MODEL SLR NEW AND SIGNIFICANT ASSESSMENT APPROACH FOR SAMA

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Executive Summary

The purpose of this document is to provide a model approach for assessing the significance of new information of which the applicant for renewal of a nuclear power reactor operating license or extension of a combined license is aware that relates to either (1) the severe accident mitigation design alternatives (SAMDA) analysis or severe accident mitigation alternatives (SAMA) analysis documented in the NRC's final environmental statement (FES, FSEIS, or EA) that supported issuance pursuant to 10 CFR Part 50 (or Part 54) of the reactor's initial (or renewed) operating license or (2) the SAMDA analysis documented in the NRC's final environmental statement (FES, FSEIS, or EA) that supported issuance pursuant to 10 CFR Part 52 of the reactor's combined license and the design certification incorporated therein by reference, if any.

The model approach provided in this document is a tiered approach that employs a coarse screening process in Stage 1 and progresses to a detailed screening process in Stage 3. Applicants that are able to demonstrate in the Stage 1 screening process that there is no potentially significant new information are not required to perform the Stage 2 or Stage 3 evaluations. New information will be deemed "potentially significant" to the extent it results in the identification in Stage 1 of an unimplemented SAMA that reduces the maximum benefit (MB) by 50% or more.

The first stage of the model approach uses PRA risk insights and/or risk model quantifications to estimate the percent reduction in MB associated with (1) any unimplemented "Final Plant-Specific SAMAs", and (2) those SAMAs identified as potentially cost beneficial for other industry plants that have been determined to be applicable to but not already implemented at the analyzed plant (referred to herein as "Applicable Industry SAMAs"). In the event that one or more unimplemented Final Plant-Specific SAMAs or Applicable Industry SAMAs are shown in Stage 1 to reduce the MB by 50 percent or more, the applicant must develop an updated averted cost-risk estimate for implementing those SAMAs. Such development is the Stage 2 assessment.

In the event that the results of the Stage 2 assessment support the Stage 1 conclusion that one or more SAMAs reduce the MB by 50% or more, those "potentially significant" SAMAs must be further assessed in Stage 3.

The Stage 3 assessment consists of performing a cost-benefit analysis for the "potentially significant" SAMAs identified in Stage 2. If any "potentially significant" SAMA is found in Stage 3 to be also potentially cost-beneficial, then the finding indicates the existence of "new and significant'' information. Hence, because "new and significant" information exists, the applicant must supplement the previous SAMA analysis.

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Revision	Description of Changes	Date Modified	Responsible Person
0	Initial Issuance	June 2017	Jerud Hanson
1	Clarification of the definition of SAMAs to be analyzed in first stage of the model approach and clarification of the processes that may be used to estimate Stage 1 risk reduction.	August 2019	Chris Earls

Notice

TABLE OF CONTENTS

List of Figures

List of Acronyms, Abbreviations and Initialisms

ANS	American Nuclear Society
ASME	American Society of Mechanical Engineers
BWR	Boiling water reactor
CDF	Core damage frequency
CFR	Code of Federal Regulations
e.g.	For example
EA	Environmental assessment
EIS	Environmental impact statement
ER	Environmental report
FES	Final environmental statement
FLEX	Diverse and flexible coping capability to implement lessons learned from the Fukushima Daiichi nuclear plant accident
FR	Federal Register
FSEIS	Final supplemental environmental impact statement
FV	Fussell-Vesely
i.e.	That is
IPE	Individual Plant Examination
IPEEE	Individual Plant Examination of External Events
LERF	Large early release frequency
MACCS	MELCOR Accident Consequences Code System
MB	Maximum Benefit
MSIV	Main steam isolation valve
NRC	U.S. Nuclear Regulatory Commission
PRA	Probabilistic Risk Assessment
PWR	Pressurized water reactor
RAI	Request for additional information
RAW	Risk Achievement Worth
RRW	Risk reduction worth
SAMA	Severe accident mitigation alternatives
SAMDA	Severe accident mitigation design alternatives
SGTR	Steam generator tube rupture
SLR	Second license renewal
SSC	Structure, system, or component

1 OVERVIEW

CAUTION

The purpose of this document is to provide a model approach for assessing the significance of new information of which the applicant for renewal of a nuclear power reactor operating license or extension of a combined license is aware that relates to either (1) the severe accident mitigation design alternatives (SAMDA) analysis or severe accident mitigation alternatives (SAMA) analysis documented in the NRC's final environmental statement (FES, FSEIS, or EA) that supported issuance pursuant to 10 CFR Part 50 (or Part 54) of the reactor's initial (or renewed) operating license or (2) the SAMDA analysis documented in the NRC's final environmental statement (FES, FSEIS, or EA) that supported issuance pursuant to 10 CFR Part 52 of the reactor's combined license and the design certification incorporated therein by reference, if any.

Only after prior consultation with the NRC Staff, should this model approach be applied in any other context.

The purpose of the evaluation of severe accident mitigation alternatives (SAMAs) is to identify design alternatives, procedural modifications, or training activities that are cost-beneficial and further reduce the risks of severe accidents [1]. The analysis of SAMAs includes the identification and evaluation of alternatives that reduce the risk from a severe accident by preventing substantial core damage (i.e., preventing a severe accident) or by limiting releases from containment in the event that substantial core damage occurs (i.e., mitigating the impacts of a severe accident) [2]. In accordance with 10 CFR 51.53(c)(3)(ii)(L) and Table B-1 of Appendix B to 10 CFR Part 51, Subpart A, license renewal Environmental Reports (ERs) must provide a consideration of alternatives to mitigate severe accidents if the NRC staff has not previously considered such alternatives[1] for the applicant's plant in an environmental impact statement (EIS) or related supplement or in an environmental assessment (EA).

A license renewal applicant for a plant that has already had a SAMA analysis considered by the NRC as part of an EIS, supplement to an EIS, or EA, does not need to provide another SAMA analysis in the license renewal ER. In forming its basis for determining which plants needed to submit SAMA analyses at license renewal, the Commission noted that all licensees had undergone, or were in the process of undergoing, more detailed site-specific severe accident mitigation analyses through processes separate from license renewal, specifically the Containment Performance Improvement, Individual Plant Examination (IPE), and Individual Plant Examination of External Events (IPEEE) programs (61 FR 28467, 28481; June 30, 1996). In light of these studies, the Commission stated that it did not expect future SAMA analyses to uncover "major plant design changes or modifications that will prove to be cost-beneficial" (61 FR 28467, 28481; June 30, 1996). The NRC's experience in completed license renewal proceedings has confirmed this prediction.[2]

Nevertheless, the applicant's ER must contain any new and significant information of which the applicant is aware (10 CFR 51.53(c)(iv)) and the NRC Staff must consider whether such information affects prior

[1] Some plants (e.g., Limerick Generating Station) performed analyses of severe accident mitigation design alternatives as components of initial plant licensing environmental reviews. Hence, the NRC considered such analyses in the EISs regarding initial plant licenses for those plants. Also, for plants seeking second license renewals (i.e., 60-to-80 years of operation), the NRC will have previously considered SAMA analyses for them in their first license renewal (i.e., 40-to-60 years of operation) EISs.

[2] As stated in Appendix E of NUREG-1437, Revision 1 at E-45 [13].

generic environmental determinations, reflected in the Category 1 issues in Table B-1. See 61 FR 28467 to 28468. Although the issue of severe accidents (Issue 66 in Table B-1) is classified as a Category 2 issue, it reads as follows:

> *"The probability-weighted consequences of atmospheric releases, fallout onto open bodies of water, releases to groundwater, 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."*

The exception in 10 CFR 51.53(c)(3)(ii)(L) operates to convert this Category 2 issue into the "functional equivalent" of a Category 1 issue for plants to which it applies (*Exelon Generation Company, LLC* (Limerick Generating Station, Units 1 and 2), CLI-12-19, 76 NRC 377, 386, October 23, 2012). Hence, the ER in a license renewal application for a nuclear plant that qualifies for the exception must identify new and significant information of which the applicant is aware that relates to the previous evaluation of the issue.

To support the Second License Renewal (SLR) efforts for nuclear power plants, the approach presented in this document provides a model structure for defining, identifying, evaluating, and documenting whether "new" information is "significant" with respect to a SAMA analysis previously considered by the NRC. However, this document does not provide guidance on the process to be used by license renewal applicants for evaluating the significance of new information related to the NRC's other conclusion in Table B-1, Issue 66. That is, the conclusion that "[t]he probability-weighted consequences of atmospheric releases, fallout onto open bodies of water, releases to groundwater, and societal and economic impacts from severe accidents are small for all plants." Hence, license renewal applicants are cautioned to separately explore new and significant information that relates to this non-SAMA-analysis conclusion.

2 DEFINITION OF "NEW AND SIGNIFICANT"

In order to provide an assessment of whether "new and significant" information exists with respect to a prior SAMA analysis, it is first necessary to define the term. As discussed by the NRC in section 5.3.9 of NUREG-1437, Supplement 49 [8], "New information is significant if it provides a seriously different picture of the impacts of the Federal action under consideration. Thus, for mitigation alternatives such as SAMAs, new information is significant if it indicates that a mitigation alternative would substantially reduce an impact of the Federal action on the environment. Consequently, with respect to SAMAs, new information may be significant if it indicated a given cost-beneficial SAMA would substantially reduce the impacts of a severe accident or the probability or consequences (risk) of a severe accident occurring."[3] The implication of this statement is that "significance" is not solely related to whether or not a SAMA is cost beneficial, but depends also on a SAMA's potential to significantly reduce risk to the public.

At the time of this writing, the NRC has not provided a quantitative methodology for interpreting the above definition of "new and significant information". Accordingly, for the purposes of this model approach, the term "new and significant" has been broken down into its constituent parts to aid in the development of a functional definition.

There are various inputs to the SAMA analysis that could be affected by "new" information (e.g., population changes, risk model updates, etc.), but in the context of a SAMA analysis, the determination of whether "new" information is also "significant" is ultimately made in relation to averted cost-risk values, which is a primary output metric of a SAMA analysis. The averted cost-risk of a SAMA candidate is a measure of the change in risk, expressed in dollars, associated with implementation of the SAMA, and it is considered to be an appropriate means of characterizing the potential impacts of plant operation on the public and environment. The definition of "new and significant" that is developed below is designed to include inputs that can be reflected in terms of an averted cost-risk.

2.1 Definition of "New" Information

"New" information pertains to data used in a SAMA analysis that has changed or become available since the time the preceding SAMA analysis was performed.

There are some inputs to the SAMA analysis that are expected to change, or to potentially change, for all plants. These inputs include:

- Updated Level 3 Model consequence results, which may be impacted by multiple inputs, including, but not limited to, the following:
  - Projected population within a 50-mile radius of the plant
  - Regional economic data (e.g., value farm wealth, value of non-farm wealth
  - Core inventory (e.g., due to power uprate)
  - Release category source term characteristics
  - Event response cost data
  - Emergency response costs (e.g., per diem food and housing expenses, per capita relocation expenses)

[3] Information is "new and significant" if it is sufficient to show that the federal action will affect the quality of the human environment either in a significant manner or to a significant extent not already considered in an EIS. See *Marsh v. Oregon Natural Resources Council*, 490 U.S. 360, 374 (1989). To be significant, such information must "paint a dramatically different picture of impacts" compared to those previously evaluated. Massachusetts v. NRC, 708 F.3d 63, 68-69 (1st Cir. 2013).

- General Level 3 methodology guidance and generic inputs
- NUREG/BR-0058 [10] cost benefit methodology updates

In addition, other changes that could be considered to be "new information" are dependent on plant activities or site specific changes. These types of changes include:

- The identification of a new hazard (e.g., a fault that was not previously analyzed in the seismic analysis)
- An updated plant risk model (e.g., a fire probabilistic risk assessment [PRA] that replaces the IPEEE analysis)
  - The impacts of plant changes that are included in the plant risk models will be reflected in the model results and do not need to be assessed separately.
- Non-modeled modifications/changes to the plant
  - Modifications determined to have no risk impact need not be included (e.g., replacement of the condenser vacuum pumps)[4]

For risk model updates performed to reflect the latest PRA model state of the practice, it is noted that the actual physical plant risk may not have changed, but because the best estimate assessment/understanding of the risk has changed, it is considered to be "new information".

At the direction of the Commission [12], the NRC Staff asked the applicant in a request for additional information (RAI) [7] why the set of potentially cost beneficial SAMAs that were identified for plants similar in design to Limerick after the performance of Limerick's 1989 Severe Accident Mitigation Design Alternatives (SAMDA) analysis were not new and significant information. This event was site-specific; however, because a similar request could be made of any SLR applicant, it may be advisable for applicants to consider whether potentially cost beneficial SAMAs identified in U.S. license renewal applications after submittal of the SAMA analysis for the analyzed plant could be new information.

- BWRs should assess SAMAs from other BWRs and PWRs should assess SAMAs from other PWRs.

If there is a basis for excluding this body of SAMAs from the pool of "new information" to be evaluated for significance, the rationale should be documented.

2.2 "Significant" Information

In Section 5.3.9 of the Generic Environmental Impact Statement for License Renewal of Nuclear Plants Regarding Limerick Generating Station, NUREG-1437, Supplement 49 [8], the NRC explained that "with respect to SAMAs, new information may be significant if it indicated that a given *cost-beneficial* SAMA would *substantially* reduce the impacts of a severe accident or the probability or consequences (risk) of severe accident occurring." Thus, to be significant, new information must result in identification of a SAMA that (1) is cost beneficial and (2) substantially reduces risk.

To apply this framework, it is necessary to provide a quantitative threshold for substantial risk reduction from a SAMA. Such a threshold was previously developed to support the Limerick Generating Station License Renewal Application, which has been reviewed and accepted by the NRC. Based on the successful application of the threshold used in the Limerick License Renewal proceeding to determine whether potentially cost beneficial SAMAs are significant, the same definition is proposed herein. The remainder of this section describes that threshold.

[4] Unless they impact a specific input to SAMA (e.g., a new low pressure turbine in the power conversion system that results in a greater net electrical output).

2.2.1 Threshold for Potential Significance

PRA standards and other relevant industry guidance documents can be reviewed to identify the thresholds for what may be considered "significant" in risk evaluations to help develop a basis for the term's definition. Results of such a review were reported to the NRC in Reference 7 and are reproduced below.

There were a few notable documents that provide numerical criteria that may be applied to determine the threshold for potential significance. The first one is the American Society of Mechanical Engineers ("ASME")/American Nuclear Society ("ANS") PRA Standard [4], which includes the following definition of a significant basic event:

> *Significant basic event: a basic event that contributes significantly to the computed risks for a specific hazard group. For internal events, this includes any basic event that has an FV [Fussell-Vesely] importance[5] greater than 0.005 or a RAW [Risk Achievement Worth][6] importance greater than 2.*

Similar numerical criteria also appear in NUMARC 93-01 [5], which includes the following guidance:

> *An SSC would probably be considered risk significant if its Risk Reduction Worth exceeds 0.5 percent of the overall Core Damage Frequency (Risk Reduction Worth >1.005).*
>
> *[…]*
>
> *An SSC [structure, system or component] would probably be considered risk significant if its Risk Achievement Worth shows at least a doubling of the overall Core Damage Frequency and should be provided to the expert panel as an input in risk determination.*

Finally, NEI 00-04 [6] provides detailed guidance on categorizing structures, systems and components for licensees that choose to adopt 10 CFR § 50.69, *Risk-Informed Categorization and Treatment of Structures, Systems and Components for Nuclear Power Reactors*. In the discussion of using risk analyses for SSC categorization, the following guidance is provided:

> *The risk importance process uses two standard PRA importance measures, risk achievement worth (RAW) and Fussell-Vesely (FV), as screening tools to identify candidate safety-significant SSCs. The criteria chosen for safety significance using these importance measures are based on previously accepted values for similar applications.*
>
> *[…]*
>
> *The importance measure criteria used to identify candidate safety significance are:*
>
> - *Sum of FV for all basic events modeling the SSC of interest, including common cause events > 0.005*
> - *Maximum of component basic event RAW values > 2*

In summary, an FV value > 0.005 and a RAW value > 2 are well established indicators of PRA significance. This can be extended to apply to not just internal events core damage frequency ("CDF") and large early release frequency ("LERF"), but to external events CDF and LERF, and other integrated key output figures of merit. In the context of license renewal, the accepted key output figure of merit for decision making is potential "averted cost risk."

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[5] For a specified basic event, Fussell-Vesely importance is the fractional contribution to the total of a selected figure of merit for all accident sequences containing that basic event.

[6] For a specified basic event, risk achievement worth importance reflects the increase in a selected figure of merit when an SSC is assumed to be unable to perform its function due to testing, maintenance, or failure. It is the ratio or interval of the figure of merit, evaluated with the SSC's basic event probability set to one, to the base case figure of merit.

When averted cost risks are analyzed, the FV importance measure is found to be highly dependent on the assumed reliability of the system once it is installed. This is illustrated in Figure 1 which shows an example of how the FV value changes with assumed failure probability values given a case where a 50% reduction in the measured parameter is estimated assuming perfect reliability. In this example, a 0.005 FV value would be obtained when the failure probability is ~0.005. This failure probability represents a system or component that is 99.5% reliable, which is fairly representative of many components modeled in typical PRA analyses.

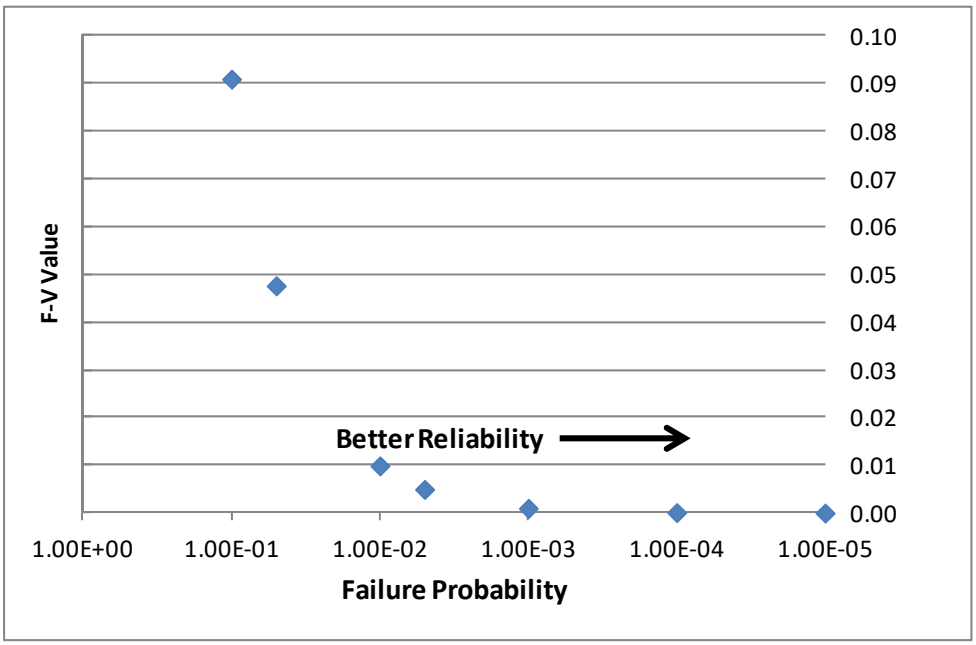

Figure 1 – FV as a Function of Failure Probability

On the other hand, as the reliability of the system increases (i.e., as the likelihood of system failure decreases), the RAW importance measure would asymptotically approach a RAW of 2 if 50% of the measured parameter can be averted. This is illustrated in Figure 2, which shows an example of how the RAW changes with assumed failure probability values when a 50% reduction in the measured parameter is estimated assuming perfect reliability. Therefore, a correlation to a RAW > 2 as the acceptance threshold for "significance" is established, and a 50% reduction in a plant's Maximum Benefit (MB) (as defined in Section 4.5 of Reference 9) is chosen for the "significance" threshold (i.e., a 50% reduction in the MB is a monetary measure of reducing the plant's risk by 50%).

In other words, the threshold that has been described here would be equivalent to a highly reliable system leading to doubling the cost risk when it is taken out of service for maintenance. This correlates to a well-established threshold for determining risk significance in the PRA applications discussed above. Based on this characterization of "significance", a change that would reduce a plant's MB by a factor of at least 2 would be considered potentially "significant" pending the determination of whether it is also potentially cost beneficial. For this approach, therefore, plant changes that would reduce the MB by a factor of 2 are characterized as "potentially significant" SAMAs with the final determination of significance dependent on the results of a cost benefit analysis.

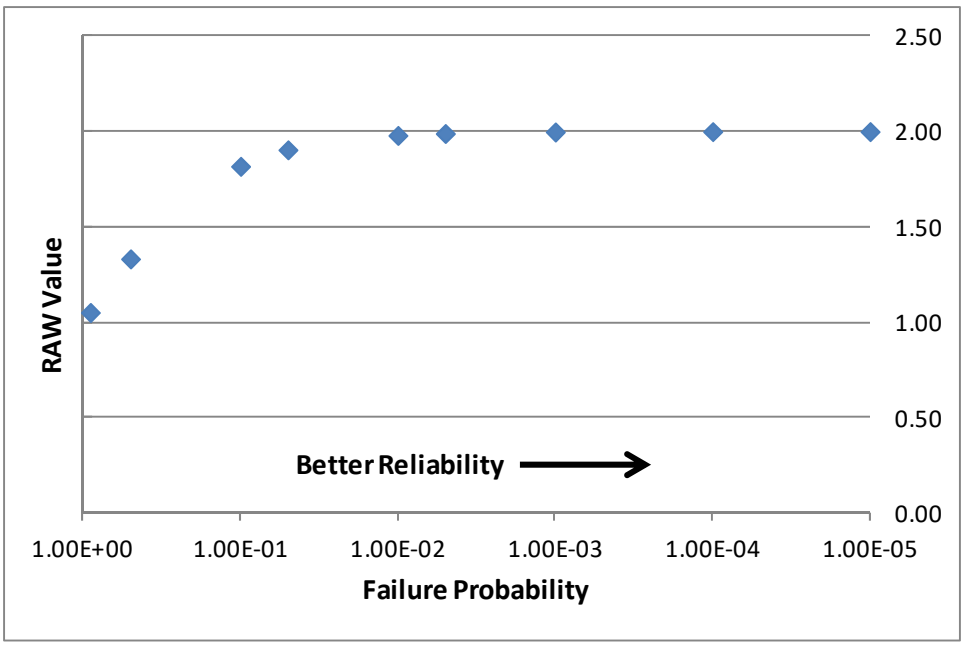

Figure 2 - RAW as a Function of Failure Probability

In order to apply this threshold in the context of determining whether new information might be significant, however, it is necessary to identify the model that will be used to measure the MB reduction, which for this application is considered to be the model that reflects the most up to date understanding of plant risk (i.e., the current model of record). The implication of using the current model of record with this definition of "significant" is that the cost benefit information from the original SAMA evaluation is superseded by that which would be derived by the current model. Because the MB and averted cost-risk calculations are directly correlated to plant risk, the assessment of significance can be performed using only the Level 1 and Level 2 PRA models (i.e., it may not be necessary to update the Level 3 model or other parts of the cost benefit analysis). If it can be shown that a particular SAMA would not reduce the CDF or any of the important Level 2 release category frequencies in the model of record by more than a factor of two, then that particular SAMA could not reduce the MB by a factor of more than two. Therefore, that SAMA would not be considered potentially significant and would not be evaluated further in assessing the significance of new information.

This is consistent with the following statement from NUREG-1437, Supplement 49 [8], which indicates the assessment of "new information" can be framed in terms of the impact of SAMA implementation: "**new information may be significant if it indicated a given cost-beneficial SAMA would substantially reduce the impacts of a severe accident or the probability or consequences (risk) of a severe accident occurring**." If there are no potentially significant SAMAs, no new information would be deemed "significant."

3 ASSESSMENT PROCESS

This section describes a multi-stage assessment process to determine whether or not there is any "new and significant" information relevant to a previous SAMA analysis. If "new" and "significant" information has been determined to exist, an updated SAMA assessment as described in NEI 05-01 or a supplement to the SAMA analysis would follow.

The first stage of the process (see Section 3.1) uses PRA risk insights and/or risk model quantifications to estimate the percent MB reduction associated with (1) any unimplemented "Final Plant-Specific SAMAs" (see Section 3.1, "Stage 1 Assessment 'New Information' Elements), and (2) those SAMAs identified as potentially cost beneficial for other industry plants that have been determined to be applicable to but not already implemented at the analyzed plant (referred to herein as "Applicable Industry SAMAs"; see subsection 3.2.1). If it can be demonstrated that none of the SAMAs being evaluated can reduce the MB by 50 percent or more[7], then the applicant may document the conclusion that there is no "new and significant" information relevant to the previous SAMA analysis.

In the event that one or more unimplemented Final Plant-Specific SAMAs or Applicable Industry SAMAs are shown to reduce the MB by 50 percent or more, the applicant must develop an updated averted cost-risk estimate for implementing those SAMAs. Such development is the Stage 2 assessment (see Section 3.2). Two options are provided for performing the Stage 2 assessment:

- Option 1: Perform a simplified (conservative) Level 3 model update to support the update of the averted cost-risk calculations.
- Option 2: Perform a full Level 3 model update to support the update of the averted cost-risk calculations.

The desirability of using Option 1 will vary by plant depending on the availability of information.

In the event that refinements to the averted cost-risk calculations related to the Stage 2 assessment demonstrate that the MB reduction is less than 50% for all SAMAs, then the applicant may document the conclusion that there is no "new and significant" information relevant to the previous SAMA analysis.

If the results of the Stage 2 assessment indicate that one or more SAMAs reduce the MB by 50% or more, then the impact of new information on those SAMAs must be further assessed to determine whether it is significant. New information will be deemed "potentially significant" to the extent it results in the *identification of an unimplemented SAMA that reduces the MB by 50% or more*.

The final determination of significance will be made in the Stage 3 assessment, which consists of performing a cost-benefit analysis for unimplemented SAMAs that reduce the MB by 50% or more (i.e., "potentially significant" SAMAs). If such SAMAs are found to be potentially cost-beneficial, then they indicate the existence of "new and significant" information relevant to the previous SAMA analysis.

Figure 3 provides a flowchart of the 3-stage assessment process.

[7] A SAMA that reduces the MB by 50% or more is not considered to be "new and significant" if it was also determined in the previous SAMA analysis to reduce the MB by 50 percent or more (i.e., in the 40-to-60-year ER).

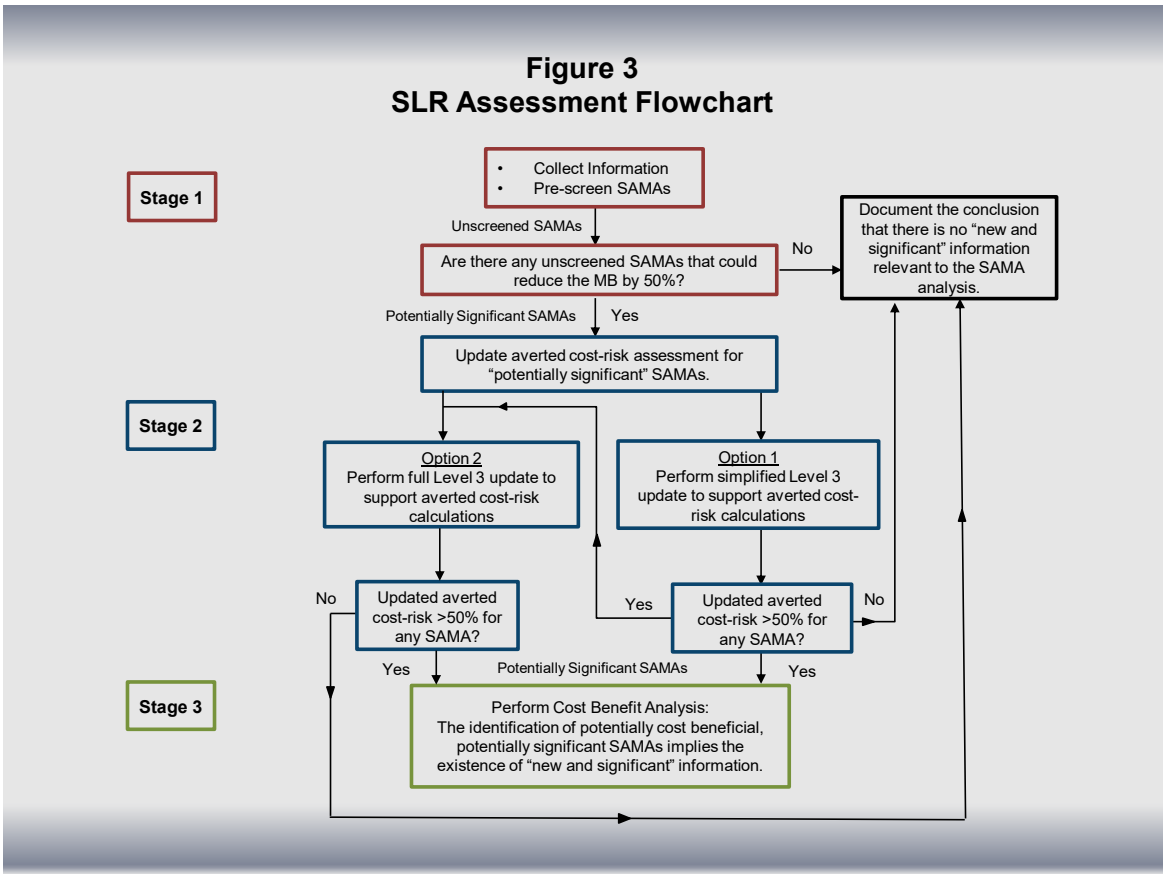

Figure 3 - SAMA "New & Significant" Assessment Flowchart

3.1 Data Collection

An initial step of the assessment process is to identify the "new information" relevant to the SAMA analysis and to collect/develop those elements of information that will be used to support the assessment.

The information elements that are relevant to each of the NEI assessment stages shown in Figure 3 are provided below. Each applicant should collect, develop, and document the information elements corresponding to the stage(s) of the analysis performed for the site. For those stages of analysis that are not required to be performed, the corresponding information elements should be documented as "new information" relevant to the SAMA analysis, but determined not to be potentially significant based on the analysis process. It is not necessary to develop the details of these information elements. For example, if a plant is able to demonstrate that none of the SAMAs evaluated in the Stage 1 assessment are potentially significant, then the Stage 2 inputs, such as the projected population within a 50-mile radius of the plant, should be listed as "new information", but no work to estimate the actual 50-mile population is required.

The ability to classify "new" information pertaining to assessment stages that are not required to be performed as "not significant" is possible because, as discussed in Section 2.0, information that is "significant" in the context of a SAMA analysis is information the implies a cost beneficial SAMA exists that would substantially reduce plant risk. Section 2.2.1, defines a "substantial" or "significant" reduction in risk as a 50% reduction in the MB; therefore, if the Stage 1 assessment demonstrates that no SAMAs can reduce the MB by 50% or more, then "new" information elements that impact the cost benefit analysis cannot alter this conclusion. Changes in the estimates of the consequences of an accident may impact

whether or not SAMAs are cost beneficial, but if all Stage 1 SAMAs have been shown to reduce the MB by less than 50 percent, then reclassification of a SAMA as "cost beneficial" alone would not provide "a seriously different picture of the impacts of the Federal action "(i.e., license renewal) and the information would not be classified as "significant".

The following are the information elements that should be collected and identified as "new" information for each of the assessment stages:

Stage 1 Assessment "New Information" Elements

- PRA models (Level 1 and 2)
  - Use the latest risk models that are available for Internal Events (including internal flooding) and for each of the external events contributors identified for evaluation in NEI 05-01 [9].
    - For those plants that have not maintained a full Level 2 model, it will be necessary to either update the Level 2 model or develop a process by which the relevant release category frequencies can be estimated for each SAMA considered to ensure the full spectrum of plant risk can be accounted for in the Stage 1 assessment. Regarding the degree of granularity required if a full Level 2 model has not been maintained, the following processes are possible alternatives.
      1. Grouping of release category results into high level categories (e.g., "Large/Early", "Moderate/Late") is adequate for the Stage 1 assessment. That is, it is not necessary to explicitly quantify subgroups such as Large/Early-01, Large/Early-02, etc., even if the 40-to-60-year SAMA analysis did so.
      2. A technical basis can be provided to support the use of a reduced set of release categories for the Stage 1 assessment. For example, if information is available that demonstrates a subset of release categories are not significant contributors to risk, it would be possible to preclude them from explicit quantification for most conditions (see Section 3.2.2).
  - Note that RAIs on 40-to-60-year SAMA analyses have often requested the assessment of new information not in the plant risk models; therefore, applicants should be prepared to extrapolate the impact of forthcoming model revisions and/or updated modeling techniques into the results of the evaluation.
  - These types of issues will vary by plant, and they may be influenced by current industry issues.
- Plant changes not yet incorporated into plant risk models
- Unimplemented Final Plant-Specific SAMAs
  - These are unimplemented SAMAs whose status was determined through a cost-benefit analysis comparing plant-specific averted cost-risk to projected implementation cost.
  - SAMAs that were dispositioned using other evaluation criteria in the 40-to-60 year SAMA analysis would not be Final Plant-Specific SAMAs. For example, neither SAMAs that were determined to be not potentially cost beneficial because their costs of implementation exceeded the MB nor SAMAs that were determined to be not applicable to the plant are Final Plant-Specific SAMAs. Hence, they do not need to be evaluated again.
  - Sources for identifying Final Plant-Specific SAMAs are:

- The 40-to-60-year SAMA analysis, which is typically an appendix to the Environmental Report in the 40-to-60-year License Renewal Application (or its equivalent if severe accident mitigation alternatives were considered during initial plant licensing).
- Responses to RAIs issued on the 40-to-60-year SAMA analysis (or its equivalent if severe accident mitigation alternatives were considered during initial plant licensing).
- The Generic Environmental Impact Statement (NUREG-1437) Supplement for the analyzed plant.

- Potentially cost beneficial SAMAs identified in SAMA analyses for other similar plants submitted after that of the analyzed plant.
  - Include those SAMAs of the same general plant type (i.e., BWR or PWR)[8],
  - The potentially cost beneficial SAMAs are identified in the plant specific Supplements of the Generic Environmental Impact Statement (NUREG-1437).

Stage 2 Assessment "New Information" Elements

- Plant source term radiological release information
  - Core inventory (e.g., power uprate)
  - Release category source term characteristics (e.g., release fraction, release start time, release duration)
- Evacuation preparedness plans (e.g., evacuation timing, evacuation speed)
- Site regional data
  - Projected population within a 50-mile radius of the plant
  - Regional economic data (e.g., value of farm wealth, value of non-farm wealth)
- Event response cost data
  - Emergency response costs (e.g., per diem food and housing expenses, per capita relocation expenses)
  - Decontamination costs
- General Level 3 methodology guidance and generic inputs
- Cost benefit methodology
  - The draft version of NUREG/BR-0058 [10] contains the current guidance for developing the Maximum Benefit (also used to perform the cost benefit analysis for a Stage 3 analysis). The finalized version of the document, when available, would be the basis for a Stage 2 analysis.
  - NUREG-1530, Revision 1 [15] provides the basis for the dollar per person-rem cost, which has been updated since the release of NEI 05-01 and is referenced in NUREG/BR-0058 as the source for this value.
  - Includes information previously contained in NUREG/BR-0184 [3]

Stage 3 Assessment "New Information" Elements

- Implementation costs for those SAMAs not screened in Stage 2

[8] Commission Order CLI-13-07 indicates that SAMAs identified for Mark II BWRs could be used for any BWR. This assertion is used as the basis for not limiting the scope of potentially cost beneficial SAMAs to be considered to only those associated with a particular plant sub-type. A coarse screening step is performed later to eliminate those SAMA candidates that are not applicable to the design of the analyzed plant.

The analyst should review plant specific conditions to identify, document, and develop, as necessary, any other inputs to the SAMA analysis that have changed since the 40-to-60-year SAMA analysis was completed.

3.2 Stage 1 Assessment

The Stage 1 Assessment includes subtasks for pre-screening industry SAMA candidates and for estimating the risk reduction of the unscreened SAMA candidates, which are described in further detail below.

3.2.1 Pre-screening Industry SAMAs

While this model approach advises including the potentially cost beneficial SAMAs from industry plants of the same general type in the body of SAMAs to be considered, it is not expected that a risk reduction assessment would be necessary for each of those SAMAs. Before the risk reduction estimates are developed, the SAMA candidates should be pre-screened to identify 1) those SAMAs that are not applicable to the design of the analyzed plant, 2) those SAMAs that have already been implemented at the analyzed plant, and 3) those SAMAs that are already addressed by a functionally equivalent SAMA or that may be combined with or subsumed by a more comprehensive SAMA. This step is similar to the Phase 1 screening process in NEI 05-01 with the exceptions that SAMAs are not eliminated due to excessive implementation cost (because an updated MB is not developed for the Stage 1 analysis) and SAMAs with very low benefits are not exempted from an explicit risk reduction assessment.

The pre-screening criteria, which have been adopted from NEI 05-01 and slightly modified, are provided below:

- Not Applicable: If a SAMA candidate does not apply to the plant design, it may be excluded from further review. For example, installation of accumulators for turbine-driven feedwater pump flow control valves would not be further analyzed for a plant with motor operated turbine-driven feedwater pump flow control valves.
- Already Implemented: If a SAMA candidate has already been implemented at the plant, or its benefit achieved by other means, it may be excluded from further review. For example, installation of motor generator set trip breakers in the control room to reduce the frequency of core damage due to an ATWS would not be further analyzed for a plant with a control room actuated diverse scram system.
- Combined: If a SAMA candidate is similar in nature and can be combined with another SAMA candidate to develop a more comprehensive or plant-specific SAMA candidate, only the combined SAMA candidate is retained. For example, addition of an independent reactor coolant pump seal injection system and use of an existing hydro test pump for reactor coolant pump seal injection provide similar risk-reduction benefits. If the lower-cost alternative is not cost-beneficial, the higher-cost alternative also will not be cost-beneficial. Therefore, the higher-cost alternative would not be further analyzed.

For each of the SAMAs that are pre-screened using the above criteria, document the criterion used to eliminate the SAMA from further consideration. The remaining SAMA candidates are referred to herein as “Applicable Industry SAMAs.”

3.2.2 Evaluation of Risk Reduction

For the unimplemented Final Plant-Specific SAMAs and Applicable Industry SAMAs, estimate the percent by which the MB would be reduced if the SAMA were implemented. There are different methods that may be used to accomplish this goal, but whichever method is used, the risk insights must be correlated to the ultimate metric, which is the averted cost-risk. For example, it is critical that an assessment of a

SAMA impacting Steam Generator Tube Rupture accounts for the reduction in the Level 2 "bypass" release category frequency in addition to the CDF because a majority of the averted cost-risk may be associated with the "bypass" frequency.

Without the insights of an updated Level 3 model and MB calculation, it is difficult to correlate specific changes to the CDF and Level 2 release categories to a current averted cost-risk; therefore, in this stage of the analysis, the approach is to bound the impact by demonstrating that SAMA implementation would not reduce the CDF or any of the Level 2 release category frequencies by 50 percent or more. If this can be demonstrated, it can be inferred that the SAMA's averted cost-risk would not be more than 50 percent of the MB. This is because the averted cost-risk is directly tied to the changes in CDF and the Level 2 release category frequencies. Note that as an alternative to calculating the percent reduction in each Level 2 release category frequency subgroup, such as Large/Early-01, Large/Early-02, etc., it would be sufficient to group release category results into high level categories (e.g., "Large/Early"," Moderate/Late"), even if the 40-to-60-year SAMA analysis reported values for the subgroups. Another alternative, if a technical basis is provided that demonstrates the overall risk reduction for the plant can be adequately quantified using a subset of Level 2 release categories, would be to perform the demonstration for that subset of the Level 2 release categories. For example, if there is information to show that (i) 99% of a plant's risk is represented by the High-Early, High-Intermediate, and Moderate-Intermediate release categories and (ii) the same plant's nine other release categories represent less than 1 percent of that plant's risk, there would be no need to quantify the reductions in the frequencies of the nine other release categories for the Stage 1 analysis.

The impact of SAMA implementation on the CDF and the Level 2 release category frequencies can be estimated using importance measures for events that capture the impact of the SAMA. For example, the impact of implementing a SAMA to install a bypass switch for the low level MSIV isolation logic in a BWR may be directly correlated to the operator action for performing the MSIV low level isolation logic bypass. If this is true, the importance lists for the CDF and each of the release categories could be reviewed to identify the RRW values (or FV values) for that operator action, and the percent reduction in CDF and release category frequencies could then be estimated from this information. More specifically, if the operator action to bypass the MSIV low level isolation logic correlates to Risk Reduction Worth (RRW)[9] values of 1.05 or less for CDF and each of the analyzed Level 2 release categories, the averted cost-risk would be limited to about 5 percent of the MB and the SAMA could not be "potentially significant".

If correlating the impact of SAMA implementation to basic event importance measures is not straightforward, the SAMA can be modeled in the PRA to obtain estimates of CDF and release category frequency reductions.

A potential difficulty is a scenario in which implementation of a SAMA reduces some frequencies by more than 50 percent while it does not impact others at all. In these "borderline" cases, it may be possible to justify that the SAMA's averted cost-risk would still be less than 50 percent of the MB if the release category with the reduction that is greater than 50 percent is a low consequence release category. For example, if a SAMA has a large impact on SGTR scenarios in which steam generator makeup is available (i.e., the releases are scrubbed), a discussion could be provided that includes both qualitative and quantitative insights about why the reduction in that release category frequency would not also reduce the MB by more than 50 percent.

[9] For a specified basic event, risk reduction worth importance reflects the decrease in a selected figure of merit when an SSC is assumed to be perfectly reliable. It is the ratio or interval of the figure of merit, evaluated with the SSC's basic event probability set to zero, to the base case figure of merit.

If one or more SAMAs are found to reduce the MB by at least 50 percent, then the SAMAs are considered to be "potentially significant" and a Stage 2 assessment is required.

While the approach described above is adequate for most SAMAs, an alternate quantification process is required for any SAMAs that reduce the consequences of accidents without reducing the CDF or release category frequencies. An example of such a SAMA is the installation of an exterior containment spray system that would deluge the containment break point after a containment failure in order to provide a scrubbing function for materials released through the break. For these types of SAMAs, it would be necessary to develop a plant-specific basis for the MB reduction that would result from implementation of the SAMA. The approach taken may include the use of insights from the Level 2 analysis to identify the frequencies of relevant containment failure modes, and information from the available Level 3 analysis (updated to account for conditions relevant to SLR) to determine the relative importance of the accident scenarios that would be mitigated. If a clear basis cannot be developed that would characterize the reduction in the MB resulting from implementation of the SAMA, then a Stage 2 evaluation of the SAMA would be necessary.

Assessment Considerations:

- As identified above, Risk Reduction Worth values for CDF and all release categories can be used to approximate the percent reduction in the MB for a SAMA. If this process is used, however, care should be taken to ensure that all of the events impacted by the SAMA are considered in the assessment and that the combined impacts of multiple events are appropriately accounted for (e.g., do the events impact some of the same cutsets, or are the events always in separate cutsets).
- Account for the impact of unimplemented plant changes on the SAMA averted cost-risk assessments. In some cases, a general assessment may be appropriate (e.g., no impact on plant risk) while in others it may be necessary to consider such an impact explicitly for each SAMA.
- If the PRA model has been updated since the performance of the 40-to-60-year SAMA, it is possible that the risk profile has changed substantially even if the overall CDF and release category frequencies have not. For this reason, do not use risk reduction assessments from the 40-to-60-year SAMA analysis directly if the PRA model has changed.

3.3 Stage 2 Assessment

If the Stage 1 analysis cannot definitively determine that all of the unimplemented Final Plant-Specific and Applicable Industry SAMAs have averted cost-risk values that are less than 50% of the MB, it will be necessary to perform a more detailed averted cost-risk calculation for the "potentially significant" SAMAs. This requires an update of the Level 3 consequence model and recalculation of the averted cost-risk for each "potentially significant" SAMA using the latest plant risk models.

3.3.1 Stage 2 Averted Cost-Risk Assessment

Once the "new" information has been collected/developed for the Stage 2 assessment (Section 3.1), the following principal steps should be performed to assess the averted cost-risk for the "potentially significant" SAMAs:

1. Update the Level 3 consequence analysis:
    a. Option 1 – Simplified Level 3 Update: In general, the scope of new information that will potentially impact the Level 3 model is broad, which makes it difficult to estimate how the Level 3 results (Dose-Risk, Offsite Economic Cost-Risk) will be changed without directly integrating the new information into the Level 3 model. For example, the forthcoming version

of the MACCS code and associated guidance is anticipated to include changes to the internal economic cost models related to population relocation, which will have release category-specific impacts (i.e., the offsite economic results will scale differently for different plants). If the applicant can develop a strategy to estimate the impact of the new information on the previous Level 3 results (e.g., using insights from previous Level 3 model sensitivity case results) and defend the quality of the strategy, it may be used to justify Option1; otherwise, Option 2 should be used. Issues to consider include, but are not limited to, the following:

i. Changes to "50-mile" population
ii. Changes to agricultural and land-based economic data for the 50-mile radius area
iii. Changes to core inventory (e.g., due to power uprate)
iv. Changes to evacuation times
v. Changes to MACCS code

b. Option 2 – Full Level 3 Update: Use the Level 1 and 2 Internal Events PRA output and site specific meteorology, demographic, land use, and emergency response data as inputs to update the Level 3 consequence analysis performed using the latest available MELCOR Accident Consequences Code System version (as was done for the 40-to-60-year SAMA analysis).

2. Baseline Risk Monetization – Use NRC regulatory analysis techniques [10] to calculate the monetary value of the severe accident risk. That value represents the updated maximum averted cost-risk (MB).
3. Evaluate the "potentially significant" SAMAs in a manner consistent with the NEI 05-01 [9] methodology.
   - Calculate the averted cost-risk.
     - In the event that this averted cost-risk calculation demonstrates that the SAMA does not reduce the updated MB by 50 percent or more, the SAMA may be classified as "not significant."

       This reclassification could occur when the detailed averted cost-risk calculations remove the conservatisms of the Stage 1 assessments for "borderline" SAMAs.
     - SAMAs with averted cost-risk values that are equal to or greater than 50 percent of the MB remain "potentially significant."

3.4 Stage 3 Cost Benefit Assessment

For those SAMAs classified as "potentially significant" in the Stage 2 assessment, determine whether they are potentially cost beneficial in accordance with the process described in Sections 7 and 8 of NEI 05-01. If the new information considered in this assessment does not result in identification of any "potentially significant" SAMAs that are also potentially cost beneficial, the new information is not significant. The identification of a "potentially significant" SAMA that is also potentially cost beneficial is an indication that "new and significant" information exists relevant to the previous SAMA analysis.

3.5 Documentation of the New and Significant Information Review for SAMA

3.5.1 Applicant's Environmental Report

Consistent with guidance in NRC Regulatory Guide 4.2, Supplement 1, Revision 1 [16], the SLR ER should briefly describe the processes that were used for identifying new information and determining its

significance. If a determination is made that no new and significant information exists, then the SLR ER should state this determination.

Alternatively, if a determination is made that one or more "potentially significant" SAMAs are also potentially cost beneficial, then the SLR ER should describe those SAMAs and state that "new and significant" information has been identified. The ER should also indicate whether the "new and significant" SAMAs are aging-related and describe supplementary actions to be taken relative to their discovery, if any.

Further documentation of the new and significant information review that should be maintained is listed in Section 3.5.2, below. Such documentation should be available to the NRC either in the SLR ER (at the SLR applicant's discretion), or in supplemental information for review via E-document reading room, audit, and RAIs.

3.5.2 Supporting Documentation

- Description of data review
- Description of current risk models (at a level of detail consistent with what was expected for the 40-to-60-year License Renewal Application)
    - Level 1
    - Level 2
    - Level 3 (if applicable)

      If only a Stage 1 analysis is required, no Level 3 model discussion is needed[10].

      If a "borderline," "potentially significant" SAMA is assessed using a Stage 2 averted cost-risk calculation and determined not to be significant, indicate the SAMA was assessed according to the model approach and determined not to be "significant." Maintain the Level 3 model in a separate document to support any audit related activities.

      If one or more SAMAs has been determined to be "potentially significant," describe the updated Level 3 model.
- Description of changes to the risk models since the 40-to-60-year License Renewal Application
    - List of PRA revisions
    - Qualitative descriptions of the most significant changes for each revision
    - Include a discussion of the changes made at the plant that have reduced risk.
- The pre-screening criterion used to exclude any of the Stage 1 SAMA candidates from further consideration, including if applicable, the rationale for excluding potentially cost beneficial SAMAs identified in U.S. license renewal applications after submittal of the SAMA analysis for the analyzed plant (i.e., industry SAMAs).
- Percent risk reduction for the non-screened Stage 1 SAMAs
- MB calculation (if applicable)
- Stage 2 averted cost-risk calculation and results for the "potentially significant" SAMAs (if applicable)

[10] As documented in Section 3.1, "new" information elements associated with those stages of the assessment process that were not required to be performed in a plant's analysis should be identified and documented as "new" information, but they do not need to be further developed.

- Modeling description (PRA model changes, assumptions, etc.)
- CDF, release category frequencies, and averted cost-risk values for "potentially significant" SAMAs

- Implementation costs for the "potentially significant" SAMAs passed to the Stage 3 assessment (if applicable)
- Net values for the "potentially significant" SAMAs passed to the Stage 3 assessment (if applicable)
- Conclusions
  - Identify SAMAs, if any, determined in the Stage 1 assessment to be potentially "potentially significant" (i.e., the SAMAs determined to reduce the MB by 50 percent or more).
  - Identify SAMAs, if any, that are considered to be "potentially significant" after the Stage 2 assessment

    Also identify SAMAs that were determined to be "potentially significant" in Stage 1, but were demonstrated to be not "potentially significant" in Stage 2.
  - Identify as "significant" any "potentially significant" SAMAs determined in Stage 3 to be also potentially cost beneficial.

    Indicate whether "new and significant" SAMAs are aging related.

    Describe supplementary actions, if any, to be taken relative to discovery of "new and significant" SAMAs.

    Identify any "new and significant" SAMAs that were not potentially cost beneficial in the 40-to-60-year SAMA analysis.
  - Identify how any "new and significant" SAMAs that were not potentially cost beneficial in the 40-to-60-year SAMA analysis will be further assessed. The discussion should include:

    An explanation of the process by which they will be further considered/ evaluated by the plant.

    An assessment of whether they are aging related.

4 CONCLUSIONS

This document provides a model approach for assessing whether "new and significant" information exists at the license renewal stage with respect to a prior SAMA (or SAMDA) analysis and evaluating any such information, which is a topic that must be considered in a successful SLR application. The intent is to describe the high level steps that are required to perform the analysis and to leave the details of how each of the steps should be performed to the individual analysts to ensure that any plant specific issues are properly addressed. Identifying and prescribing a process to address these types of plant specific issues is beyond the scope of this document and it is incumbent on the analyst to identify and evaluate such issues as part of preparing the SLR application.

Additionally, license renewal applicants are cautioned that for a nuclear plant for which Issue 66 in Table B-1 of Appendix B to 10 CFR Part 51, Subpart A is a "functional equivalent" Category 1 issue, the applicant should also investigate non-SAMA-related new and significant information relevant to the NRC's conclusion for this issue that "[t]he probability-weighted consequences of atmospheric releases, fallout onto open bodies of water, releases to groundwater, and societal and economic impacts from severe accidents are small for all plants."

5 REFERENCES

1. NRC (U.S. Nuclear Regulatory Commission). 2013. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants,* Appendix E, "Environmental Impact of Postulated Accidents." Washington, D.C. NUREG-1437, Volume 3, Revision 1. June 2013. ADAMS No. ML13106A244.

2. NRC (U.S. Nuclear Regulatory Commission). 2013. *Standard Review Plans For Environmental Reviews for Nuclear Power Plants, Supplement 1*. Washington, DC. NUREG-1555, Supplement 1, Revision 1. June 2013. ADAMS No. ML13106A246.

3. NRC (U.S. Nuclear Regulatory Commission). 1997. *Regulatory Analysis Technical Evaluation Handbook*. Washington, D.C. NUREG/BR-0184. January 1997. ADAMS No. ML050190193.

4. ASME (American Society of Mechanical Engineers/American Nuclear Society). 2009. *Addenda to ASME/ANS RA-S-2008, Standard for Level 1/Large Early Release Frequency Probabilistic Risk Assessment for Nuclear Power Plant Applications*. ASME/ANS RA Sa-2009. New York, New York. February.

5. NUMARC 93-01, Industry Guideline for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants, Rev. 2, April 1996.

6. NEI 00-04, 10 CFR 50.69 SSC Categorization Guideline, July 2005.

7. Exelon (Exelon Generation Company, LLC.). *Response to Request for Additional Information*. Kennett Square, PA: Exelon. March 12, 2014. 17 p. ADAMS No. ML14071A378.

8. NRC (U.S. Nuclear Regulatory Commission). *Generic Environmental Impact Statement for License Renewal of Nuclear Plants Regarding Limerick Generating Station Units 1 and 2.* Washington, D.C. NUREG-1437, Supplement 49, Final Report. August 2013.

9. NEI 05-01a, "Severe Accident Mitigation Alternatives (SAMA) Analysis Guidance Document". Rev A. November 2005.

10. NRC (U.S. Nuclear Regulatory Commission). *Regulatory Analysis Guidelines of the U.S. Nuclear Regulatory Commission*. Draft Report. Washington, D.C. NUREG/BR-0058, Rev. 5. April 2017.

11. NRC (U.S. Nuclear Regulatory Commission). 1990. *Backfitting Guidelines*. Washington, D.C. NUREG-1409. July 1990.

12. Exelon Generation Co., LLC (Limerick Generating Station, Units 1 and 2), CLI-13-07, 78 NRC, page 23. October 31, 2013.

13. NRC (U.S. Nuclear Regulatory Commission). Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Appendices, NUREG-1437, Volume 3, Revision 1, Final Report. June 2013

14. Exelon (Exelon Generation Company, LLC.). 2013. Applicant's Environmental Report – Operating License Renewal Stage; Braidwood Station. Appendix F Severe Accident Mitigation Alternatives Analysis. May.

15. NRC (U.S. Nuclear Regulatory Commission). 2017. *Reassessment of NRC's Dollar per Person-Rem Conversion Factor Policy*. NUREG-1530, Revision 1. January 2017.

16. NRC (U.S. Nuclear Regulatory Commission). 2013. *Preparation of Environmental Reports for Nuclear Power Plant License Renewal Applications*. Regulatory Guide 4.2, Supplement 1, Revision 1. June 2013.