U.S.NRC

United States Nuclear Regulatory Commission

Protecting People and the Environment

NUREG-1855: Treatment of PRA Uncertainties in Risk-Informed Decision Making and Revision 2 to Regulatory Guide 1.200

Public Meeting – Savannah, Georgia

February 29, 2008

Objective of Meeting

- Solicit stakeholder on:
  - Draft NUREG-1855
  - Revision 2 to RG 1.200

Meeting Structure/Agenda

- Category 2 Meeting
- Agenda

8:30 am	-	8:45 am	Introduction
8:45 am	-	9:00 am	NRC presentation on Draft NUREG-1855
9:00 am	-	11:30 am	Stakeholder presentations/Open discussion
11:30 am	-	12:30 pm	LUNCH
12:30 pm	-	1:45 pm	NRC presentation on Rev 2, RG 1.200
1:45 pm	-	2:15 pm	Open discussion
2:15 pm	-	2:30 pm	Summary/wrap-up

Draft NUREG-1855

NRC Presentation

NUREG-1855

Chapter 1:	Introduction
Chapter 2:	Overall Approach
Chapter 3:	Understanding the PRA Model
Chapter 4:	Parameter Uncertainty
Chapter 5:	Model Uncertainty
Chapter 6:	Completeness Uncertainty
Chapter 7:	Risk-Informed Decision-Making: Dealing with Uncertainty
Appendix A:	Staff position on EPRI documents

EPRI Interface

- EPRI developing companion documents intended to support NRC NUREG, national consensus PRA standards, and industry PRA related efforts
- NRC working closely with EPRI
- Staff plans to “endorse” EPRI documents in appendix to NUREG-1855

Status and Schedule

- Issued as draft for public review and comment
  - Public review and comment period ends March 28, 2008
- Future public meeting dates:
  - Public meeting, tentative date of April 24, 2008 to go over public comments and staff position
- ACRS meetings
  - Subcommittee, scheduled for April 18, 2008
  - Full committee, scheduled for May 8/9, 2008
- Issue for use, tentatively scheduled June 2008

Future Work

- Training
  - Due to the complexity and importance of this issue, training is being developed to assist users
  - Structure/format of the training being discussed

Stakeholder’s Presentation

Open Discussion

Chapter 1: Objectives

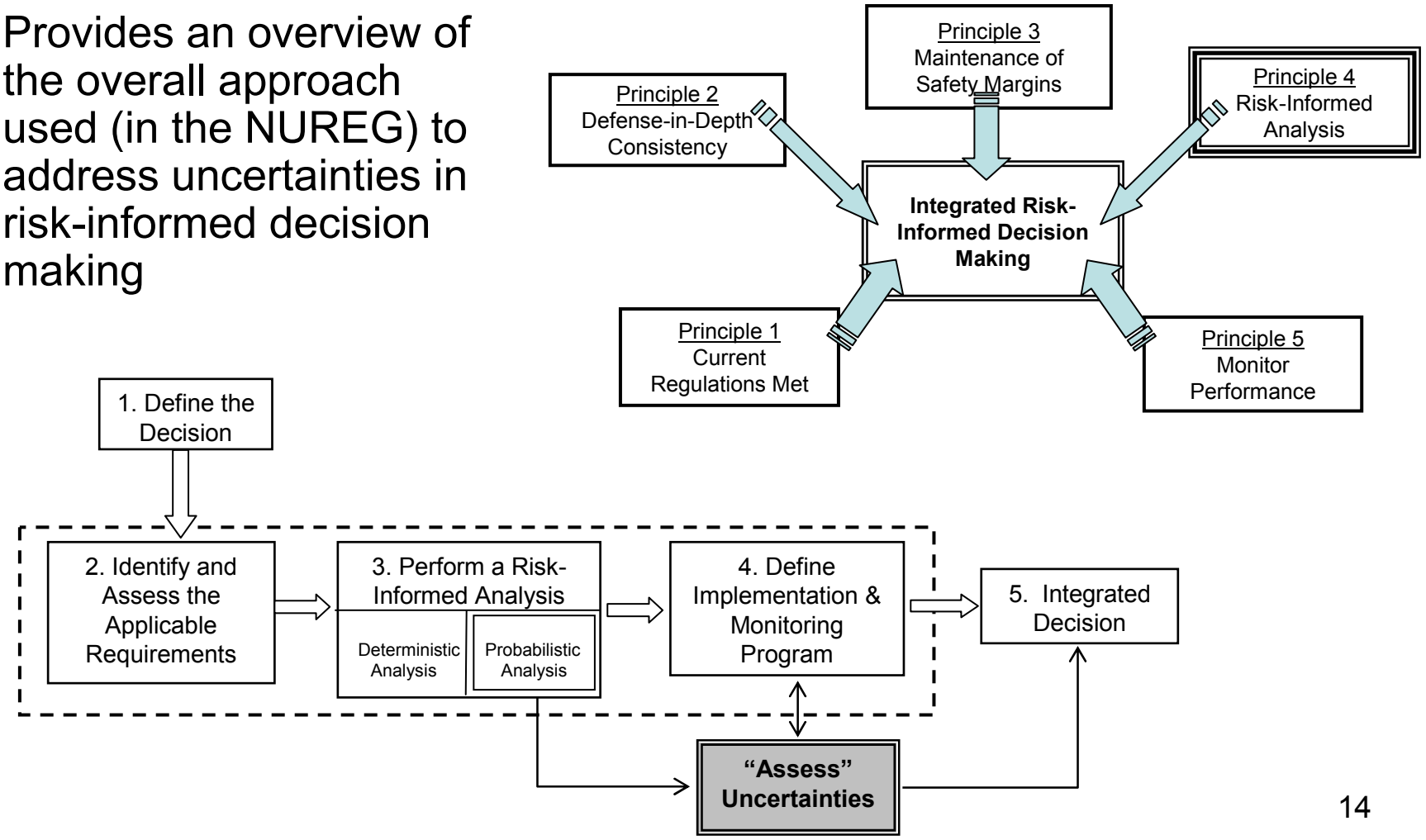
- Provide guidance on how to treat uncertainties associated with PRA in risk-informed decision making
- Objectives of this guidance include fostering an understanding of:
  - The uncertainties associated with PRA
  - The impact of the uncertainties on the results of the PRA
  - The uncertainties in the context of the decision making

Chapter 1: Scope/Application

- Focuses on the use of PRA insights and results and ways to address the associated uncertainties
- Guidance limited to addressing uncertainties associated with use of the risk model results
- Guidance to be consistent with NRC's PRA policy statement and Regulatory Guides 1.174 and 1.200
- Guidance intended to support national consensus PRA standards and industry related work

Chapter 2: Overall Approach

Provides an overview of the overall approach used (in the NUREG) to address uncertainties in risk-informed decision making



Chapter 3: Understanding the PRA Model

- Provides an overview of the characteristics of the PRA model and the different sources of uncertainty associated with a PRA model
  - Focuses on the nature of the model used to characterize risk (i.e., a PRA model)
  - Defines the types of uncertainty that result from the modeling process
  - Describes how these uncertainties are addressed

Chapter 4: Parameter Uncertainty

- Provides guidance on how to address parameter uncertainty in the use of PRA results for decision making
  - Characterization of parameter uncertainty
  - Propagation of uncertainty
    - State of knowledge correlation
  - Comparison of results with acceptance criteria

Chapter 5: Model Uncertainty

- Provides guidance for identifying and characterizing model uncertainties in PRAs and assessing what the impact of model uncertainties is on insights used for risk-informed applications
  - Provides definitions on the concepts of key model uncertainties and related key assumptions
  - Provides process used to identify and characterize key model uncertainties and related assumptions

Chapter 6: Completeness Uncertainty

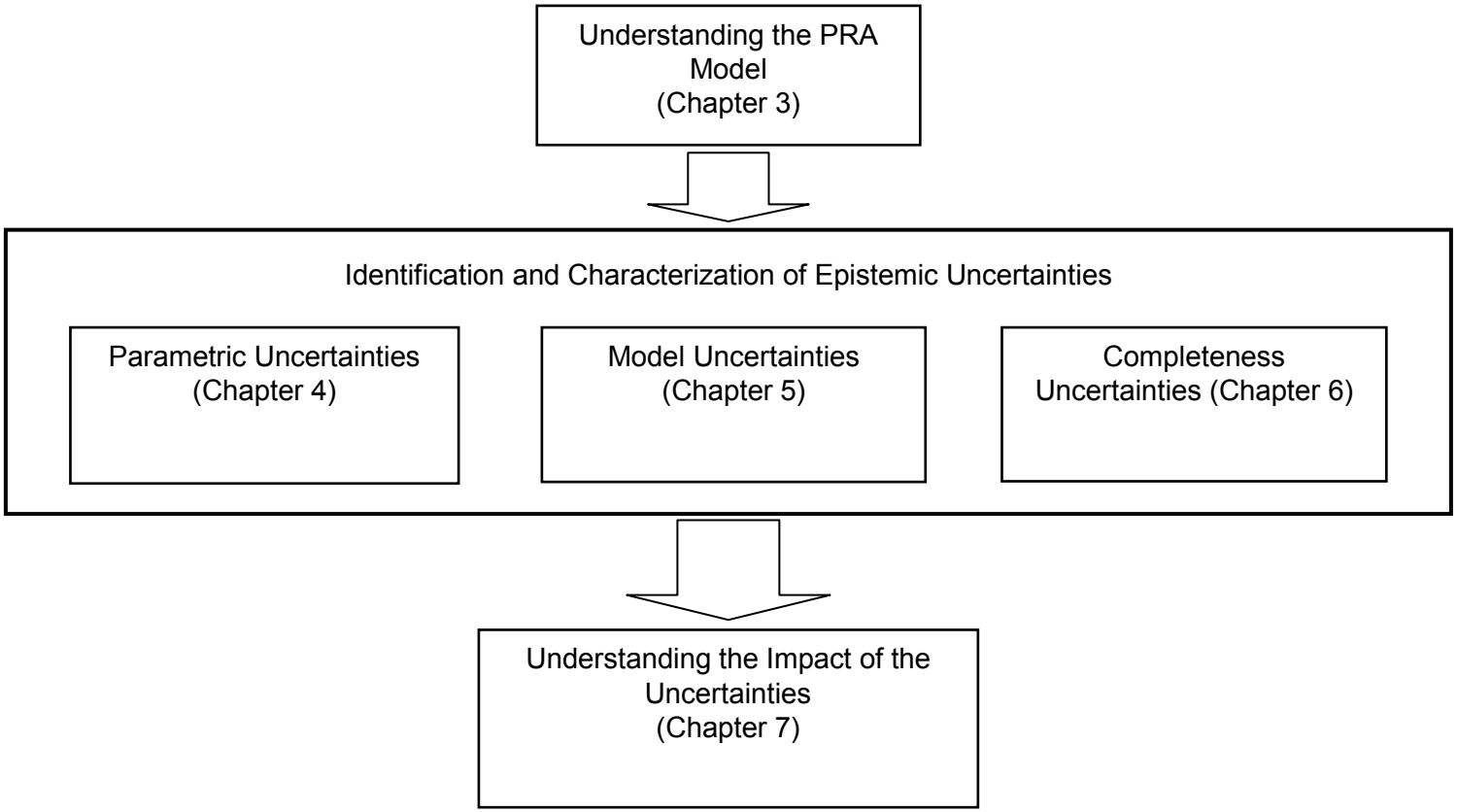
- Provides guidance on addressing one aspect of completeness uncertainty in risk-informed applications – incomplete PRA scope or incomplete PRA level of detail
- Specifically, guidance is provided on
  - Determining the required scope of an application
  - Defining the types of bounding analyses
  - Selecting and using bounding approaches

Chapter 7 -- Risk-Informed Decision Making: Dealing with Uncertainty

- Provides guidance on addressing the uncertainty in PRA results in the context of risk-informed decision making
  - The risk input is only one input to the decision
  - The decision-maker needs an understanding of the robustness of the risk input to the decision
- Specifically, guidance provided on
  - Presenting the results of PRA uncertainty analysis
  - Taking uncertainty into account in addressing the comparison of PRA results with quantitative acceptance criteria
  - Addressing uncertainty in SSC categorization
  - Using qualitative approaches to address uncertainty in integrated decision making

Back-Up Slides
(Draft NUREG-1855 Presentation)

Chapter 2: Overall Approach



The Risk Model

- Introduction of the PRA as the Risk Model
  - All models are approximations
  - Need to “understand” the model to use it correctly
    - PRAs address rare events
      - No direct verification
      - Uncertainties on how to model phenomena or equipment behavior
    - Scope and level of detail at discretion of the analyst

Characteristics of a PRA Model

- Structure of the PRA Model
  - Accident sequences/scenarios as a simplified (discretized) representation of all possible outcomes
  - Probabilistic models for basic events
- Role of Assumptions
  - Assumptions related to scope or level of detail
  - Assumptions related to model uncertainty
- Scope
  - Risk metrics
  - Plant operating states
  - Initiating events

Characteristics of a PRA Model (cont'd)

- Level of Detail
  - A certain level of detail is inherent in the PRA standards (e.g., inter-system dependencies)
  - Some at the discretion of the analyst and driven by the projected use of the PRA
- Combination of Results
  - The models for the different scope items vary in level of detail and conservatism
    - Screening approaches
    - Approximations
  - Needs to be recognized when combining the results

PRA Models and Uncertainty

- Types of epistemic uncertainty
  - Parameter
  - Model
  - Completeness
    - Known omissions
    - Unknown omissions
- Assessing the impact of uncertainty
  - Chapter 4 - Parameter uncertainty
  - Chapter 5 - Model uncertainty
  - Chapter 6 – Completeness
    - Known omissions only - Unknown unknowns addressed through defense-in-depth, safety margins, and performance monitoring
  - Chapter 7 – Uncertainty and risk-informed decision making

Characterization of Parameter Uncertainty

- Parameter uncertainty is the uncertainty in the values of the parameters of a model, given that the mathematical form of the model has been agreed on
  - Usually characterized by using probability distributions on the parameter values
  - Bayesian estimation is commonly used for the characterization

Propagation of Parameter Uncertainty

- Uncertainties in parameters of basic events need to be combined to estimate uncertainty of risk metrics such as CDF, LERF, or intermediate results. Propagation carried out using:
  - Monte Carlo method
  - Latin Hypercube Sampling
- State of Knowledge Correlation must be considered to avoid underestimate of uncertainty

Comparison of Parameter Uncertainties with Acceptance Criteria

- SECY-97-221 identified three possible approaches for comparison with acceptance criteria:
  - Comparing mean values
  - Use of percentile measures
  - Use of one criteria for mean values and a second for a percentile measure
- Most acceptance criteria currently are expressed in terms of mean values, and using mean values for comparison is the current recommended approach

Definitions – Source of Model Uncertainty

A ***source of model uncertainty*** is one that is related to an issue in which there is no consensus approach or model and where the choice of approach or model is known to have an effect on the PRA model (e.g., introduction of a new basic event, changes to basic event probabilities, change in success criterion, introduction of a new initiating event).

A source of model uncertainty is labeled ***key*** when it could impact the PRA results that are being used in a decision and, consequently, may influence the decision being made. Therefore, a key source of model uncertainty is identified in the context of an application. This impact would need to be significant enough that it changes the degree to which the risk acceptance criteria are met and, therefore, could potentially influence the decision. For example, for an application for a licensing basis change using the acceptance criteria in RG 1.174 [NRC, 2002a], a source of model uncertainty or related assumption could be considered "key" if it results in uncertainty regarding whether the result lies in Region II or Region I, or if it results in uncertainty regarding whether the result becomes close to the region boundary or not.

Definitions -- Assumption

- An ***assumption related to a model uncertainty*** is made with the knowledge that a different reasonable alternative assumption exists. A reasonable alternative assumption is one that has broad acceptance within the technical community and for which the technical basis for consideration is at least as sound as that of the assumption being made.

- An ***assumption related to scope or level of detail*** is one that is made for modeling convenience.

- An ***assumption*** is a decision or judgment that is made in the development of the PRA model. An assumption is either related to a source of model uncertainty or is related to scope or level of detail.

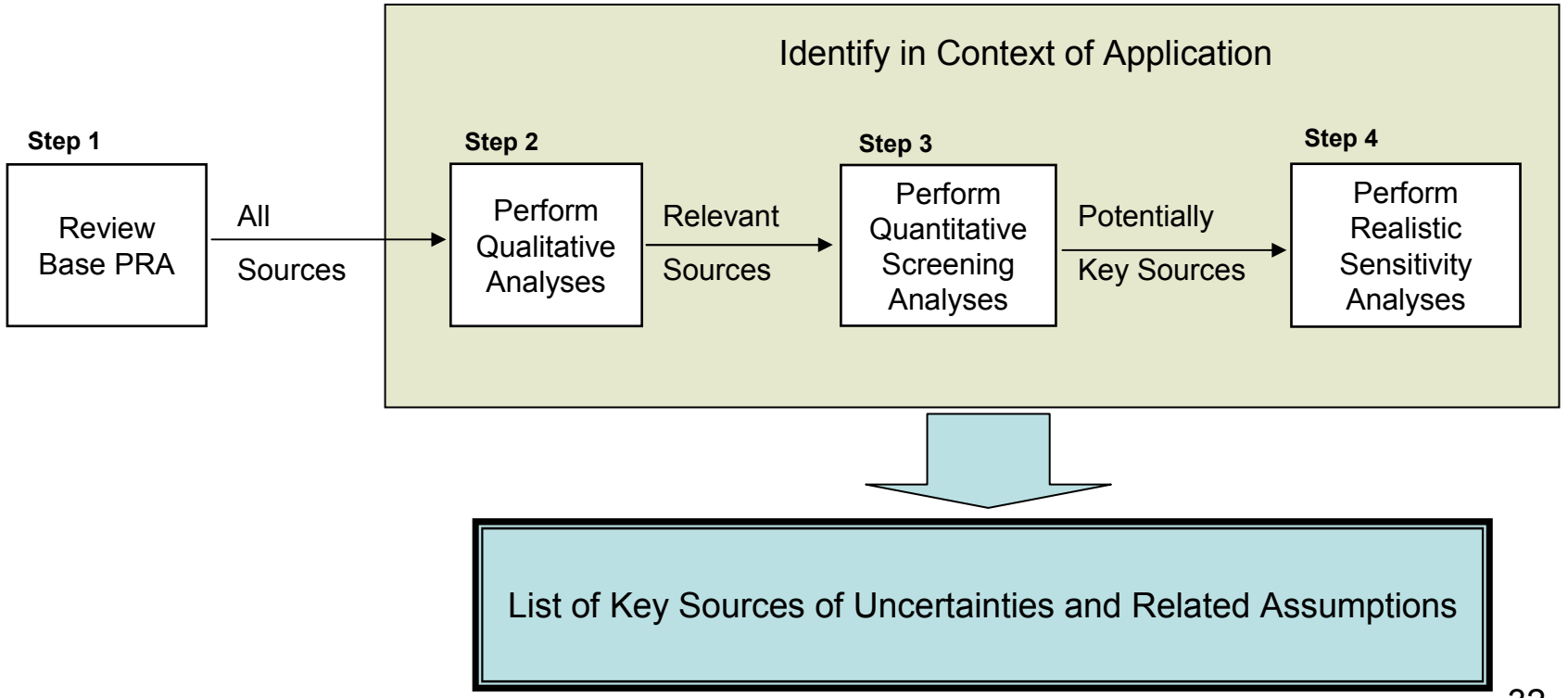
- An assumption is labeled ***key*** when it may influence (i.e., have the potential to change) the decision being made. Therefore, a key assumption is identified in the context of an application.

Definitions – Consensus Model

- ***Consensus model:*** in the most general sense, is a model that has a publicly available published basis and has been peer reviewed and widely adopted by an appropriate stakeholder group. In addition, widely accepted PRA practices may be regarded as consensus models. Examples of the latter include the use of the constant probability of failure on demand model for standby components and the Poisson model for initiating events. For risk-informed regulatory decisions, the consensus model approach is one that the NRC has utilized or accepted for the specific risk-informed application for which it is proposed.

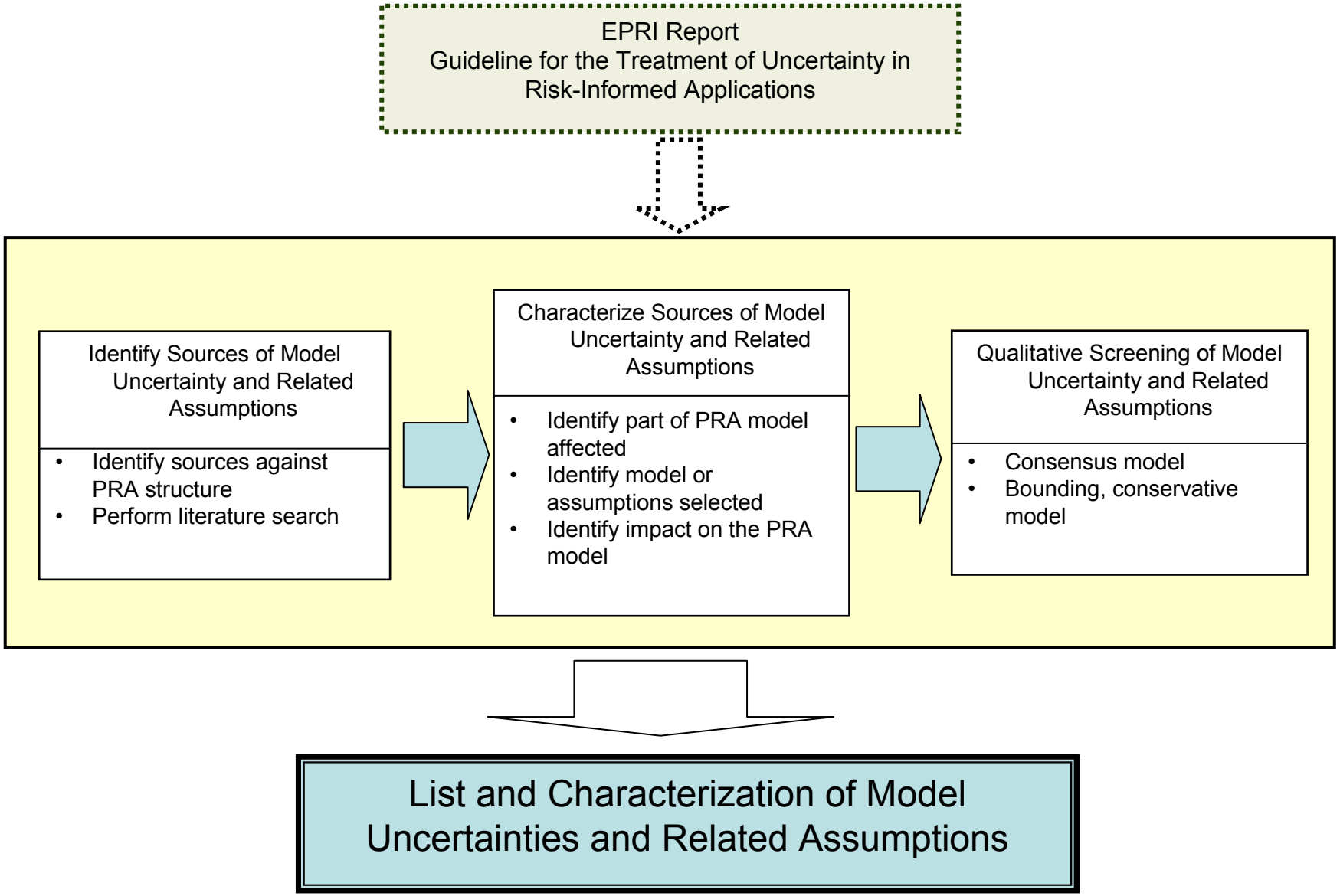
Chapter 5: Overall Process to Identify Key Sources of Model Uncertainties

Four Step Process:



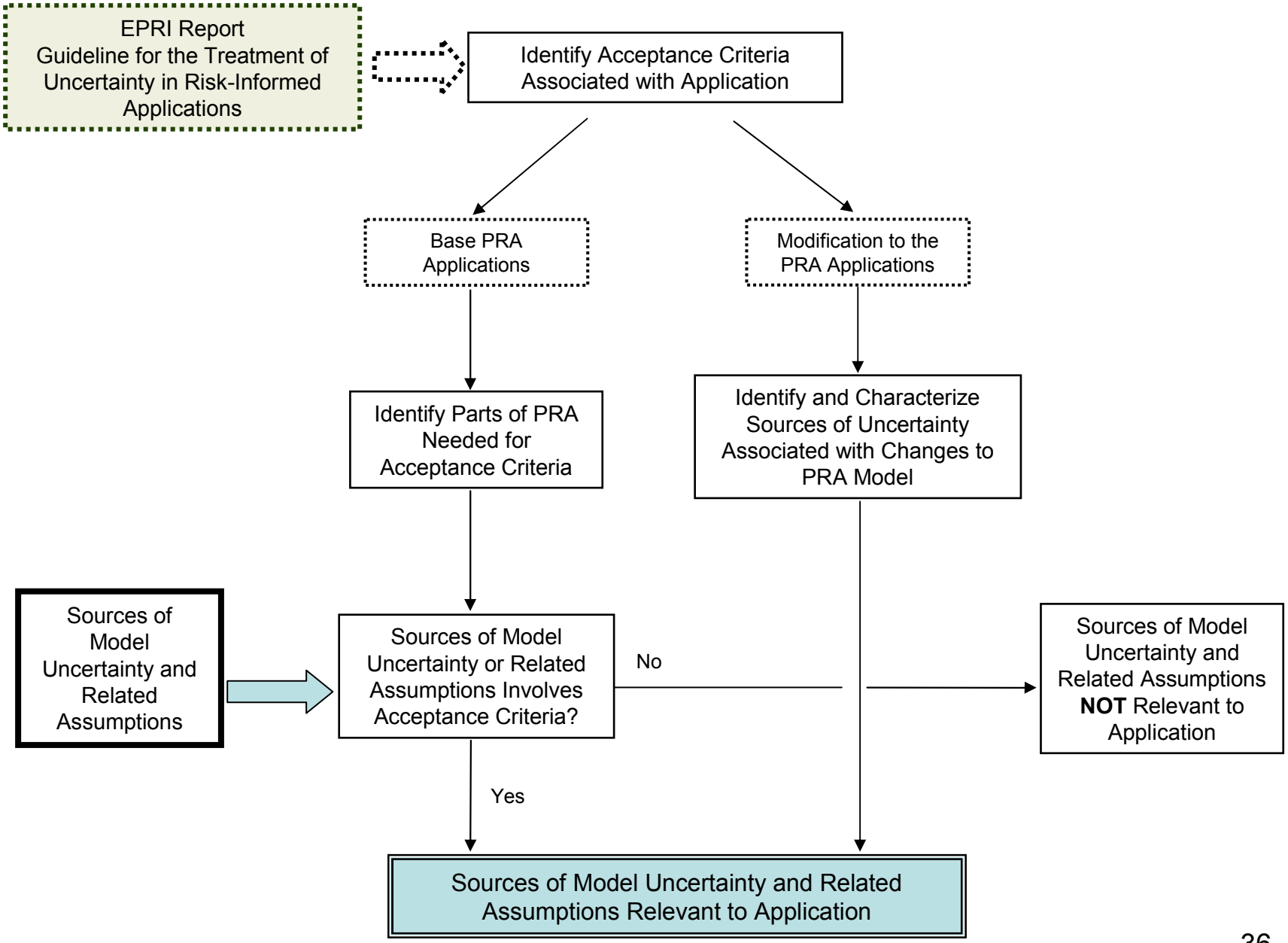
Step 1: Base PRA Sources

- Identify and characterize those sources of uncertainty and related assumptions in the base PRA model
- Three step approach
  - Identification
  - Characterization
  - Qualitative screening
- PRA model can be affected:
  - at the basic event level
  - in the logic structure
  - or both


EPRI Report
Guideline for the Treatment of Uncertainty in Risk-Informed Applications
Identify Sources of Model Uncertainty and Related Assumptions
• Identify sources against PRA structure
• Perform literature search
Characterize Sources of Model Uncertainty and Related Assumptions
• Identify part of PRA model affected
• Identify model or assumptions selected
• Identify impact on the PRA model
Qualitative Screening of Model Uncertainty and Related Assumptions
• Consensus model
• Bounding, conservative model
List and Characterization of Model Uncertainties and Related Assumptions

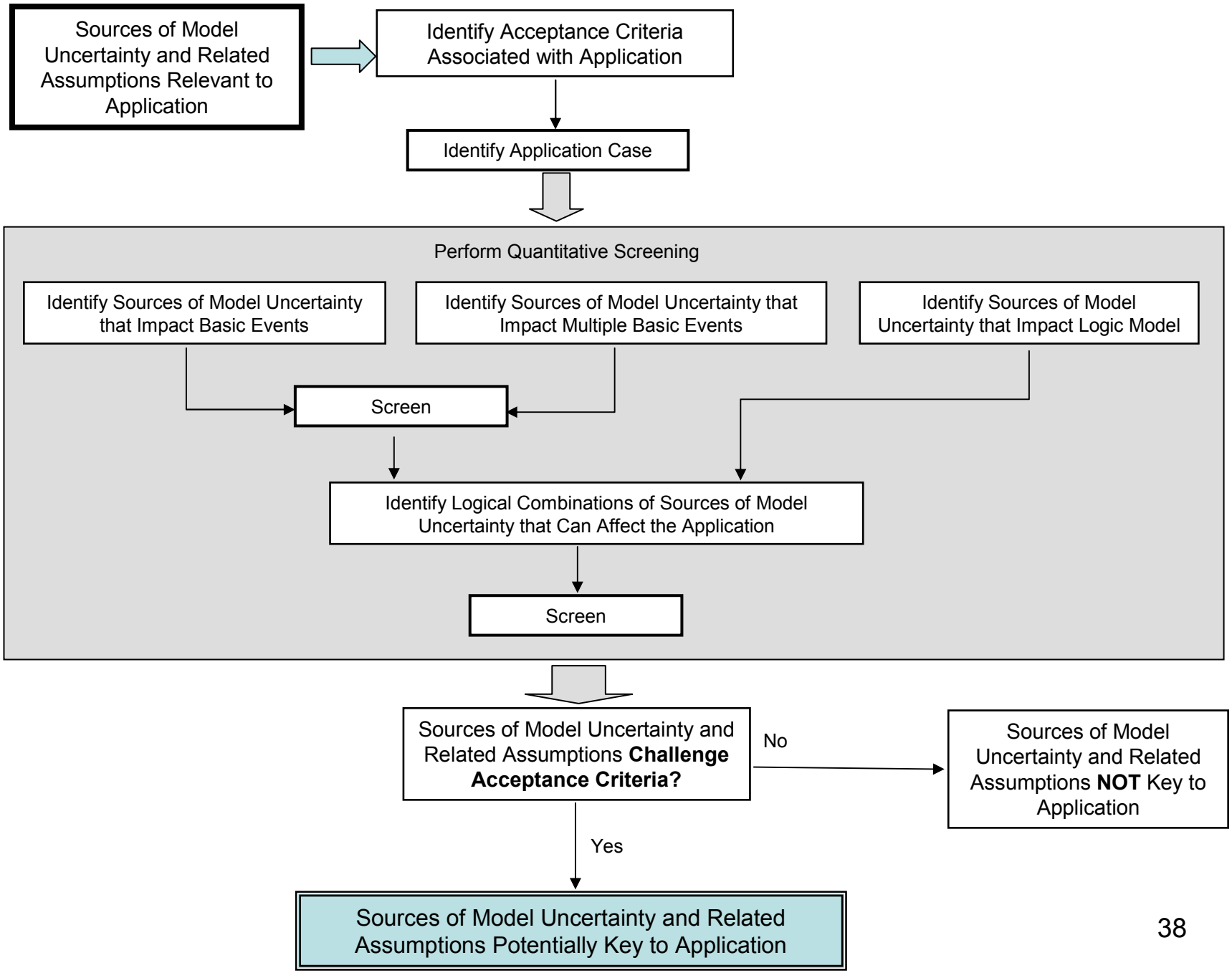
Step 2: Sources Relevant to Application

- Sources only relevant in context of an application
- Approach
  - Understanding application
  - Screening
- Acceptance criteria for the application will include cumulative objectives, incremental objectives, or both
- New sources may be introduced by the application


EPRI Report
Guideline for the Treatment of Uncertainty in Risk-Informed Applications
Identify Acceptance Criteria Associated with Application
Base PRA Applications
Modification to the PRA Applications
Identify Parts of PRA Needed for Acceptance Criteria
Identify and Characterize Sources of Uncertainty Associated with Changes to PRA Model
Sources of Model Uncertainty and Related Assumptions
Sources of Model Uncertainty or Related Assumptions Involves Acceptance Criteria?
No
Yes
Sources of Model Uncertainty and Related Assumptions **NOT** Relevant to Application
Sources of Model Uncertainty and Related Assumptions Relevant to Application

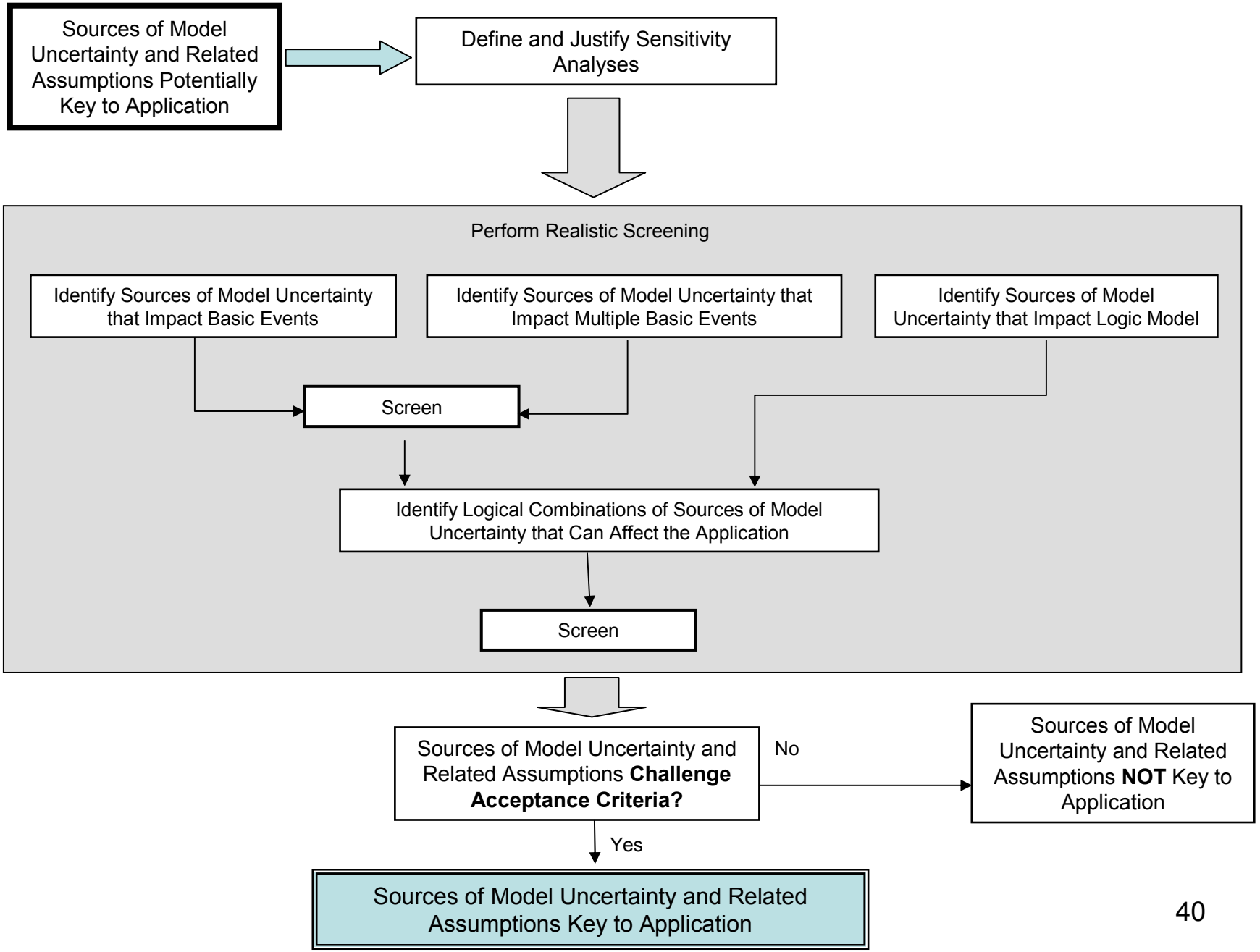
Step 3: Potential Key Sources

- Identify sources that can potentially impact the decision
- Evaluate the “importance” of the source
- Evaluate in terms of:
  - Cumulative or incremental acceptance criteria
  - Single basic event, multiple events, logic structure, or logical combinations


Sources of Model Uncertainty and Related Assumptions Relevant to Application
Identify Acceptance Criteria Associated with Application
Identify Application Case
Perform Quantitative Screening
Identify Sources of Model Uncertainty that Impact Basic Events
Identify Sources of Model Uncertainty that Impact Multiple Basic Events
Identify Sources of Model Uncertainty that Impact Logic Model
Screen
Identify Logical Combinations of Sources of Model Uncertainty that Can Affect the Application
Screen
Sources of Model Uncertainty and Related Assumptions **Challenge Acceptance Criteria?**
No
Sources of Model Uncertainty and Related Assumptions **NOT** Key to Application
Yes
Sources of Model Uncertainty and Related Assumptions Potentially Key to Application

Step 4: Key Sources

- Perform realistic sensitivity analyses
- Identify sources that actually influence the decision
- Define acceptable sensitivity analyses
- Evaluate in terms of:
  - Cumulative or incremental acceptance criteria
  - Single basic event, multiple events, logic structure, or logical combinations


Sources of Model Uncertainty and Related Assumptions Potentially Key to Application
Define and Justify Sensitivity Analyses
Perform Realistic Screening
Identify Sources of Model Uncertainty that Impact Basic Events
Identify Sources of Model Uncertainty that Impact Multiple Basic Events
Identify Sources of Model Uncertainty that Impact Logic Model
Screen
Identify Logical Combinations of Sources of Model Uncertainty that Can Affect the Application
Screen
Sources of Model Uncertainty and Related Assumptions **Challenge Acceptance Criteria?**
No
Sources of Model Uncertainty and Related Assumptions **NOT** Key to Application
Yes
Sources of Model Uncertainty and Related Assumptions Key to Application

Required PRA Scope for Application

- Scope of the required PRA defined by:
  - Risk metrics relevant to the application
  - Plant operating states affected by application
  - Initiating events affected by the application
- PRA level of detail
  - Minimum level determined by PRA standards
  - Applications can require higher or lower levels
- Base PRA scope or level of detail may require upgrading if important to application

Bounding Analyses

- Bounding analyses can be used to address missing PRA scope or level of detail
  - Demonstrate that the missing scope is not important to risk, or
  - Provide a bounding risk estimate
- Bounding analyses capture the worst credible outcome and frequency of that outcome
  - Screening can be performed based on frequency, outcome, or both
- Acceptable bounding analyses address:
  - Completeness of potential impacts and their effects
  - Frequency

Selection and Use of Bounding Approaches

- Bounding approach is specific to event being considered
- Screening of risk contributors – progressive process
  - Qualitative screening
  - Quantitative screening
- Bounding risk contributors
  - Simplified risk assessment with conservative quantification
  - Use of surrogate events

Presenting the Results of PRA Uncertainty Analysis

- Approaches to presentation
  - Continuous probability distribution
  - Discrete probability distribution
  - Provide results for different assumptions/models
  - Bounds or ranges
- Tools for understanding what is driving the uncertainty
  - Importance analysis
  - Sensitivity analysis

Comparison of PRA Results with Acceptance Criteria

- Uncertainty arising from level of detail
  - The model must have sufficient level of detail to address the decision
  - Minor differences can occur
- Parameter uncertainty
  - Method of comparison is dictated by the formulation of the acceptance criteria
  - Results should be qualified recognizing any conservatisms associated with the level of detail
  - Issues with “bright line” criteria

Comparison of PRA Results with Acceptance Criteria (Cont'd)

- Model Uncertainty
  - Focus on supplying the decision maker(s) with an assessment of the credibility of alternate hypotheses that affect the decision
- Completeness
  - For those contributors not included in the PRA, either demonstrate the effect is insignificant, or modify the implementation of the decision
- Combining results
  - Essential to understand the contributors to the risk results, and their risk pedigree

Qualitative Approaches

- Used when contribution to risk are not or cannot be addressed quantitatively
  - Performance monitoring
    - Used to confirm an assumption (e.g. 50.69)
  - Limiting scope of plant modification
    - NEI 00-04 approach to dealing with less than full scope PRAs
  - Use of compensatory measures
    - Used to neutralize the expected impact of a change

Revision 2 to Regulatory Guide 1.200 (NRC Presentation)

Scope of RG 1.200

- Address technical acceptability for Level 1 and Level 2 (i.e., LERF) for PRA for at-power, low power and shutdown conditions for both internal and external events
- Address PRA technical acceptability to support both operating reactors (Part 50) and new reactors (Part 52)
- Does not address future advanced reactors

Revision 2 to RG 1.200

- Further clarification on staff position regarding
  - Relationship to Part 52
  - High level requirements for low power and shutdown PRA
  - Treatment of uncertainties
  - Risk aggregation
- Staff Endorsement
  - ASME/ANS PRA standard RA-S-2007
  - NEI 00-02
  - NEI 05-04
  - NEI 07-12

Relationship to Part 52

- Large release risk metric for Part 52
  - Regulatory Position (RP) 1.1, Scope of PRA
  - RP 1.2.2, Footnote 4
  - RP 1.2.6, Interpretation of Results
- As-designed for DC and COL applicants as opposed to as-built and as-operated for operating plants
- Plant walkdowns
- Plant-specific site characteristics
- Peer review experience

Low Power And Shutdown PRA

- RP 1.3
  - Table 2, addresses at-power conditions
  - New table added providing high level requirements for low power and shutdown (LPSD) for each technical element

Treatment of Uncertainties

- NUREG-1855 referenced
- Clarification published on Revision 1 will be incorporated
- Definitions added consistent with ASME/ANS standard

Risk Aggregation

- All contributors have to be considered
- Need to understand:
  - Different levels of detail
  - Different levels of uncertainty
  - Sources of uncertainty and related assumptions

Staff Endorsement – Parts 1 and 2 of ASME/ANS Standard

Initial views: does not represent a final or complete set of staff comments

- See comments provided in letter to ASME on combined standard in ADAMS accession #ML073030364

Overall Comments Parts 1 and 2

Initial views: does not represent a final or complete set of staff comments

- Majority of the staff concerns are “clarifications”
- Part 1(General)
  - definitions containing the term “key assumptions” and “key sources of uncertainties”
  - need to be consistently addressed across all four parts of the combined standard.
- Part 2 (Internal Events)
  - “qualification” regarding the lack of a requirement for quantification of the probability of failure to repair
  - Clarification on scope of supporting requirements addressed by peer review

Staff Endorsement – Part 3 of ASME/ANS Standard

Initial views: does not represent a final or complete set of staff comments

- Comments provided in letter to ASME on combined standard ADAMS # ML073030364
  - General comment: while the requirements are thorough, they are possibly overly complex. However, this complexity should be addressed in the pilot applications of this part of the standard
- Concern with the way in which the term “significant’ has been used in Part 3 (e.g., FSS-C2, CF-A1, HLR FQ-E, QNS-C1)
  - term should be interpreted as being assessed with respect to the fire risk
- Some issues related to use of the term “bounded or accurately characterized” e.g. FSS-B2, FSS-D3
- Clarification on plant partitioning requirements

Staff Endorsement – Part 4 of ASME/ANS Standard

Initial views: does not represent a final or complete set of staff comments

- See comments provided in letter to ASME on combined standard in ADAMS accession #ML073030364
  - Overall comment Part 4 (External Events): This part of the standard is difficult to use because it is not formulated in a parallel manner to the other parts (i.e., Parts 2 and 3). This difficulty should be addressed in future revisions of the combined standard.
- Majority of staff objections believed to be addressed
- Hazard curve for tornadoes – some information in note should be in the requirements

Staff Endorsement – NEI 00-02

Initial views: does not represent a final or complete set of staff comments

- No changes from staff position in Revision 1other than for support of Part 52
  - Reliability and assurance program
  - Risk significant system list

Staff Endorsement – NEI 05-04

Initial views: does not represent a final or complete set of staff comments

- Majority of staff objections believed to be addressed
- Concern about the discussion of skipping of SRs to be reviewed in Section 4.6
  - all SRs affected by the upgrade need to be assessed

Staff Endorsement – NEI 07-12

Initial views: does not represent a final or complete set of staff comments

- Qualifications
  - NEI 07-12 should refer to ASME/ANS combined standard rather than the ANS Fire PRA Standard
  - Section 3.2, the assessment should be based on the fire PRA standard AND on the NRC clarifications or qualifications
  - Section 3.2 would allow the peer review team to skip selected SRs
    - all SRs need to be assessed
- Clarifications
  - Supporting requirements addressed by reference
  - Others more of a minor nature

Tentative Schedule for Issuance of Revision 2 and Public Meetings

- April 2008 – public meeting
  - Share final staff comments
  - Tentative date of April 17, 2008
- May 2008 – issue for public review and comment
- Early/mid June – public meeting
  - Solicit public comments
- July/August – public meeting
  - Share staff response to public comments
- December 2008 – publish Revision 2 to RG 1.200