in Figure F.1-1.

A majority of the SAMAs were removed from further consideration because they did not apply to the Westinghouse 3 Loop PWR design used at VCSNS. The SAMA candidates that were found to be in place at VCSNS were also screened from further consideration.

The SAMAs related to design changes prior to construction (primarily consisting of those candidates taken from the ABWR SAMAs) were removed, as they were not applicable to an existing site. Any candidate known to have an implementation cost that far exceeds any possible risk benefit was screened from further analysis. Any SAMA candidates that were sufficiently similar to other SAMA candidates were treated in the same manner as those to which they were related to; either combined or screened from further consideration.

A preliminary cost estimate was prepared for each of the remaining candidates to focus on those that had the possibility of having a positive benefit and to eliminate those whose costs were beyond the possibility of any corresponding benefit (as determined by the VCSNS baseline screening cost). When the screening cutoff of $1,203,380 was applied, a majority of the remaining SAMA candidates were eliminated, as their implementation costs were more expensive than the maximum postulated benefit associated with the elimination of all risk associated with full power internal events. This left 32 SAMA candidates for further analysis (Table F.4-2). Those SAMAs that required a more detailed cost-benefit analysis are evaluated in Section F.5, using the combined methods described in F.2 and F.3.

TABLE F.4-1
PHASE 1 SAMA

Phase 1 SAMA ID number	SAMA title	Source Reference of SAMA	Result of potential enhancement	Screening Criteria [See Notes]	Disposition	Phase 2 SAMA ID number
			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.	1	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.	#3 - Already implemented at VCSNS	This modification has already been implemented at VCSNS (Reference 21).	N/A
2	Enhance loss of component cooling procedure to facilitate stopping reactor coolant pumps.	2	SAMA would reduce the potential for reactor coolant pump (RCP) seal damage due to pump bearing failure.	#3 - Already implemented at VCSNS	Plant abnormal operating procedures direct trip of RCPs on loss of CCW or high temperature of the motor bearings, seal water bearings, or seal water outlet.	N/A
3	Enhance loss of component cooling procedure to present desirability of cooling down reactor coolant system (RCS) prior to seal LOCA.	2	SAMA would reduce the potential for RCP seal failure.	#2 - Similar item is addressed under other proposed SAMAs	Loss of component cooling water at VCSNS does not lead directly to a seal LOCA. While CCW provides cooling to the Charging Pumps, there are alternate methods of cooling the Charging Pumps. Abnormal operating procedures provide directions to align a diverse set of cooling sources including Chilled Water, Fire Service Water, and Demineralized Water. Use of these systems to provide cooling to the Charging Pumps such that seal injection remains available is considered to be preferable to a rapid cooldown of the plant to prevent seal failure. This is treated in SAMA #5.	N/A

TABLE F.4-1
PHASE 1 SAMA (Cont'd)

Phase 1 SAMA ID number	SAMA title	Source Reference of SAMA	Result of potential enhancement	Screening Criteria [See Notes]	Disposition	Phase 2 SAMA ID number
4	Provide additional training on the loss of component cooling.	2	SAMA would potentially improve the success rate of operator actions after a loss of component cooling (to restore RCP seal damage).	#3 - Already implemented at VCSNS	Loss of Component Cooling Water scenarios receive significant attention in the VCSNS training program. Further training or enhancements would impact operator action reliability however, the potential improvement would be difficult to quantify. No measurable change would result from implementing this change at V.C. Summer.	N/A
5	Provide hardware connections to allow another essential raw cooling water system to cool charging pump seals.	1 2	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.	#3 - Already implemented at VCSNS	The charging pumps are normally cooled by Component Cooling Water (CCW); however, on loss of normal cooling, abnormal operating procedures have been developed to direct alignment of Chilled Water (VU) (preferred system), Demineralized Water (DW), or the Fire Service Water System to the charging pumps (Reference 16).	N/A
6	Procedure changes to allow cross connection of motor cooling for RHRSW pumps.	11	SAMA would allow continued operation of both RHRSW pumps on a failure of one train of PSW.	#1 - Not applicable to the VCSNS Design	Emergency Feedwater pumps (an approximate PWR equivalent) are cooled by the process fluid (Reference 16).	N/A
7	Proceduralize shedding component cooling water loads to extend component cooling heatup on loss of essential raw cooling water.	2	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.	#3 - Already implemented at VCSNS	VCSNS abnormal operating procedures direct shedding unnecessary CCW loads.	N/A
8	Increase charging pump lube oil capacity.	2	SAMA would lengthen the time before centrifugal charging pump failure due to lube oil overheating in loss of CC sequences.	#6 - Retain	N/A	1
9	Eliminate the RCP thermal barrier dependence on component cooling such that loss of component cooling does not result directly in core damage.	2	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.	#3 - Already implemented at VCSNS	Loss of Component Cooling Water does not directly result in core damage at VCSNS. The charging pumps, which provide seal injection to the RCPs, are normally cooled by Component Cooling Water with backup cooling from Chilled Water, Demineralized Water or Fire Service Water (Reference 16).	N/A

TABLE F.4-1
PHASE 1 SAMA (Cont'd)

Phase 1 SAMA ID number	SAMA title	Source Reference of SAMA	Result of potential enhancement	Screening Criteria [See Notes]	Disposition	Phase 2 SAMA ID number
10	Add redundant DC control power for PSW pumps C and D.	3	SAMA would increase reliability of PSW and decrease core damage frequency due to a loss of SW.	#6 - Retain	N/A	2
11	Create an independent RCP seal injection system, with a dedicated diesel.	1	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.	#5 - Cost would be more than risk benefit	While seal injection is an important function, the cost estimate for installation of new seals alone exceeds $2.5 million. A new, independent seal injection system is judged to greatly exceed this cost and the maximum averted cost risk of $1.2 million (Reference 24).	N/A
12	Use existing hydro-test pump for RCP seal injection.	4	SAMA would provide an independent seal injection source, without the cost of a new system.	#6 - Retain	N/A	3
13	Replace ECCS pump motor with air-cooled motors.	1	SAMA would eliminate ECCS dependency on component cooling system (but not on room cooling).	#5 - Cost would be more than risk benefit	The cost of this enhancement is expected to greatly exceed the maximum averted cost risk that could be gained by its implementation. Installation of an additional Service Water pump has been estimated at $5.9 million; this change is considered to be similar to installing new ECCS pumps. While new piping and power supplies would not have to be installed to support the new ECCS pumps, unneeded CCW and Chilled Water piping would have to be removed and capped and the number of new ECCS pumps is five compared with only one in the reference case.	N/A
14	Install improved RCS pump seals.	1	SAMA would reduce probability of RCP seal LOCA by installing RCP seal O-ring constructed of improved materials.	#3 - Already implemented at VCSNS	New RCP seals were installed over the span of refuel outages 10, 11, and 12.	N/A
15	Install additional component cooling water pump.	1	SAMA would reduce probability of loss of component cooling leading to RCP seal LOCA.	#5 - Cost would be more than risk benefit	Based on engineering judgement, the cost of this enhancement is expected to greatly exceed the maximum averted cost risk ($1.2 million) that could be gained by its implementation. Installation of an additional Service Water pump has been estimated at $5.9 million; this change is considered to be similar to installing an additional CCW pump.	N/A

TABLE F.4-1
PHASE 1 SAMA (Cont'd)

Phase 1 SAMA ID number	SAMA title	Source Reference of SAMA	Result of potential enhancement	Screening Criteria [See Notes]	Disposition	Phase 2 SAMA ID number
16	Prevent centrifugal charging pump flow diversion from the relief valves.	1	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.	#6 - Retain	N/A	4
17	Change procedures to isolate RCP seal letdown flow on loss of component cooling, and guidance on loss of injection during seal LOCA.	1	SAMA would reduce CDF from loss of seal cooling.	#3 - Already implemented at VCSNS	Letdown flow isolation is already directed in plant AOPs on loss of CCW.	N/A
18	Implement procedures to stagger high-pressure safety injection (HPSI) pump use after a loss of service water.	1	SAMA would allow HPSI to be extended after a loss of service water.	#4 - No significant safety benefit.	The high pressure injection pumps at VCSNS (the charging pumps) are normally cooled by CCW, which in turn is cooled by Service Water; however, the charging pumps have three alternate, diverse cooling sources (Fire Service Water, Demineralized Water, and Chilled Water). Addition of another method to prevent charging pump overheating on loss of Service Water would not significantly improve charging pump reliability (Reference 16).	N/A
19	Use fire protection system pumps as a backup seal injection and high-pressure makeup.	1	SAMA would reduce the frequency of the RCP seal LOCA and the SBO CDF.	#5 - Cost would be more than risk benefit	Fire protection is a low head system at VCSNS and cannot be used as a HP injection source. Modifications to convert it to a high pressure system would be a high cost improvement. Installation of new high pressure piping, a high head, high flow pump (as it would also have to support the fire system) and a supporting diesel generator or pump motor is similar in scope to SAMA 179. The cost is also considered to be similar ($5 million to $10 million, Reference 24) and is greater than the maximum averted cost-risk for VCSNS ($1.2 million).	N/A

TABLE F.4-1
PHASE 1 SAMA (Cont'd)

Phase 1 SAMA ID number	SAMA title	Source Reference of SAMA	Result of potential enhancement	Screening Criteria [See Notes]	Disposition	Phase 2 SAMA ID number
20	Enhance procedural guidance for use of cross-tied component cooling or service water pumps.	1	SAMA would reduce the frequency of the loss of component cooling water and service water.	#3 - Already implemented at VCSNS	VCSNS is equipped with a third "swing" pump that can be aligned to either CCW loop on loss of the running pump. Use of this pump is proceduralized and is judged to meet the intent of this SAMA. The Service Water System is designed in the same way.	N/A
21	Procedure enhancements and operator training in support system failure sequences, with emphasis on anticipating problems and coping.	1 2 16	SAMA would potentially improve the success rate of operator actions subsequent to support system failures.	#2 - Similar item is addressed under other proposed SAMAs.	See SAMAs 20, 27, 30, 90, 95, 96, 97, and 103	N/A
22	Improved ability to cool the residual heat removal heat exchangers.	1	SAMA would reduce the probability of a loss of decay heat removal by implementing procedure and hardware modifications to allow manual alignment of the fire protection system or by installing a component cooling water cross-tie.	#6 - Retain	Any CCW train can be aligned to either RHR load and VCSNS is a single unit site, so there can be no inter-unit cross-tie. Service water can also be cross-tied to CCW for emergency cooling. Modification of the fire protection system to provide cooling to the CCW heat exchangers has been estimated at $565,000 in Reference 19. While this estimate appears to include only the piping modifications, purchase of new pump(s) may not increase the cost of implementation above the maximum averted cost-risk for VCSNS ($1.2 million). This SAMA will be examined in more detail in Phase 2.	5
23	8.a. Additional Service Water Pump	Advanced Reactors SAMDAs	SAMA would conceivably reduce common cause dependencies from SW system and thus reduce plant risk through system reliability improvement.	#5 - Cost would be more than risk benefit	The cost of implementing this SAMA has been estimated at approximately $5.9 million and is greater than the maximum averted cost-risk ($1.2 million).	N/A

TABLE F.4-1
PHASE 1 SAMA (Cont'd)

Phase 1 SAMA ID number	SAMA title	Source Reference of SAMA	Result of potential enhancement	Screening Criteria [See Notes]	Disposition	Phase 2 SAMA ID number
24	Create an independent RCP seal injection system, without dedicated diesel	15	This SAMA would add redundancy to RCP seal cooling alternatives, reducing the CDF from loss of CC or SW, but not SBO.	#5 - Cost would be more than risk benefit	Calvert Cliffs Nuclear Power Plant estimated the cost of installing new seals that do not require cooling to be greater than $2.5 million (Reference 24). Based on this estimate and engineering judgement, the cost of installing a completely new and independent seal injection system would significantly exceed the maximum averted cost-risk ($1.2 million).	N/A
			Improvements Related to Heating, Ventilation, and Air Conditioning (HVAC)			
25	Provide reliable power to control building fans.	2	SAMA would increase availability of control room ventilation on a loss of power.	#3 - Already implemented at VCSNS	CR HVAC is supplied by Class 1E, redundant power (Reference 16).	N/A
26	Provide a redundant train of ventilation.	1	SAMA would increase the availability of components dependent on room cooling.	#5 - Cost would be more than risk benefit	Three rooms have been identified as requiring room cooling at VCSNS: the ESF switchgear room, the Relay Room, and the EDG room. The Relay Room and EDG rooms already have redundant HVAC trains. While the switchgear rooms themselves are redundant, there is only one train of HVAC to each room. The cost of installing a redundant, diverse train of HVAC for a switchgear room has been estimated at $10 million (Reference 24) and far exceeds the maximum averted cost-risk for VCSNS ($1.2 million).	N/A
27	Procedures for actions on loss of HVAC.	11	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).	#3 - Already implemented at VCSNS	Individual losses of room cooling are addressed by the VCSNS annunciator response procedures and plant AOPs direct alternate cooling given loss of the Chilled Water system, which supplies the HVAC system with cooling water.	N/A
28	Add a diesel building switchgear room high temperature alarm.	1	SAMA would improve diagnosis of a loss of switchgear room HVAC. Option 1: Install high-temp alarm. Option 2: Redundant louver and thermostat	#3 - Already implemented at VCSNS	High temperature in the switchgear room is already alarmed in the VCSNS Control Room.	N/A

TABLE F.4-1
PHASE 1 SAMA (Cont'd)

Phase 1 SAMA ID number	SAMA title	Source Reference of SAMA	Result of potential enhancement	Screening Criteria [See Notes]	Disposition	Phase 2 SAMA ID number
29	Create ability to switch fan power supply to DC in an SBO event.	1	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.	#1 - Not applicable to the VCSNS Design	In the IPE, room cooling has been shown to be required only for ESF Switchgear (SG), the Relay Room (RR), and the EDG rooms (Reference 16). Room heat-up calcs show that RR temp remains below 120° F. for the first 4 hours of an SBO with loss of HVAC. No equipment operability issues are identified for these conditions and given the 4 hour life of the batteries, no power would be available for cooling after this time. For the SG room, the major heat loads will not be present in an SBO as high voltage AC in unavailable by definition; however, there is a room heatup analysis available that shows the equipment in the room will remain operable even when energized during loss of HVAC. The SG room reaches 132° F. at 4 hours without HVAC. The equipment in this room can operate for 8 hours with the temp. above 102° F. and 4 hours if greater than 132° F. For the EDG rooms, the EDGs will not be running in an SBO; thus, there will not be a significant heat load. Once the EDGs are available, the batteries would not be required to provide power for HVAC. For these reasons, use of the station batteries to provide power for HVAC does not benefit VCSNS.	N/A
30	Enhance procedure to instruct operators to trip unneeded RHR/CS pumps on loss of room ventilation.	11	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.	#1 - Not applicable to the VCSNS Design	Room cooling is not required for operation of SI or EFW at VCSNS.	N/A

TABLE F.4-1
PHASE 1 SAMA (Cont'd)

Phase 1 SAMA ID number	SAMA title	Source Reference of SAMA	Result of potential enhancement	Screening Criteria [See Notes]	Disposition	Phase 2 SAMA ID number
31	Stage backup fans in switchgear (SGR) rooms	15	This SAMA would provide alternate ventilation in the event of a loss of SGR room ventilation.	#3 - Already implemented at VCSNS	There is already an alternate room cooling action implemented at VCSNS for high switchgear room temperature. This action is to open the rooms' doors to allow natural circulation. Additionally, when Chilled Water is unavailable, each ESF switchgear room air handling unit has a non-safety direct expansion coil and associated condensing unit.	N/A
Improvements Related to Ex-Vessel Accident Mitigation/Containment Phenomena						
32	Delay containment spray actuation after large LOCA.	2	SAMA would lengthen time of RWST availability.	#4 - No significant safety benefit.	For Large LOCA initiators, use of the sump as an injection source is required regardless of any action to extend RWST availability. A potential benefit of this SAMA would be an increase in the time between the cue to switch to sump suction and core damage due. This is due to the lower decay heat level that would be present at the time swap is required. The benefit would be reflected in the evaluation of the human action to complete the suction swap-over; however, the change in the HEP would be negligible as would the impact on the CDF and LERF (Reference 16).	N/A
33	Install containment spray pump header automatic throttle valves.	4 7	SAMA would extend the time over which water remains in the RWST, when full CS flow is not needed.	#2 - Similar item is addressed under other proposed SAMAs.	See SAMA 32	N/A
34	Install an independent method of suppression pool cooling.	5	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.	#5 - Cost would be more than risk benefit	Installation of a new, independent, suppression pool cooling system is similar in scope to installing a new containment spray system, which has been estimated to cost approximately \$5.8 million (Reference 24). This exceeds the maximum averted cost-risk for VCSNS (\$1.2 million).	N/A

TABLE F.4-1
PHASE 1 SAMA (Cont'd)

Phase 1 SAMA ID number	SAMA title	Source Reference of SAMA	Result of potential enhancement	Screening Criteria [See Notes]	Disposition	Phase 2 SAMA ID number
35	Develop an enhanced drywell spray system. At VCSNS, use of the CRDM Cooling System was suggested as an additional containment temperature and pressure control source.	5	SAMA would provide a redundant source of water to the containment to control containment pressure, when used in conjunction with containment heat removal.	#6 - Retain	N/A	6
36	Provide dedicated existing drywell spray system.	5	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.	#2 - Similar item is addressed under other proposed SAMAs.	See SAMA 35	N/A
37	Install an unfiltered hardened containment vent.	5	SAMA would provide an alternate decay heat removal method for non-ATWS events, with the released fission products not being scrubbed.	#1 - Not applicable to the VCSNS Design	Containment heat removal to preserve containment integrity is not an issue for large, dry containments. The long time periods associated with the need to vent with this type of containment would rule out any contribution to LERF, which dominates the offsite consequences. In addition, the estimated cost of installing an unfiltered containment vent ($3.1 million) (Reference 24) is greater than the maximum averted cost-risk for VCSNS ($1.2 million).	N/A
38	Install a filtered containment vent to remove decay heat.	5	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	#1 - Not applicable to the VCSNS Design	Containment heat removal to preserve containment integrity is not an issue for large, dry containments. The long time periods associated with the need to vent with this type of containment would rule out any contribution to LERF, which dominates the offsite consequences. In addition, the estimated cost of installing a filtered containment vent ($5.7 million) (Reference 24) is significantly greater than the maximum averted cost-risk for VCSNS.	N/A

TABLE F.4-1
PHASE 1 SAMA (Cont'd)

Phase 1 SAMA ID number	SAMA title	Source Reference of SAMA	Result of potential enhancement	Screening Criteria [See Notes]	Disposition	Phase 2 SAMA ID number
39	Install a containment vent large enough to remove ATWS decay heat.	5	Assuming that injection is available, this SAMA would provide alternate decay heat removal in an ATWS event.	#2 - Similar item is addressed under other proposed SAMAs.	See SAMAs 37, 38	N/A
40	Create/enhance hydrogen recombiners with independent power supply.	10	SAMA would reduce hydrogen detonation at lower cost, using 1) a new independent power supply 2) a non-safety-grade portable generator 3) existing station batteries 4) existing AC/DC independent power supplies.	#6 - Retain	N/A	7
41	Install hydrogen recombiners.	10	SAMA would provide a means to reduce the chance of hydrogen detonation.	#3 - Already implemented at VCSNS	VCSNS already has thermal hydrogen recombiners.	N/A
42	Create a passive design hydrogen ignition system.	4	SAMA would reduce hydrogen denotation system without requiring electric power.	#2 - Similar item is addressed under other proposed SAMAs.	See SAMA 40	N/A
43	Create a large concrete crucible with heat removal potential under the basemat to contain molten core debris.	5	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.	#5 - Cost would be more than risk benefit	Core retention devices have been investigated in previous studies. IDCOR concluded that "core retention devices are not effective risk reduction devices for degraded core events." Other evaluations have shown the worth value for a core retention device to be on the order of $7,000 (averted cost-risk) compared to an estimated implementation cost of over $1 million (per unit).	N/A

TABLE F.4-1
PHASE 1 SAMA (Cont'd)

Phase 1 SAMA ID number	SAMA title	Source Reference of SAMA	Result of potential enhancement	Screening Criteria [See Notes]	Disposition	Phase 2 SAMA ID number
44	Create a water-cooled rubble bed on the pedestal.	5	SAMA would contain molten core debris dropping on to the pedestal and would allow the debris to be cooled.	#5 - Cost would be more than risk benefit	Core retention devices have been investigated in previous studies. IDCOR concluded that "core retention devices are not effective risk reduction devices for degraded core events." Other evaluations have shown the worth value for a core retention device to be on the order of $7,000 (averted cost-risk) compared to an estimated implementation cost of over $1 million (per unit) (Reference 33).	N/A
45	Provide modification for flooding the drywell head.	5	SAMA would help mitigate accidents that result in the leakage through the drywell head seal.	#1 - N/A to VCSNS Design	This is a BWR issue. PWR containment does not include an equivalent structure/component that this modification could be applied to and is screened from further consideration (Reference 16).	N/A
46	Enhance fire protection system and/or standby gas treatment system hardware and procedures.	5	SAMA would improve fission product scrubbing in severe accidents.	#1 - N/A to VCSNS Design	Current Fire Protection and Standby Gas Treatment Systems do not have sufficient capacity to handle the loads from severe accidents that result in a bypass or breach of the containment. Loads produced as a result of RPV or containment blowdown would require large filtering capacities. These filtered vented systems have been previously investigated and found not to provide sufficient cost benefit.	N/A
47	Create a reactor cavity flooding system.	1 3 6 7	SAMA would enhance debris coolability, reduce core concrete interaction, and provide fission product scrubbing.	#5 - Cost would be more than risk benefit	The estimated cost of implementation for this SAMA is $8.75 million (Reference 24), which greatly exceeds the maximum averted cost-risk ($1.2 million).	N/A
48	Create other options for reactor cavity flooding. VCSNS identified Fire Water as a potential system that could be used as an alternate source for containment flooding.	1	SAMA would enhance debris coolability, reduce core concrete interaction, and provide fission product scrubbing.	#6 - Retain	N/A	8

TABLE F.4-1
PHASE 1 SAMA (Cont'd)

Phase 1 SAMA ID number	SAMA title	Source Reference of SAMA	Result of potential enhancement	Screening Criteria [See Notes]	Disposition	Phase 2 SAMA ID number
49	Enhance air return fans (ice condenser plants).	1	SAMA would provide an independent power supply for the air return fans, reducing containment failure in SBO sequences.	#1 - N/A to VCSNS Design	VCSNS is not an ice condenser plant (Reference 16).	N/A
50	Create a core melt source reduction system.	8	SAMA would provide cooling and containment of molten core debris. Refractory material would be placed underneath the reactor vessel such that a molten core falling on the material would melt and combine with the material. Subsequent spreading and heat removal from the vitrified compound would be facilitated, and concrete attack would not occur.	#5 - Cost would be more than risk benefit	Core retention devices have been investigated in previous studies. IDCOR concluded that "core retention devices are not effective risk reduction devices for degraded core events." Other evaluations have shown the worth value for a core retention device to be on the order of $7,000 compared to an estimated implementation cost of over $1 million (Reference 33).	N/A
51	Provide a containment inerting capability.	6 7	SAMA would prevent combustion of hydrogen and carbon monoxide gases.	#1 - N/A to VCSNS Design	Containment inerting is important in small volume containments where hydrogen combustion can challenge maximum pressure limits. Overpressure from ignition of combustible gases is not an important contributor to large, dry containment failures. In addition, this SAMA is not considered viable in a large volume containment where access may be required.	N/A
52	Use the fire protection system as a backup source for the containment spray system.	4	SAMA would provide redundant containment spray function without the cost of installing a new system.	#2 - Similar item is addressed under other proposed SAMAs.	See SAMA 35	N/A
53	Install a secondary containment filtered vent.	9	SAMA would filter fission products released from primary containment.	#2 - Similar item is addressed under other proposed SAMAs.	See SAMA 38	N/A

TABLE F.4-1
PHASE 1 SAMA (Cont'd)

Phase 1 SAMA ID number	SAMA title	Source Reference of SAMA	Result of potential enhancement	Screening Criteria [See Notes]	Disposition	Phase 2 SAMA ID number
54	Install a passive containment spray system.	9	SAMA would provide redundant containment spray method without high cost.	#2 - Similar item is addressed under other proposed SAMAs.	See SAMAs 35 and 52	N/A
55	Strengthen primary/secondary containment.	9 10	SAMA would reduce the probability of containment overpressurization to failure.	#5 - Cost would be more than risk benefit	Vendor documents discuss the cost of increasing the containment pressure capacity, which is effectively strengthening the containment. This cost is estimated assuming the change is made during the design phase whereas for VCSNS, the changes would have to be made as a retrofit. The cost estimated for the ABWR was $12 million and it is judged that to properly retrofit an existing containment that the cost would be greater. This cost of implementation for this SAMA exceeds the maximum averted cost-risk for VCSNS ($1.2 million).	N/A
56	Increase the depth of the concrete basemat or use an alternative concrete material to ensure melt-through does not occur.	10	SAMA would prevent basemat melt-through.	#5 - Cost would be more than risk benefit	Core retention devices have been investigated in previous studies. IDCOR concluded that "core retention devices are not effective risk reduction devices for degraded core events." Other evaluations have shown the worth value for a core retention device to be on the order of $7,000 compared to an estimated implementation cost of over $1 million/site (Reference 33).	N/A
57	Provide a reactor vessel exterior cooling system.	10	SAMA would provide the potential to cool a molten core before it causes vessel failure, if the lower head could be submerged in water.	#5 - Cost would be more than risk benefit	This has been estimated to cost $2.5 million (Reference 24) and exceeds the maximum averted cost-risk for VCSNS ($1.2 million).	N/A
58	Construct a building to be connected to primary/secondary containment that is maintained at a vacuum.	10	SAMA would provide a method to depressurize containment and reduce fission product release.	#5 - Cost would be more than risk benefit	Based on engineering judgement, the cost of this enhancement is expected to greatly exceed the maximum averted cost risk ($1.2 million).	N/A

TABLE F.4-1
PHASE 1 SAMA (Cont'd)

Phase 1 SAMA ID number	SAMA title	Source Reference of SAMA	Result of potential enhancement	Screening Criteria [See Notes]	Disposition	Phase 2 SAMA ID number
59	Refill CST.	14	SAMA would reduce the risk of core damage during events such as extended station blackouts or LOCAs that render the suppression pool unavailable as an injection source due to heat up.	#6 - Retain	This is primarily a BWR issue; however, a similar case for a PWR may be the use of the sump as a suction source while in recirculation mode. In this case, the water used to refill the RWST is required to be borated. This would require installation of equipment that can provide borated makeup water at a high flow-rate, which is not currently installed at VCSNS.	9
60	Maintain ECCS suction on CST.	14	SAMA would maintain suction on the CST as long as possible to avoid pump failure as a result of high suppression pool temperature.	#3 - Already implemented at VCSNS	For a PWR, a similar change could be to delay swapping the suction source from the RWST to the sump; however, it is already common practice to inject with the RWST for as long as is safely possible prior to swapping to recirc mode. VCSNS EOPs do not direct swap to recirc until RWST level is below 18 percent, where 6 percent is considered to be "empty."	N/A
61	Modify containment flooding procedure to restrict flooding to below Top of Active Fuel.	Industry IPEEE Insights	SAMA would avoid forcing containment venting.	#4 - No significant safety benefit	For smaller containments such as the BWR Mark I, flooding to higher containment levels can cause unnecessary pressurization of the containment and force venting. Adequate cooling is possible with the level at top of active fuel. This is not an issue for larger volume containments.	N/A
62	Enhance containment venting procedures with respect to timing, path selection and technique.	Industry IPEEE Insights	SAMA would improve likelihood of successful venting strategies.	#3 - Already implemented at VCSNS	These steps are addressed in the VCSNS SAMGs.	N/A
63	1.a. Severe Accident EPGs/AMGs	Advanced Reactors SAMDAs	SAMA would lead to improved arrest of core melt progress and prevention of containment failure.	#3 - Already Implemented at VCSNS	The SAMGs have been implemented at VCSNS.	N/A
64	1.h. Simulator Training for Severe Accident	Advanced Reactors SAMDAs	SAMA would lead to improved arrest of core melt progress and prevention of containment failure.	#3 - Already Implemented at VCSNS	VCSNS already provides Control Room Operators and Technical Support Center staff with training on using the SAMGs to diagnose and to implement mitigative actions. Classroom training, self-study, and procedure driven drills are used to prepare personnel for plant operation during severe accidents.	N/A

TABLE F.4-1
PHASE 1 SAMA (Cont'd)

Phase 1 SAMA ID number	SAMA title	Source Reference of SAMA	Result of potential enhancement	Screening Criteria [See Notes]	Disposition	Phase 2 SAMA ID number
65	2.g. Dedicated Suppression Pool Cooling	Advanced Reactors SAMDAs	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.	#2 - Similar item is addressed under other proposed SAMAs.	See SAMA 34	N/A
66	3.a. Larger Volume Containment	Advanced Reactors SAMDAs	SAMA increases time before containment failure and increases time for recovery.	#5 - Cost would be more than risk benefit	VCS is already a large, dry containment. Further enlargement of the containment would be similar in scope to the ABWR design change SAMA to implement a larger volume containment, but would likely exceed the $8 million estimate for that change as a retrofit would be required. This is greater than the maximum averted cost-risk ($1.2 million).	N/A
67	3.b. Increased Containment Pressure Capability (sufficient pressure to withstand severe accidents)	Advanced Reactors SAMDAs	SAMA minimizes likelihood of large releases.	#2 - Similar item is addressed under other proposed SAMAs.	See SAMA 55	N/A
68	3.c. Improved Vacuum Breakers (redundant valves in each line)	Advanced Reactors SAMDAs	SAMA reduces the probability of a stuck open vacuum breaker.	#1 - N/A to VCSNS Design	This is a BWR issue. PWR containment does not include an equivalent structure/component that this modification could be applied to and is screened from further consideration (Reference 16).	N/A
69	3.d. Increased Temperature Margin for Seals	Advanced Reactors SAMDAs	This SAMA would reduce the probability of seal failure given loss of containment heat removal. It would improve containment response and reduce the probability of a radioactive release.	#1 - N/A to VCSNS Design	High temperature containment seal failure is not an issue for a large, dry containment; computed containment temperatures are generally below the failure threshold (Reference 16).	N/A

TABLE F.4-1
PHASE 1 SAMA (Cont'd)

Phase 1 SAMA ID number	SAMA title	Source Reference of SAMA	Result of potential enhancement	Screening Criteria [See Notes]	Disposition	Phase 2 SAMA ID number
70	3.e. Improved Leak Detection	Advanced Reactors SAMDAs	Improved leak detection within the containment would help identify primary system leaks. This would lead to early identification of potential LOCAs because leaks are often precursors of breaks.	#3 - Already implemented at VCSNS	Leak rates from the primary system are already monitored as part of tech spec requirements and instrumentation is available to identify leaks (Reference 19). Enhancing the procedures or equipment is possible, but the reduction in the LOCA frequency resulting from these changes is judged to be negligible (Reference 16).	N/A
71	3.f. Suppression Pool Scrubbing	Advanced Reactors SAMDAs	Modifications to route release paths through the suppression pool would provide a means of filtering the release gases in the suppression pool water volume. This would reduce the amount of radionuclides released to the environment from the containment.	#1 - N/A to VCSNS Design	This is a BWR issue. PWR containment does not include an equivalent structure/component that this modification could be applied to and is screened from further consideration.	N/A
72	3.g. Improved Bottom Penetration Design	Advanced Reactors SAMDAs	SAMA reduces failure likelihood of RPV bottom head penetrations	#7 - ABWR Design Issue; not practical.	This is primarily a BWR issue. The mechanisms of vessel breach due to contact with core debris are more of a concern with the larger penetrations present in the BWR bottom head design. Also, this is considered to be an initial design issue rather than a mod due to the prohibitive cost. Screened from further consideration.	N/A
73	4.a. Larger Volume Suppression Pool (double effective liquid volume)	Advanced Reactors SAMDAs	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.	#1 - N/A to VCSNS Design	This is a BWR issue. PWR containment does not include an equivalent structure/component that this modification could be applied to and is screened from further consideration. The pressure relief tanks are not used as an injection source and an increase in their size would not provide additional time to recover heat removal (Reference 16).	N/A
74	5.a/d. Unfiltered Vent	Advanced Reactors SAMDAs	SAMA would provide an alternate decay heat removal method with the released fission products not being scrubbed.	#2 - Similar item is addressed under other proposed SAMAs.	See SAMA 37	N/A

TABLE F.4-1
PHASE 1 SAMA (Cont'd)

Phase 1 SAMA ID number	SAMA title	Source Reference of SAMA	Result of potential enhancement	Screening Criteria [See Notes]	Disposition	Phase 2 SAMA ID number
75	5.b/c. Filtered Vent	Advanced Reactors SAMDAs	SAMA would provide an alternate decay heat removal method with the released fission products being scrubbed.	#2 - Similar item is addressed under other proposed SAMAs.	See SAMA 38 and 53	N/A
76	6.a. Post Accident Inerting System	Advanced Reactors SAMDAs	SAMA would reduce likelihood of gas combustion inside containment.	#2 - Similar item is addressed under other proposed SAMAs.	See SAMA 51	N/A
77	6.b. Hydrogen Control by Venting	Advanced Reactors SAMDAs	SAMA would reduce likelihood of gas combustion inside containment.	#3 - Already Implemented at VCSNS	The SAMG developers have considered the possibility of venting for hydrogen control, but the actions considered most appropriate for VCSNS do not include venting for control. Hydrogen ignition and hydrogen recombination are directed to maintain low hydrogen concentrations within containment during an accident.	N/A
78	6.c. Pre-inerting	Advanced Reactors SAMDAs	SAMA would reduce likelihood of gas combustion inside containment.	#2 - Similar item is addressed under other proposed SAMAs.	See SAMAs 51 and 76	N/A
79	6.d. Ignition Systems	Advanced Reactors SAMDAs	This SAMA would burn combustible gases before they reach levels at which combustion would challenge containment integrity.	#2 - Similar item is addressed under other proposed SAMAs.	See SAMA 42	N/A

TABLE F.4-1
PHASE 1 SAMA (Cont'd)

Phase 1 SAMA ID number	SAMA title	Source Reference of SAMA	Result of potential enhancement	Screening Criteria [See Notes]	Disposition	Phase 2 SAMA ID number
80	6.e. Fire Suppression System Inerting	Advanced Reactors SAMDAs	This SAMA would help maintain a non-combustible atmosphere within containment.	#1 - N/A to VCSNS Design	This is a BWR issue. PWR containments are large and this SAMA would require extremely costly modifications to implement and would inhibit access to the containment. Screened from further consideration (Reference 16). See SAMAs 51, 76, and 78	N/A
81	7.a. Drywell Head Flooding	Advanced Reactors SAMDAs	SAMA would provide intentional flooding of the upper drywell head such that if high drywell temperatures occurred, the drywell head seal would not fail.	#2 - Similar item is addressed under other proposed SAMAs.	See SAMA 45	N/A
82	7.b. Containment Spray Augmentation	Advanced Reactors SAMDAs	This SAMA would provide additional methods of spraying the containment.	#2 - Similar item is addressed under other proposed SAMAs.	See SAMAs 32, 33, 35, 36, 52, and 54	N/A
83	12.b. Integral Basemat	Advanced Reactors SAMDAs	This SAMA would improve containment and system survivability for seismic events.	#8 - ABWR Design Issue; not practical.	This is an ABWR design issue and is not considered for retrofit due to a cost of implementation that is judged to far exceed the maximum averted cost-risk.	N/A
84	13.a. Reactor Building Sprays	Advanced Reactors SAMDAs	This SAMA provides the capability to use firewater sprays in the reactor building to mitigate release of fission products into the Reactor Bldg. following an accident.	#2 - Similar item is addressed under other proposed SAMAs.	See SAMAs 32, 33, 35, 36, 52, 54, and 82	N/A
85	14.a. Flooded Rubble Bed	Advanced Reactors SAMDAs	SAMA would contain molten core debris dropping on to the pedestal and would allow the debris to be cooled.	#2 - Similar item is addressed under other proposed SAMAs.	See SAMA 44	N/A

TABLE F.4-1
PHASE 1 SAMA (Cont'd)

Phase 1 SAMA ID number	SAMA title	Source Reference of SAMA	Result of potential enhancement	Screening Criteria [See Notes]	Disposition	Phase 2 SAMA ID number
86	14.b. Reactor Cavity Flooder	Advanced Reactors SAMDAs	SAMA would enhance debris coolability, reduce core concrete interaction, and provide fission product scrubbing.	#2 - Similar item is addressed under other proposed SAMAs.	Addressed in SAMAs 47 and 57	N/A
87	14.c. Use Basaltic Cements for Reactor Containment, Pedestal, and Basement	Advanced Reactors SAMDAs	SAMA would minimize carbon dioxide production during core concrete interaction.	#7 - ABWR Design Issue; not practical.	This is a SAMA that was considered for ABWR design. It is not practical to backfit this modification into a plant that is already built and operating due to prohibitive cost.	N/A
88	Provide a core debris control system	15	(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.	#1 - N/A to VCSNS Design	VCSNS is not an ice condenser plant (Reference 16).	N/A
89	Add ribbing to the containment shell	15	This SAMA would reduce the risk of buckling of containment under reverse pressure loading.	#2 - Similar item is addressed under other proposed SAMAs.	This item is similar in nature to SAMA 55, but for protection against negative pressure. Using SAMA 55 as an upper bound and a relatively simple modification such as SAMA 37 as a lower bound, the cost of performing structural enhancements to the reactor building that will significantly strengthen the containment is judged to exceed the maximum averted cost-risk for VCSNS ($1.2 million).	N/A
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.	1 3 6	SAMA would reduce the SBO frequency.	#1 - N/A to VCSNS Design	There is no "spare" diesel at VCSNS (Reference 16). This SAMA requires the installation of an additional diesel to yield credit, which is screened based on cost in SAMA 91.	N/A

TABLE F.4-1
PHASE 1 SAMA (Cont'd)

Phase 1 SAMA ID number	SAMA title	Source Reference of SAMA	Result of potential enhancement	Screening Criteria [See Notes]	Disposition	Phase 2 SAMA ID number
91	Provide an additional diesel generator.	1 3 6 10	SAMA would increase the reliability and availability of onsite emergency AC power sources.	#5 - Cost would be more than risk benefit	The cost of installing an additional diesel generator has been estimated at over $20 million in Reference 24. The cost of implementation for this SAMA greatly exceeds the maximum averted cost-risk for VCSNS ($1.2 million).	N/A
92	Provide additional DC battery capacity.	1 3 6 10 11	SAMA would ensure longer battery capability during an SBO, reducing the frequency of long-term SBO sequences.	#5 - Cost would be more than risk benefit	The cost of implementation for this SAMA has been estimated to be $1.88 million in Reference 24. This exceeds the maximum averted cost-risk for VCSNS ($1.2 million).	N/A
93	Use fuel cells instead of lead-acid batteries.	10	SAMA would extend DC power availability in an SBO.	#5 - Cost would be more than risk benefit	The cost of implementation for this SAMA has been estimated to be $2 million in Reference 24. This exceeds the maximum averted cost-risk for VCSNS ($1.2 million).	N/A
94	Procedure to cross-tie high-pressure core spray diesel.	1	SAMA would improve core injection availability by providing a more reliable power supply for the high-pressure core spray pumps.	#2 - Similar item is addressed under other proposed SAMAs.	See SAMA 95.	N/A
95	Improve 4-kV bus cross-tie ability.	1	Enhance procedures to direct 4-kV bus cross-tie. If this procedural step already exists, investigate installation of hardware that would perform an automatic cross-tie to the opposite 4kV bus given failure of the dedicated diesel. (7.2-kV at VCSNS)	#6 - Retain	N/A	10
96	Incorporate an alternate battery charging capability.	1 7 8	SAMA would improve DC power reliability by either cross-tying the AC busses, or installing a portable diesel-driven battery charger.	#3 - Already implemented at VCSNS	A swing battery charger is installed at VCSNS that can be powered by either division of Class 1E AC power (Reference 16). Plant system operating procedures provide the step by step instructions to align the swing charger to either DC division using power from either AC division.	N/A

TABLE F.4-1
PHASE 1 SAMA (Cont'd)

Phase 1 SAMA ID number	SAMA title	Source Reference of SAMA	Result of potential enhancement	Screening Criteria [See Notes]	Disposition	Phase 2 SAMA ID number
97	Increase/improve DC bus load shedding.	1 7	SAMA would extend battery life in an SBO event.	#3 - Already implemented at VCSNS	The DC loads that may be shed at VCSNS are limited and are provided in plant EOPs.	N/A
98	Replace existing batteries with more reliable ones.	10	SAMA would improve DC power reliability and thus increase available SBO recovery time.	#3 - Already implemented at VCSNS	Reliable batteries are already installed (Reference 16). In addition, the battery life was extended in an SBO to 4 hours. This upgrade replaced the C and D Type LC-15 batteries with Type L-31 cells.	N/A
99	Mod for DC Bus A reliability.	1	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.	#1 - N/A to VCSNS Design	Loss of a single DC bus does not have a large impact on VCSNS (Reference 16). The DC configuration is different than the BWRs that this SAMA was derived from.	N/A
100	Create AC power cross-tie capability with other unit.	1 7 8	SAMA would improve AC power reliability.	#1 - N/A to VCSNS Design	VCSNS is not a multi-unit site (Reference 16); screened from further analysis.	N/A
101	Create a cross-tie for diesel fuel oil.	1	SAMA would increase diesel fuel oil supply, and thus diesel generator reliability.	#3 - Already implemented at VCSNS.	The diesel fuel oil storage tanks (52,000 gallons each) are already crosstied such that either tank may be used as the suction source to fill either diesel's day tank (Reference 20).	N/A
102	Develop procedures to repair or replace failed 4-kV breakers.	1	SAMA would offer a recovery path from a failure of the breakers that perform transfer of 4-kV non-emergency busses from unit station service transformers, leading to loss of emergency AC power. (7.2-kV at VCSNS)	#3 - Already implemented at VCSNS.	VCSNS operating procedures direct identification and correction of the causes of power failures. Replacement of the breaker itself is a skill of the craft action.	N/A

TABLE F.4-1
PHASE 1 SAMA (Cont'd)

Phase 1 SAMA ID number	SAMA title	Source Reference of SAMA	Result of potential enhancement	Screening Criteria [See Notes]	Disposition	Phase 2 SAMA ID number
103	Emphasize steps in recovery of offsite power after an SBO.	1	SAMA would reduce human error probability during offsite power recovery.	#3 - Already implemented at VCSNS	Plant personnel are aware of the importance of recovering offsite power in a LOOP event. In addition, EOPs direct control room operators to monitor the status of offsite power recovery actions so that the operations staff remains informed of the progress of recovery actions. Procedural enhancements related to emphasizing offsite power recovery steps in the procedure would have a negligible impact on the CDF and LERF results and are not considered further as any related changes would not be cost beneficial.	N/A
104	Develop a severe weather conditions procedure.	1 12	For plants that do not already have one, this SAMA would reduce the CDF for external weather-related events.	#3 - Already implemented at VCSNS	Plant procedures provide instructions for severe weather.	N/A
105	Develop procedures for replenishing diesel fuel oil.	1	SAMA would allow for long-term diesel operation.	#3 - Already implemented at VCSNS	This function is performed automatically so that fuel level is maintained between 300 and 450 gallons in the diesel day tank.	N/A
106	Install gas turbine generator.	1	SAMA would improve onsite AC power reliability by providing a redundant and diverse emergency power system.	#5 - Cost would be more than risk benefit	The cost of installing a diverse, redundant, gas turbine generator is similar in scope to installing a new diesel generator. The cost of installing an additional diesel generator has been estimated at over $20 million in Reference 24. This cost of implementation for this SAMA greatly exceeds the maximum averted cost-risk for VCSNS ($1.2 million).	N/A
107	Create a backup source for diesel cooling (not from existing system).	1	This SAMA would provide a redundant and diverse source of cooling for the diesel generators, which would contribute to enhanced diesel reliability.	#5 - Cost would be more than risk benefit	The VCSNS EDGs can already be cooled by the Fire Service system; (Reference 16) a potential enhancement would be to make them air cooled such that they do not rely on any service water systems for cooling. The cost of implementation is estimated to be $1.7 million per diesel (Reference 24). At $3.4 million for the site, this SAMA exceeds the maximum averted cost-risk ($1.2 million).	N/A

TABLE F.4-1
PHASE 1 SAMA (Cont'd)

Phase 1 SAMA ID number	SAMA title	Source Reference of SAMA	Result of potential enhancement	Screening Criteria [See Notes]	Disposition	Phase 2 SAMA ID number
108	Use fire protection system as a backup source for diesel cooling.	1 16	This SAMA would provide a redundant and diverse source of cooling for the diesel generators, which would contribute to enhanced diesel reliability.	#3 - Already implemented at VCSNS	The Fire Service (FS) System is already included as an automatic backup to Service Water for DG cooling at VCSNS. The operators are directed to ensure Fire Service (FS) flow to the Emergency Diesel Generator (EDG) and to locally monitor diesel temperatures whenever FS is supplying cooling to the EDGs (Reference 16).	N/A
109	Provide a connection to an alternate source of offsite power.	1	SAMA would reduce the probability of a loss of offsite power event.	#5 - Cost would be more than risk benefit	While the actual cost of this SAMA will vary depending on site characteristics, the cost of connecting to an alternate source of power has been estimated at >$25 million for another U.S. PWR (Reference 24). Implementing this SAMA at VCSNS is considered to be within the same order of magnitude and exceeds the maximum averted cost-risk for the plant ($1.2 million).	N/A
110	Bury offsite power lines.	1	SAMA could improve offsite power reliability, particularly during severe weather.	#5 - Cost would be more than risk benefit	While the actual cost of this SAMA will vary depending on site characteristics, the cost of burying offsite power lines has been estimated at a cost significantly greater than $25 million for another US PWR (Reference 24). Implementing this SAMA at VCSNS is considered to be within the same order of magnitude and exceeds the maximum averted cost-risk for the plant ($1.2 million).	N/A
111	Replace anchor bolts on diesel generator oil cooler.	1	Millstone 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.	#3 - Already implemented at VCSNS	The VCSNS IPEEE included an assessment of the plant's ability to cope with seismic events. No changes were identified for the EDG oil coolers, and the current restraints are considered to be sufficient (Reference 17).	N/A

TABLE F.4-1
PHASE 1 SAMA (Cont'd)

Phase 1 SAMA ID number	SAMA title	Source Reference of SAMA	Result of potential enhancement	Screening Criteria [See Notes]	Disposition	Phase 2 SAMA ID number
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.	1	SAMA would reduce risk of 2/4 inverter failure.	#1 - N/A to VCSNS Design	The VCSNS actuation logic is not configured in the same manner as the original plant. The logic typically trips on 2/3 or 1/2 channels and not on 2/4. Loss of two 120V AC panels, which is potentially more severe than loss of two inverters (due to multiple feeds to the panels from multiple inverters), has been included in the PRA as an initiating event. This event has a Risk Reduction Worth and Risk Achievement Worth value of 1.000 (with respect to both CDF and LERF). These types of failures are not risk significant for VCSNS and no amount of spending to mitigate the effects of inverter failure would be cost beneficial.	N/A
113	Provide DC power to the 120/240-volt vital AC system from the Class 1E station service battery system instead of its own battery.	11	SAMA would increase the reliability of the 120-volt AC Bus.	#3 - Already implemented at VCSNS	The Class 1E batteries already provide power to 120-volt AC at VCSNS (Reference 16).	N/A
114	Bypass Diesel Generator Trips	14	SAMA would allow DGs to operate for longer.	#3 - Already implemented at VCSNS and #4 - No Significant Safety Benefit	DG trips are automatically bypassed on emergency start. Spurious DG trip signals are negligible contributors and are not currently modeled; thus, bypassing a spurious signal would not affect the VCSNS CDF or LERF. No credit is taken for bypassing legitimate trip signals.	N/A
115	2.i. 16 hour Station Blackout Injection	Advanced Reactors SAMDAs	SAMA includes improved capability to cope with longer SBO scenarios.	#2 - Similar item is addressed under other proposed SAMAs.	Part of SAMA 128	N/A

TABLE F.4-1
PHASE 1 SAMA (Cont'd)

Phase 1 SAMA ID number	SAMA title	Source Reference of SAMA	Result of potential enhancement	Screening Criteria [See Notes]	Disposition	Phase 2 SAMA ID number
116	9.a. Steam-Driven Turbine Generator	Advanced Reactors SAMDAs	This SAMA would provide a steam-driven turbine generator that uses reactor steam and exhausts to the suppression pool. If large enough, it could provide power to additional equipment.	#5 - Cost would be more than risk benefit	The cost of installing a steam-driven turbine generator is greater in scope than installing a new DG due to the interface with the plant's steam system. The cost of installing an additional DG has been estimated at over $20 million in Reference 24. This cost of implementation for this SAMA is expected to exceed even this estimate and is considerably greater than the maximum averted cost-risk for VCSNS ($1.2 million).	N/A
117	9.b. Alternate Pump Power Source	Advanced Reactors SAMDAs	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.	#2 - Similar item is addressed under other proposed SAMAs and/or #3 - Already implemented at VCSNS	VCSNS has turbine-driven feedwater pumps and replacement or addition of an independent feedwater pump would be cost-prohibitive (based on an enhancement of similar scope in SAMA 179). In addition, VCSNS is equipped with the Emergency Feedwater System which consists of 2 EDG-powered pumps and a turbine-driven pump (does not require electric power for sustained operation). None of these pumps require offsite power for operation and addition of an independent power source for the normal Feedwater pumps will not provide significant benefit (Reference 16).	N/A
118	9.d. Additional Diesel Generator	Advanced Reactors SAMDAs	SAMA would reduce the SBO frequency.	#2 - Similar item is addressed under other proposed SAMAs.	See SAMAs 90 and 91	N/A
119	9.e. Increased Electrical Divisions	Advanced Reactors SAMDAs	SAMA would provide increased reliability of AC power system to reduce core damage and release frequencies.	#7 - ABWR Design Issue; not practical.	This is a SAMA that was considered for ABWR design. It is not practical to backfit this modification into a plant that is already built and operating.	N/A

TABLE F.4-1
PHASE 1 SAMA (Cont'd)

Phase 1 SAMA ID number	SAMA title	Source Reference of SAMA	Result of potential enhancement	Screening Criteria [See Notes]	Disposition	Phase 2 SAMA ID number
120	9.f. Improved Uninterruptable Power Supplies	Advanced Reactors SAMDAs	SAMA would provide increased reliability of power supplies supporting front-line equipment, thus reducing core damage and release frequencies.	#3 - Already implemented at VCSNS	VCSNS has replaced the original inverters with newly designed inverters.	N/A
121	9.g. AC Bus Cross-Ties	Advanced Reactors SAMDAs	SAMA would provide increased reliability of AC power system to reduce core damage and release frequencies.	#2 - Similar item is addressed under other proposed SAMAs.	See SAMA 95	N/A
122	9.h. Gas Turbine	Advanced Reactors SAMDAs	SAMA would improve onsite AC power reliability by providing a redundant and diverse emergency power system.	#2 - Similar item is addressed under other proposed SAMAs.	See SAMA 106	N/A
123	9.i. Dedicated RHR (bunkered) Power Supply	Advanced Reactors SAMDAs	SAMA would provide RHR with more reliable AC power.	#5 - Cost would be more than risk benefit	This is estimated to cost more than $1.2 million, the maximum averted cost-risk for VCSNS.	N/A
124	10.a. Dedicated DC Power Supply	Advanced Reactors SAMDAs	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).	#5 - Cost would be more than risk benefit	The cost of implementation for this mod is estimated at $3 million, which is greater than the maximum averted cost-risk for VCSNS ($1.2 million).	N/A
125	10.b. Additional Batteries/Divisions	Advanced Reactors SAMDAs	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).	#2 - Similar item is addressed under other proposed SAMAs.	Part of 124	N/A

TABLE F.4-1
PHASE 1 SAMA (Cont'd)

Phase 1 SAMA ID number	SAMA title	Source Reference of SAMA	Result of potential enhancement	Screening Criteria [See Notes]	Disposition	Phase 2 SAMA ID number
126	10.c. Fuel Cells	Advanced Reactors SAMDAs	SAMA would extend DC power availability in an SBO.	#2 - Similar item is addressed under other proposed SAMAs.	See SAMA 93	N/A
127	10.d. DC Cross-ties	Advanced Reactors SAMDAs	This SAMA would improve DC power reliability.	#2 - Similar item is addressed under other proposed SAMAs.	See SAMA 96. VCSNS is equipped with a swing DC charger that can be powered from either AC division. As the DC batteries and buses are already reliable, providing an AC source to the battery chargers is the most beneficial way to ensure that DC power is available in the plant. Cross-tying DC buses for VCSNS would not significantly affect the CDF or LERF.	N/A
128	10.e. Extended Station Blackout Provisions	Advanced Reactors SAMDAs	SAMA would provide reduction in SBO sequence frequencies.	#2 - Similar item is addressed under other proposed SAMAs.	See SAMAs 29, 90, 92, 93, 97, 98, 103, and 105	N/A
129	Add an automatic bus transfer feature to allow automatic transfer of the 120V vital AC bus from the on-line unit to the standby unit	15	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.	#1 - N/A to VCSNS Design	VCSNS is not a multi-unit site; screened from further analysis (Reference 16).	N/A
			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).	1	SAMA would enhance depressurization during an SGTR.	#3 - Already implemented at VCSNS	VCSNS already has pressurizer spray available from 2 of 3 RCPs as well as from any of the three charging pumps (Reference 16). Additional redundancy beyond what is present would provide minimal benefit.	N/A

TABLE F.4-1
PHASE 1 SAMA (Cont'd)

Phase 1 SAMA ID number	SAMA title	Source Reference of SAMA	Result of potential enhancement	Screening Criteria [See Notes]	Disposition	Phase 2 SAMA ID number
131	Improve SGTR coping abilities.	1 4 10	SAMA would improve instrumentation to detect SGTR, or additional system to scrub fission product releases.	#2 - Similar item is addressed under other proposed SAMAs.	See SAMAs 133, 134, 135, 136, and 137	N/A
132	Add other SGTR coping abilities.	4 9 10	SAMA would decrease the consequences of an SGTR.	#2 - Similar item is addressed under other proposed SAMAs.	See SAMAs 133, 134, 135, 136, and 137	N/A
133	Increase secondary side pressure capacity such that an SGTR would not cause the relief valves to lift.	9 10	SAMA would eliminate direct release pathway for SGTR sequences.	#5 - Cost would be more than risk benefit	Based on engineering judgement, increasing the secondary side pressure capacity is not feasible as it would require an entirely new secondary system. The cost of this modification would greatly exceed the maximum averted cost-risk for VCSNS ($1.2 million).	N/A
134	Replace steam generators (SGs) with a new design.	1	SAMA would lower the frequency of an SGTR.	#3 - Already implemented at VCSNS	The steam generators were replaced in 1994 at VCSNS.	N/A
135	Revise emergency operating procedures to direct that a faulted SG be isolated.	1	SAMA would reduce the consequences of an SGTR.	#3 - Already implemented at VCSNS	Steam Generator Isolation is directed at VCSNS and is credited in the IPE (Reference 16).	N/A
136	Direct SG flooding after a SGTR, prior to core damage.	9	SAMA would provide for improved scrubbing of SGTR releases.	#3 - Already implemented at VCSNS	Level in the steam generators is maintained above the top of the U-tubes at an indicated 30 percent-50 percent when the containment has adverse environment.	N/A

TABLE F.4-1
PHASE 1 SAMA (Cont'd)

Phase 1 SAMA ID number	SAMA title	Source Reference of SAMA	Result of potential enhancement	Screening Criteria [See Notes]	Disposition	Phase 2 SAMA ID number
137	Implement a maintenance practice that inspects 100 percent of the tubes in a SG.	10	SAMA would reduce the potential for an SGTR.	#3 - Already implemented at VCSNS	VCSNS currently inspects 100 percent of the SG tubes every other outage and is committed to NEI 97-06 as part of an industry wide effort concerning steam generator maintenance. VCSNS is considering an option to extend this inspection to every third outage pending NRC approval.	N/A
138	Locate residual heat removal (RHR) inside of containment.	9	SAMA would prevent intersystem LOCA (ISLOCA) out the RHR pathway.	#5 - Cost would be more than risk benefit	For an existing plant, the cost of moving an entire system is judged to greatly exceed the maximum averted cost-risk for VCSNS ($1.2 million).	N/A
139	Install additional instrumentation for ISLOCAs.	3 4 6 7	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.	#5 - Cost would be more than risk benefit	The cost of implementation for this SAMA has been estimated at $2.3 million in Reference 24. This is greater than the maximum averted cost-risk for VCSNS ($1.2 million).	N/A
140	Increase frequency for valve leak testing.	1	SAMA could reduce ISLOCA frequency.	#3 - Already implemented at VCSNS	Valve testing at VCSNS is performed as directed by Tech Spec 3.4.6.2f (Reference 19). The valves in the ISLOCA pathways require manual valve manipulation inside the secondary wall, which prohibits testing when the reactor is at-power. As these valves are already tested every refueling outage, further tests would require plant shutdown. This would not be cost beneficial.	N/A
141	Improve operator training on ISLOCA coping.	1	SAMA would decrease ISLOCA effects.	#3 - Already implemented at VCSNS	The training department already performs operator training on ISLOCA initiators, including specific flowpaths that have been identified as susceptible to ISLOCAs. Further training on mitigation of this initiating event may result in an improvement in operator response, but this would only be reflected by a minimal change in a human error probability.	N/A

TABLE F.4-1
PHASE 1 SAMA (Cont'd)

Phase 1 SAMA ID number	SAMA title	Source Reference of SAMA	Result of potential enhancement	Screening Criteria [See Notes]	Disposition	Phase 2 SAMA ID number
142	Install relief valves in the CC System.	1	SAMA would relieve pressure buildup from an RCP thermal barrier tube rupture, preventing an ISLOCA.	#6 - Retain	N/A	11
143	Provide leak testing of valves in ISLOCA paths.	1	SAMA would help reduce ISLOCA frequency. At Kewaunee Nuclear Power Plant, four MOVs isolating RHR from the RCS were not leak tested.	#3 - Already implemented at VCSNS	Leak testing of these valves is already performed at VCSNS (Reference 19).	N/A
144	Revise EOPs to improve ISLOCA identification.	1	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.	#3 - Already implemented at VCSNS	VCSNS EOPs direct the operators to isolate the significant ISLOCA paths and to evaluate the consequences of the isolations by monitoring RCS pressure. This is considered to be an adequate response to mitigate ISLOCAs.	N/A
145	Ensure that all ISLOCA releases are scrubbed.	1	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.	#6 - Retain	N/A	12
146	Add redundant and diverse limit switches to each containment isolation valve.	1	SAMA could reduce the frequency of containment isolation failure and ISLOCAs through enhanced isolation valve position indication.	#3 - Already implemented at VCSNS	The VCSNS containment isolation valves are equipped with redundant position indication through the Main Control Board, ESF Monitor lights, and plant computer points. The switches supporting these indicators are also redundant. If the same limit switches were used for position indication lights and the plant computer, then a different switch was used for the ESF monitor light, or vice versa (Reference 22).	N/A

TABLE F.4-1
PHASE 1 SAMA (Cont'd)

Phase 1 SAMA ID number	SAMA title	Source Reference of SAMA	Result of potential enhancement	Screening Criteria [See Notes]	Disposition	Phase 2 SAMA ID number
147	Early detection and mitigation of ISLOCA	14	SAMA would limit the effects of ISLOCA accidents by early detection and isolation.	#2 - Similar item is addressed under other proposed SAMAs.	See SAMA 139	N/A
148	8.e. Improved MSIV Design	Advanced Reactors SAMDAs	This SAMA would improve isolation reliability and reduce spurious actuations that could be initiating events.	#6 - Retain	N/A	13
149	Proceduralize use of pressurizer vent valves during steam generator tube rupture (SGTR) sequences.	15	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.	#3 - Already implemented at VCSNS	Use of the pressurizer vent valves is already directed by EOPs at VCSNS.	N/A
150	Implement a maintenance practice that inspects 100 percent of the tubes in an SG.	15	This SAMA would reduce the potential for a tube rupture.	#2 - Similar item is addressed under other proposed SAMAs.	See SAMA 137	N/A
151	Locate RHR inside of containment.	15	This SAMA would prevent ISLOCA out the RHR pathway.	#2 - Similar item is addressed under other proposed SAMAs.	See SAMA 138	N/A

TABLE F.4-1
PHASE 1 SAMA (Cont'd)

Phase 1 SAMA ID number	SAMA title	Source Reference of SAMA	Result of potential enhancement	Screening Criteria [See Notes]	Disposition	Phase 2 SAMA ID number
152	Install self-actuating containment isolation valves	15	For plants that do not have these devices, it would reduce the frequency of isolation failure.	#3 - Already implemented at VCSNS	Only 12 reactor building penetrations have been identified which present realistic pathways for large releases from containment. This calculation is based on the individual penetration size as well as the availability of a pathway from the RCS or reactor building atmosphere to the outside environment (other penetrations are not considered here as releases through these pathways would have a negligible impact on the analysis). The twelve penetrations, by number, are: 101 and 402, 103 and 302, 319, 226 and 316, 227, 322, and 325, and 303 and 401. This SAMA recommends that automatic actuating devices be installed on containment isolation valves to reduce the frequency of isolation failure. Of the twelve penetrations listed above, five already have automatic actuating devices and receive closure signals based on pertinent plant conditions. Of the remaining seven, five are maintained closed during normal operation, and therefore have no need for isolating automatically. In fact, two of these five penetrations (226/316—loop suction isolations for RHR) previously had autoclosure capability, but the auto-close feature was removed due to several "loss of decay heat removal" events throughout the industry during half-pipe operations as a result of spurious closure. The remaining two penetrations (227/322—low head SI to RCS loops) are normally maintained in the open position during power operation such that injection to the RCS is automatic given an RHR pump start and decreased RCS system pressure. From a design standpoint, it is important that these valves do not close automatically on high RB pressure because they must be in the open position to mitigate a LOCA. Based on this, VCSNS does not need to install any additional auto-closure capability in the containment isolation system.	N/A

TABLE F.4-1
PHASE 1 SAMA (Cont'd)

Phase 1 SAMA ID number	SAMA title	Source Reference of SAMA	Result of potential enhancement	Screening Criteria [See Notes]	Disposition	Phase 2 SAMA ID number
			Improvements in Reducing Internal Flooding Frequency			
153	Modify swing direction of doors separating turbine building basement from areas containing safeguards equipment.	1	SAMA would prevent flood propagation for a plant where internal flooding from turbine building to safeguards areas is a concern.	#6 - Retain	N/A	14
154	Improve inspection of rubber expansion joints on main condenser.	1	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.	#6 - Retain	N/A	15
155	Implement internal flood prevention and mitigation enhancements.	1	This SAMA would reduce the consequences of internal flooding.	#6 - Retain	N/A	16
156	Implement internal flooding improvements such as those implemented at Fort Calhoun.	1	This SAMA would reduce flooding risk by preventing or mitigating rupture in the RCP seal cooler of the component cooling system, ISLOCA in a shutdown cooling line, and an auxiliary feedwater (AFW) flood involving the need to remove a watertight door.	#6 - Retain	N/A	17
157	Shield electrical equipment from potential water spray.	Industry IPEEE Insights	SAMA would decrease risk associated with seismically induced internal flooding.	#6 - Retain	N/A	18
158	13.c. Reduction in Reactor Building Flooding	Advanced Reactors SAMDAs	This SAMA reduces the Reactor Building Flood Scenarios contribution to core damage and release.	#6 - Retain	N/A	19

TABLE F.4-1
PHASE 1 SAMA (Cont'd)

Phase 1 SAMA ID number	SAMA title	Source Reference of SAMA	Result of potential enhancement	Screening Criteria [See Notes]	Disposition	Phase 2 SAMA ID number
			Improvements Related to Feedwater/Feed and Bleed Reliability/Availability			
159	Install a digital feedwater upgrade.	1	This SAMA would reduce the chance of a loss of main feedwater following a plant trip due to high pump discharge pressure to the SGs. Without rapid pump speed reduction after a reactor trip, the pumps may trip on high discharge pressure. Digital control will provide improved speed control.	#3 - Already implemented at VCSNS	VCSNS upgraded to digital speed control for the feedwater pumps in Refueling Outage 13.	N/A
160	Perform surveillances on manual valves used for backup AFW pump suction.	1	This SAMA would improve success probability for providing alternative water supply to the AFW pumps.	#3 - Already implemented at VCSNS	Surveillance testing is already performed on the Emergency Feedwater alternate suction path isolation valves.	N/A
161	Install manual isolation valves around AFW turbine-driven steam admission valves.	1	This SAMA would reduce the dual turbine-driven AFW pump maintenance unavailability.	#1 - N/A to VCSNS Design	VCSNS has only one turbine-driven Emergency Feedwater Pump; the other two are motor driven (Reference 16).	N/A
162	Install accumulators for turbine-driven AFW pump flow control valves (CVs).	4 7	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.	#1 - N/A to VCSNS Design	Instrument Air includes an EDG-powered compressor that is capable of running during LOOP conditions (including motor/oil cooling) (Reference 16); as Instrument Air supplies the FCVs for EFW at VCSNS, the benefit gained for LOOP scenarios by adding accumulators is minimal as a reliable air source already exists. For SBO, the current accumulators last for 3 hours, but the batteries, which are needed for control power, are only assumed available for 4 hours. The benefit of this mod for SBO is also considered to be negligible.	N/A
163	Install separate accumulators for the AFW cross-connect to the opposite unit and block valves	15	This SAMA would enhance the operator's ability to operate the AFW cross-connect and block valves following loss of air support.	#1 - N/A to VCSNS Design	VCSNS is not a multi-unit site; screened from further analysis (Reference 16).	N/A

TABLE F.4-1
PHASE 1 SAMA (Cont'd)

Phase 1 SAMA ID number	SAMA title	Source Reference of SAMA	Result of potential enhancement	Screening Criteria [See Notes]	Disposition	Phase 2 SAMA ID number
164	Install a new condensate storage tank (CST)	15	Either replace the existing tank with a larger one, or install a back-up tank.	#3 -Already Installed at VCSNS	VCSNS's Emergency Feedwater System is equipped with a connection to the Service Water System such that the SW System can serve as the alternate pump suction source. On low CST level, an automatic swap function opens the EFW pump suction to the Service Water System and allows operation for an indefinite period of time. This capability is considered to address the intent of the SAMA.	N/A
165	Provide cooling of the steam-driven AFW pump in an SBO event	15	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.	#3 -Already Installed at VCSNS	This pump is cooled by the process fluid and does not require support systems for cooling (Reference 16).	N/A
166	Proceduralize local manual operation of AFW when control power is lost.	15	This SAMA would lengthen AFW availability in an SBO. Also provides a success path should AFW control power be lost in non-SBO sequences.	#3 -Already Installed at VCSNS	This action is directed after battery depletion, but the manual action is not credited in the PRA and is not included in the fault tree.	N/A
167	Provide portable generators to be hooked into the turbine-driven AFW, after battery depletion.	15	This SAMA would extend AFW availability in an SBO (assuming the turbine driven AFW requires DC power).	#1 - N/A to VCSNS Design	The turbine-driven EFW pump at VCSNS is capable of successful operation after battery depletion.	N/A
168	Add a motor train of AFW to the steam trains.	15	For PWRs that do not have any motor trains of AFW, this would increase reliability in non-SBO sequences.	#3 - Already implemented at VCSNS.	VCSNS has 1 turbine-driven and two motor-driven Emergency Feedwater Pumps (Reference 16).	N/A
169	Create ability for emergency connections of existing or alternate water sources to feedwater/ condensate.	15	This SAMA would be a back-up water supply for the feedwater/condensate systems.	#3 - Already implemented at VCSNS.	Service Water is connected to Emergency Feedwater (References 16 and 25).	N/A

TABLE F.4-1
PHASE 1 SAMA (Cont'd)

Phase 1 SAMA ID number	SAMA title	Source Reference of SAMA	Result of potential enhancement	Screening Criteria [See Notes]	Disposition	Phase 2 SAMA ID number
170	Use FP system as a back-up for SG inventory.	15	This SAMA would create a back-up to main and AFW for SG water supply.	#2 - Similar item is addressed under other proposed SAMAs.	See SAMA 169	N/A
171	Procure a portable diesel pump for isolation condenser make-up.	15	This SAMA would provide a back-up to the city water supply and diesel FP system pump for isolation condenser make-up.	#1 - N/A to VCSNS Design	VCSNS does not have an Isolation Condenser System (Reference 16).	N/A
172	Install an independent diesel generator for the CST make-up pumps.	15	This SAMA would allow continued inventory make-up to the CST during an SBO.	#3 - Already implemented at VCSNS.	The VCSNS CST is already capable of being re-filled using the alternate diesel fire pump. This action is directed by plant EOPs.	N/A
173	Change failure position of condenser make-up valve.	15	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.	#3 - Already implemented at VCSNS.	The condenser makeup valve fails closed on loss of control signal or air.	N/A
174	Create passive secondary side coolers.	15	This SAMA would reduce CDF from the loss of feedwater by providing a passive heat removal loop with a condenser and heat sink.	#5 - Cost would be more than risk benefit	This SAMA would require major modifications to be made to the plant and the cost would far exceed the maximum averted cost-risk for VCSNS ($1.2 million).	N/A
175	Replace current PORVs with larger ones so only one is required for successful feed and bleed.	15	This SAMA would reduce the dependencies required for successful feed and bleed.	#6 - Retain	Currently, 2 out of 3 PORVs are required with feed and bleed.	20
176	Install motor-driven feedwater pump.	1 11	SAMA would increase the availability of injection subsequent to MSIV closure.	#2 - Similar item is addressed under other proposed SAMAs.	See SAMA 168	N/A

TABLE F.4-1
PHASE 1 SAMA (Cont'd)

Phase 1 SAMA ID number	SAMA title	Source Reference of SAMA	Result of potential enhancement	Screening Criteria [See Notes]	Disposition	Phase 2 SAMA ID number
177	Use Main FW pumps for a Loss of Heat Sink Event	16	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.	#3 - Already implemented at VCSNS.	The EOPs have been updated to direct use of the turbine-driven feedwater pumps as the primary SG injection source.	N/A
			Improvements in Core Cooling Systems			
178	Provide the capability for diesel driven, low pressure vessel make-up.	15	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).	#5 - Cost would be more than risk benefit	Based on engineering judgement and similarities to SAMA 179, the installation of a new, diesel-driven, low pressure injection system is judged to greatly exceed the maximum averted cost-risk for VCSNS ($1.2 million).	N/A
179	Provide an additional HPSI pump with an independent diesel.	15	This SAMA would reduce the frequency of core melt from small LOCA and SBO sequences.	#5 - Cost would be more than risk benefit	The cost of implementation for this SAMA has been estimated to be between $5 and $10 million (Reference 24). This greatly exceeds the maximum averted cost-risk for VCSNS ($1.2 million).	N/A
180	Install an independent AC HPSI system.	15	This SAMA would allow make-up and feed and bleed capabilities during an SBO.	#2 - Similar item is addressed under other proposed SAMAs.	See SAMA 179	N/A
181	Create the ability to manually align ECCS recirculation.	15	This SAMA would provide a back-up should automatic or remote operation fail.	#6 - Retain	N/A	21

TABLE F.4-1
PHASE 1 SAMA (Cont'd)

Phase 1 SAMA ID number	SAMA title	Source Reference of SAMA	Result of potential enhancement	Screening Criteria [See Notes]	Disposition	Phase 2 SAMA ID number
182	Implement an RWT make-up procedure.	15	This SAMA would decrease CDF from ISLOCA scenarios, some smaller-break LOCA scenarios, and SGTR.	#3 - Already implemented at VCSNS.	The annunciator response procedure for low RWST level directs the operator to refill the RWST using Reactor Makeup Water.	N/A
183	Stop low pressure safety injection pumps earlier in medium or large LOCAs.	15	This SAMA would provide more time to perform recirculation swap-over.	#1 - N/A to VCSNS Design	The sump suction valves automatically open on a low-low level indication from the RWST such that a water supply is available. The remaining actions to isolate the RWST are manually performed by the operator, but it is judged that stopping the pumps earlier is not a beneficial method to increase the reliability of the RWST isolation actions. Additional requirements for the operator to perform pump stops and re-starts complicate the semi-automatic process that is already in place.	N/A
184	Emphasize timely swap-over in operator training.	15	This SAMA would reduce human error probability of recirculation failure.	#3 - Already implemented at VCSNS.	This is extensively addressed in VCSNS operator training.	N/A
185	Upgrade Chemical and Volume Control System to mitigate small LOCAs.	15	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.	#3 - Already implemented at VCSNS.	Chemical and Volume Control System already includes the charging pumps which are part of the LOCA mitigation function (Reference 16).	N/A
186	Install an active HPSI system.	15	For a plant like the AP600 where an active HPSI system does not exist, this SAMA would add redundancy in HPSI.	#3 - Already implemented at VCSNS.	The charging pumps provide high pressure injection for VCSNS (Reference 16).	N/A
187	Change "in-containment" RWT suction from 4 check valves to 2 check and 2 air operated valves.	15	This SAMA would remove common mode failure of all four injection paths.	#6 - Retain	N/A	22

TABLE F.4-1
PHASE 1 SAMA (Cont'd)

Phase 1 SAMA ID number	SAMA title	Source Reference of SAMA	Result of potential enhancement	Screening Criteria [See Notes]	Disposition	Phase 2 SAMA ID number
188	Replace 2 of the 4 safety injection (SI) pumps with diesel-powered pumps.	15	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.	#6 - Retain	N/A	23
189	Align low pressure core injection or core spray to the CST on loss of suppression pool cooling.	15	This SAMA would help to ensure low pressure ECCS can be maintained in loss of suppression pool cooling scenarios.	#1 - N/A to VCSNS Design	This is a BWR issue not applicable to the VCSNS design (Reference 16). Screened from further analysis.	N/A
190	Raise high pressure core injection/reactor core isolation cooling backpressure trip setpoints.	15	This SAMA would ensure high pressure core injection/reactor core isolation cooling availability when high suppression pool temperatures exist.	#1 - N/A to VCSNS Design	This is a BWR issue not applicable to the VCSNS design (Reference 16). Screened from further analysis.	N/A
191	Improve the reliability of the automatic depressurization system.	15	This SAMA would reduce the frequency of high pressure core damage sequences.	#1 - N/A to VCSNS Design	This is a BWR issue not applicable to the VCSNS design (Reference 16). Screened from further analysis.	N/A
192	Disallow automatic vessel depressurization in non-ATWS scenarios	15	This SAMA would improve operator control of the plant.	#1 - N/A to VCSNS Design	This is a BWR issue not applicable to the VCSNS design (Reference 16). Screened from further analysis.	N/A
193	Create automatic swap-over to recirculation on RWT depletion.	15	This SAMA would reduce the human error contribution from recirculation failure.	#6 - Retain	Auto-swap to sump is already installed at VCSNS (Reference 16). Additional hardware and procedure modifications to completely automate the swap-over (for RWST isolation) could be made.	24
194	Proceduralize intermittent operation of HPCI.	1	SAMA would allow for extended duration of HPCI availability.	#1 - N/A to VCSNS Design	This is a BWR issue not applicable to the VCSNS design (Reference 16). Screened from further analysis.	N/A
195	Increase available net positive suction head (NPSH) for injection pumps.	1	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.	#5 - Cost would be more than risk benefit	Requires major plant mods such as new RHR pumps, moving the RHR pumps, a new sump design, or a larger RWST (only applicable for injection phase). The cost of these changes would exceed the maximum averted cost-risk for VCSNS ($1.2 million).	N/A

TABLE F.4-1
PHASE 1 SAMA (Cont'd)

Phase 1 SAMA ID number	SAMA title	Source Reference of SAMA	Result of potential enhancement	Screening Criteria [See Notes]	Disposition	Phase 2 SAMA ID number
196	Modify Reactor Water Cleanup (RWCU) for use as a decay heat removal system and proceduralize use.	1	SAMA would provide an additional source of decay heat removal.	#1 - N/A to VCSNS Design	This is a BWR issue not applicable to the VCSNS design. An "equivalent" system, the Chemical and Volume Control System, is already used in a heat removal process at VCSNS (Reference 16).	N/A
197	CRD Injection	14	SAMA would supply an additional method of level restoration by using a non-safety system.	#1 - N/A to VCSNS Design	This is a BWR issue not applicable to the VCSNS design (Reference 16). Screened from further analysis.	N/A
198	Condensate Pumps for Injection	14	SAMA to provide an additional option for coolant injection when other systems are unavailable or inadequate	#3 - Already implemented at VCSNS.	VCSNS allows injection to the SGs with FW booster pumps in combination with the condensate pumps (Reference 16).	N/A
199	Align EDG to CRD for Injection	14	SAMA to provide power to an additional injection source during loss of power events	#1 - N/A to VCSNS Design	This is a BWR issue not applicable to the VCSNS design (Reference 16). Screened from further analysis.	N/A
200	Re-open MSIVs	14	SAMA to regain the main condenser as a heat sink by re-opening the MSIVs.	#3 - Already implemented at VCSNS.	The VCSNS EOPs already provide for regaining the main condenser as a heat sink when the condenser is available. This is accomplished by resetting the main steam isolation signals (both trains) and opening main steam isolation bypass valves (PVM-2869A/B/C).	N/A
201	Bypass RCIC Turbine Exhaust Pressure Trip	14	SAMA would allow RCIC to operate longer.	#1 - N/A to VCSNS Design	This is a BWR issue not applicable to the VCSNS design (Reference 16). Screened from further analysis.	N/A
202	2.a. Passive High Pressure System	Advanced Reactors SAMDAs	SAMA will improve prevention of core melt sequences by providing additional high pressure capability to remove decay heat through an isolation condenser type system	#5 - Cost would be more than risk benefit	The cost of this enhancement has been estimated to be $1.7 million. This is greater than the maximum averted cost-risk for VCSNS ($1.2 million).	N/A

TABLE F.4-1
PHASE 1 SAMA (Cont'd)

Phase 1 SAMA ID number	SAMA title	Source Reference of SAMA	Result of potential enhancement	Screening Criteria [See Notes]	Disposition	Phase 2 SAMA ID number
203	2.c. Suppression Pool Jockey Pump	Advanced Reactors SAMDAs	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.	#1 - N/A to VCSNS Design	This is a BWR issue not applicable to the VCSNS design (Reference 16). Screened from further analysis.	N/A
204	2.d. Improved High Pressure Systems	Advanced Reactors SAMDAs	SAMA will improve prevention of core melt sequences by improving reliability of high pressure capability to remove decay heat.	#2 - Similar item is addressed under other proposed SAMAs.	See SAMAs 179, 180, 186, 202, and 205	N/A
205	2.e. Additional Active High Pressure System	Advanced Reactors SAMDAs	SAMA will improve reliability of high pressure decay heat removal by adding an additional system.	#2 - Similar item is addressed under other proposed SAMAs.	See SAMAs 179, 180, 186, and 202	N/A
206	2.f. Improved Low Pressure System (Firepump)	Advanced Reactors SAMDAs	SAMA would provide fire protection system pump(s) for use in low pressure scenarios.	#6 - Retain	N/A	25
207	4.b. CUW Decay Heat Removal	Advanced Reactors SAMDAs	This SAMA provides a means for Alternate Decay Heat Removal.	#2 - Similar item is addressed under other proposed SAMAs	See SAMA 196. The CUW system in an ABWR is equivalent to the RWCU system.	N/A
208	4.c. High Flow Suppression Pool Cooling	Advanced Reactors SAMDAs	SAMA would improve suppression pool cooling.	#1 - N/A to VCSNS Design	This is a BWR issue not applicable to the VCSNS design (Reference 16). Screened from further analysis.	N/A

TABLE F.4-1
PHASE 1 SAMA (Cont'd)

Phase 1 SAMA ID number	SAMA title	Source Reference of SAMA	Result of potential enhancement	Screening Criteria [See Notes]	Disposition	Phase 2 SAMA ID number
209	8.c. Diverse Injection System	Advanced Reactors SAMDAs	SAMA will improve prevention of core melt sequences by providing additional injection capabilities.	#2 - Similar item is addressed under other proposed SAMAs	See SAMAs 178, 179, 180, 186, 202, 205, and 206	N/A
210	Alternate Charging Pump Cooling	16	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 CCW, AOPs would direct alignment of chilled water, Demineralized Water, or the Fire System to the CCW System to provide cooling to the SI pumps' gear and oil box (and the other normal loads).	#3 - Already implemented at VCSNS	An AOP has been implemented at VCSNS to direct alignment of alternate cooling to the SI pumps on loss of the normal supply.	N/A
211	Chiller Operation Rotation	16	This SAMA will improve the high pressure core flooding capabilities by providing the SI pumps with a more reliable source of Chilled Water to the gear and oil coolers in the event that CCW is lost. The VCSNS operations group identified a detriment in the Chiller pumps' start probability related to prolonged "standby times." Standby times would be reduced by rotating the operating chiller train.	#3 - Already implemented at VCSNS.	The operation schedule has been updated at VCSNS to alternate the normally running chiller trains, Also, chilled water provides only backup cooling for the SI pumps. The normal cooling supply for these pumps is Component Cooling Water, which is nuclear safety-related.	N/A

TABLE F.4-1
PHASE 1 SAMA (Cont'd)

Phase 1 SAMA ID number	SAMA title	Source Reference of SAMA	Result of potential enhancement	Screening Criteria [See Notes]	Disposition	Phase 2 SAMA ID number
			Instrument Air/Gas Improvements			
212	Modify EOPs for ability to align diesel power to more air compressors.	15	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.	#1 - N/A to VCSNS Design	Two of the three IA compressors are already powered by the ESF buses while the third is powered by BOP power. The compressor powered by the BOP bus and one of the EDG backed compressors rely on BOP power for supporting the air aftercoolers and for oil cooling. Only the third compressor is truly independent of BOP power (Reference 16). Supplying the compressor that is currently powered from the BOP bus with ESF power will not increase its availability due to the cooling dependencies.	N/A
213	Replace old air compressors with more reliable ones.	15	This SAMA would improve reliability and increase availability of the IA compressors.	#6 - Retain	N/A	26
214	Install nitrogen bottles as a back-up gas supply for safety relief valves.	15	This SAMA would extend operation of safety relief valves during an SBO and loss of air events (BWRs).	#1 - N/A to VCSNS Design	This is primarily a BWR issue. A potential functional equivalent would be use of the PORVs in an SBO. The VCSNS pressurizer PORVs already have an air tank supply for operation after loss of air (Reference 16). The SG PORVs can be manually operated given an SBO (Reference 42). This is considered to address the SAMA's intent of providing the capability to operate in an SBO.	N/A
215	Allow cross connection of uninterruptable compressed air supply to opposite unit.	11 12	SAMA would increase the ability to vent containment using the hardened vent.	#1 - N/A to VCSNS Design	VCSNS is not a multi-unit site; screened from further analysis (Reference 16).	N/A

TABLE F.4-1
PHASE 1 SAMA (Cont'd)

Phase 1 SAMA ID number	SAMA title	Source Reference of SAMA	Result of potential enhancement	Screening Criteria [See Notes]	Disposition	Phase 2 SAMA ID number
216	Allow local, manual operation of Instrument Air isolation valves.	16	This SAMA will allow re-establishment of Instrument Air flow to the Pressurizer PORVs and subsequent alignment of feed and bleed for sequences in which the accumulators have been depleted and the IA isolation valves' air operators fail to cycle on an "open" signal (assuming Instrument Air is available).	#3 - Already implemented at VCSNS	Procedures have been revised to direct this action and a hand wheel has been added to the Instrument Air isolation valve to allow manual operation of the valve when remote operation has failed.	N/A
ATWS Mitigation						
217	Install MG set trip breakers in control room.	15	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).	#6 - Retain	N/A	27
218	Add capability to remove power from the bus powering the control rods.	15	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).	#2 - Similar item is addressed under other proposed SAMAs	See SAMA 217	N/A
219	Create cross-connect ability for standby liquid control trains.	15	This SAMA would improve reliability for boron injection during an ATWS event.	#1 - N/A to VCSNS Design	This is a BWR issue; PWRs have diverse means of injecting borated water into the RCS during an ATWS including RWST water from RHR and/or the charging pumps, the ECCS accumulators, and the boric acid tank with the boric acid transfer pumps and charging pumps (Reference 16).	N/A

TABLE F.4-1
PHASE 1 SAMA (Cont'd)

Phase 1 SAMA ID number	SAMA title	Source Reference of SAMA	Result of potential enhancement	Screening Criteria [See Notes]	Disposition	Phase 2 SAMA ID number
220	Create an alternate boron injection capability (back-up to standby liquid control).	15	This SAMA would improve reliability for boron injection during an ATWS event.	#1 - N/A to VCSNS Design	This is a BWR issue; PWRs have diverse means of injecting borated water into the RCS during an ATWS including RWST water from RHR and/or the charging pumps, the ECCS accumulators, and the boric acid tank with the boric acid transfer pumps and charging pumps (Reference 16).	N/A
221	Remove or allow override of low pressure core injection during an ATWS.	15	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.	#1 - N/A to VCSNS Design	This is a BWR issue. PWRs do not implement the same logic for governing low pressure injection that is used in BWRs (Reference 16).	N/A
222	Install a system of relief valves that prevents any equipment damage from a pressure spike during an ATWS.	15	This SAMA would improve equipment availability after an ATWS.	#3 - Already implemented at VCSNS.	VCSNS meets the requirements of 10 CFR 50.62 by use of AMSAC (ATWS Mitigation System Actuation Circuitry) as described in FSAR Section 7.8 (Reference 23). This is considered to address the potential for overpressurization by providing a diverse, automatic system to shut down the reactor and initiate Emergency Feedwater Flow to the SGs given ATWS conditions.	N/A
223	Create a boron injection system to back up the mechanical control rods.	15	This SAMA would provide a redundant means to shut down the reactor.	#3 - Already implemented at VCSNS.	VCSNS already has injection from the RWST and the boric acid tanks (Reference 16).	N/A
224	Provide an additional instrument system for ATWS mitigation (e.g., ATWS mitigation scram actuation circuitry).	15	This SAMA would improve instrument and control redundancy and reduce the ATWS frequency.	#3 - Already implemented at VCSNS.	VCSNS meets the requirements of 10 CFR 50.62 by use of AMSAC (ATWS Mitigation System Actuation Circuitry) as described in FSAR Section 7.8 (Reference 23).	N/A
225	Increase the safety relief valve (SRV) reseat reliability.	1	SAMA addresses the risk associated with dilution of boron caused by the failure of the SRVs to reseat after standby liquid control (SLC) injection.	#1 - N/A to VCSNS Design	This is a BWR issue related to boron dilution and is not applicable to the VCSNS design (Reference 16). Screened from further analysis.	N/A

TABLE F.4-1
PHASE 1 SAMA (Cont'd)

Phase 1 SAMA ID number	SAMA title	Source Reference of SAMA	Result of potential enhancement	Screening Criteria [See Notes]	Disposition	Phase 2 SAMA ID number
226	Use control rod drive (CRD) for alternate boron injection.	1	SAMA provides an additional system to address ATWS with SLC failure or unavailability.	#1 - N/A to VCSNS Design	This is a BWR issue not applicable to the VCSNS design (Reference 16). Screened from further analysis.	N/A
227	Bypass MSIV isolation in Turbine Trip ATWS scenarios	Industry IPEEE Insights	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., SLC injection, lower water level, depressurize RPV) than if the main condenser was unavailable, resulting in lower human error probabilities.	#1 - N/A to VCSNS Design	This is a BWR issue not applicable to the VCSNS design (Reference 16). Screened from further analysis.	N/A
228	Enhance operator actions during ATWS	Industry IPEEE Insights	SAMA will reduce human error probabilities during ATWS.	#3 - Already implemented at VCSNS.	ATWS training is already performed at VCSNS. Further training or enhancements could impact operator action reliability; however, the potential improvement would be difficult to quantify. No measurable change would result from implementing this change at VCSNS.	N/A
229	Guard against SLC dilution	14	SAMA to control vessel injection to prevent boron loss or dilution following SLC injection.	#1 - N/A to VCSNS Design	This is a BWR issue not applicable to the VCSNS design (Reference 16). Screened from further analysis.	N/A
230	11.a. ATWS Sized Vent	Advanced Reactors SAMDAs	This SAMA would provide the ability to remove reactor heat from ATWS events.	#2 - Similar item is addressed under other proposed SAMAs.	See SAMA 39	N/A

TABLE F.4-1
PHASE 1 SAMA (Cont'd)

Phase 1 SAMA ID number	SAMA title	Source Reference of SAMA	Result of potential enhancement	Screening Criteria [See Notes]	Disposition	Phase 2 SAMA ID number
231	11.b. Improved ATWS Capability	Advanced Reactors SAMDAs	This SAMA includes items which reduce the contribution of ATWS to core damage and release frequencies.	#2 - Similar item is addressed under other proposed SAMAs.	Addressed by SAMAs 222, 223, and 224	N/A
Other Improvements						
232	Provide capability for remote operation of secondary side relief valves in an SBO.	15	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.	#1 - N/A to VCSNS Design	Local operation of the PORVs is possible with a hand wheel and the system is designed for operation under conditions such as an SBO (Reference 16). Environmental conditions have been shown to be acceptable in the valve operation area at V.C. Summer for SBO scenarios (Reference 42).	N/A
233	Create/enhance RCS depressurization ability	15	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.	#5 - Cost would be more than risk benefit	Reference 24 estimates the cost of this SAMA at between $500,000 and $4.6 million. For VCSNS, more effective depressurization capabilities would require significant hardware changes and/or additions on top of the analysis that would be required to implement the change. The cost estimate for the modification is considered to be on the high end of the range provided in Reference 24. The cost of implementation for this SAMA is judged to greatly exceed the maximum averted cost-risk for VCSNS ($1.2 million).	N/A
234	Make procedural changes only for the RCS depressurization option	15	This SAMA would reduce RCS pressure without the cost of a new system.	#3 - Already implemented at VCSNS.	RCS depressurization has been enhanced at VCSNS through the implementation of procedural revisions that move critical depressurization steps so they are performed earlier in the accident. These steps direct the operators to re-energize any pressurizer PORV block valves that were closed and racked-out to isolate a leaking PORV. This change allows the operators more time to prepare for feed and bleed before total loss of the secondary heat sink.	N/A

TABLE F.4-1
PHASE 1 SAMA (Cont'd)

Phase 1 SAMA ID number	SAMA title	Source Reference of SAMA	Result of potential enhancement	Screening Criteria [See Notes]	Disposition	Phase 2 SAMA ID number
235	Defeat 100 percent load rejection capability.	15	This SAMA would eliminate the possibility of a stuck-open PORV after a LOOP, since PORV opening would not be needed.	#4 - No significant safety benefit	The PORVs were included on the pressurizer, in part, to prevent overpressurization (Reference 16). It is judged that defeating this function would be more detrimental than beneficial. In addition, the Risk Reduction Worth of a PORV failing to re-close is 1.001 with respect to both CDF and LERF (e.g., for WARVXVC8010AFC); thus, implementing this SAMA would not result in a significant averted cost-risk for VCSNS and no amount of spending would be cost beneficial for this SAMA.	N/A
236	Change control rod drive flow CV failure position	15	Change failure position to the "fail-safest" position.	#1 - N/A to VCSNS Design	This is a BWR issue not applicable to the VCSNS design (Reference 16). Screened from further analysis.	N/A
237	Install secondary side guard pipes up to the MSIVs	15	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.	#6 - Retain	N/A	28
238	Install digital large break LOCA protection	15	Upgrade plant instrumentation and logic to improve the capability to identify symptoms/precursors of a large break LOCA (leak before break).	#6 - Retain	N/A	29
239	Increase seismic capacity of the plant to a high confidence, low probability failure of twice the Safe Shutdown Earthquake.	15	This SAMA would reduce seismically -induced CDF.	#5 - Cost would be more than risk benefit	Seismic issues were examined in the VCSNS IPEEE and the cost-effective means of reducing plant risk were implemented as part of the program (Reference 17). This SAMA was considered in the System 80+ original design submittal and is not applicable to an existing plant due to high cost.	N/A

TABLE F.4-1
PHASE 1 SAMA (Cont'd)

Phase 1 SAMA ID number	SAMA title	Source Reference of SAMA	Result of potential enhancement	Screening Criteria [See Notes]	Disposition	Phase 2 SAMA ID number
240	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.	15	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).	#3 - Already implemented at VCSNS.	VCSNS is equipped with a Service Water connection to CC for makeup in the event that DW makeup fails. The Service Water System is supplied by EDG powered buses and is considered to be a reliable means of providing water to the CC system (Reference 16).	N/A
241	Increase the reliability of safety relief valves by adding signals to open them automatically.	11	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.	#6 - Retain	N/A	30
242	Reduce DC dependency between high-pressure injection system and ADS.	1	SAMA would ensure containment depressurization and high-pressure injection upon a DC failure.	#1 - N/A to VCSNS Design	This is a BWR issue not applicable to the VCSNS design (Reference 16). Screened from further analysis.	N/A
243	Increase seismic ruggedness of plant components.	10 12 17	SAMA would increase the availability of necessary plant equipment during and after seismic events.	#3 - Already implemented at VCSNS.	Seismic issues were examined in the VCSNS IPEEE and the cost-effective means of reducing plant risk were implemented as part of the program (Reference 17). The cost of increasing the seismic ruggedness of all the components identified as required for safe shutdown in the IPEEE would far exceed the maximum averted cost-risk for VCSNS.	N/A
244	Enhance RPV depressurization capability	13	SAMA would decrease the likelihood of core damage in loss of high pressure coolant injection scenarios.	#2 - Similar item is addressed under other proposed SAMAs.	See SAMA 233	N/A

TABLE F.4-1
PHASE 1 SAMA (Cont'd)

Phase 1 SAMA ID number	SAMA title	Source Reference of SAMA	Result of potential enhancement	Screening Criteria [See Notes]	Disposition	Phase 2 SAMA ID number
245	Enhance RPV depressurization procedures	13	SAMA would decrease the likelihood of core damage in loss of high pressure coolant injection scenarios.	#2 - Similar item is addressed under other proposed SAMAs.	See SAMA 234	N/A
246	Replace mercury switches on fire protection systems	Industry IPEEE Insights	SAMA would decrease probability of spurious fire suppression system actuation given a seismic event.	#1 - N/A to VCSNS Design	Seismic issues were examined in the VCSNS IPEEE and the cost-effective means of reducing plant risk were implemented as part of the program. No mercury switches were identified in the plant walkdown (Reference 17).	N/A
247	Provide additional restraints for CO_2 tanks	Industry IPEEE Insights	SAMA would increase availability of fire protection, given a seismic event.	#3 - Already implemented at VCSNS.	Seismic issues were examined in the VCSNS IPEEE and the cost-effective means of reducing plant risk were implemented as part of the program. The compressed gas tanks identified in the plant walkdown were analyzed and screened as having sufficient anchorage (Reference 17).	N/A
248	Enhance control of transient combustibles	Industry IPEEE Insights	SAMA would minimize risk associated with important fire areas.	#3 - Already implemented at VCSNS.	The IPEEE included an analysis of fire events and evaluated cost effective methods to reduce fire risk as part of the study (Reference 17). Control of transient combustibles is in place at VCSNS and no enhancements to the controls were suggested as a result of this study. This SAMA is considered to have been addressed by the IPEEE.	N/A
249	Enhance fire brigade awareness	Industry IPEEE Insights	SAMA would minimize risk associated with important fire areas.	#3 - Already implemented at VCSNS.	The IPEEE included an analysis of fire events and evaluated cost effective methods to reduce fire risk as part of the study (Reference 17). Fire brigade member training has been enhanced as a result of this study. This SAMA is considered to have been addressed by the IPEEE.	N/A

TABLE F.4-1
PHASE 1 SAMA (Cont'd)

Phase 1 SAMA ID number	SAMA title	Source Reference of SAMA	Result of potential enhancement	Screening Criteria [See Notes]	Disposition	Phase 2 SAMA ID number
250	Upgrade fire compartment barriers	Industry IPEEE Insights	SAMA would minimize risk associated with important fire areas.	#3 - Already implemented at VCSNS.	The IPEEE included an analysis of fire events and evaluated cost-effective methods to reduce fire risk as part of the study (Reference 17). No fire barrier upgrades were suggested as a result of this study. This SAMA is considered to have been addressed by the IPEEE.	N/A
251	Enhance procedures to allow specific operator actions	Industry IPEEE Insights	SAMA would minimize risk associated with important fire areas.	#3 - Already implemented at VCSNS.	The IPEEE included an analysis of fire events and evaluated cost-effective methods to reduce fire risk as part of the study (Reference 17). Several procedure enhancements and training improvements were suggested as a result of the fire analysis; however, these changes were judged to have little or no impact on the HRA quantifications for the corresponding operator actions. This SAMA is considered to have been addressed by the IPEEE.	N/A
252	Develop procedures for transportation and nearby facility accidents	Industry IPEEE Insights	SAMA would minimize risk associated with transportation and nearby facility accidents.	#4 - No significant safety benefit.	Transportation and nearby facility accidents were analyzed as part of the IPEEE and it was determined that these accidents did not pose a significant safety threat to VCSNS (Reference 17). The contribution from these events is considered to be low and not risk-significant.	N/A
253	Enhance procedures to mitigate Large LOCA	Industry IPEEE Insights	SAMA would minimize risk associated with Large LOCA.	#2 - Similar item is addressed under other proposed SAMAs.	See SAMA 238	N/A
254	1.b. Computer Aided Instrumentation	16	SAMA will improve prevention of core melt sequences by making operator actions more reliable.	#3 - Already implemented at VCSNS.	The Bypassed and Inoperable Status Indication (BISI) System provides graphic control room indication of critical system operability based on a variety of digital and analog inputs (Reference 16). This system was updated based on insights from the VCSNS IPE.	N/A

TABLE F.4-1
PHASE 1 SAMA (Cont'd)

Phase 1 SAMA ID number	SAMA title	Source Reference of SAMA	Result of potential enhancement	Screening Criteria [See Notes]	Disposition	Phase 2 SAMA ID number
255	1.c/d. Improved Maintenance Procedures/Manuals	Advanced Reactors SAMDAs	SAMA will improve prevention of core melt sequences by increasing reliability of important equipment.	#3 - Already implemented at VCSNS.	The maintenance rule has been implemented in the industry to balance reliability and availability and in doing so attempts to optimize the maintenance process. Root cause analysis is required as part of this program and will result in procedure enhancements where they are necessary and where they will be effective in reducing maintenance errors.	N/A
256	1.e. Improved Accident Management Instrumentation	Advanced Reactors SAMDAs	SAMA will improve prevention of core melt sequences by making operator actions more reliable.	#2 - Similar item is addressed under other proposed SAMAs.	See SAMA 254	N/A
257	1.f. Remote Shutdown Station	Advanced Reactors SAMDAs		#3 - Already implemented at VCSNS.	VCSNS has a Control Room Evacuation Panel that can be used to operate critical shutdown functions in the event the Main Control Room must be evacuated.	N/A
258	1.g. Security System	16	Improvements in the site's security system would decrease the potential for successful sabotage.	#3 - Already implemented at VCSNS.	At the request of the VCSNS Security Department, the PSA group conducted a vulnerability assessment of the site based on insights gained from the IPEEE to identify potential target sites. The results were provided to the Security Department for consideration.	N/A
259	2.b. Improved Depressurization	Advanced Reactors SAMDAs	SAMA will improve depressurization system to allow more reliable access to low pressure systems.	#2 - Similar item is addressed under other proposed SAMAs.	Addressed in SAMAs 237, 240, and 241	N/A
260	2.h. Safety Related Condensate Storage Tank	Advanced Reactors SAMDAs	SAMA will improve availability of CST following a Seismic event.	#2 - Similar item is addressed under other proposed SAMAs.	See SAMA 164	N/A

TABLE F.4-1
PHASE 1 SAMA (Cont'd)

Phase 1 SAMA ID number	SAMA title	Source Reference of SAMA	Result of potential enhancement	Screening Criteria [See Notes]	Disposition	Phase 2 SAMA ID number
261	4.d. Passive Overpressure Relief	Advanced Reactors SAMDAs	This SAMA would prevent vessel overpressurization.	#3 - Already implemented at VCSNS.	Safety valves are installed.	N/A
262	8.b. Improved Operating Response	Advanced Reactors SAMDAs	Improved operator reliability would improve accident mitigation and prevention.	#3 - Already implemented at VCSNS.	The industry has improved over the last 20 years and the development of enhanced procedures combined with simulator training at VCSNS is judged to address this issue.	N/A
263	8.d. Operation Experience Feedback	Advanced Reactors SAMDAs	This SAMA would identify areas requiring increased attention in plant operation through review of equipment performance.	#3 - Already implemented at VCSNS.	The Maintenance Rule has enforced the industry trend of tracking component performance. This issue is judged to be addressed by the Maintenance Rule.	N/A
264	8.e. Improved SRV Design	Advanced Reactors SAMDAs	This SAMA would improve SRV reliability, thus increasing the likelihood that sequences could be mitigated using low pressure heat removal.	#2 - Similar item is addressed under other proposed SAMAs.	See SAMAs 221 and 237	N/A
265	12.a. Increased Seismic Margins	Advanced Reactors SAMDAs	This SAMA would reduce the risk of core damage and release during seismic events.	#2 - Similar item is addressed under other proposed SAMAs.	See SAMAs 111 and 239	N/A
266	13.b. System Simplification	Advanced Reactors SAMDAs	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.	#2 - Similar item is addressed under other proposed SAMAs.	Addressed by SAMAs 13, 107, 113, 146, 194, 237, and 238	N/A
267	Train operations crew for response to inadvertent actuation signals	15	This SAMA would improve chances of a successful response to the loss of two 120V AC buses, which may cause inadvertent signal generation.	#6 - Retain	N/A	31

TABLE F.4-1
PHASE 1 SAMA (Cont'd)

Phase 1 SAMA ID number	SAMA title	Source Reference of SAMA	Result of potential enhancement	Screening Criteria [See Notes]	Disposition	Phase 2 SAMA ID number
268	Install tornado protection on gas turbine generators	15	This SAMA would improve onsite AC power reliability.	#6 - Retain	N/A	32

#1 Not applicable to the VCSNS Design
#2 Similar item is addressed under other proposed SAMAs.
#3 Already implemented.
#4 No significant safety benefit associated with the systems/items associated with this SAMA.
#5 The cost of implementation is greater than the cost-risk averted for the plant change or modification.
#6 Retain
#7 ABWR Design Issue; not practical.

TABLE F.4-2
PHASE 2 SAMA

Phase 2 SAMA ID number	Phase 1 SAMA ID number	SAMA title	Source Reference of SAMA	Result of potential enhancement	Estimated cost	Comment	Phase 2 disposition
1	8	Increase charging pump lube oil capacity.	2	SAMA would lengthen the time before centrifugal charging pump failure due to lube oil overheating in loss of CC sequences.	Not estimated.	The charging pumps are normally cooled by CCW; however, on loss of normal cooling, abnormal operating procedures have been developed to direct alignment of chilled water, the Demineralized Water System or the Fire Service System to the charging pumps. This SAMA would only allow for increased credit to be taken for CCW recovery based on the delay in charging pump failure due to oil heatup. Compared with the availability of these two alternate cooling methods, this credit is not significant. As a point of reference, the Risk Reduction Worth of common cause failure of the CCW system (event “LCC-CCF”) is only 1.001 with respect to both CDF and LERF. In addition, 1) the current model does not even credit CCW recovery for charging pump cooling as the effect is negligible and 2) this SAMA does not place the plant in a stable state; without recovery of a cooling system, the charging pumps will eventually be lost.	Screened out. The cost of implementation would be greater than the averted cost-risk associated with implementing this SAMA.

TABLE F.4-2 (Cont'd)
PHASE 2 SAMA

Phase 2 SAMA ID number	Phase 1 SAMA ID number	SAMA title	Source Reference of SAMA	Result of potential enhancement	Estimated cost	Comment	Phase 2 disposition
2	10	Add redundant DC control power for PSW pumps C and D.	3	SAMA would increase reliability of PSW and decrease core damage frequency due to a loss of SW.	Not estimated.	DC control power to the Service Water Pumps is already relatively reliable at VCSNS. Modifications to allow alignment of the opposite division of 125V DC to the Service Water Pumps result in minimal benefit to the plant. The averted cost-risk associated with this SAMA is $1,249. This is well below the cost of implementing the hardware and procedural changes required for this SAMA.	Screened out. The cost of implementation would be greater than the averted cost-risk associated with implementing this SAMA. Refer to Section F.5.1 for additional information.
3	12	Use existing hydro-test pump for RCP seal injection.	4	SAMA would provide an independent seal injection source, without the cost of a new system.	Between $150,000 and $175,000	Enhancements to systems which provide cooling to RCP seals are typically high impact changes. The use of the existing hydrostatic test pump for alternate seal injection is estimated to yield an averted cost-risk of $103,093. The cost of implementation for this SAMA is estimated to be between $150,000 and $175,000, which exceeds the averted cost-risk by greater than 45 percent.	Screened out. The cost of implementation would be greater than the averted cost-risk associated with implementing this SAMA. Refer to Section F.5.2 for additional information.

TABLE F.4-2 (Cont'd)
PHASE 2 SAMA

Phase 2 SAMA ID number	Phase 1 SAMA ID number	SAMA title	Source Reference of SAMA	Result of potential enhancement	Estimated cost	Comment	Phase 2 disposition
4	16	Prevent centrifugal charging pump flow diversion from the relief valves.	1	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.	Not estimated.	While the flow diversion through a relief valve failure mode is not directly modeled in the VCSNS PRA, it is considered to be subsumed by the event for common cause failure of charging pump seal injection (SINJ1-CCF). The charging pump seal injection function (SINJ1-CCF) has a Risk Reduction Worth of 1.000 with respect to both CDF and LERF. Thus, the averted cost-risk associated with implementing this SAMA is negligible and no amount of spending to reduce the flow diversion failure mode would be cost-beneficial.	Screened out. Implementation of this SAMA would not result in a significant averted cost-risk for VCSNS.
5	22	Improved ability to cool the residual heat removal heat exchangers.	1	SAMA would reduce the probability of a loss of decay heat removal by implementing procedure and hardware modifications to allow manual alignment of the fire protection system or by installing a component cooling water cross-tie.	Not estimated.	While the Fire Service System is a potential independent system that could be used to cool the RHR heat exchangers, the operator action to align CCW to the heat exchangers and the action to align the Fire Service System to the RHR heat exchangers is considered to be completely dependent. The failure to supply cooling to the RHR heat exchangers is dominated by the operator action for CCW alignment, thus, an additional water source that relies on the same operator action provides no measurable benefit. The averted cost-risk for this SAMA is approximately $0.00.	Screened out. Implementation of this SAMA would not result in a significant averted cost-risk for VCSNS.

TABLE F.4-2 (Cont'd)
PHASE 2 SAMA

Phase 2 SAMA ID number	Phase 1 SAMA ID number	SAMA title	Source Reference of SAMA	Result of potential enhancement	Estimated cost	Comment	Phase 2 disposition
6	35	Develop an enhanced drywell spray system.	5	SAMA would provide a redundant source of water to the containment to control containment pressure, when used in conjunction with containment heat removal.	Not estimated.	Reference 18 indicates that the VCSNS containment would not fail due to overpressure in postulated scenarios even with the loss of both Containment Spray and Containment Cooling. In addition, the Risk Reduction Worth of Containment Spray common cause failure is 1.000 with respect to CDF and LERF. Thus, improving Containment Spray reliability would result in a negligible averted cost-risk.	Screened out. Implementation of this SAMA would not result in a significant averted cost-risk for VCSNS.
7	40	Create/enhance hydrogen recombiners with independent power supply.	10	SAMA would reduce hydrogen detonation at lower cost, using 1) a new independent power supply 2) a non-safety-grade portable generator 3) existing station batteries 4) existing AC/DC independent power supplies.	Not estimated.	Reference 18 indicates that VCSNS containment would not fail due to overpressure in any postulated scenario (including H2 detonation) even with loss of Containment Spray and Containment Cooling. From a quantitative perspective, the VCSNS cost-risk associated with plant operation is driven by the core damage frequency; therefore, reducing the LERF contribution from hydrogen detonation would have a negligible impact on the results. In addition, the LERF model for VCSNS does not include containment failure sequences. These sequences are judged to be small contributors to plant risk compared with ISLOCA, Steam Generator Tube Rupture, and Containment Isolation failures. Implementation of this SAMA would not be cost beneficial.	Screened out. Implementation of this SAMA would not result in a significant averted cost-risk for VCSNS.

TABLE F.4-2 (Cont'd)
PHASE 2 SAMA

Phase 2 SAMA ID number	Phase 1 SAMA ID number	SAMA title	Source Reference of SAMA	Result of potential enhancement	Estimated cost	Comment	Phase 2 disposition
8	48	Create other options for reactor cavity flooding. For example, Fire Water could be used as an alternate source for containment flooding.	1	SAMA would enhance debris coolability, reduce core concrete interaction, and provide fission product scrubbing.	Not estimated.	The intent of this SAMA is to reduce the consequences of a core melt once it has occurred. VCSNS's cost-risk is dominated by the CDF rather than the LERF; thus, the impact of installing a device or making a change that does not reduce the CDF will be small. In addition, reducing the core-concrete interaction by flooding the cavity will not have a significant impact on LERF. The timing related to containment failure due to contact with the core is generally long, categorized as a late containment failure mode, and does not significantly impact the LERF. The effects of scrubbing due to a flooded cavity are not currently credited.	Screened out. Implementation of this SAMA would not result in a significant averted cost-risk for VCSNS.
9	59	Refill CST	14	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.	Not estimated.	The cost of installing a system that could provide borated make-up water to the RWST at a flowrate sufficient to mitigate a LOCA is judged to greatly exceed the averted cost-risk calculated for this SAMA ($23,818). Note that for PWRs this SAMA is functionally linked to the RWST/sump rather than the CST. The CST already has refill capability at VCSNS.	Screened out. Implementation of this SAMA would not result in a significant averted cost-risk for VCSNS. Refer to Section F.5.3 for additional information.

TABLE F.4-2 (Cont'd)
PHASE 2 SAMA

Phase 2 SAMA ID number	Phase 1 SAMA ID number	SAMA title	Source Reference of SAMA	Result of potential enhancement	Estimated cost	Comment	Phase 2 disposition
10	95	Improve 4-kV bus cross-tie ability.	1	Enhance procedures to direct 4-kV bus cross-tie. If this procedural step already exists, investigate installation of hardware that would perform an automatic cross-tie to the opposite 4-kV bus given failure of the dedicated diesel. (7.2-kV at VCSNS)	$25,000 to $50,000	The averted cost-risk associated with implementing this SAMA is estimated to be $20,630. Development of EMERGENCY 7.2-kV AC cross-tie procedures is not identified as a cost beneficial change.	Screened out. The cost of implementation would be greater than the averted cost-risk associated with implementing this SAMA. Refer to Section F.5.4 for additional information.
11	142	Install relief valves in the CC System.	1	SAMA would relieve pressure buildup from an RCP thermal barrier tube rupture, preventing an ISLOCA.	Not estimated.	The estimated averted cost-risk for averting all ISLOCA contributions is $39,725. The cost of performing the hardware modifications to install relief valves in the CC system is judged to greatly exceed this estimate (engineering judgement).	Screened out. The cost of implementation would be greater than the averted cost-risk associated with implementing this SAMA. Refer to Section F.5.5 for additional information.

TABLE F.4-2 (Cont'd)
PHASE 2 SAMA

Phase 2 SAMA ID number	Phase 1 SAMA ID number	SAMA title	Source Reference of SAMA	Result of potential enhancement	Estimated cost	Comment	Phase 2 disposition
12	145	Ensure that all ISLOCA releases are scrubbed.	1	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.	>> $39,725	The estimated averted cost-risk for averting all ISLOCA contributions is $39,725. The cost of performing the analysis to identify all ISLOCA pathways and to ensure that any physical modifications implemented to mitigate ISLOCAs are not detrimental to the plant (e.g., cause flooding hazards) combined with the cost of installation is judged to greatly exceed this estimate (engineering judgement). The suggested enhancement of plugging drain lines would not guarantee a release would be scrubbed as the release may occur prior to the submergence of the break. Room flooding equipment and waterproofing of mitigative components would be required to make this SAMA potentially effective. Such changes would be extremely costly.	Screened out. The cost of implementation would be greater than the averted cost-risk associated with implementing this SAMA. Refer to Section F.5.5 for additional information.
13	148	8.e. Improved MSIV Design	Advanced Reactor SAMDAs	This SAMA would improve isolation reliability and reduce spurious actuations that could be initiating events.	Not estimated.	The estimated averted cost-risk associated with implementing this SAMA is $5,788. The cost of replacing the MSIVs is judged to greatly exceed this value.	Screened out. The cost of implementation would be greater than the averted cost-risk associated with implementing this SAMA. Refer to Section F.5.6 for additional information.

TABLE F.4-2 (Cont'd)
PHASE 2 SAMA

Phase 2 SAMA ID number	Phase 1 SAMA ID number	SAMA title	Source Reference of SAMA	Result of potential enhancement	Estimated cost	Comment	Phase 2 disposition
14	153	Modify swing direction of doors separating turbine building basement from areas containing safeguards equipment.	1	SAMA would prevent flood propagation, for a plant at which internal flooding from turbine building to safeguards areas is a concern.	Not estimated.	The flooding initiating events all have Risk Reduction Worth values of 1.000 (with respect to both CDF and LERF); thus, elimination of all flood risk included in the internal events PRA would result in an insignificant change in LERF. No amount of spending to mitigate flood events would result in a cost-beneficial solution based on the current PRA model.	Screened out. Implementation of this SAMA would not result in a significant averted cost-risk for VCSNS.
15	154	Improve inspection of rubber expansion joints on main condenser.	1	SAMA would reduce the frequency of internal flooding, for a plant at which internal flooding (due to a failure of circulating water system expansion joints) is a concern.	Not estimated.	The flooding initiating events all have Risk Reduction Worth values of 1.000 (with respect to both CDF and LERF); thus, elimination of all flood risk included in the internal events PRA would result in an insignificant change in LERF. No amount of spending to mitigate flood events would result in a cost-beneficial solution based on the current PRA model.	Screened out. Implementation of this SAMA would not result in a significant averted cost-risk for VCSNS.
16	155	Implement internal flood prevention and mitigation enhancements.	1	This SAMA would reduce the consequences of internal flooding.	Not estimated.	The flooding initiating events all have Risk Reduction Worth values of 1.000 (with respect to both CDF and LERF); thus, elimination of all flood risk included in the internal events PRA would result in an insignificant change in LERF. No amount of spending to mitigate flood events would result in a cost-beneficial solution based on the current PRA model.	Screened out. Implementation of this SAMA would not result in a significant averted cost-risk for VCSNS.

TABLE F.4-2 (Cont'd)
PHASE 2 SAMA

Phase 2 SAMA ID number	Phase 1 SAMA ID number	SAMA title	Source Reference of SAMA	Result of potential enhancement	Estimated cost	Comment	Phase 2 disposition
17	156	Implement internal flooding improvements such as those implemented at Fort Calhoun.	1	This SAMA would reduce flooding risk by preventing or mitigating rupture in the RCP seal cooler of the component cooling system, ISLOCA in a shutdown cooling line, and an auxiliary feedwater (AFW) flood involving the need to remove a watertight door.	Not estimated.	The flooding initiating events all have Risk Reduction Worth values of 1.000 (with respect to both CDF and LERF); thus, elimination of all flood risk included in the internal events PRA would result in an insignificant change in LERF. No amount of spending to mitigate flood events would result in a cost-beneficial solution based on the current PRA model.	Screened out. Implementation of this SAMA would not result in a significant averted cost-risk for VCSNS.
18	157	Shield electrical equipment from potential water spray.	Industry IPEEE Insights	SAMA would decrease risk associated with seismically induced internal flooding	Not estimated.	The flooding initiating events all have Risk Reduction Worth values of 1.000 (with respect to both CDF and LERF); thus, elimination of all flood risk included in the internal events PRA would result in an insignificant change in LERF. No amount of spending to mitigate flood events would result in a cost-beneficial solution based on the current PRA model.	Screened out. Implementation of this SAMA would not result in a significant averted cost-risk for VCSNS.
19	158	13.c. Reduction in Reactor Building Flooding	Advanced Reactor SAMDAs	This SAMA reduces the Reactor Building Flood Scenarios contribution to core damage and release.	Not estimated.	The flooding initiating events all have Risk Reduction Worth values of 1.000 (with respect to both CDF and LERF); thus, elimination of all flood risk included in the internal events PRA would result in an insignificant change in LERF. No amount of spending to mitigate flood events would result in a cost-beneficial solution, based on the current PRA model.	Screened out. Implementation of this SAMA would not result in a significant averted cost-risk for VCSNS.

TABLE F.4-2 (Cont'd)
PHASE 2 SAMA

Phase 2 SAMA ID number	Phase 1 SAMA ID number	SAMA title	Source Reference of SAMA	Result of potential enhancement	Estimated cost	Comment	Phase 2 disposition
20	175	Replace current PORVs with larger ones so only one is required for successful feed and bleed.	15	This SAMA would reduce the dependencies required for successful feed and bleed.	Not estimated.	Installation of new pressurizer PORVs that each have the capacity to pass the required feed and bleed flow alone increases the reliability of the feed and bleed function. For VCSNS, this change is estimated to yield an averted cost-risk of $17,766. The cost of purchasing and installing new PORVs is judged to greatly exceed the averted cost-risk for this SAMA.	Screened out. The cost of implementation would be greater than the averted cost-risk associated with implementing this SAMA. Refer to Section F.5.7 for additional information.

TABLE F.4-2 (Cont'd)
PHASE 2 SAMA

Phase 2 SAMA ID number	Phase 1 SAMA ID number	SAMA title	Source Reference of SAMA	Result of potential enhancement	Estimated cost	Comment	Phase 2 disposition
21	181	Create the ability to manually align ECCS recirculation	15	This SAMA would provide a back-up should automatic or remote operation fail.	Not estimated	VCSNS has the capability of allowing for manual alignment of ECCS recirculation with the exception of 4 valves (1 for SI and one for CS per train). Valves XVG08811A(B)-SI and XVG03004A(B)-SP are located within the containment boundary and are not accessible to operators without extensive work (and unacceptable dose levels during a LOCA). Allowing access to this valve would require re-defining the containment boundary and performing physical changes to the boundary. Currently, the VCSNS model does not credit local, manual action to operate failed power operated valve; thus, this SAMA would have no measurable impact. In addition, recirculation failure is dominated by human error (OAR1, 2, 4, 5, C) and recovery of a failed power operated valve would not be significant relative to the HEPs for recirculation alignment. This SAMA yields a negligible averted cost-risk.	Screened out. Implementation of this SAMA would not result in a significant averted cost-risk for VCSNS

TABLE F.4-2 (Cont'd)
PHASE 2 SAMA

Phase 2 SAMA ID number	Phase 1 SAMA ID number	SAMA title	Source Reference of SAMA	Result of potential enhancement	Estimated cost	Comment	Phase 2 disposition
22	187	Change "in-containment" RWT suction from 4 check valves to 2 check and 2 air operated valves.	15	This SAMA would remove common mode failure of all four injection paths.	Not estimated	The RWST suction valves impact high and low head injection at V.C. Summer. These functions are not dominant contributors to plant risk. High pressure injection is represented by the common cause failure of all high head injection (HPI-CCF-ALL) and has a risk reduction worth of 1.002 based on CDF (which drives V.C. Summer's cost beneficial analysis). Low pressure injection is represented by two common cause failure events, one for Large and Medium LOCAs (RHR-CCF-LH1A), and one for Small LOCAs (RHR-CCF-LH8). The Risk Reduction Worth of RHR-CCF-LH1A is 1.000. RHR-CCF-LH4 was not in any cutsets above the truncation limit and no importance was calculated for the event. Alteration of the RWST suction check valves would have a minimal impact on plant risk and the cost of replacing the suction valves would greatly exceed the associated averted cost-risk.	Screened out. Implementation of this SAMA would not result in a significant averted cost-risk for VCSNS

TABLE F.4-2 (Cont'd)
PHASE 2 SAMA

Phase 2 SAMA ID number	Phase 1 SAMA ID number	SAMA title	Source Reference of SAMA	Result of potential enhancement	Estimated cost	Comment	Phase 2 disposition
23	188	Replace 2 of the 4 safety injection (SI) pumps with diesel-powered pumps.	15	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.	Not estimated	High pressure SI injection is represented by the common cause failure of all high head injection (HPI-CCF-ALL) and High Head Recirc (HPR-CCF-ALL), both of which have a risk reduction worth of 1.002 based on CDF (which drives V.C. Summer's cost benefit analysis). Low pressure SI is represented by common cause of low pressure recirc and Low pressure injection. Low pressure SI injection is represented by two common cause failure events, one for Large and Medium LOCAs (RHR-CCF-LH1A), and one for Small LOCAs (RHR-CCF-LH8). The Risk Reduction Worth of RHR-CCF-LH1A is 1.000. RHR-CCF-LH4 was not in any cutsets above the truncation limit and no importance was calculated for the event. Low pressure recirc is represented by the common cause failure of the function for LLOCAs/MLOCAs (RHR-CCF-LH2) and SGTR/SLOCA scenarios (RHR-CCF-LH5). The risk reduction worths of these events are 1.000 and 1.001, respectively. Alteration of the SI pumps would have a minimal impact on plant risk and the cost of replacing the SI pumps would greatly exceed the associated averted cost-risk.	Screened out. Implementation of this SAMA would not result in a significant averted cost-risk for VCSNS

TABLE F.4-2 (Cont'd)
PHASE 2 SAMA

Phase 2 SAMA ID number	Phase 1 SAMA ID number	SAMA title	Source Reference of SAMA	Result of potential enhancement	Estimated cost	Comment	Phase 2 disposition
24	193	Create automatic swap-over to recirculation on RWT depletion	15	This SAMA would reduce the human error contribution from recirculation failure.	$1,225,000	Installation of equipment that would fully automate 1) charging pump suction swap to the RHR Hx discharge, and 2) the RHR suction swap to the sump from the RWST given RWST depletion increases the probability of successful recirculation initiation. The averted cost-risk associated with this SAMA is $377,828.	Screened out. The cost of implementation would be greater than the averted cost-risk associated with implementing this SAMA. Refer to Section F.5.8 for additional information.
25	206	2.f. Improved Low Pressure System (Firepump)	Advanced Reactor SAMDAs	SAMA would provide fire protection system pump(s) for use in low pressure scenarios.	$565,000	Installation of an additional, diesel driven fire system pump that would be capable of providing low pressure injection to the RPV from the RWST through existing RHR piping is estimated to yield an averted cost-risk of $117,510. Enhancement of the fire protection system to provide flow to the containment spray system has been estimated to cost about $565,000 (Reference 24). The systems considered in this enhancement are similar to those relevant to this SAMA and the scope of the change is approximately the same; thus, $565,000 is judged to be an appropriate estimate for the cost of implementation for this SAMA. The averted cost-risk resulting from this enhancement is less than the cost of implementation and yields a negative net value. This SAMA is not cost beneficial.	Screened out. The cost of implementation would be greater than the averted cost-risk associated with implementing this SAMA. Refer to Section F.5.9 for additional information.

TABLE F.4-2 (Cont'd)
PHASE 2 SAMA

Phase 2 SAMA ID number	Phase 1 SAMA ID number	SAMA title	Source Reference of SAMA	Result of potential enhancement	Estimated cost	Comment	Phase 2 disposition
26	213	Replace old air compressors with more reliable ones	15	This SAMA would improve reliability and increase availability of the IA compressors.	Not estimated.	The new air compressors were assumed to be more reliable by a factor of 10, which is considered to be an exaggerated estimate of the increase in compressor reliability. However, the averted cost-risk associated with this change is only $13,147 and is far less than the cost of installing new air compressors at VCSNS.	Screened out. The cost of implementation would be greater than the averted cost-risk associated with implementing this SAMA. Refer to Section F.5.10 for additional information.
27	217	Install MG set trip breakers in control room	15	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).	Not estimated.	For the purposes of calculating an averted cost risk for this SAMA, it was conservatively assumed that installation of MG set trip breakers would remove all ATWS contribution to CDF and LERF. ATWS is a low contributor to both CDF and LERF at VCSNS and this change resulted in an averted cost-risk of $18,556. The hardware change required to complete this SAMA is considered to cost significantly more than the associated averted cost-risk and is screened from further analysis (engineering judgement).	Screened out. The cost of implementation would be greater than the averted cost-risk associated with implementing this SAMA. Refer to Section F.5.11 for additional information.

TABLE F.4-2 (Cont'd)
PHASE 2 SAMA

Phase 2 SAMA ID number	Phase 1 SAMA ID number	SAMA title	Source Reference of SAMA	Result of potential enhancement	Estimated cost	Comment	Phase 2 disposition
28	237	Install secondary side guard pipes up to the MSIVs	15	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.	Not estimated	The Risk Reduction Worth for a Secondary Side Break inside containment is 1.032 with respect to CDF and 1.019 with respect to LERF. Assuming the larger of the two RRWs is applicable to the entire maximum averted cost risk of $1.2 million, eliminating ALL secondary side break initiating events (not just those between the RPV and the MSIVs) would result in an averted cost risk of $38,508. Based on engineering judgement, the cost of implementing this SAMA would far exceed this averted cost-risk; therefore, this is not a cost beneficial SAMA.	Screened out. The cost of implementation would be greater than the averted cost-risk associated with implementing this SAMA.
29	238	Install digital large-break LOCA protection	15	Upgrade plant instrumentation and logic to improve the capability to identify symptoms/precursors of a large-break LOCA (leak before break).	Not estimated.	The Risk Reduction Worth of the Large LOCA initiator is 1.000 (with respect to both CDF and LERF); thus, even if this SAMA could prevent ALL Large LOCAs from occurring, the reduction in LERF would be insignificant. No amount of spending will be cost beneficial for this SAMA.	Screened out. Implementation of this SAMA would not result in a significant averted cost-risk for VCSNS.

TABLE F.4-2 (Cont'd)
PHASE 2 SAMA

Phase 2 SAMA ID number	Phase 1 SAMA ID number	SAMA title	Source Reference of SAMA	Result of potential enhancement	Estimated cost	Comment	Phase 2 disposition
30	241	Increase the reliability of safety relief valves by adding signals to open them automatically.	11	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.	Not estimated.	The Risk Reduction Worth of the Medium LOCA initiator is 1.003 with respect to CDF and 1.002 with respect to LERF. Elimination of all Medium LOCA risk corresponds to a maximum of approximately $3,600 in averted cost-risk; thus, even if this SAMA could prevent ALL Medium LOCAs from occurring (not only those caused by SRV failures), the benefit would be minimal. The hardware addition required to automatically operate the Safety Relief Valves will cost more than the $3,600 averted cost-risk associated with this SAMA and is therefore not cost beneficial.	Screened out. Implementation of this SAMA would not result in a significant averted cost-risk for VCSNS.
31	267	Train operations crew for response to inadvertent actuation signals	15	This SAMA would improve chances of a successful response to the loss of two 120V AC buses, which may cause inadvertent signal generation.	Not estimated.	Inadvertent actuation signals have been considered for VCSNS. Loss of two 120V AC panels, which would generate inadvertent actuation signals, has been included in the PRA as an initiating event. This event has a Risk Reduction Worth and Risk Achievement Worth value of 1.000 (with respect to both CDF and LERF). These types of failures are not risk significant for VCSNS and no amount of spending to mitigate the effects of inverter failure would be cost beneficial.	Screened out. Implementation of this SAMA would not result in a significant averted cost-risk for VCSNS.

TABLE F.4-2 (Cont'd)
PHASE 2 SAMA

Phase 2 SAMA ID number	Phase 1 SAMA ID number	SAMA title	Source Reference of SAMA	Result of potential enhancement	Estimated cost	Comment	Phase 2 disposition
32	268	Install tornado protection on gas turbine generators	15	This SAMA would improve onsite AC power reliability.	Not estimated.	While VCSNS does not have gas turbine generators, tornado strikes at the site were examined in the IPEEE (Reference 17). This analysis indicates that the plant critical structures were designed to withstand winds of up to 360 mph. The frequency that an event would occur on an individual structure with winds greater than this speed is estimated to be less than 1E-7/yr (<1E-6 for the entire site). The low initiating event frequency identifies this as a non-significant contributor to risk at VCSNS and no amount of spending to protect against tornado strikes would be cost beneficial.	Screened out. Implementation of this SAMA would not result in a significant averted cost-risk for VCSNS.

F.5 Phase 2 SAMA Analysis

It was possible to screen some of the remaining SAMA candidates from further analysis based on plant-specific insights regarding the risk significance of the systems that would be affected by the proposed SAMAs. The SAMAs related to non-risk-significant systems were screened from a detailed cost-benefit analysis because any change in the reliability of these systems is known to have a negligible impact on the PSA evaluation. In these cases, the estimated cost for the SAMA is listed as "Not estimated" in Table F.4-2, as any realistic monetary expenditure for the SAMA would be greater than the benefit that the SAMA would provide (essentially $0).

For each of the remaining SAMA candidates that could not be eliminated based on screening cost or PSA/application insights, 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 used to determine the desirability of implementing a given SAMA is defined by the following equation:

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

For the SAMAs which yield a non-zero averted cost-risk that is obviously less than any realistic cost of implementation, no specific cost estimate is provided. The estimated cost is listed as "Not estimated" in Table F.4-2 and the SAMA is screened from further analysis. Otherwise, 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 F.3. The cost-risk of plant operation with the SAMA implemented is determined in the same manner with the exception that the PSA results reflect the application of the SAMA to the plant (the baseline input is replaced by the results of a PSA sensitivity with the SAMA change in effect).

Subsections F.5.1 – F.5.11 describe the detailed cost-benefit analysis that was used to determine how the remaining candidates were ultimately treated.

F.5.1 Phase 2 SAMA Number 2: Add Redundant DC Control Power for PSW Pumps C and D (A, B, and C Pumps for VCSNS)

Description: This SAMA is intended to reduce the CDF by lowering the failure probability of the Service Water System. This would be accomplished by providing alternate DC control power to the pumps. A redundant power supply would allow operation of a given division of Service Water pumps when the normal supply has failed. Such capability is beneficial when control power is not available to the "A" division and the "B" division pumps have failed for non-control power reasons. The benefit is shown in a reduction of the Loss of Service Water initiating event frequency and an improved system reliability.

Table F.5.1-1 summarizes the model changes that were made to the PSA to represent the implementation of this SAMA at VCSNS:

TABLE F.5.1-1
PHASE 2 SAMA NUMBER 2 MODEL CHANGES

Gate ID and Description:	Description of Change:
DCP-DPN1HA3: LOSS OF POWER FROM 125 VDC	Changed DCP-DPN1HA3 to an "AND" gate. Added gates: DCP-DPN1-HA3-A DCP-DPN-1HB3-A Deleted gates: DCP-DPN1HA RACB-DPN1HA3C9 RACB-DPN1HA3OP
DCP-DPN1HA3-SBO: LOSS OF POWER FROM 125 VDC PANEL - SBO	Changed DCP-DPN1HA3-SBO to an "AND" gate. Added gates: DCP-DPN1HA3SBO-A DCP-DPN1HB3SBO-A Deleted gates: DCP-DPN1HA-SBO RACB-DPN1HA3CO RADP-DPN1HA3OP
DCP-DPN1HA3-DR: LOSS OF POWER FROM 125 VDC (DG RUN SUPPORT)	Changed DCP-DPN1HA3-DR to an "AND" gate. Added gates: DCP-DPN1HA3-DR-A DCP-DPN1HB3-DR-A Deleted gates: DCP-DPN1HA-DR RACB-DPN1HA3CO RADP-DPN1HA3OP
LSW-024: NO DC ELECTRIC POWER TO COMPONENT FED BY 125 VDC	Changed LSW-024 to an "AND" gate. Added gates: G063 G064 Deleted gates: RACB--DPN1HACO RACB-DPN1HA3CO RADP-DPN1HA3OP

TABLE F.5.1-1 (Cont'd)
PHASE 2 SAMA NUMBER 2 MODEL CHANGES

Gate ID and Description:	Description of Change:
DCP-DPN1HA3-A: LOSS OF POWER FROM 125 VDC PANEL DPN1HA3	New "OR" gate with: DCP-DPN1HA RACB-DPN1HA3CO RADP-DPN1HA3OP
DCP-DPN1HB3-A: LOSS OF POWER FROM 125 VDC PANEL DPN1HB3	New "OR" gate with: DCP-DPN1HB RBCB-DPN1HB3CO RBDP-DPN1HB3OP
DCP-DPN1HA3SBO-A: LOSS OF POWER FROM 125 VDC PANEL DPN1HA3 - SBO	New "OR" gate with: DCP-DPN1HA-SBO RACB-DPN1HA3CO RADP-DPN1HA3OP
DCP-DPN1HB3SBO-A: LOSS OF POWER FROM 125 VDC PANEL DPN1HB3 - SBO	New "OR" gate with: DCP-DPN1HB-SBO RBCB-DPN1HB3CO RBDP-DPN1HB3OP
DCP-DPN1HA3-DR-A: LOSS OF POWER FROM 125 VDC PANEL DPN1HA3 (DG RUN SUPPORT)	New "OR" gate with: DCP-DPN1HA-DR RACB-DPN1HA3CO RADP-DPN1HA3OP
DCP-DPN1HB3-DR-A: LOSS OF POWER FROM 125 VDC PANEL DPN1HB3 (DG RUN SUPPORT)	New "OR" gate with: DCP-DPN1HB-DR RBCB-DPN1HB3CO RBDP-DPN1HB3OP
G063: NO DC ELECTRIC POWER TO COMPONENT FED BY 125 VDC PANEL DPN1HA3	New "OR" gate with: RACB-DPN1HACO RACB-DPN1HA3CO RADP-DPN1HA3OP
G064: NO DC ELECTRIC POWER TO COMPONENT FED BY 125 VDC PANEL DPN1HB3	New "OR" gate with: RBCB-DPN1HBCO RBCB-DPN1HB3CO RBDP-DPN1HB3OP

Similar changes were made for DCP-DPN1HB3, DCP-DPN1HB3-DR, and DCP-DPN1HB3-SBO.

PSA Model Results (Phase 2 SAMA Number 2)

The results from this case indicate about a 0.2 percent reduction in CDF (CDF_{new}=5.59E-5/yr) and a 0.1 percent reduction in LERF ($LERF_{new}$=6.99E-7/yr). The results of the cost-benefit analysis are shown in Table F.5.1-2.

TABLE F.5.1-2
PHASE 2 SAMA NUMBER 2 NET VALUE

Base Case: Cost-Risk for VCSNS	Cost-Risk for VCSNS	Averted Cost-Risk	Cost of Implementation	Net Value
$1,203,380	$1,202,131	$1,249	Not estimated	Large Negative Value

As the averted cost-risk is minimal for this SAMA, no detailed cost of implementation was derived as the cost of the hardware changes would clearly be larger than the averted cost-risk.

F.5.2 Phase 2 SAMA Number 3: Use Existing Hydro-Test Pump for RCP Seal Injection

Description: In this sensitivity, it was assumed that the existing hydrostatic test pump was modified such that it could be used for RCP seal injection. In the event that the plant's other sources of RCP seal injection and thermal barrier cooling have failed, the hydro-test pump could be used to prevent RCP seal failure and the consequential seal LOCA.

To implement this change, a "super-event" was added to the model to represent the seal injection function of the hydro-test pump. A failure probability of 1E-3 was assigned to the event. While it may be argued that a 1E-3 failure probability overestimates the capability of this system, a lower failure probability will result in a greater benefit for the SAMA, which is conservative.

Table F.5.2-1 summarizes the changes made to the VCSNS PSA model to simulate the capability of using the station's hydro-test pump for RCP seal injection.

TABLE F.5.2-1
PHASE 2 SAMA NUMBER 3 MODEL CHANGES

System: Basic Events	Added Under Gate(s):	Value
HYDROPUMP: ALTERNATE SEAL INJECTION FROM HYDRO PUMP	RCPCOOL	1E-3

PSA Model Results (Phase 2 SAMA Number 3)

The results from this case indicate about a 9 percent reduction in CDF (CDF_{new}=5.10E-5/yr) and a 5.3 percent reduction in LERF ($LERF_{new}$=6.63E-7/yr). The results of the cost-benefit analysis are shown in Table F.5.2-2.

TABLE F.5.2-2
PHASE 2 SAMA NUMBER 3 NET VALUE

Base Case: Cost-Risk for VCSNS	Cost-Risk for VCSNS	Averted Cost-Risk	Cost of Implementation	Net Value
$1,203,380	$1,100,287	$103,093	$150,000 to $175,000	-$46,907 to -$71,907

The negative net value of this SAMA candidate indicates that its implementation is not beneficial.

F.5.3 Phase 2 SAMA Number 9: Refill CST (RWST for VCSNS)

Description: While this SAMA was developed for a BWR, the function of this enhancement is to provide a cool injection source to the RPV given that heat removal to the re-circulated volume has failed. Without a cool suction source for RHR, the pumps will fail due to seal damage or loss of NPSH. Use of the relatively cool RWST water for injection allows the RHR pumps to operate without pump cooling and without the use of the RHR heat exchangers.

For PWRs, the injection water is required to be borated. In order for RWST make-up to be viable for use in medium or large LOCA scenarios, the make-up rate to the RWST must be equivalent to the flowrate through the break. This requires an unlimited, high capacity water source, a supply of boration material to last the 24-hour mission time, and a high-speed mixer to ensure that the injection water is appropriately borated.

Representing this change in the model required extensive revisions to the fault tree structure. The changes made to Loop "B" are documented in Table F.5.3-1 for demonstration purposes; the changes to Loop "A" are similar.

The RWST refill system is represented by a single lumped event, RWST-REFILL. This is considered to quantitatively account for all RWST-REFILL system failures as well as support system dependencies that are not explicitly included in the fault tree. A failure probability of 1E-2 is assigned to the RWST-REFILL event for this evaluation.

TABLE F.5.3-1
PHASE 2 SAMA NUMBER 9 MODEL CHANGES

Gate ID and Description:	Description of Change:
RHR-LPR-014: INSUFFICIENT FLOW TO SUCTION OF RHR PUMP B	Change RHR-LPR-014 to an "AND" gate. Add: RWST-REFILL Delete: RHR-LPR-30
RHR-LPR-014-SBO: INSUFFICIENT FLOW TO SUCTION OF RHR PUMP B	Change RHR-LPR-014-SBO to an "AND" gate. Add: RWST-REFILL Delete: RHR-LPR-30-SBO
RHR-SUMP-B: INSUFFICIENT FLOW FROM CONTAINMENT SUMPS (TRAIN B)	Change RHR-SUMP-B to an "AND" gate. Add: RWST-REFILL Delete: RHR-SUMP-B-002
RHR-SUMP-B-SBO: INSUFFICIENT FLOW FROM CONTAINMENT SUMPS (TRAIN B)	Change RHR-SUMP-B-SBO to an "AND" gate. Add: RWST-REFILL Delete: RHR-SUMP-B-002SB
RHR-LPR-005: INSUFFICIENT COOLING FLOW FROM HCV-603B	Add: "AND" gate with RWST-REFILL and 1BHEXHE0005BRP (moved from under RHR-LPR-005)
RHR-REC-COOL-B: FAILURE TO COOL WATER FROM TRAIN B SUMP	Add: RWST-REFILL

TABLE F.5.3-1 (Cont'd)
PHASE 2 SAMA NUMBER 9 MODEL CHANGES

Gate ID and Description:	Description of Change:
RHR-LPR-005-SBO: INSUFFICIENT COOLING FLOW FROM HCV-603B	Add: "AND" gate with RWST-REFILL and 1BHEXHE0005BRP (moved from under RHR-LPR-005-SBO)
RHR-REC-COOL-BSB: FAILURE TO COOL WATER FROM TRAIN B SUMP	Add: RWST-REFILL
RHR-RECIRC-B: INSUFFICIENT FLOW FROM RHR HEAT EXCHANGER XHE-5B (RECIRC TRAIN B)	Add: "AND" gate with RWST-REFILL and 1BHEXHE0005BRP (moved from under RHR-RECIRC-B)
RHR-PUMP-B-REC: B RHR PUMP XPP-31B FAILS DURING RECIRC	Add: "AND" gate with RWST-REFILL and CCWHDRB (moved from under RHR-PUMP-B-REC)
RHR-RECIRC-B-SBO: INSUFFICIENT FLOW FROM RHR HEAT EXCHANGER XHE-5B (RECIRC TRAIN B)	Add: "AND" gate with RWST-REFILL and 1BHEXHE0005BRP (moved from under RHR-RECIRC-B-SBO)
RHR-PUMP-B-RECSB: B RHR PUMP XPP-31B FAILS DURING RECIRC	Add: "AND" gate with RWST-REFILL and CCWHDRB-SBO (moved from under RHR-PUMP-B-RECSB)
RHR-LPR-006: B RHR PUMP FAILS XPP-31B	Add: "AND" gate with RWST-REFILL and CCWHDRB (moved from under RHR-LPR-006)
RHR-LPR-006-SBO: B RHR PUMP FAILS XPP-31B	Add: "AND" gate with RWST-REFILL and CCWHDRB-SBO (moved from under RHR-LPR-006-SBO)

PSA Model Results (Phase 2 SAMA Number 9)

The results from this case indicate about a 2.0 percent reduction in CDF (CDF_{new}=5.48E-5/yr) and a 1.7 percent reduction in LERF ($LERF_{new}$=6.88E-7/yr). The results of the cost-benefit analysis are shown in Table F.5.3-2.

TABLE F.5.3-2
PHASE 2 SAMA NUMBER 9 NET VALUE

Base Case: Cost-Risk for VCSNS	Cost-Risk for VCSNS	Averted Cost-Risk	Cost of Implementation	Net Value
$1,203,380	$1,179,562	$23,818	Not Estimated	Large Negative

The averted cost-risk is relatively small for this SAMA with respect to the resources required for a significant plant hardware modification. No detailed cost of implementation was derived, as the cost of the hardware changes would clearly be larger than the averted cost-risk.

F.5.4 Phase 2 SAMA Number 10: Improve 7.2-kV Bus Cross-Tie Ability

Description: Many plants have the ability to cross-tie their emergency AC buses. This is important in a loss of offsite power scenario with 1 failed EDG in combination with failure of required equipment on the remaining powered emergency bus. For example, if the Alpha diesel fails to run and the Bravo RHR system fails to operate, it would be possible to run the Alpha RHR pumps with the Bravo diesel given a successful power cross-tie. Typically, a cross-tie does not require cutting wires or other semi-permanent changes for success. The cross-tie usually requires operation of breakers from the main control room and no ex-control room action. It is difficult to credit operator actions that are not procedurally directed even if an action is physically capable of being performed. A potential improvement would be the development of emergency procedures that contained step-by-step instructions for performing the cross-tie (given that it could be performed in a reasonable time, perhaps 30 to 45 minutes). Hardware changes that prevented the requirement to cut wires to perform the cross-tie would be a desirable enhancement to the base requirement.

Representing this change in the model required extensive revisions to the fault tree structure. The changes made to Loop "A" are documented in Table F.5.4-1 for demonstration purposes; the changes to Loop "B" are similar.

TABLE F.5.4-1
PHASE 2 SAMA NUMBER 10 MODEL CHANGES

Gate or Event ID and Description:	Description of Change:
ACP-001: LOSS OF POWER TO 7.2 KV BUS XSW1DA	Delete GATE ACP-003 Add NEW GATE ACP-003-X
ACP-003-X: LOSS OF ON-SITE EMERGENCY POWER TO 7.2 KV BUS XSW1DA	Add BE ACP-CCF-ONSITE NEW GATE ACP-003-XTIE
ACP-003-XTIE: NO POWER FROM DG A OR CROSS-TIE	Add: GATE ACP-011 NEW GATE BTOAXTIE
ACP-003-SDX: LOSS OF ON-SITE EMERGENCY POWER TO 7.2 KV BUS XSW1DA	Add: NEW GATE ACP-003-SDX-XTIE Delete: GATE ACP-011-SDX
ACP-003-SDX-XTIE: NO POWER FROM DG A OR X-TIE	Add: GATE ACP-011-SDX NEW GATE BTOAXTIE
ATOBXTIE: NO POWER FROM DG A THROUGH X-TIE (NEW GATE)	Add: BE OP-X-TIE (1E-2) GATE X-TIE-BREAK GATE XTIEDGA
X-TIE-BREAK: X-TIE BREAKERS FAIL	Add: NEW BE AACB-----DGTIEA (3E-3) NEW BE AACB-----DGTIEB (3E-3)
XTIEDGA: DG A FAILS	Add: BE ACP-CCF-ONSITE GATE X-ACP-011-SDX
GATES X-ACP-011-SDX AND X-ACP-027	These gates are equivalent to ACP-011-SDX and ACP-027 except for the replacement of the service water dependencies with undeveloped diamond events (1E-2). This was done to prevent the introduction of circular logic through the cross-tie.

PSA Model Results (Phase 2 SAMA Number 10)

The results from this case indicate about a 1 percent reduction in CDF (CDF_{new}=5.50E-5/yr) and a 0.9 percent reduction in LERF ($LERF_{new}$=6.93E-7/yr). The results of the cost-benefit analysis are shown in Table F.5.4-2.

The negative net value for this SAMA indicates that the proposed change would not be cost beneficial.

TABLE F.5.4-2
PHASE 2 SAMA NUMBER 10 NET VALUE

Base Case: Cost-Risk for VCSNS	Cost-Risk for VCSNS	Averted Cost-Risk	Cost of Implementation	Net Value
$1,203,380	$1,182,349	$20,630	$25,000 to $50,000	-$4,370 to -$29,370

F.5.5 Phase 2 SAMA Number 11: Install Relief Valves in the CC System and Number 12: Ensure all ISLOCA Releases are Scrubbed

Description: These two SAMAs are documented together as they are both related to the reduction of risk related to ISLOCA.

The purpose of Phase 2 SAMA 11 is to decrease the ISLOCA frequency by providing overpressure protection for the CC system.

The purpose of Phase 2 SAMA 12 is to reduce the radionuclide release to the environment given that an ISLOCA has occurred.

The impact of each of these SAMAs can be bounded assuming that all ISLOCA risk is eliminated through the implementation of the SAMAs. If the averted cost-risk can be shown to be less than the cost of implementation for the bounding case, then detailed modeling techniques are not required to develop a more realistic representation of the SAMAs.

The bounding case is developed by setting the ISLOCA frequency to 0.0, as shown in Table F.5.5-1.

TABLE F.5.5-1
PHASE 2 SAMA NUMBERS 11 AND 12 MODEL CHANGES

Gate or Event ID and Description:	Description of Change:
%ISL: INTERFACING SYSTEMS LOCA INITIATING EVENT	Probability changed from 1.54E-6 to 0.0

PSA Model Results (Phase 2 SAMA Numbers 11 and 12)

The results from this case indicate about a 0.2 percent reduction in CDF (CDF_{new}=5.58E-5/yr) and a 25.6 percent reduction in LERF ($LERF_{new}$=5.22E-7/yr). The results of the cost-benefit analysis are shown in Table F.5.5-2.

TABLE F.5.5-2
PHASE 2 SAMA NUMBERS 11 AND 12 NET VALUE

Base Case: Cost-Risk for VCSNS	Cost-Risk for VCSNS	Averted Cost-Risk	Cost of Implementation	Net Value
$1,203,380	$1,163,655	$39,725	Not Estimated	Large Negative

The cost of implementation for both SAMAs 11 and 12 is considered to be much larger than the averted cost-risk. This calculation assumes that all ISLOCA risk is eliminated by implementation of these SAMAs. The actual impact of implementation would only be a fraction of what is estimated here. These SAMAs would not be cost beneficial for VCSNS given the major hardware changes required to make them viable.

F.5.6 Phase 2 SAMA Number 13: Improved MSIV Design

Description: A better MSIV design is suggested to improve reliability of valve operation. This is considered to impact isolation capability in accident response scenarios as well as for spurious closures that could be classified as initiating events (e.g., loss of condenser). To capture the impact of this SAMA's implementation, the "failure to close" probability of the MSIVs is reduced by a factor of 10 as is the loss of condenser initiating event. The model changes representing these modifications are summarized in Table F.5.6-1.

TABLE F.5.6-1
PHASE 2 SAMA NUMBER 13 MODEL CHANGES

Gate or Event ID and Description:	Description of Change:
EAAVXVM2801AFC: FAILURE TO ISOL MS FLOW FROM SG A, XVM-2801A FAILS TO CLOSE	Probability changed from 4.49E-3 to 4.49E-4
EBAVXVM2801BFC: FAILURE TO ISOL MS FLOW FROM SG B, XVM-2801B FAILS TO CLOSE	Probability changed from 4.49E-3 to 4.49E-4
ECAVXVM2801CFC: FAILURE TO ISOL MS FLOW FROM SG C, XVM-2801C FAILS TO CLOSE	Probability changed from 4.49E-3 to 4.49E-4

TABLE F.5.6-1
PHASE 2 SAMA NUMBER 13 MODEL CHANGES (Cont'd)

Gate or Event ID and Description:	Description of Change:
%LOC: LOSS OF CONDENSER INITIATING EVENT	Probability changed from 1.03E-1 to 1.03E-2

PSA Model Results (Phase 2 SAMA Number 13)

The results from this case indicate about a 0.4 percent reduction in CDF (CDF_{new}=5.57E-5/yr) and a 0.2 percent reduction in LERF ($LERF_{new}$=6.98E-7/yr). The results of the cost-benefit analysis are shown in Table F.5.6-2.

TABLE F.5.6-2
PHASE 2 SAMA NUMBER 13 NET VALUE

Base Case: Cost-Risk for VCSNS	Cost-Risk for VCSNS	Averted Cost-Risk	Cost of Implementation	Net Value
$1,203,380	$1,197,191	$5,788	Not Estimated	Large Negative

The cost of implementation for SAMA 13 is considered to be much larger than the averted cost-risk. This SAMA would not be cost beneficial for VCSNS.

F.5.7 Phase 2 SAMA Number 20: Replace Current PORVs with Larger Ones So That Only One is Required for Successful Feed and Bleed

Description: The purpose of this SAMA is to improve feed and bleed reliability by replacing the pressurizer PORVs with new valves that are each capable of passing the required flow for feed and bleed. The size of the current PORVs limits flow so that at least two of the three are required for successful heat removal.

Table F.5.7-1 summarizes the changes made to the VCSNS PSA model to simulate the change in success criteria for feed and bleed from two of three PORVs to one of three PORVs.

TABLE F.5.7-1
PHASE 2 SAMA NUMBER 21 MODEL CHANGES

Gate or Event ID and Description:	Description of Change:
PZR-002: FAILURE OF PZR PRESSURE RELIEF 2 OF 3 PORVS FAIL TO OPEN (RANDOM FAILURES)	Changed gate from a “2/3” gate to an “AND” gate.

PSA Model Results (Phase 2 SAMA Number 20)

The results from this case indicate about a 1.6 percent reduction in CDF (CDF_{new}=5.51E-5/yr) and a 0.9 percent reduction in LERF ($LERF_{new}$=6.94E-7/yr). The results of the cost-benefit analysis are shown in Table F.5.7-2.

TABLE F.5.7-2
PHASE 2 SAMA NUMBER 20 NET VALUE

Base Case: Cost-Risk for VCSNS	Cost-Risk for VCSNS	Averted Cost-Risk	Cost of Implementation	Net Value
$1,203,380	$1,185,614	$17,766	Not Estimated	Large Negative

The averted cost-risk is relatively small for this SAMA with respect to the resources required for a significant plant hardware modification. No detailed cost of implementation was derived as the cost of the hardware changes would clearly be larger than the averted cost-risk.

F.5.8 Phase 2 SAMA Number 24: Create Automatic Swap-Over to Recirculation on RWST Depletion

Description: The purpose of this SAMA is to improve the reliability of the transition to re-circulation mode after depletion of the RWST. VCSNS has a semi-automatic swap to re-circulation mode that could be improved by automating RWST isolation (to prevent air entrainment in the RHR and charging pumps). While the sump suction valves automatically open on RWST low level (18 percent), no logic currently exists to isolate the RWST suction path or to align the charging pumps to the RHR heat exchanger discharge for high pressure recirculation. Addition of new logic to control the RWST and charging pump suction valves could be performed to address this SAMA.

Table F.5.8-1 summarizes changes made to the VCSNS PSA model to simulate full automatic swap over to re-circulation mode. The changes are characterized by reducing the operator actions for aligning re-circulation to very low values. OAR1 and OAR2 are changed to 1E-6 to represent auto closure of the RHR system's RWST suction valves (considered to represent recirculation alignment). OAR4 and OAR5 are also set to 1E-6 to represent auto alignment of charging pump suction to the RHR heat exchanger discharge for high pressure recirculation mode. OARC is assigned a failure probability of 1E-6. This event was used to account for the dependence between failing to align the initially running CCW train to the RHR heat exchangers given failure of the initially standby CCW train and the alignment of cold log recirculation mode. As the recirculation alignment function is automated by this SAMA, no dependence exists between the two events and the low failure probability is judged to be appropriate for this event. This SAMA assumes that CCW is auto-aligned given failure of the standby train or that all trains are aligned and started on swap. While this may overestimate the capability of the hardware responsible for performing the automatic swap, the change will conservatively show increased benefit for the SAMA. A sensitivity case (24a) has been performed assuming that OARC always fails. Due to model limitations, this implies that failure to manually align CCW to RHR fails recirc mode even if there was no failure of the original RHR cooling function. This greatly overestimates the impact of the manual action to align CCW to RHR on failure of the preferred train.

TABLE F.5.8-1
PHASE 2 SAMA NUMBERS 24 AND 24A MODEL CHANGES

System: Basic Events	Original Value	Revised Value
OAR1: OPERATOR FAILS TO ALIGN FOR LOW PRESSURE CL RECIRC (RHR PUMP RUNNING)	1.5E-3	1E-6
OAR2: OPERATOR FAILS TO ALIGN FOR LOW PRESSURE CL RECIRC (RHR PUMPS STOPPED)	3.7E-4	1E-6
OAR4: OPERATOR FAILS TO ALIGN HIGH PRESSURE CL RECIRC (RHR PUMP STOPPED)	3.2E-2	1E-6
OAR5: OPERATOR FAILS TO ALIGN HP CL RECIRC (RHR PUMPS STOPPED, ISLOCA)	4.7E-2	1E-6
OARC: OPERATOR FAILS TO ALIGN & ESTABLISH CL RECIRC (CONDITIONAL) (BASE CASE)	1.5E-1	1E-6
OARC: OPERATOR FAILS TO ALIGN & ESTABLISH CL RECIRC (CONDITIONAL) (SENSITIVITY CASE 23a)	1.5E-1	1.0

PSA Model Results (Phase 2 SAMA Number 24)

The results from this case indicate about a 31 percent reduction in CDF (CDF_{new}=3.84E-5/yr) and a 29 percent reduction in LERF ($LERF_{new}$=4.96E-7/yr). The results of the cost-benefit analysis are shown in Table F.5.8-2.

TABLE F.5.8-2
PHASE 2 SAMA NUMBER 24 NET VALUE

Base Case: Cost-Risk for VCSNS	Cost-Risk for VCSNS	Averted Cost-Risk	Cost of Implementation	Net Value
$1,203,380	$825,552	$377,828	$1,225,000	-$847,172

PSA Model Results (Phase 2 SAMA Number 24a)

The results from this case indicate about a 9 percent reduction in CDF (CDF_{new}=5.10E-5/yr) and a 16 percent reduction in LERF ($LERF_{new}$=5.88E-7/yr). The results of the cost-benefit analysis are shown in Table F.5.8-3.

TABLE F.5.8-3
PHASE 2 SAMA NUMBER 24a NET VALUE

Base Case: Cost-Risk for VCSNS	Cost-Risk for VCSNS	Averted Cost-Risk	Cost of Implementation	Net Value
$1,203,380	$1,085,622	$117,758	$1,225,000	-$1,107,242

The negative net values for both SAMA 24 and 24a indicate that the proposed change would not be cost beneficial.

F.5.9 Phase 2 SAMA Number 25: Improved Low Pressure System (Firepump)

Description: Use of the Fire Service System pumps for low pressure injection in a PWR requires use of the RWST and sump as potential suction sources. Creation of an entirely new piping path is judged to be too costly for consideration; this SAMA assumes that the current RHR piping is used as the injection path for the fire pumps. The additional valves in the fire pump's path from the RWST to the RHR system are lumped into a single event (BEID = FIREPUMP, failure probability = 1E-2) representing the hardware and operator actions associated with alignment of the fire pump for injection.

Due to known limitations in the VCSNS Fire Service System's capacity, a new diesel driven pump is assumed to be required to support this modification. The cost of implementation for this SAMA is considered to be similar in scope to enhancing the fire protection system to provide flow to the containment spray system. The cost for this SAMA was estimated at $565,000 (Reference 24) and is considered to be a comparable estimate for using the fire pump as a low pressure injection source. Table F.5.9-1 summarizes the changes made to the VCSNS PSA model to simulate modification of the Fire Service System to support low pressure injection.

TABLE F.5.9-1
PHASE 2 SAMA NUMBER 24 MODEL CHANGES

Gate or Event ID and Description:	Description of Change:
RHR-LPI-011: INSUFFICIENT FLOW THROUGH RHR PUMP A AND FIREPUMP	Changed RHR-LPI-011 to an "AND" gate. Added: New BE FIREPUMP New "OR" gate RHR-LPI-011-A Deleted: Gate GAPMXPP0031APS Gate RHR-PUMP-POWER-A Gate RHR-PMP-ACT-A Gate HAPMXPP0031ATM Gate CCWHDRA
RHR-LPI-011-A:	Added: Gate GAPMXPP0031APS Gate RHR-PUMP-POWER-A Gate RHR-PMP-ACT-A Gate HAPMXPP0031ATM Gate CCWHDRA
Similar changes made to gates: RHR-LPI-011-SBO RHR-LPR-038 RHR-LPR-038-SBO RHR-PUMP-A-REC RHR-PUMP-A-RECSB RHR-LPI-054 RHR-LPI-054-SBO RHR-LPR-006 RHR-LPR-006-SBO RHR-PUMP-B-REC RHR-PUMP-B-RECSB	

PSA Model Results (Phase 2 SAMA Number 25)

The results from this case indicate about a 9.3 percent reduction in CDF (CDF_{new}=5.08E-5/yr) and a 13.5 percent reduction in LERF ($LERF_{new}$=6.06E-7/yr). The results of the cost-benefit analysis are shown in Table F.5.9-2.

TABLE F.5.9-2
PHASE 2 SAMA NUMBER 25 NET VALUE

Base Case: Cost-Risk for VCSNS	Cost-Risk for VCSNS	Averted Cost-Risk	Cost of Implementation	Net Value
$1,203,380	$1,085,870	$117,510	$565,000	-$447,490

The negative net value for this SAMA indicates that it would not be cost beneficial for VCSNS.

F.5.10 Phase 2 SAMA Number 26: Replace Old Air Compressors with More Reliable Ones

Description: The purpose of this SAMA is to increase the reliability of the Instrument Air system by replacing the old air compressors with new compressors. This would affect the initiating event frequency for Loss of Instrument Air and the failure to start and run probabilities of the air compressors. For the purposes of this analysis, the new compressors are assumed to improve reliability by a factor of 10.

Table F.5.10-1 summarizes the changes made to the VCSNS PSA model to simulate the implementation of this SAMA.

TABLE F.5.10-1
PHASE 2 SAMA NUMBER 26 MODEL CHANGES

System: Basic Events	Original Value	Revised Value
%LIA1: LOSS INSTRUMENT AIR INITIATING EVENT (DOES NOT INCLUDE DSL SULLAIR)	1/yr	1E-1/yr
XACM---XAC3AFR: COMPRESSOR XAC-3A FAILS TO RUN	4.8E-3	4.8E-4
XACMI1-XAC3AFR: COMPRESSOR XAC-3A FAILS TO RUN	8.76E-1	8.76E-2
XACMI2-XAC3AFR: COMPRESSOR XAC-3A FAILS TO RUN	8.76E-1	8.76E-2
XBCM---XAC3BFR: COMPRESSOR XAC-3B FAILS TO RUN	4.8E-3	4.8E-3
XBCM---XAC3BFS: COMPRESSOR XAC-3B FAILS TO START	8E-2	8E-3
XCCM---XAC12FR: COMPRESSOR XAC-12 FAILS TO RUN	4.8E-3	4.8E-4
XCCM---XAC12FS: COMPRESSOR XAC-12 FAILS TO START	8E-2	8E-3
XDCM--DIESELFS: DIESEL COMPRESSOR FAILS TO START	5.7E-3	5.7E-4
XDCM--DIESELFR: DIESEL COMPRESSOR FAILS TO RUN	9.1E-4	9.1E-5

PSA Model Results (Phase 2 SAMA Number 26)

The results from this case indicate about a 1.1 percent reduction in CDF (CDF_{new}=5.54E-5/yr) and a 0.8 percent reduction in LERF ($LERF_{new}$=6.94E-7/yr). The results of the cost-benefit analysis are shown in Table F.5.10-2.

TABLE F.5.10-2
PHASE 2 SAMA NUMBER 26 NET VALUE

Base Case: Cost-Risk for VCSNS	Cost-Risk for VCSNS	Averted Cost-Risk	Cost of Implementation	Net Value
$1,203,380	$1,189,832	$13,147	Not estimated	Large negative

The averted cost-risk is relatively small for this SAMA with respect to the resources required for a significant plant hardware modification. No detailed cost of implementation was derived because the cost of the hardware changes would clearly be larger than the averted cost-risk.

F.5.11 Phase 2 SAMA Number 27: Install MG Set Trip Breakers in Control Room

Description: The purpose of this SAMA is to increase the reliability of manual RCP trip in an Anticipated Transient Without SCRAM (ATWS). In the event that ATWS Mitigating System Activation Circuitry (AMSAC) logic fails to produce an RCP trip during an ATWS, the MG set breakers can be manually tripped from outside the control room. In the event of an ATWS, the time available to perform this action is typically judged to be too short to perform this ex-control room action. If the control room was equipped with the hardware to perform this action locally, it would increase the likelihood that this action could successfully be performed.

Because the ATWS contribution to the VCSNS CDF and LERF is small, this evaluation assumes that the modifications proposed by this SAMA would eliminate all ATWS risk as a bounding estimate.

Due to the nature of the PSA model, the cost-benefit analysis is performed by quantifying the ATWS sequences and then subtracting those results from the base case to represent plant operation with no ATWS contribution. This result is then used to calculate the averted cost-risk.

The ATWS contributions to CDF and LERF are 9.33E-7/yr (1.6 percent) and 6.57E-9/yr (0.94 percent), respectively. Removing the ATWS contribution from the base case yields a CDF of 5.51E-5/yr and a LERF of 6.93E-7/yr.

Table F.5.11-1 summarizes cost benefit results for this SAMA.

TABLE F.5.11-1
PHASE 2 SAMA NUMBER 27 NET VALUE

Base Case: Cost-Risk for VCSNS	Cost-Risk for VCSNS	Averted Cost-Risk	Cost of Implementation	Net Value
$1,203,380	$1,184,824	$18,556	Not estimated	Large negative

The averted cost-risk is relatively small for this SAMA with respect to the resources required for a significant plant hardware modification. No detailed cost of implementation was derived, as the cost of the hardware changes would clearly be larger than the averted cost-risk.

F.6 Phase 2 SAMA Analysis Summary

The SAMA candidates that could not be eliminated from consideration by the baseline screening process or other PSA insights required the performance of a detailed analysis of the averted cost-risk and SAMA implementation costs. SAMA candidates are only judged to be justified modifications if the averted cost-risk resulting from the modification is greater than the cost of implementing the SAMA. Table F.6-1 summarizes the results of the detailed analyses that were performed for the SAMA candidates requiring a detailed assessment. Two of the SAMAs analyzed were found to be cost-beneficial as defined by the methodology used in this study. However, this evaluation should not necessarily be considered a definitive guide in determining the disposition of a plant modification that has been analyzed using other engineering methods. These results are intended to provide information about the relative estimated risk benefit associated with a plant change or modification compared with its cost of implementation, and should be used as an aid in the decision-making process.

TABLE F.6-1
SUMMARY OF THE DETAILED SAMA ANALYSES

Phase 2 SAMA ID	Averted Cost-Risk	Cost of Implementation	Net Value	Cost Beneficial?
2	$1,249	Not Estimated	Large Negative	No
3	$103,093	$150,000 to $170,000	-$46,907 to -$71,907	No
9	$23,818	Not Estimated	Large Negative	No
10	$20,630	$25,000 to $50,000	-$4,370 to -$29,370	No
11/12	$39,725	Not Estimated	Large Negative	No
13	$5,788	Not Estimated	Large Negative	No
20	$17,766	Not Estimated	Large Negative	No
24	$377,828	$1,225,000	-$847,172	No
24a	$117,758	$1,225,000	-$1,107,242	No
25	$117,510	$565,000	-$447,490	No
26	$13,147	Not Estimated	Large Negative	No
27	$18,556	Not Estimated	Large Negative	No

F.7 Sensitivities

As part of the SAMA analysis, several variables were examined to help define the influence they have on the results of the cost-benefit evaluation. These variables include the use of LERF as the sole contributor to source terms, the value chosen as the real discount rate, and other potentially influential parameters. These cases are summarized below.

F.7.1 Large Early Release Frequency

This uncertainty analysis involves an investigation into the accident sequences selected for the SAMA evaluation. LERF is used as one of the measures to estimate the cost benefit of implementing potential plant modifications. The VCSNS SAMA evaluation has focused only on the accident sequences that contribute to the LERF. The current VCSNS PRA is limited to an evaluation of the LERF probability and does not provide details on the non-LERF sequences. For VCSNS, the LERF represents approximately 1.2 percent of the total CDF. The remaining sequences involve accidents that do not contribute to LERF and would be made up of a significant fraction of sequences that do not result in containment failure. For example, based on the VCSNS IPE (Reference 16), about 19 percent of the non-LERF cases involve a potential late release of radionuclides due to containment failure. One major difference between these sequences and the LERF events is that natural removal of airborne fission products could occur over the period from vessel breach to containment failure. In fact, it has been calculated that for many PWR containments, late containment failure could occur on the order of 48 hours after accident initiation. This extended time would provide for removal and decay of radionuclides prior to release from containment.

To provide an assessment of the non-LERF events, two sensitivity cases were developed. Case 1 assumes that the non-LERF releases are represented by the containment isolation failure source term from the LERF evaluation with a release time at 48 hours (late) and a frequency of CDF-LERF (5.59E-5/yr - 6.99E-7/yr = 4.42E-5/yr). This is considered to be a bounding estimate because it takes no credit for natural removal mechanisms in containment. Case 2 assumes the non-LERF source term is represented by the VCSNS IPE's non-LERF release source term (long term loss of containment heat removal). This release occurs at approximately 48 hours with a frequency of about 20 percent of the CDF (1.12E-5/yr). This is considered to be a "more realistic" case.

Assuming that all of the non-LERF cases resulted in a Large Release at 48 hours greatly overestimates the impact on the SAMA evaluation. The maximum averted cost-risk was recalculated including the non-LERF accidents and found to increase by less than 10 percent. The resulting total averted cost-risk was $1.31 million. This is a modest increase and would not be expected to substantially impact the screening process. In addition, the conclusions reached in the SAMA analysis would not be changed due to this uncertainty.

The second case, which is judged to better represent actual conditions, has an even smaller impact. This source term is based on long-term loss of containment heat removal and subsequent containment failure. The source term implemented in this sensitivity was chosen because it was the only case identified in the VCSNS IPE that resulted in a release that was not categorized as a LERF. The other non-LERF accidents did not result in a significant release of radionuclides to the environment. If this release is combined with the LERF releases, the maximum averted cost-risk increases by only 0.1 percent ($1,204,226). This is a negligible increase and would clearly not impact the results of the SAMA analysis.

For VCSNS, the LERF model provides results that are not substantially different from those that might be derived from a full Level 2 PRA. This is primarily due to the sparse population and limited land development around the VCSNS site. The dominant contributors to the plant's cost-risk are driven by the CDF and are not influenced by the Level 2 or Level 3 results.

F.7.2 Real Discount Rate and Other Parameters

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 7 percent has been changed to 3 percent and the maximum averted cost-risk was re-calculated using the methodology outlined in Section F.3. The Phase 1 screening against the maximum averted cost-risk was re-examined using the revised base case to identify any SAMA candidates that could no longer be screened based on the premise that their costs of implementation exceeded all possible benefit. In addition, the Phase 2 analysis was re-performed using the 3 percent real discount rate.

Implementation of the 3 percent RDR increased the maximum averted cost-risk by 13 percent compared with the case where a 7 percent RDR was used. This relates to a maximum averted cost-risk increase from $1.20M to $1.36M. The results of the Phase 1 screening process were not affected by this small change in maximum averted cost-risk. The costs of implementation for the SAMAs screened in Phase 1 were all greater than $1.36 million.

The Phase 2 SAMAs are dispositioned based on PSA insights or detailed analysis. All of the PSA insights used to screen the SAMAs are still applicable given the use of the 3 percent real discount rate. 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 3 percent real discount rate to calculate the net values for the SAMAs.

As shown in Table F.7.2-1, the determination of cost-effectiveness did not change for any of the Phase 2 SAMAs when the 3 percent real discount rate was used in lieu of 7 percent.

TABLE F.7.2-1
SUMMARY OF REAL DISCOUNT RATE IMPACT

Phase 2 SAMA ID	Cost of Site Implementation	Averted Cost Risk (7 percent RDR)	Net Value (using 7 percent RDR)	Averted Cost Risk (3 percent RDR)	Net Value (using 3 percent RDR)	Change in Cost Effectiveness?
Base	N/A	$1,203,380	N/A	$1,359,468	N/A	N/A
2	Not Estimated	$1249	Large Negative	$1400	Large Negative	No
3	$150,000 to $170,000	$103,093	-$46,907 to -$71,907	$115,300	-$34,700 to -$54,700	No
9	Not Estimated	$23,818	Large Negative	$26,841	Large Negative	No
10	$25,000 to $50,000	$20,630	-$4,370 to -$29,370	$23,076	-$1924 to -$26,924	No
11/12	Not Estimated	$39,725	Large Negative	$54,187	Large Negative	No
13	Not Estimated	$5788	Large Negative	$6478	Large Negative	No
20	Not Estimated	$17,766	Large Negative	$19,879	Large Negative	No
24	$1,225,000	$377,828	-$847,172	$426,735	-$798,265	No
24a	$1,225,000	$117,758	-$1,107,242	$135,793	-$1,089,207	No
25	$565,000	$117,510	-$447,490	$134,295	-$430,705	No
26	Not Estimated	$13,147	Large Negative	$14,730	Large Negative	No
27	Not Estimated	$18,556	Large Negative	$20,752	Large Negative	No

While the potential exists for the choice of the RDR to change the net value of borderline cases from positive to negative or from negative to positive, the impact of these types of changes on the decision making process should be small. Borderline cases require other engineering analyses as the primary decision-making tools. In conclusion, the choice of the RDR has a negligible impact on the VCSNS SAMA analysis.

There are other variables in the SAMA analysis that could realistically assume a range of values. These variables include items such as evacuation timing assumptions, population and meteorology data, property values, costs of implementation, and the effectiveness of proposed SAMA modifications. These factors either have a small impact on the results or are accounted for in the method of the analysis.

For example, while the effectiveness of evacuating the relevant population during an accident is difficult to assess, there is little variance in the results based on the values assigned to the evacuation parameters. This is also true for reasonable assumptions related to the meteorology, population data, and economic worth of the surrounding area. This sensitivity was identified as part of the evaluation performed in Section F.7.1. The Level 1 results are the dominant influence in the cost-benefit analysis for VCSNS.

The estimated costs of implementation are typically below the actual costs of implementation due to additional analysis and labor that were not considered in the conceptual stages of planning. Lower costs of implementation reduce the likelihood that SAMA candidates will be screened because they are "not cost beneficial." Thus, in the SAMA analysis, low estimates for cost of implementation are conservative as they retain SAMAs for more detailed analysis when those candidates could be screened given a more realistic estimate for the cost of implementation. The impact of the values derived for the costs of implementation is judged to be low.

Another variable is the assumed effectiveness of the SAMA enhancement. The method chosen for representing SAMA enhancements in the PSA model is to overestimate the impact of the change. For instance, if a SAMA is being considered that would improve the Containment Heat Removal capability of the plant, the enhancement is modeled as 100 percent effective such that all loss of CHR sequences are mitigated. This results in a greater cost benefit for the SAMA and a greater likelihood that the candidate will be retained. In cases where the results of this coarse method of evaluation do not provide a clear indication of the SAMA's worth, more realistic estimates are taken from similar systems already modeled in the VCSNS PSA or from other industry PSAs.

While variations in these types of parameters will produce small changes in the SAMA analysis, they do not influence the conclusions of the analysis.

F.8 Conclusions

The benefits of revising the operational strategies in place at VCSNS and/or implementing hardware modifications can be evaluated without insight from a risk-based analysis. The SAMA analysis has, however, provided an enhanced understanding of the effects of the proposed changes relative to the cost of implementation and projected impact on a much larger future population. The results of the SAMA analysis indicate that none of the potential plant improvements identified are cost beneficial based on the methodology defined in this document. No SAMAs are suggested for implementation on a cost-benefit basis.

F.9 References

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