5.0 Environmental Impacts of Postulated Accidents

Environmental issues associated with postulated accidents are discussed in the *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (GEIS), NUREG-1437, Volumes 1 and 2 (NRC 1996; 1999a).[a] The GEIS includes a determination of whether the analysis of the environmental issue could be applied to all plants and whether additional mitigation measures would be warranted. Issues are then assigned a Category 1 or a Category 2 designation. As set forth in the GEIS, Category 1 issues are those that meet all of the following criteria:

(1) The environmental impacts associated with the issue have been determined to apply either to all plants or, for some issues, to plants having a specific type of cooling system or other specified plant or site characteristic.

(2) Single significance level (i.e., SMALL, MODERATE, or LARGE) has been assigned to the impacts (except for collective off site radiological impacts from the fuel cycle and from high level waste and spent fuel disposal).

(3) Mitigation of adverse impacts associated with the issue has been considered in the analysis, and it has been determined that additional plant-specific mitigation measures are likely not to be sufficiently beneficial to warrant implementation.

For issues that meet the three Category 1 criteria, no additional plant-specific analysis is required unless new and significant information is identified.

Category 2 issues are those that do not meet one or more of the criteria for Category 1, and therefore, additional plant-specific review of these issues is required.

This chapter describes the environmental impacts from postulated accidents that might occur during the license renewal term.

5.1 Postulated Plant Accidents

Two classes of accidents are evaluated in the GEIS. These are design-basis accidents (DBAs) and severe accidents, as discussed below.

(a) The GEIS was originally issued in 1996. Addendum 1 to the GEIS was issued in 1999. Hereafter, all references to the "GEIS" include the GEIS and Addendum 1.

5.1.1 Design-Basis Accidents

In order to receive NRC approval to operate a nuclear power facility, an applicant must submit a safety analysis report (SAR) as part of its application. The SAR presents the design criteria and design information for the proposed reactor and comprehensive data on the proposed site. The SAR also discusses various hypothetical accident situations and the safety features that are provided to prevent and mitigate accidents. The NRC staff reviews the application to determine whether the plant design meets the Commission's regulations and requirements and includes, in part, the nuclear plant design and its anticipated response to an accident.

DBAs are those accidents that both the licensee and the NRC staff evaluate to ensure that the plant can withstand normal and abnormal transients, and a broad spectrum of postulated accidents without undue hazard to the health and safety of the public. A number of these postulated accidents are not expected to occur during the life of the plant, but are evaluated to establish the design basis for the preventive and mitigative safety systems of the facility. The acceptance criteria for DBAs are described in 10 CFR Part 50 and 10 CFR Part 100.

The environmental impacts of DBAs are evaluated during the initial licensing process, and the ability of the plant to withstand these accidents is demonstrated to be acceptable before issuance of the operating license (OL). The results of these evaluations are found in license documentation such as the staff's Safety Evaluation Report (SER), the Final Environmental Statement (FES), the licensee's Updated Final Safety Analysis Report (UFSAR), and Section 5.1 of this supplemental environmental impact statement (SEIS). The licensee is required to maintain the acceptable design and performance criteria throughout the life of the plant including any extended-life operation. The consequences for these events are evaluated for the hypothetical maximum exposed individual; as such, changes in the plant environment will not affect these evaluations. Because of the requirements that continuous acceptability of the consequences and aging management programs be in effect for license renewal, the environmental impacts as calculated for DBAs should not differ significantly from initial licensing assessments over the life of the plant, including the license renewal period. Accordingly, the design of the plant relative to DBAs during the extended period is considered to remain acceptable and the environmental impacts of those accidents were not examined further in the GEIS.

The Commission has determined that the environmental impacts of DBAs are of SMALL significance for all plants because the plants were designed to successfully withstand these accidents. Therefore, for the purposes of license renewal, design-basis events are designated as a Category 1 issue in 10 CFR Part 51, Subpart A, Appendix B, Table B-1. The early resolution of the DBAs make them a part of the current licensing basis of the plant; the current licensing basis of the plant is to be maintained by the licensee under its current license and, therefore, under the provisions of 10 CFR 54.30, is not subject to review under license renewal. This issue, applicable to Peach Bottom Units 2 and 3, is listed in Table 5-1.

Table 5-1. Category 1 Issue Applicable to Postulated Accidents During the Renewal Term

ISSUE—10 CFR Part 51, Subpart A, Appendix B, Table B-1	GEIS Section
POSTULATED ACCIDENTS	
Design-basis accidents	5.3.2; 5.5.1

Exelon Generation Company, LLC (Exelon) stated in its Environmental Report (ER; Exelon 2001) that it is not aware of any new and significant information associated with the renewal of the Peach Bottom Units 2 and 3 OLs. The staff has not identified any significant new information during its independent review of the Exelon ER, the staff's site visit, the scoping process, or its evaluation of other available information. Therefore, the staff concludes that there are no impacts related to this issue beyond those discussed in the GEIS.

5.1.2 Severe Accidents

Severe nuclear accidents are more severe than DBAs because they could result in substantial damage to the reactor core, whether or not there are serious offsite consequences. The GEIS assessed the impacts of severe accidents during the license renewal period, using the results of existing analyses and site-specific information to conservatively predict the environmental impacts of severe accidents for each plant during the renewal period.

Based on information in the GEIS, the Commission found that

> The probability weighted consequences of atmospheric releases, fallout onto open bodies of water, releases to ground water, and societal and economic impacts from severe accidents are small for all plants. However, alternatives to mitigate severe accidents must be considered for all plants that have not considered such alternatives.

Therefore, the Commission has designated mitigation of severe accidents as a Category 2 issue in 10 CFR Part 51, Subpart A, Appendix B, Table B-1. This issue, applicable to Peach Bottom Units 2 and 3, is listed in Table 5-2.

Table 5-2. Category 2 Issue Applicable to Postulated Accidents During the Renewal Term

ISSUE—10 CFR Part 51, Subpart A, Appendix B, Table B-1	GEIS Sections	10 CFR 51.53(c)(3)(ii) Subparagraph	SEIS Section
	POSTULATED ACCIDENTS		
Severe Accidents	5.3.3; 5.3.3.2; 5.3.3.3; 5.3.3.4; 5.3.3.5; 5.4; 5.5.2	L	5.2

The staff has not identified any significant new information with regard to the consequences from severe accidents during its independent review of the Exelon ER (Exelon 2001), the staff's site visit, the scoping process, or its evaluation of other available information. Therefore, the staff concludes that there are no impacts of severe accidents beyond those discussed in the GEIS. However, in accordance with 10 CFR 51.53(c)(3)(ii)(L), the staff has reviewed severe accident mitigation alternatives (SAMAs) for Peach Bottom Units 2 and 3. The results of its review are discussed in Section 5.2.

5.2 Severe Accident Mitigation Alternatives

10 CFR 51.53(c)(3)(ii)(L) requires that license renewal applicants consider alternatives to mitigate severe accidents if the staff has not previously evaluated severe accident mitigation alternatives (SAMAs) for the applicant's plant in an environmental impact statement (EIS) or related supplement or in an environmental assessment. The purpose of this consideration is to ensure that plant changes (i.e., hardware, procedures, and training) with the potential for improving severe accident safety performance are identified and evaluated. SAMAs have not been previously considered for Peach Bottom Units 2 and 3; therefore, the following addresses those alternatives.

5.2.1 Introduction

Exelon submitted an assessment of SAMAs for Peach Bottom Units 2 and 3 as part of the ER (Exelon 2001). This assessment was based on the current Peach Bottom Probabilistic Safety Analysis (PSA), a plant-specific adaptation of the offsite consequence analysis performed as part of the NRC-sponsored probabilistic safety assessment for Peach Bottom Units 2 and 3 and documented in NUREG/CR-4551 (NRC 1990b), and insights from the Peach Bottom Individual Plant Examination of External Events (IPEEE) (PECO 1996). In identifying and evaluating potential SAMAs, Exelon considered several SAMA analyses for other plants (Limerick, Watts Bar, Comanche Peak, and Hatch) and other documents that discuss potential plant improvements, such as NUREG-1560 (NRC 1997a) and NUREG-1462 (NRC 1994a). Exelon identified and evaluated 204 potential SAMA candidates. This list was reduced to 30 unique SAMA candidates by eliminating SAMAs that were either not applicable to Peach Bottom Units 2 and 3, were related to phenomena that are not risk-significant in BWRs, or were similar to other SAMAs being considered. Other SAMAs were excluded because they had already been implemented at Peach Bottom Units 2 and 3. This list was further screened and the remaining SAMAs were evaluated in detail. The study concluded that none of the SAMAs identified would be cost-beneficial.

Based on a review of the SAMA assessment, the NRC issued a request for additional information (RAI) to Exelon by letter dated December 20, 2001 (NRC 2001). Key questions concerned differences between the updated PSA used for the SAMA analysis and earlier risk assessments for Peach Bottom Units 2 and 3, the potential impact of uncertainties and external event risk contributors on the study results, the role of the plant-specific risk study in the SAMA identification process, and the effects of the power uprate on the risk profile. Exelon submitted additional information on January 30, 2002 (Exelon 2002) in response to the RAIs. In these responses, Exelon included supplemental tables showing the impacts of uncertainties, additional sensitivity analyses, and an assessment of the impact of the power uprate on accident progression. Exelon submitted further information on April 8, 2002 (Enclosure 3 to NRC 2002) clarifying remaining issues. In these responses, Exelon provided additional information on the jockey pump SAMA and on the averted risk values determined for SAMA candidates. Exelon's responses addressed the staff's concerns and reaffirmed that none of the SAMAs would be cost-beneficial.

An assessment of SAMAs for Peach Bottom Units 2 and 3 is presented below.

5.2.2 Estimate of Risk for Peach Bottom Units 2 and 3

Exelon's estimates of offsite risk at Peach Bottom Units 2 and 3 are summarized in Section 5.2.2.1. The summary is followed by a review of Exelon's risk estimates in Section 5.2.2.2.

5.2.2.1 Exelon's Risk Estimates

The SAMA analysis is based on two distinct analyses: (1) the Level 1 and 2 probabilistic safety assessment performed by Exelon and documented as Peach Bottom PSA, Revision 1, and (2) the extension of the Level 2 PSA to a Level 3 assessment based on application of the NUREG-1150 (NRC 1990a) consequence analysis results for Peach Bottom Units 2 and 3, as reported in NUREG/CR-4551 (NRC 1990b). The Peach Bottom PSA is an update to the Peach Bottom IPE submittal (PECO 1992) and reflects plant changes since the issuance of NUREG-1150 (NRC 1990a) and NUREG/CR-4551 (NRC 1990b). The scope of the Peach Bottom PSA does not include seismic or fire PSA models. As such, the Peach Bottom PSA does not permit either the numerical assessment of the baseline risk or identification of the quantitative change in risk that could be attributed to any proposed SAMA due to seismic or fire accident initiators. As described in Section 5.2.2.2, Exelon chose to evaluate the potential effects associated with these initiators through a sensitivity study.

The total core damage frequency (CDF) for internal events is 4.5×10^{-6} per reactor-year. The breakdown of CDF is provided in Table 5-3 . As shown in this table, the current analyses show that loss of offsite power (LOOP) and transient events, including station blackout (SBO) and anticipated transient without scram (ATWS), are the dominant contributors to CDF. The contribution of loss-of-coolant accidents (LOCAs) and other internal event initiators to CDF is less than 8 percent.

Table 5-3. Peach Bottom Units 2 and 3 Core Damage Frequency (Revision 1 of PSA)

Initiating Event	Frequency (per reactor-year)	% Contribution to CDF
Loss of Offsite Power (LOOP)	2.1×10^{-6}	46
Transients	1.2×10^{-6}	28
Station Blackout (SBO)	4.7×10^{-7}	10
Anticipated Transient Without Scram (ATWS)	4.3×10^{-7}	10
Loss-of-Coolant Accident (LOCA)	1.9×10^{-7}	4
Internal floods	6.0×10^{-8}	1
Others	4.8×10^{-8}	1
Total CDF (from internal events)	4.5×10^{-6}	100

The total Peach Bottom Unit 2 Level 1 CDF used in the SAMA submittal is 4.5×10^{-6} per reactor-year. The frequency associated with the plant damage states (PDSs) with significant offsite releases is 2.4×10^{-6} per reactor-year. The difference between the Level 1 CDF and the Level 2 endstate frequency represents those core damage sequences that lead to negligible or no release from the primary containment.

The total CDF for Peach Bottom Unit 3 is 4.2×10^{-6} per reactor-year, which is about 8 percent lower than that of Unit 2. This difference is attributed mostly to LOOP sequences involving the loss of 2 or 3 shared diesel generators. Asymmetry in emergency electric power distribution between the units and the diesel loading capability (one RHR pump per diesel generator) concurrent with the common LOOP initiator result in different diesel failure combinations having different CDF impacts at each unit.

The Peach Bottom PSA is limited to Level 1 and 2 and does not include an assessment of off-site consequences. Exelon extended the Level 2 PSA to a Level 3 assessment based on use of the NUREG/CR-4551 consequence analyses, and then scaled these results to account for increased population in the vicinity of Peach Bottom Units 2 and 3 at end of the license renewal period, as described below.

Each sequence in the Peach Bottom Level 2 PSA was reviewed and binned into one of 10 collapsed accident progression bins (APBs) used in NUREG/CR-4551. NUREG/CR-4551 provides the fractional contribution of the ten collapsed APBs and sufficient information to determine the frequency associated with each of the ten collapsed APBs. Exelon determined the population dose by multiplying the ratio of the CDF in the Peach Bottom PSA to the CDF in the NUREG/CR-4551 study by the product of the fractional contribution of the collapsed APBs and the total risk estimate from NUREG/CR-4551. Specifically, for a given collapsed APB the submittal defines the population dose risk as:

$$PDR_{PBAPS-PSA} = \frac{Frequency_{PBAPS\text{-}PSA}}{Frequency_{NUREG/CR-4551}} \bullet f_{APB} \bullet PDR_{NUREG/CR-4551}$$

where

$PDR_{PBAPS\text{-}PSA}$ = population dose risk at 50 miles for Peach Bottom (person-rem per reactor-year)

$Frequency_{PBAPS\text{-}PSA}$ = frequency of each collapsed APB in Peach Bottom PSA (per reactor-year)

$Frequency_{NUREG/CR\text{-}4551}$ = frequency of each collapsed APB in NUREG/CR-4551 (per reactor-year)

f_{APB} = fractional contribution of the collapsed APB to the population dose risk in NUREG/CR-4551

$PDR_{NUREG/CR\text{-}4551}$ = population dose risk at 50 miles for NUREG/CR-4551 (person-rem per reactor-year).

The resulting population dose estimates were summed over all bins to arrive at a total population dose.

The NUREG/CR-4551 consequence analyses were based on Version 1.5 of the MACCS computer code and site-specific data available at the time of the study (e.g., meteorology, demographics, and offsite property values). For purposes of the SAMA analysis, the population dose estimates were adjusted to account for the increase in population at the end of the proposed license extension. The population distribution used as input to the NUREG/CR-4551 MACCS analyses is based on the 1980 sector population data for the Peach Bottom site. Using 1990 and 1980 Census data, a growth ratio was developed and used to extrapolate the population out to 2034 to approximate the population at the end of the license renewal period. The ratio of the population density was calculated as:

$$P_{2034/1980} = \frac{\left(\frac{PD_{50(1990)} - PD_{50(1980)}}{1990 - 1980} \bullet 44 \text{ years} + PD_{50(1990)} \right)}{PD_{50(1990)}} \approx 4$$

where

$P_{2034/1980}$ = ratio of the population density for the area within 50 miles of the plant in 2034 to the population density for the area within 50 miles of the plant in 1980

$PD_{50(1980)}$ = population density for the area within 50 miles of the plant in 1980

$PD_{50(1990)}$ = population density for the area within 50 miles of the plant in 1990

Based on this analysis, Exelon estimates the dose to the population within 80 km (50 mi) of the Peach Bottom site to be 0.147 person-Sv (14.7 person-rem) per reactor-year. The contribution to total population dose from the various containment release modes is shown in Table 5-4. Early containment failure dominates the population dose risk at Peach Bottom Units 2 and 3.

Table 5-4. Breakdown of Population Dose by Containment Release Mode

Containment Release Mode	Population Dose [person-Sv (person-rem) per reactor-year]	
Late containment failure	0.006	0.6
Early containment failure	0.133	13.3
Vessel breach, no containment failure	0.002	0.2
No vessel breach, no containment failure	0.006	0.6
Total	0.147	14.7

5.2.2.2 Review of Exelon's Risk Estimates

Exelon's estimate of offsite risk at the Peach Bottom site is based on Revision 1 of the Peach Bottom PSA and the application of the NUREG-1150 Level 3 PSA results as reported in NUREG/CR-4551 (NRC 1990b) to the results of plant-specific Peach Bottom Level 2 PSA. This review considered the following major elements of the analysis:

- the Level 1 and 2 risk models that form the bases for the 1992 IPE and 1996 IPEEE submittals (PECO 1992, 1996)
- the major modifications to the IPE model that have been incorporated in the Peach Bottom PSA
- the extension of the Level 2 PSA to a Level 3 assessment based on use of the NUREG/CR-4551 consequence analyses and subsequent scaling of these results to account for increased population in the vicinity of the Peach Bottom site at the end of the period of extended operation
- the contribution to risk due to internal and external initiating events, as reflected in the NRC-sponsored PSA for Peach Bottom Units 2 and 3 conducted as part of the NUREG-1150 studies.

Each of these analyses was reviewed to determine the acceptability of Exelon's risk estimates for the SAMA analysis, as summarized below.

The staff's review of the Peach Bottom IPE is described in an NRC safety evaluation dated October 25, 1995 (NRC 1995). The review was based on a comparison between the results reported in the IPE submittal and the results of the staff study documented in NUREG-1150 and NUREG/CR-4551. Based on this review, the staff concluded that Exelon's analysis met the intent of Generic Letter 88-20 (NRC 1988); that is, the IPE was of adequate quality to be used to look for design or operational vulnerabilities. Overall, the staff believed that the Peach Bottom IPE was of adequate quality to be used as a tool in searching for areas with high potential for risk reduction and to assess such risk reductions.

A comparison of risk profiles between the original IPE (which was reviewed by the NRC staff) and the current PSA used in the SAMA analysis indicates a 20 percent reduction in the total Peach Bottom Unit 2 CDF. The PSA was updated twice (in 1997 and again in 1999) since the original IPE was submitted to the NRC to reflect model enhancements and plant changes, such as a 5 percent power uprate approved in 1994. The specific changes since the Peach Bottom IPE include (Exelon 2002):

- improved plant operating experience was reflected in the overall frequency of initiating events

- initiating events that were previously subsumed within other initiators (e.g., loss of instrument air and service water) were modeled as separate initiating events
- more detailed modeling of operator actions directed by procedures during LOOP events was incorporated, including credit for the Conowingo tie-line
- common cause failure terms for high pressure coolant injection (HPCI)/reactor core isolation cooling (RCIC), direct current (dc) battery pairs, and other miscellaneous systems were added
- treatment of common cause failures was reevaluated using the new Idaho National Engineering and Environmental Laboratory (INEEL) database (INEEL 1998)
- implementation of improved technical specifications was reflected in the model.

The incorporation of lower initiating event frequencies, additional LOOP recovery capabilities such as the Conowingo tie-line, and the INEEL common cause database have resulted in a reduction in total internal events CDF from that reported in the IPE. On the other hand, modeling of additional initiating events, detailed operator actions for LOOP, and common cause terms for HPCI/RCIC and dc batteries have resulted in increasing the total internal events CDF. Collectively, the incorporation of all the changes have resulted in a 20 percent reduction in the total CDF, as compared with the original IPE CDF estimate of about 5.5×10^{-6} per reactor-year. This is a relatively small change. The revised CDF estimate for Peach Bottom Units 2 and 3 is still comparable to values estimated for other BWR/3 and BWR/4 model plants, which Figure 11.2 of NUREG-1560 (NRC 1997a) shows to range from 9×10^{-6} to 8×10^{-5} per reactor-year, with a point estimate value of 2×10^{-5} per reactor-year.

The staff noted that the Peach Bottom PSA has been subjected to peer review at various stages, by internal and external reviewers, including a 1998 review of Revision 1 using the BWR Owners Group (BWROG) PSA Peer Review Certification Implementation Guidelines (Exelon 2002).

Exelon submitted an IPEEE by letter dated May 29, 1996 (PECO 1996), in response to Supplement 4 of Generic Letter 88-20 (NRC 1991). Exelon did not identify fundamental weaknesses or vulnerabilities to severe accident risk in regard to the external events related to seismic, fire, or other external events. However, a number of areas were identified for improvement in both the seismic and fire areas. In a letter dated November 22, 1999, the staff concluded that the submittal met the intent of Supplement 4 to Generic Letter 88-20 (NRC 1999b).

In a response to an RAI, Exelon acknowledged (Exelon 2002) that the risk assessment methods used for the Peach Bottom IPEEE do not provide the means to determine the numerical estimates of the CDF contributions from seismic and fire initiators. However, the licensee states that the current risk associated with external events at Peach Bottom Units 2 and 3 is much lower than that which existed at the time of the publication of NUREG/CR-4551 because of many plant improvements that have been made since that time, mostly as a result of the insights gained from the Peach Bottom IPEEE. These improvements include:

- Increased fire brigade awareness of important fire areas
- Incorporated automatic sprinklers in 4 kV switchgear areas
- Incorporated sprinklers in the 13 kV area and added sprinkler heads on the 116 ft elevation between the 13 kV area and the remainder of the turbine building (i.e., creating a water curtain at the openings)
- Replaced or upgraded Thermo-lag fire barriers in several fire areas
- Replaced or upgraded miscellaneous equipment for resolution of Generic Safety Issue A-46, “Seismic Qualification of Equipment in Operating Plants.”

In addition, Exelon notes that the quantitative contributions from external events, as estimated in NUREG/CR-4551 for Peach Bottom Units 2 and 3, would be bounded by the 95th percentile CDF estimate for internal events (see Table 5-6). An associated sensitivity study by Exelon shows that use of the 95th percentile CDF in the cost-benefit evaluation in lieu of the point estimate value impacts the screening for only two SAMAs. However, a further evaluation of these two SAMAs indicates that they would not be cost-beneficial (Exelon 2002). This is discussed further in Section 5.2.6.2.

The failure to consider the quantitative impact of external events by the licensee is acceptable given: (1) the IPEEE process has led to the identification and disposition of potential external events vulnerabilities; and (2) the insights from the consideration of the 95th percentile of the risk of core damage, which bound the potential impact if the quantitative risk of external events were included.

The process used by Exelon to extend the Peach Bottom PSA to an assessment of offsite consequences was reviewed. That process involved binning the sequences in the Peach Bottom Level 2 PSA into one of 10 collapsed APBs used in NUREG/CR-4551 and determining the population dose based on the APB frequency and the consequences of the APBs reported in NUREG/CR-4551. The relative distribution of the site-specific economic data utilized in NUREG/CR-4551 was assumed to remain constant. However, the overall growth in economy and agriculture were assumed to be reflected by the growth in the population. This increase was accounted for by scaling the population dose estimates by a factor of 4. Evacuation modeling remained unchanged from what was utilized in NUREG/CR-4551. The staff concludes that the process used by Exelon to extend the Level 2 PSA results to a Level 3 assessment, and to scale the results to account for subsequent population growth is technically sound and properly implemented, and therefore is acceptable. Furthermore, the staff concludes that the evacuation assumptions and analysis are reasonable and acceptable for the purposes of the SAMA evaluation.

The Exelon assessment has focused on the risk based on the uprate power of 3458 MW(t). In response to an RAI, Exelon qualitatively assessed the influence of the 5 percent power uprate on the containment response and radiological releases to be negligible (Exelon 2002). The staff concludes that the basis for the licensee's qualitative assessment of the 5 percent power uprate is reasonable, and that the methodology used by Exelon to estimate the CDF and offsite consequences for Peach Bottom Units 2 and 3 provides an acceptable basis from which to proceed with an assessment of risk reduction potential for candidate SAMAs. Accordingly, the staff based its assessment of risk on the CDF and population doses reported by Exelon.

5.2.3 Potential Plant Improvements

The process for identifying potential plant improvements, an evaluation of that process, and the improvements evaluated in detail by Exelon are discussed in this section.

5.2.3.1 Process for Identifying Potential Plant Improvements

Exelon's process for identifying potential plant improvements (SAMAs) consisted of the following elements:

- review of SAMA analyses submitted in support of original licensing and license renewal activities for other operating nuclear power plants and advanced light-water reactor plants
- review of other NRC and industry documentation
- review of plant-specific risk management insights developed as part of the accident management implementation process at Peach Bottom Units 2 and 3

Those accident management strategies that were identified in the IPE as beneficial in reducing risk in a measurable manner and applicable to Peach Bottom Units 2 and 3 have already been implemented by Exelon. These include an enhanced version of the procedure for loss of offsite power events (SE-11), and the Torus Hard Piped Vent. The review of the updated PSA in 1997 and 1999 did not reveal any significant changes in the risk profile originally assessed as part of the IPE process (Exelon 2002).

Based on this process, an initial list of 204 candidate improvements was identified, as reported in Table G.4-16 of Appendix G to the ER. Exelon performed a qualitative, Phase I screening of the initial list of SAMAs using the following criteria:

- The SAMA is not applicable to Peach Bottom Units 2 and 3 due to design differences (e.g., not applicable to the BWR/4 Mark I design).

- The SAMA is related to an interfacing system loss-of-coolant accident (ISLOCA). These types of events are not considered to be significant risk contributors for BWRs, as described in NRC Information Notice 92-36 (NRC 1992) and its supplement (NRC 1994b).

- The SAMA is related to the mitigation of recirculation pump seal failures. NUREG-1560 indicates that although reactor coolant pump (RCP) seal leakage is important to pressurized water reactors (PWRs), it does not significantly contribute to CDF in BWRs [NRC 1997a].

- The SAMA has already been implemented at Peach Bottom Units 2 and 3.

- The SAMA is related to design changes that would be implemented prior to construction (primarily those taken from the severe accident mitigation design alternative analysis for the Advanced Boiling Water Reactor).

- The SAMA was known to have an implementation cost that far exceeds any possible risk benefit.

Any SAMA candidates that were sufficiently similar to other SAMA candidates were either combined or screened from further consideration. Based on the Phase I screening, 174 SAMAs were eliminated, leaving 30 SAMAs which were considered applicable to Peach Bottom Units 2 and 3 and of potential value in reducing the risk of severe accidents.

These 30 candidate SAMAs were further evaluated and screened as part of a Phase II evaluation. Exelon quantitatively evaluated the risk-reduction potential and the implementation costs for each of the 30 SAMA candidates, as described in Sections 5.2.4 and 5.2.5, respectively. If the implementation costs were greater than the maximum benefit, then the SAMA was screened from further consideration. Using this approach, all but 12 SAMAs were eliminated because the cost was expected to exceed the maximum benefit. Of the 12 remaining candidates, 7 were screened from further analysis based on plant-specific risk insights regarding the systems that would be affected by the proposed SAMA (i.e., a more realistic evaluation of the benefit that would be obtained). These are:

- SAMA 2 - Improved ability to cool the residual heat removal (RHR) heat exchangers. This was screened out on the basis that a procedure is already in-place to cross-tie to the opposite unit High Pressure Service Water (HPSW) pumps, a cross-tie to the Fire Protection System (FPS) would not provide sufficient flow for cooling, and the cost of new hardware addition would be more than $2 million.

- SAMA 6 - Use the fire protection system as a backup source for the containment spray system. This was originally screened out on the basis that adding a backup source would not contribute to risk reduction because the Emergency Operating Procedures (EOPs), based on EPG Revision 4 guidance, would preclude using the sprays. In a response to an RAI (Exelon 2002), Exelon did clarify that new in-place procedures, based on Revision 1 of the Emergency Procedure and Severe Accident Guidelines (EP/SAG), would allow for the drywell sprays to be used to cool debris and thereby reduce probability for shell melt-through. Thus a backup source could possibly contribute to risk reduction. However, Exelon points our that the maximum benefit resulting from using the fire protection system is $284,000. This is contrasted with the cost of $0.5M/unit or $1.0M/site, which would include hardware changes to enhance the flow rate and to supply supplemental power to the RHR injection valves.

- SAMA 15 - Proceduralize intermittent operation of HPCI. This was screened out based on Exelon's judgement that intermittent operation of HPCI during SBO events would be detrimental to battery life and would not be desirable.

- SAMA 17 - Enhance procedure to instruct operators to trip unneeded RHR/containment spray (CS) pumps on loss of room ventilation. This was screened out on the basis that the risk reduction worth associated with CS, LPCI, and Normal Service Water (NSW) is minimal and therefore only a small change in the CDF would be expected due to improvements in room cooling dependency.

- SAMA 19 - Modify Reactor Water Cleanup (RWCU) for use as decay heat removal system and proceduralize use. This was screened out on the basis that the Peach Bottom RWCU system is incapable of serving as the sole decay heat removal system until many days after reactor shutdown.

- SAMA 27 - Improve Uninterruptible Power Supplies (UPS). This was screened out on the basis that the UPSs are not considered by Exelon to be risk significant, although they would increase the reliability of power supplies supporting front-line safety equipment. Because they are considered risk insignificant, the UPSs are not even modeled in the Peach Bottom PRA. Thus, no quantitative measure of averted risk, however small, could be made by Exelon.

- SAMA 30 - DC Cross-ties. This was screened out on the basis that a procedure (SE-11) has already been developed to optimize cross-tie capabilities of the 4 kV buses and various power supplies afforded by the emergency diesel generators and the dedicated power source from Conowingo Dam. Because the benefit is already obtained from the SE-11 procedure, the addition of the DC cross-ties would not be cost effective.

The five remaining SAMA candidates are listed in Table 5-5. For each of the five remaining SAMA candidates, a more detailed conceptual design was prepared along with a more detailed estimated cost, as described in Section 5.2.5.

5.2.3.2 Staff Evaluation

Exelon's efforts to identify potential SAMAs focused primarily on areas associated with internal initiating events. The initial list of SAMAs generally addressed the accident categories that are dominant CDF contributors or issues that tend to have a large impact on a number of accident sequences at Peach Bottom Units 2 and 3. The preliminary review of Exelon's SAMA identification process raised some concerns that plant-specific risk contributors were not fully considered. The staff requested additional plant-specific risk information (e.g. importance measures) to determine if any significant SAMAs might have been overlooked. Exelon's response to the RAI indicated that all important plant-specific candidate SAMAs had been considered (Exelon 2002). However, importance measures were only used on a selected basis. Exelon did not provide information indicating that they had performed a systematic and comprehensive evaluation of importance measures and their relation to potential SAMAs. Exelon indicated that, because there are only small differences between the IPE PRA and the current (Revision 1) PSA, the original and subsequent evaluations of plant-specific accident mitigation strategies is sufficient for SAMA candidate determination. While the staff's position is that a comprehensive assessment of importance measures and/or cut sets is important to determining SAMA candidates, it does recognize that Exelon used the plant-specific risk study to identify candidate SAMAs and therefore concludes that the list of SAMA candidates appears to address the major contributors to risk for both the IPE and the PSA.

The list of 204 candidate SAMAs focuses on hardware changes that tend to be expensive to implement. However, about one-third of the 204 candidate SAMAs involve something other than hardware changes. These options could provide marginally smaller risk reductions with much smaller implementation costs.

Of the 204 SAMA candidates, Exelon eliminated 26 because they were associated with reactor coolant pump seal failures or ISLOCA (both considered to be too insignificant with respect to BWR risk to pursue), 31 were eliminated because they were determined to not be applicable to Peach Bottom Units 2 and 3 (for various reasons), 39 were combined with other similar candidate SAMAs, 61 were already implemented at Peach Bottom Units 2 and 3, 10 were determined to not be cost beneficial (cost of implementation would exceed risk benefit), and 7 were judged to provide no safety benefit. This left 30 SAMA candidates for further consideration. Of the 30 remaining SAMAs that were applicable to Peach Bottom Units 2 and 3 and were of potential value in averting the risk of severe accidents, 7 were not hardware changes.

As described in Section 5.2.3.1, Exelon eliminated 18 of the remaining 30 SAMA candidates as part of the Phase II screening by comparing the estimated costs of the candidates to the maximum benefit ($2.04M/site, see Section 5.2.6 for further discussion) attained by eliminating all risk, and finding that costs for each of the eighteen were much greater than the maximum benefit. Because the actual benefit for any of the eighteen would be considerably less than this maximum, the staff concludes that these eighteen were properly eliminated.

The next step in the process was to reduce the remaining 12 SAMA candidates further. Seven were eliminated by Exelon by considering cost, enhancements and qualitative arguments for disposition. The staff considered each and concluded that the Exelon position was acceptable except for the matter of the fire protection system as a containment spray source backup (SAMA 6). In response to RAIs, Exelon addressed this matter further and also addressed a SAMA candidate not considered in its original SAMA list. These two potential SAMAs are discussed below.

The staff questioned Exelon's basis for screening out SAMA 6 (use the fire protection system [FPS] as a backup source for the containment spray system) given that the plant-specific emergency operating procedures had been modified since the original screening, potentially impacting the value of this SAMA. In response to an RAI, Exelon indicated that the SAMAs were dispositioned when procedures based on Revision 4 of the Emergency Procedure Guidelines (EPG) were in place at Peach Bottom Units 2 and 3. These guidelines severely restricted the ability to use drywell sprays, making this hardware modification ineffective. Since that time, the procedures have been revised based on Revision 1 of the Emergency Procedure and Severe Accident Guidelines (EP/SAG), which provide less restrictive guidance concerning the use of drywell sprays for accident mitigation. Revision 2 of the EP/SAG, which was issued by the Boiling Water Reactor Owners Group in 2001 but is not yet implemented at Peach Bottom Units 2 and 3, provides additional flexibility in the use of sprays.

In response to the staff's request, Exelon provided additional information regarding the benefits and costs of this SAMA. Exelon noted that the diesel fire pump could be used to supply the drywell sprays in those accident sequences for which AC power or DC power may not be available to operate RHR or HPSW. The Fussell-Vesely importance for these sequences leading to core damage is approximately 0.1. Thus, only about 10 percent of the core damage scenarios leading to possible radionuclide releases could be influenced by the use of FPS for drywell sprays. Exelon noted that FPS as a backup source for the containment spray system would require a modification to enhance the system flow rate and add supplemental power to the RHR injection values, and estimated the cost of these modifications at $0.5M/unit. The maximum benefit was estimated to be $284K based on a conservative assumption that all SBO events would be successfully mitigated using the fire protection system. On the basis of this information, Exelon concluded that this SAMA will not provide sufficient risk reduction to warrant its expense. The staff considers Exelon's dispositioning of this SAMA based on the above costs and benefits to be reasonable.

The staff's risk study of Peach Bottom Units 2 and 3 (NRC 1990b) concluded that a potentially beneficial procedural modification might be one to reduce the probability of a common-mode DC power failure. Exelon addressed this possible additional candidate in their responses to RAIs (Exelon 2002). They state that the DC system and associated common cause events have a low impact on the baseline CDF and risk (e.g., the Fussell-Vesely importance is 4.3×10^{-5}) and that therefore, justification for a modification is not supported as being cost beneficial. The staff concludes that the Exelon evaluation is reasonable.

The remaining 5 SAMA candidates are addressed quantitatively in Sections 5.2.4 and 5.2.5.

The NRC notes that the set of SAMAs submitted is not all inclusive, because additional, possibly even less expensive, design alternatives can always be postulated. However, the staff concludes that the benefits of any additional modifications are unlikely to exceed the benefits of the modifications evaluated and that the alternative improvements would not likely cost less than the least expensive alternatives evaluated, when the subsidiary costs associated with maintenance, procedures, and training are considered. On this basis, the NRC concludes that the set of potential SAMA alternatives identified by Exelon is acceptable.

5.2.4 Risk Reduction Potential of Plant Improvements

Exelon developed a quantitative estimate of the risk reduction for each of the 5 SAMAs remaining after the Phase II screening. The specific impacts on the CDF and the population dose were identified, the appropriate model elements were changed to reflect the plant or procedure enhancement, and the models were requantified. Table 5-5 lists the assumptions used to estimate the risk reduction, the estimated risk reduction in terms of percent reduction in CDF and population dose, and the estimated total benefit (present value) of the averted risk for each of the 5 SAMAs.

In response to an RAI, Exelon estimated the uncertainties associated with the calculated CDF, and reassessed the Phase II screening based on use of the 95th percentile value of the CDF in the cost-benefit analysis instead of the point estimate value. Exelon found that two of the SAMAs would no longer be screened out; however, a more detailed examination by Exelon concluded that these two SAMAs would not be justified on a cost-benefit basis (Exelon 2002). In addition, Exelon states that even if the impact of external events on the CDF, as estimated in NUREG/CR-4551 in the late 1980s, were to be included in the evaluation, the increase would be less than that provided by the 95th percentile CDF estimate from internal events (Exelon 2002). These assessments are discussed further in Section 5.2.6.2.

Of the five candidates described in Table 5-5, the one that has costs and benefits that are of the same order is SAMA 21, suppression pool jockey pump. This pump would provide an independent means of providing long term injection into the reactor pressure vessel following venting or containment failure. In the PSA, the jockey pump was initially simulated by changing the failure probability for the fire pump from 0.8 to 0.01 (the PSA includes a simple representation of the fire pump to perform a similar function). This is considered optimistic by Exelon. The resulting risk reduction translated into a benefit value of $351,000. Because this risk-reduction value was large, the staff asked Exelon for additional information regarding the costs and the risk-reduction potential of this SAMA. Exelon claimed that a more realistic benefit value for SAMA 21 is about $152,000 (Enclosure 3 to NRC 2002). The PSA evaluation for the more realistic case assumed that the jockey pump is supplied by the E2 480V bus, i.e., the bus with the lowest risk achievement worth in the model, with a total system reliability of 0.05 (including human error) instead of the optimistic value of 0.01. The staff concurs that the reliability value of 0.05 is a reasonable best-estimate, and that the more realistic risk reduction estimates provided by Exelon are appropriate values to use in the SAMA assessment.

The NRC staff has reviewed Exelon's bases for calculating the risk reduction for the various plant improvements and concludes that the methodology is sound and that the values calculated are reasonable for SAMA purposes.

5.2.5 Cost Impacts of Candidate Plant Improvements

As part of the Phase II screening, Exelon developed a preliminary cost estimate for each of the 30 unique SAMA candidates remaining after the qualitative (Phase I) screening. These preliminary cost estimates, reported in Table G.4-2 of the ER, were developed to determine which SAMA candidates would clearly cost more than $2.04M (the maximum benefit associated with completely eliminating all risk, as described in Section 5.2.6.1) and could readily be dismissed. The cost estimates were based on the total costs associated with engineering, procurement, and construction. All costs for all SAMAs were provided on a per site basis. Where applicable, costs were determined on dual-unit basis (rather than doubling a single-unit estimate) to give a more accurate overall cost estimate.

Table 5-5. SAMA Cost/Benefit Screening Analysis

Phase II SAMA #	SAMA	Assumptions	% Risk Reduction		Total Benefit	Cost (2001 dollars)	Net Value ($)	
			CDF	**Population Dose**			**Base Case**	**3% Discount Rate**
1	Enhance procedural guidance for use of cross-tied component cooling or service water pumps	Eliminate initiating events related to loss of service water, by setting basic events involving failure of service water, turbine building closed cooling water, and reactor building closed cooling water pumps to zero	0.7	0.07	$8400	$50,000	(41,600)	(39,000)
11	Provide additional DC battery capacity	Extend battery life 4 hours to simulate additional battery capability. Impacts the loss of offsite power cases with HPCI and/or RCIC available.	19	13	$265,000	$1,600,000	(1,330,000)	(1,250,000)
13	Develop procedures to repair or replace failed 4-kV breakers	Improved procedures to repair or replace failed 4 kV breakers would reduce 4 kV breaker “fail to close” rates to zero, and reduce 4kV bus failure rates by a factor of 10.	0.1	very small	$400	$50,000	(49,600)	(49,500)
18	Increase the safety relief valve reseat reliability (case A)	Safety relief valve (SRV) “failure to reseat” probabilities reduced by a factor of 10.	4	5	$94,000	$2,000,000	(1,910,000)	(1,890,000)
18	Increase the safety relief valve reseat reliability (case B)	SRV “failure to reseat” probabilities reduced by a factor of 10, and stuck-open safety relief valve initiating event frequency reduced by a factor of 10.	6	10	$174,000	$2,000,000	(1,830,000)	(1,770,000)
21	Install suppression pool jockey pump for alternate injection to the reactor pressure vessel (optimistic)	Installation of a suppression pool jockey pump simulated by reducing the failure probability for the fire pump to 0.01	8	27	$351,000	$480,000	(129,000)	(19,400)
21	Install suppression pool jockey pump for alternate injection to the reactor pressure vessel (realistic)	Installation of a suppression pool jockey pump simulated by reducing the failure probability for the fire pump to 0.05	5	9	$152,000	480,000	(328,000)	(280,000)

Using the $2.04M screening value, 18 candidate SAMAs were eliminated. Of the 12 remaining candidates, 7 were screened from further analysis based on plant-specific risk insights regarding the systems that would be affected by the proposed SAMA, as described in Section 5.2.3.1 and 5.2.3.2. For the five remaining SAMA candidates, a more detailed conceptual design was prepared along with a more detailed cost estimate based on the same set of cost elements considered. Table 5-5 shows the cost estimates for the five remaining SAMAs.

The staff compared the cost estimates in Table G.4-2 of the ER to estimates developed elsewhere for similar improvements, including estimates developed as part of other licensees' analyses of SAMAs for operating reactors and advanced light-water reactors. The Exelon estimates were found to be consistent and reasonable for the SAMAs under consideration. For SAMAs 1 and 13, the estimate of $50,000 for a site procedural change is consistent with other cost assessments for similar actions. The range determined from other SAMA studies is $30,000 to $70,000.

For SAMA 18, the cost estimate of $2M is based on $200K/safety relief valve (SRV) times 10 automatic depressurization system SRVs (5 per unit). Because this SAMA assumes replacing the SRVs with new models, the cost is reasonable.

For SAMA 11, the cost estimate of $1.6M is based on $200K/battery times 8 batteries. This cost includes engineering analysis, equipment (new battery capability), and modification implementation. The cost is reasonable for a "hardware" SAMA of this size.

For SAMA 21, Exelon provided an estimated implementation cost of $480K (for both units) based on a previous cost estimate for the Advanced Boiling Water Reactor (ABWR). The ABWR cost estimate was doubled to account for the higher cost of installing the modification in an operating plant, versus during new plant construction. In response to a staff request, Exelon noted that this cost estimate was optimistic and that, in reality, when considering the costs associated with the installation of a totally independent system (new pump, power supply cables, and new piping) capable of injecting saturated water from the suppression pool, the costs would be much higher (Enclosure 3 to NRC 2002). Based on these comments from Exelon and further consideration of the modification, the staff considers the cost estimate of $480,000 not unreasonable but certainly optimistic. The lower-bound nature of this estimate should be taken into account in the cost-benefit comparison.

The staff concludes that the cost estimates are sufficient and appropriate for use in the SAMA evaluations.

5.2.6 Cost-Benefit Comparison

The staff's evaluation of Exelon's cost-benefit analysis is described in the following sections.

5.2.6.1 Exelon Evaluation

The methodology used by Exelon was based primarily on NRC's guidance for performing cost-benefit analysis, i.e., NUREG/BR-0184, *Regulatory Analysis Technical Evaluation Handbook* (NRC 1997b). The guidance involves determining the net value for each SAMA according to the following formula:

Net Value = ($APE + $AOC + $AOE + $AOSC) – COE

where

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

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

$AOE = present value of averted occupational exposure costs ($)

$AOSC = present value of averted onsite costs ($)

COE = cost of enhancement ($)

If the net value of a SAMA is negative, the cost of implementing the SAMA is larger than the benefit associated with the SAMA and it is not considered cost-beneficial. Exelon's derivation of each of the associated costs is summarized below.

<u>Averted Public Exposure (APE) Costs</u>

The APE costs were calculated using the following formula:

APE = Annual reduction in public exposure (∆person-rem/reactor-year)
x monetary equivalent of unit dose ($2000 per person-rem)
x present value conversion factor (10.76 based on a 20-year period with a 7-percent discount rate).

As stated in NUREG/BR-0184 (NRC 1997b), it is important to note that the monetary value of the public health risk after discounting does not represent the expected reduction in public health risk due to a single accident. Rather, it is the present value of a stream of potential losses extending over the remaining lifetime (in this case, the renewal period) of the facility. Thus, it reflects the expected annual loss due to a single accident, the possibility that such an accident could occur at any time over the renewal period, and the effect of discounting these potential future losses to present value. For the purposes of initial screening, Exelon calculated an APE of approximately $317,000.

Averted Offsite Property Damage Costs (AOC)

The AOCs were calculated using the following formula:

AOC = Annual CDF reduction
x offsite economic costs associated with a severe accident (on a per-event basis)
x present value conversion factor.

For the purposes of initial screening (severe accident costs eliminated), Exelon cited an annual offsite economic risk of $51,700 based on the Level 3 risk analysis. This results in a discounted value of approximately $557,000.

Averted Occupational Exposure (AOE) Costs

The AOE costs were calculated using the following formula:

AOE = Annual CDF reduction
x occupational exposure per core damage event
x monetary equivalent of unit dose
x present value conversion factor.

Exelon derived the values for averted occupational exposure from information provided in Section 5.7.3 of the regulatory analysis handbook (NRC 1997b). Best-estimate values provided for immediate occupational dose (3300 person-rem) and long-term occupational dose (20,000 person-rem over a 10-year cleanup period) were used. The present value of these doses was calculated using the equations provided in the handbook in conjunction with a monetary equivalent of unit dose of $2000 per person-rem, a real discount rate of 7 percent, and a time period of 20 years to represent the license renewal period. For the purposes of initial screening (severe accident costs eliminated), Exelon calculated an AOE of approximately $1,700.

Averted Onsite Costs (AOSC)

Averted onsite costs include averted cleanup and decontamination costs and averted power replacement costs. Repair and refurbishment costs are considered for recoverable accidents only and not for severe accidents. Exelon derived the values for AOSC based on information provided in Section 5.7.6 of the regulatory analysis handbook (NRC 1997b).

Exelon divided this cost element into two parts, the Onsite Cleanup and Decontamination Cost, also commonly referred to as averted cleanup and decontamination costs (ACC), and the Replacement Power Cost (RPC).

Averted cleanup and decontamination costs (ACC) are calculated using the following formula:

ACC = Annual CDF reduction
x present value of cleanup costs per core damage event
x present value conversion factor.

The total cost of cleanup and decontamination subsequent to a severe accident is estimated in the regulatory analysis handbook to be $\$1.1 \times 10^9$ (undiscounted). This value was converted to present costs over a 10-year cleanup period and integrated over the term of the proposed license extension. For the purposes of initial screening (severe accident costs eliminated), Exelon calculated an ACC of approximately $53,600.

Long-term RPC are calculated using the following formula:

RPC = Annual CDF reduction
x present value of replacement power for a single event
x factor to account for remaining service years for which replacement power is required
x reactor power scaling factor

For the purposes of initial screening (severe accident costs eliminated), Exelon calculated an RPC of approximately $91,000.

Exelon evaluated all costs and benefits on a per site rather than per unit basis. Accordingly, they applied a factor of two multiplier to each of the above cost elements to account for the contribution from both units. Using the above equations and applying this multiplier, Exelon estimated the total present dollar value equivalent associated with completely eliminating severe accidents at Peach Bottom Units 2 and 3 to be $2.04M for the site.

Exelon's Results

The cost-benefit results for the individual analysis of the final five SAMA candidates are presented in Table 5-5. All of the SAMAs have negative net values. Exelon concluded that implementation of any of these SAMAs is not justified because the costs of implementation exceed the benefits. Therefore, Exelon has decided not to pursue any of these SAMAs further.

5.2.6.2 Staff Evaluation

The cost-benefit analysis conducted by Exelon was based primarily on the NRC's Regulatory Analysis Technical Evaluation Handbook (NRC 1997b). Averted risks were for the Peach Bottom Units 2 and 3, and thus were twice the values for a single unit. To maintain expenditures on the same scale, Exelon either doubled the single-unit SAMA costs or assessed SAMA costs on a (shared) plant station basis. While this is not a typical practice, it is reasonable.

Exelon originally did not perform sensitivity studies as recommended in the regulatory analysis handbook (NRC 1997b). In response to an RAI, Exelon performed a sensitivity study in which the discount rate was reduced from 7 percent in the baseline analysis to 3 percent. This results in an increase in the maximum benefit (for completely eliminating all risk) from $2.04M to about $2.7M. As a result, five of the SAMAs previously eliminated in the Phase II screening (on the basis that their implementation costs were greater than the maximum benefit) were reassessed because their implementation costs would be less than the revised maximum benefit of $2.7M. These SAMAs were:

- SAMA 3 - Install an independent method of suppression pool cooling
- SAMA 5 - Install a containment vent large enough to remove ATWS decay heat
- SAMA 23 - Install a Safety-Related Condensate Storage Tank
- SAMA 24 - Install improved vacuum breakers (redundant valves in each line)
- SAMA 28 - Dedicated RHR (bunkered) Power Supply

Upon further evaluation, either the risk reduction associated with these additional SAMAs was estimated to be relatively small, or the realistic implementation costs were judged to be greater than the benefits. On this basis, Exelon determined that these SAMAs would not be cost beneficial.

Similarly, implementing any of the SAMAs in the near term instead of waiting until the start of the license renewal period (thereby extending the period in the value-impact analysis) would not increase the net benefit sufficiently to make any of the SAMA candidates cost-beneficial.

Use of a 3 percent discount rate also increases the benefits associated with the 5 candidate SAMAs that had already survived the Phase II screening. The net benefits of these SAMAs using a 3 percent discount rate is shown in the last column of Table 5-5. The net benefits for each of the SAMAs remain negative, although SAMA 21 - Install suppression pool jockey pump, is only marginally negative (-$19K), based on an averted risk value of $461K and an estimated cost of $480K.

In their responses to the staff's RAIs (Exelon 2002), Exelon addressed the impact of considering the 95th percentile CDF, a value 7 times larger than the point estimate (see Table 5-6). The resultant increase in the averted risks would tend to make the SAMAs more attractive.

Table 5-6. Uncertainty in the Calculated CDF for Peach Bottom Unit 2

Percentile	CDF (per reactor-year)
5th	$1.6x10^{-6}$
25th	$2.6x10^{-6}$
50th	$4.2x10^{-6}$
75th	$7.8x10^{-6}$
95th	$3.0x10^{-5}$

Exelon reassessed all 30 of the candidate SAMAs and found that two SAMAs became cost-beneficial under the 95^{th} percentile assumption. These were SAMA 11 - Provide additional DC battery capability, and SAMA 21 - Install suppression pool jockey pump. The benefits for SAMA 11 are still relatively close to the costs (i.e., a net value of $145K) when the 95^{th} percentile CDF is used. Since the 95^{th} percentile is an upper bound, and the net value is still relatively small, the staff agrees with Exelon that SAMA 11 is not a candidate for further consideration.

The benefits of SAMA 21 are substantially greater than the costs (i.e., a net value of $1.85M) when the 95th percentile CDF and optimistic risk reduction assumptions (see Section 5.2.4) are used, suggesting that the SAMA might also be cost-beneficial given more modest increases in the estimated CDF than a factor of seven. Also, as mentioned above, the net value of SAMA 21 is only marginally negative using a 3 percent discount rate (and point estimate CDF values). However, when averted onsite costs (AOSC) are excluded from the cost benefit, the net value becomes more negative. (The Regulatory Analysis Guidelines direct the staff to display the results with this attribute excluded if such exclusion would change the apparent conclusion to be drawn from the calculated net benefit.) Furthermore, based on a more realistic estimate of the risk reduction for this SAMA provided in Section 5.2.4, the benefits are substantially less and this SAMA would have a negative net value of approximately $300K. The impact of these major assumptions and uncertainties on the cost-benefit results are summarized in Table 5-7.

Table 5-7 Impact of Uncertainties on SAMA #21 Costs and Benefits

	Analysis Case				
Cost-Benefit Element	**Base Case**	**95th Percentile CDF**	**3% Discount Rate**	**AOSC excluded**	**"Realistic" Averted-Risk Benefit**
Benefit	$351K	$2,330K	$461K	$339K	$152K
Cost	$480K	$480K	$480K	$480K	$480K
Net Value	–$129K	+$1,850K	–$19K	–$141K	–$328K

Exelon stated that the estimated cost to implement SAMA 21 is conservative (see discussion in Section 5.2.5). The staff acknowledges that the implementation cost may be conservative, and further notes that when AOSC is excluded, the net value of the SAMA is clearly negative.

Although this SAMA may have a positive net value under certain conditions, it does not appear to be justified on a cost-benefit basis, given a broader consideration of the conservatisms, uncertainties, and assumptions inherent in the analysis.

5.2.7 Conclusions

Exelon compiled a list of 204 SAMA candidates using as resources: SAMA analyses submitted in support of licensing activities for other nuclear power plants, NRC and industry documents, and documents related to advanced power reactor designs (ABWR). A qualitative screening removed those SAMA candidates that: (1) did not apply to Peach Bottom Units 2 and 3 due to design differences, (2) were related to the mitigation of recirculation pump seal failures or ISLOCA (not significant risk contributors for BWRs), (3) had already been implemented at Peach Bottom Units 2 and 3, or (4) were related to design changes prior to construction. Using the updated Peach Bottom PSA, a maximum obtainable benefit of about $2.04M was calculated. This value was used in a second screening that eliminated the SAMA candidates whose cost to implement would exceed the maximum obtainable benefit. This process left only 12 SAMA candidates for further analysis. SAMAs related to non-risk significant systems were then screened out because any change in the reliability of these systems was found to have a negligible impact on the PSA evaluation. For the remaining 5 SAMA candidates, a more detailed conceptual design and cost estimate were developed as shown in Table 5-5.

The cost-benefit analyses showed that none of the final five SAMA candidates were cost-beneficial. Exelon concluded that there was no justification to implement any of the SAMA candidates and decided not to pursue any of the SAMA candidates further.

The staff reviewed the Exelon analysis and concluded that the methods used and the implementation of those methods were sound. The treatment of SAMA benefits and costs, the generally large negative net benefits, and the inherently small baseline risks support the general conclusion that the SAMA evaluations performed by Exelon are reasonable and sufficient for the license renewal submittal. The unavailability of a seismic and fire PSA model precluded a quantitative evaluation of SAMAs specifically aimed at reducing risk of these initiators; however, significant improvements have been realized as a result of the IPEEE process at Peach Bottom Units 2 and 3 that would minimize the likelihood of identifying cost-beneficial enhancements in this area.

Based on its review of Exelon’s SAMA analyses, the staff concludes that none of the candidate SAMAs are cost-beneficial. This conclusion is consistent with the low residual level of risk indicated in the Peach Bottom PSA and the fact that Peach Bottom Units 2 and 3 has already implemented many plant improvements identified by the IPE and IPEEE.

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10 CFR Part 51. Code of Federal Regulations, Title 10, *Energy*, Part 51, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions." |

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