OUR PFHA EXPERTISE

At RIZZO Associates, our engineers have recognized the significance of Probabilistic Flood Hazard Assessment (PFHA) for the future of engineering analysis and infrastructure risk management. PFHA supports good engineering design practice by allowing key stakeholders and decision makers to make risk informed choices rather than simply relying on traditional deterministic flood analyses (e.g., a Probable Maximum Flood).

PFHA is an actively growing area of research and is of particular interest to regulatory bodies in the United States and around the world, including the International Atomic Energy Agency (IAEA), the United States Nuclear Regulatory Commission (NRC), the United States Federal Energy Regulatory Commission (FERC), United States Army Corps of Engineers (USACE), United States Bureau of Reclamation (USBR), and many others.

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We at RIZZO are well positioned to participate in PFHA analysis, considering our extensive involvement in both the dams and nuclear industries (two industries that are actively pursuing risk-informed methods for flooding).

Our PFHA expertise includes probabilistic analysis for:

- Storm surges and seiches
- Precipitation floods
- River floods
- Tsunami
- Dam failures
- Watercourse containment structure failures

A RECOGNIZED PFHA VOICE

RIZZO regularly engages with the engineering community and was invited to join the American Nuclear Society standards committee to update Standard ANSI/ANS 2.8 regarding PFHA. RIZZO has also contributed to PFHA guidance for the International Atomic Energy Agency (IAEA). Our engineers are excited to be at the forefront of the fast-evolving field of PFHA. We are actively involved in publishing papers and presenting our methodology ideas at conferences.

In addition to performing PFHA, our expertise and current participation in PFHA methodology development put us in an excellent position to perform peer review for PFHA projects completed by others.

PROJECT PLANNING

PFHA projects require careful attention for project planning. In particular, our engineers meet with the key stakeholders to discuss the acceptable risk tolerances for the project, which affect the level of effort and details necessary in the analysis. After the risk goals are identified, our team puts together a detailed methodology for the project. RIZZO can tailor the PFHA project planning and methodology to meet a wide range of project needs, for both large and small projects.

Depending on the level of effort and risk profile of the project, the methodology document may be subject to various levels of peer review by internal RIZZO reviewers, our client’s staff, and/or third-party review by PFHA Subject Matter Experts (SMEs), including Expert Elicitation (EE) as required.
OVERVIEW OF PFHA METHODOLOGY

RIZZO understands that each PFHA project has many unique aspects. In particular, type and quantity of available data is often a key factor in PFHA at an early stage for determining the best methodology. Our PFHA expertise includes many aspects such as:

- Regional statistical analyses using the Method of L-Moments
- Joint Probability Methods (JPM) for storm surge and seiche analysis
- Historic water level analysis for storm surge and river flooding
- Incorporating paleoflood data
- Monte Carlo Simulations using variable input data in hydrologic models
- Evaluation of Epistemic and Aleatory Uncertainty
  - Logic Trees
  - Multiple probability distributions
  - Peer review
  - Confidence intervals
  - Sensitivity analyses

PFHA TOOLS

RIZZO has developed extensive sets of in-house computer scripts (MATLAB and Python) to perform statistical data analysis and make probability estimates for PFHA. For example, we have prepared a variety of scripts related to performing a regional precipitation analysis using the Method of L-Moments (MLM), as well as formulating other stochastic models and performing Monte Carlo Simulations (MCS). These in-house scripts provide the basis for efficient project implementation in future studies.

FLOOD FRAGILITIES

If a PFHA is to be used as input to a Probabilistic Risk Assessment (PRA), fragilities are necessary for individual components. RIZZO has the expertise to perform flooding fragility analysis. In fact, we have been involved in developing guidance for IAEA regarding flooding fragilities. Flood fragility requires a detailed walkdown of the site(s) of interest to inventory potentially vulnerable components. Components are then evaluated and assigned individual fragilities based on a variety of methods including: empirical observations, analytical methods, engineering judgement, or a combination of multiple factors.

A flood fragility analysis accounts for the potential for multiple failure modes in a system, including the effects of human factors. Analyses may include an evaluation of: event timelines, the availability of consumables, and the integrity of flood protection systems.

Flood fragilities may be simple step functions (e.g., electrical equipment failures) or smooth functions (e.g., hydrodynamic and debris impact forces). The level of detail included in a flood fragility calculation should be commensurate with the role the individual component plays in the PRA model. Greater detail can be included in fragility calculations for more critical components.

EXAMPLE PROJECT (CANADA) – BRUCE

RIZZO conducted a two-phase flooding hazard evaluation for the Bruce Nuclear Generating Station. The first phase of the analysis was a deterministic hazard analysis that evaluated all potential external flooding hazards (similar to the Recommendation 2.1 analyses for U.S. plants). The second phase of the analysis was a detailed probabilistic analysis for storm surge and local intense precipitation (the two flooding sources that were not screened out by the deterministic analysis).

The Probabilistic Local Intense Precipitation analysis involved a detailed regional study of precipitation based on the Method of L-Moments to determine precipitation depths for low probability rainfall events (e.g., 10^-4 Annual Exceedance Probability). The project also included a detailed evaluation of the uncertainty (aleatory and epistemic) associated with the probabilities assigned to low probability events.

The Probabilistic Storm Surge Hazard Assessment considered various components of lake level variability (e.g., mean lake level, surge levels, and wind wave run-up levels) to construct an overall hazard curve that assigned annual exceedance probabilities to total water levels near the Bruce site. The analysis approach involved applying multiple statistical distributions and performing numerous Monte Carlo simulations, as well as a detailed evaluation of the uncertainty involved in the analysis.

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