# Discussion of Guidance on Treatment of Uncertainty in Risk-Informed Oversight Activities

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***Working Group #2: Treatment of Uncertainty in Decision Making***

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# Significance Determination Process

Objective: The SDP uses risk insights, where appropriate, to help NRC inspectors and staff determine the safety or security significance of inspection findings

| Significance Determination Process (IMC0609): Estimated ΔCDF (per year) | | | |
|---|---|---|---|
| **CDF < 1E-6** | **1E-6 ↔ 1E-5** | **1E-5 ↔ 1E-4** | **CDF > 1E-4** |
| **GREEN** | | | |
| *VERY LOW* | **WHITE** | | |
| | *LOW TO MODERATE* | **YELLOW** | |
| | | *SUBSTANTIAL* | **RED** |
| | | | *HIGH* |

| Significance Determination Process (IMC0609): Estimated ΔLERF (per year) | | | |
|---|---|---|---|
| **LERF < 1E-7** | **1E-7 ↔ 1E-6** | **1E-6 ↔ 1E-5** | **LERF > 1E-5** |
| **GREEN** | | | |
| *VERY LOW* | **WHITE** | | |
| | *LOW TO MODERATE* | **YELLOW** | |
| | | *SUBSTANTIAL* | **RED** |
| | | | *HIGH* |

# Inspection Manual Chapter (IMC)

IMC 0609, "Significance Determination Process (SDP)“

- Guidance for assessing the safety or security significance of inspection findings.
- Various SDP tools for all safety cornerstones are appendices to IMC 0609.

IMC 0308, Attachment 3, "Significance Determination Process Basis Document"

- Each SDP tool (i.e., appendix) has an associated technical basis document.

# IMC 0308, Attachment 3

## Section 7:

- The risk-informed SDP process inherently and qualitatively considers uncertainty.
- The "point-estimate" numerical risk values do not represent any dispersion characteristic (i.e. spread) of these functions.
- Limitations exist for any specific risk model, in terms of completeness of the model and basis for its various probabilistic (e.g., accident sequence logic) and technical (e.g., success criteria for mitigation functions) assumptions.

# IMC 0609, Attachment 1 (SERP)

Preliminary SERP Reviews:

1. The risk analysis should include a discussion of uncertainty resulting from model completeness, parameter values, or lack of data, as well as the best case assumptions and analysis.

2. Qualitative, as well as quantitative, information should be considered in deriving a color recommendation.

3. It is not necessary to use Appendix M if existing SDP tools are generally sufficient to risk-inform the finding. However, Appendix M may be appropriate if no SDP tools exist, or inputs to an existing SDP are very influential and cannot be derived through existing SDP resources (e.g., NUREGs, industry documents, RASP guidance, etc.).

# IMC 0609, Attachment 1 (SERP)

Specific Guidance for Final Determination SERP

1. When point-estimate values of delta CDF (or delta LERF) are very close to a threshold, the SERP should re-examine the bases for all significant assumptions, to assure that they are reasonable and are not being biased. If these are judged reasonable, the decision should proceed based upon the resultant value of the point estimate.

2. …When the span between bounding results is a single color, then this may become the SDP result. If the span between bounding results includes multiple colors, then further deliberation or fact gathering must be performed to reduce the level of uncertainty to a single color span.

# IMC 0609, Attachment 1 (SERP)

SERP Package Template (Risk Analysis Section)

Sensitivity Analysis

- Contributions of greatest uncertainty factors and impact on assumptions (The staff should describe the quantitative and qualitative uncertainties and state how they impact the influential assumptions)
- The staff should bound the uncertainties, if possible, and through sensitivity analysis (quantitative and qualitative) state why they are conservative. Bounding an assumption between two reasoned limits and selecting an average value is acceptable. The SERP will judge whether the staff's arguments are reasonable and unbiased.

# Qualitative Criteria in SDP (App M)

0308 Att 3, App M Technical Basis for the Significance Determination Process (SDP) Using Qualitative Criteria

0609 App M Significance Determination Process Using Qualitative Criteria

- Used when (PRA) methods and tools cannot adequately address the finding's complexity or provide a reasonable estimate of the significance due to modeling and other uncertainties within established SDP timeliness goal

- In some instances, the uncertainties associated with a risk evaluation using an existing SDP are too broad for decision-making.

- For example, a degraded condition may be specifically modeled or uncertainties associated with an initiating event frequency or failure rate probability may not exist.

# IMC 0609, Appendix M (Qualitative)

**4.1.1** A bounding quantitative and/or qualitative evaluation (i.e., worst case analysis) should be initially performed, if feasible, using best available information to determine the significance of the finding:

**4.2.1** For findings in which the risk significance could be greater than Green, evaluate the following attributes to determine the significance of the finding:

- Defense-in-Depth
- Safety Margin
- Extent of condition
- Degree of degradation
- Exposure time
- Recovery actions

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# RASP Handbook Guidance

## Risk Assessment of Operational Events (RASP) Handbook

Methods and guidance that the NRC staff use to achieve more consistent results when performing risk assessments of operational events and licensee performance issues. Primarily applied to risk assessments:

- Detailed Significance Determination Process (SDP) evaluations
- Accident Sequence Precursor (ASP) Program, and
- Event assessments under the NRC's Incident Investigation Program [in accordance with Management Directive (MD) 8.3]

  - Volume 1 - Internal Events (Revision 2)
  - Volume 2 - External Events (Revision 1.01)
  - Volume 3 - SPAR Model Review (Revision 2)
  - Volume 4 – Shutdown Events (Revision 1.0)

# RASP Handbook v.1 - Appendix A

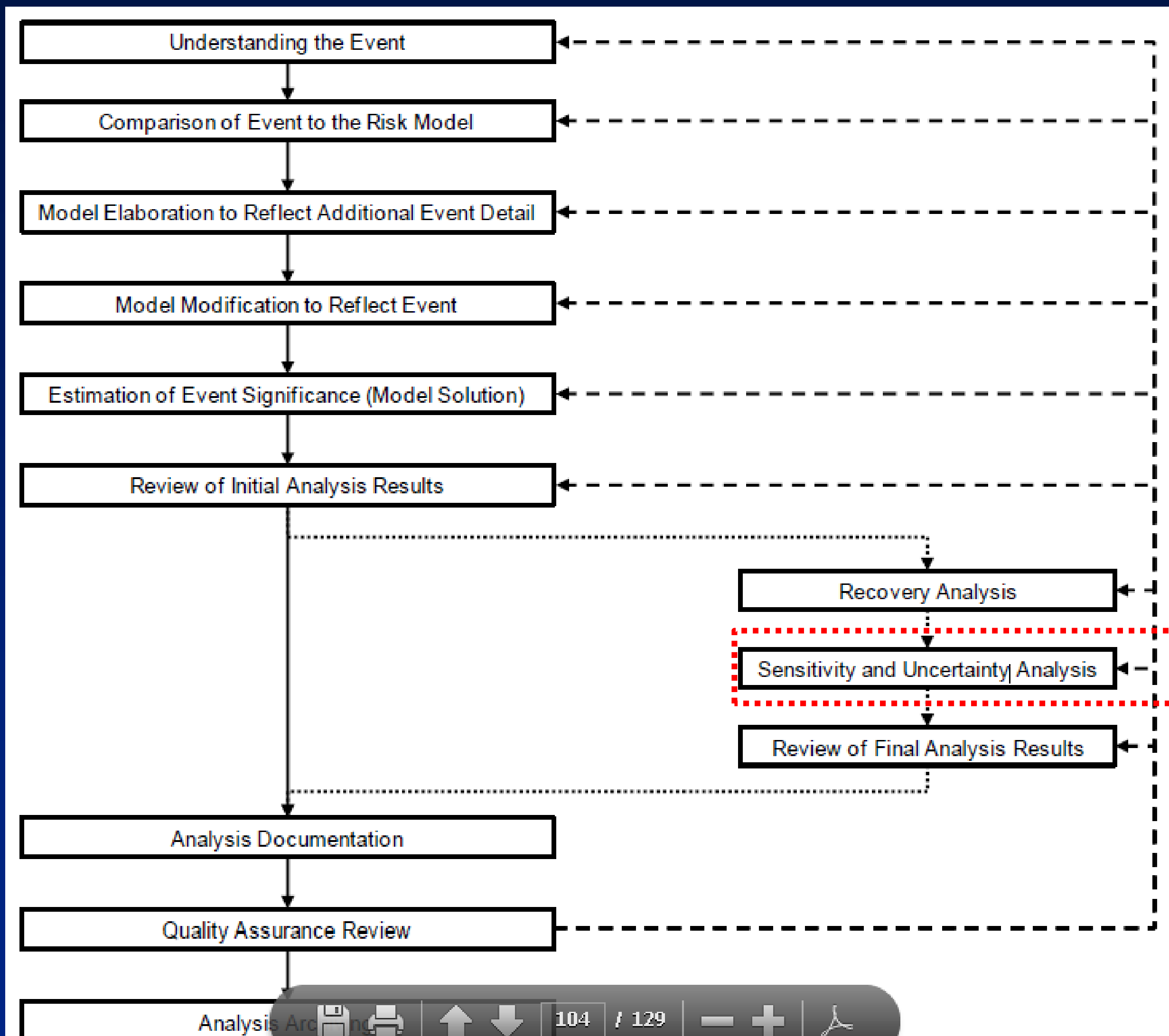


**Figure A-1.** Risk Analysis of Operational Events—Process Flow.

STEP 9

# RASP Handbook v.1 - Appendix A

**Step-9: Sensitivity and Uncertainty Analyses.** Sensitivity and uncertainty analyses provide estimates of the variability in the risk estimate due to data variability, model inaccuracy, and modeling assumptions included in the event analysis.

## ***Uncertainty analysis***

- A typical uncertainty analysis addresses the impact of data variability in the basic event parameters included in the model (e.g., initiating events frequencies, failure probabilities, unavailability probabilities, common-cause failure probabilities, human error probabilities, non-recovery probabilities).

- Two sampling techniques are provided in SAPHIRE code for estimation of the variability (due to the uncertainties in the basic event probabilities) of either a fault tree top event probability or an event tree sequence frequency: Monte Carlo simulation and Latin Hypercube simulation. Either is adequate for most ASP and SDP analyses. Monte Carlo simulation methods are generally used to perform uncertainty analysis.

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# RASP Handbook v.1 - Appendix A

**Step-9: Sensitivity and Uncertainty Analyses.** Sensitivity and uncertainty analyses provide estimates of the variability in the risk estimate due to data variability, model inaccuracy, and modeling assumptions included in the event analysis.

## ***Sensitivity analysis***

- A typical sensitivity analysis addresses the impact of alternate analysis assumptions and technical issues in SPAR models.
- Analysis assumptions are related to the uncertain specifics of the operational event, usually the reliability of a degraded component.
- Technical issues with SPAR models include known areas of uncertainties, such as CCF modeling and human reliability analysis modeling, and other potential modeling issues that have been identified through quality review process of the SPAR model. These technical issues are generic to plant classes and SPAR models.

# RASP Handbook v.1 - Appendix A

**Some considerations include the following:**

- **Sensitivity analysis.** Sensitivity analyses should be performed on assumptions developed in Steps 1 and 2 of this appendix, as well as key SPAR model assumptions and technical issues that potentially drive the risk.
- If an uncertainty analysis has been performed, address assumptions that result in point estimates outside the 5th and 95th percentile uncertainty bounds calculated below.
- **Uncertainty analysis.** A Monte Carlo uncertainty analysis should be performed using the recovered cut sets that represent the final analysis results.
  - Ensure that all basic events, including non-recovery actions added to the initial analysis cut sets, are defined in terms of probability distributions (except basic events assigned a probability of 1.0).
  - Utilize a sufficient number of trials to insure accuracy (at least 10,000 trials are recommended). Confirm that the mean estimate developed in the Monte Carlo analysis is consistent with the point estimate developed from the cut sets.
  - Include the results of the Monte Carlo analysis in the analysis documentation. Discuss the impact of the estimated range in risk significance on the overall conclusions of the analysis.

# RASP Handbook v.2

This volume is intended to complement Volume 1 for Internal Events. Specifically, this volume provides the following guidance:

- Internal Flood Modeling and Risk Quantification
- Internal Fire Modeling and Risk Quantification
- Seismic Event Modeling and Seismic Risk Quantification
- Other External Events Modeling and Risk Quantification

**Revision 2 plans.** Current plans for Revision 2 of the handbook will include the following additional method guides and tutorials:

Methods

- Common-Cause Failure Determination and Modeling
- SPAR-H Human Reliability Analysis Method
- Parameter Estimation and Update Methods
- Convolution of Failure to Run Parameters Method
- **Uncertainty Analysis Method**
- Simplified Expert Elicitation Method

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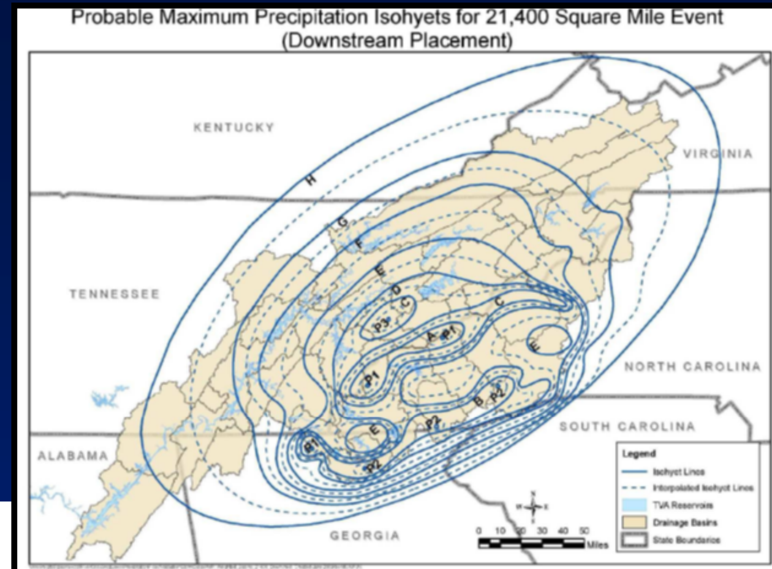
# SDP Examples – EDG FR

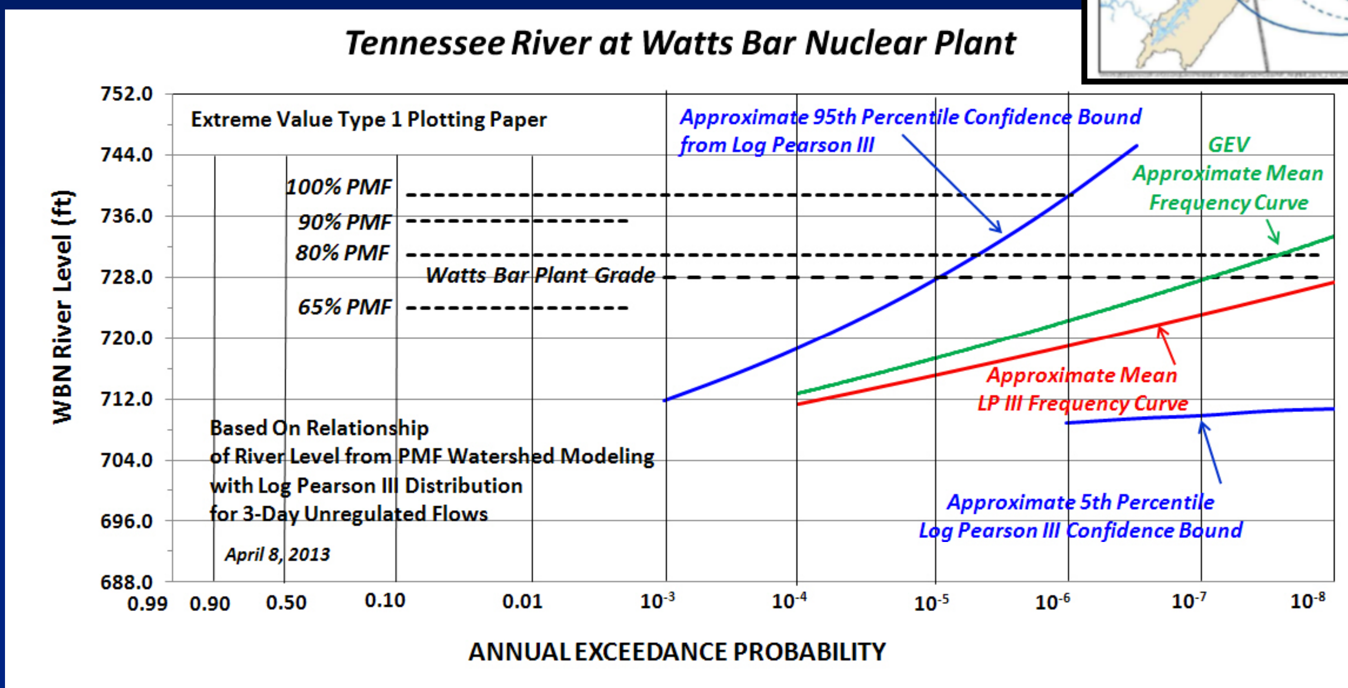
EDG failure to run (Model Uncertainties):

1. Exposure Time
2. Common Cause Failure (CCF)

| Exposure Time | CCF | Outcome |
|---|---|---|
| 22 days | Yes | 6E-6 |
| 3 days | Yes | 9E-7 |
| 22 days | No | 2E-6 |
| 3 days | No | 3E-7 |

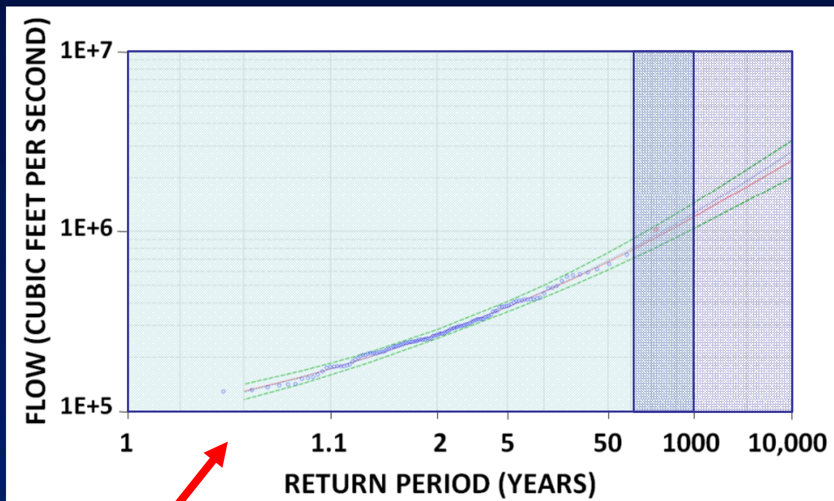
# SDP Examples – Ext. Flooding



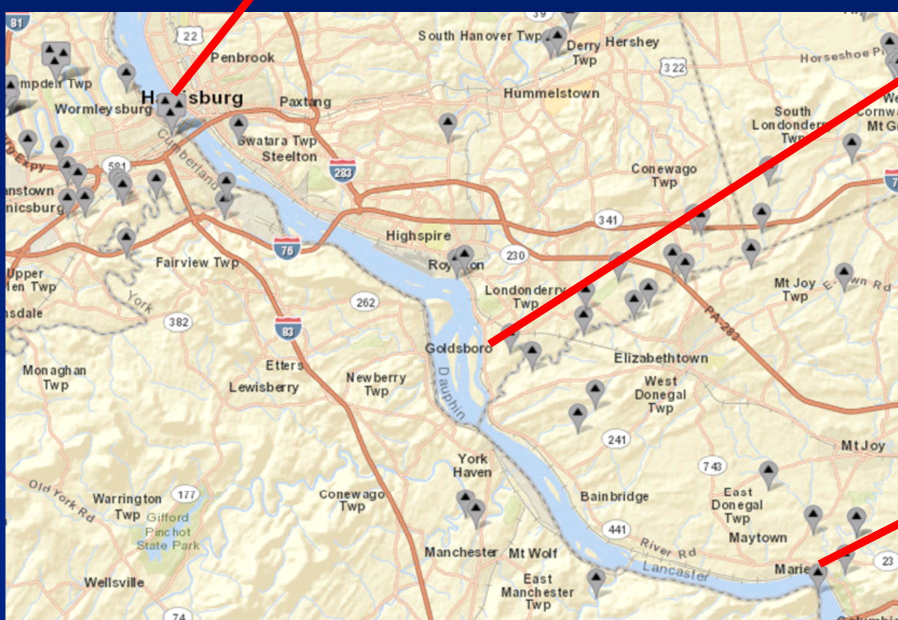



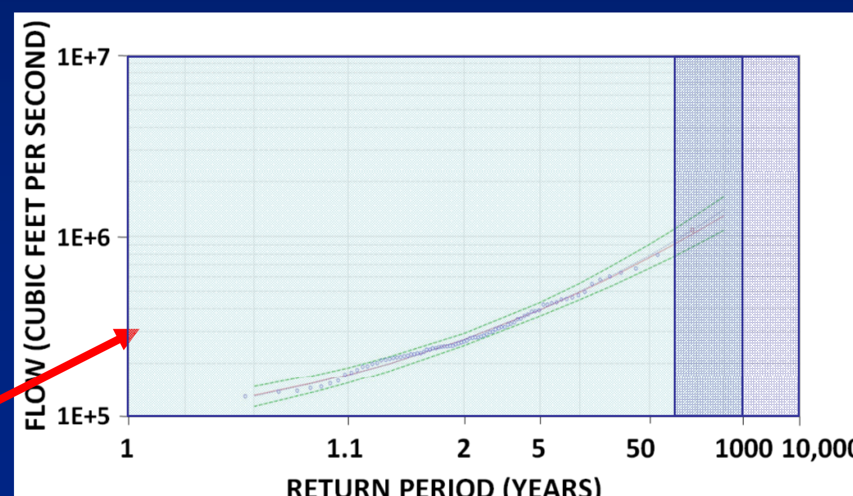

***Source: Tennessee Valley Authority Public Presentation (April 22, 2013)***

# SDP Examples – Ext. Flooding




*Source: USNRC – Public Archive*




*Sources: USGS – National Water Information System (NWIS) Mapper*