# PROBABILISTIC RISK ASSESSMENT METHODOLOGY FOR PRECLOSURE OPERATIONS AT A GEOLOGIC NUCLEAR WASTE REPOSITORY

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**PSAM 7 / ESREL '04 Abstract**

## BACKGROUND

Many nations are engaged in investigating deep geologic repositories for permanently disposing their spent nuclear fuel and high-level nuclear waste. The preclosure period before such a repository is permanently closed may vary from a few tens of years to a few hundreds of years. Handling operations are planned in a period shorter than the preclosure period. During handling operations, waste is transported to the repository site, prepared for disposal, and finally emplaced underground. After the handling operations are complete, the remaining time before permanent closure and decommissioning of the repository can be used to allow the waste to cool, provide ventilation, monitor the performance of the repository, retrieve the emplaced waste (if necessary), or enable future generations to make final decisions. In the United States, the Yucca Mountain site in Nevada is being investigated for a potential geologic repository designed to hold 70,000 metric tons uranium equivalent spent nuclear fuel and vitrified high-level radioactive waste. Due to the various surface and subsurface handling operations and the substantial amount of waste, the repository may potentially present hazards to the workers and the public during the preclosure period. The purpose of this paper is to present a probabilistic methodology for evaluating risk and the uncertainty in risk from a potential repository during the preclosure period.

## APPROACH

The basic steps of the methodology for calculating risk are (1) convert the initiating event frequencies into initiating event probabilities, (2) compute the initiating event consequences from their event sequence consequences and the conditional probabilities of the event sequences, (3) identify the set of possible outcomes based on the occurrence of the initiating events, and (4) calculate the risk of each outcomes and the total risk from all outcomes using the initiating event probabilities and consequences. The methodology treats uncertainty differently for frequencies and consequences. Specifically, the methodology accepts mean values for the initiating event frequencies and complementary cumulative distribution functions for consequences as its inputs. Prior to the risk assessment, any uncertainty analysis performed on an initiating event frequency should culminate in the calculation of mean value, which is used as a point estimate in the conversion to an initiating event probability. Combined with point estimates for probabilities (i.e., initiating event probabilities and outcome probabilities), the methodology explicitly propagates uncertainty in consequences into uncertainty in risk. Although the above risk assessment methodology is general, it should be noted that U.S. Nuclear Regulatory Commission (NRC) regulation "Disposal of High-Level Radioactive Waste in a Geologic Repository at Yucca Mountain, Nevada" in Part 63 of the 10 Code of Federal Regulations is a risk-informed performance-based regulation and does not require or endorse any methodology in assessing risk insights associated with geologic repository operations.

## SIGNIFICANCE, ORIGINALITY, AND EXPECTED RESULTS

This methodology is being implemented via a computer code called the PCSA Tool. The PCSA Tool is being designed to aid the NRC and Center for Nuclear Waste Regulatory Analyses (CNWRA) staffs in reviewing any preclosure safety analysis submitted with a potential license application for the construction of a proposed geologic nuclear waste repository at Yucca Mountain. The full paper will use sample data from the Yucca Mountain project to illustrate application of the probabilistic risk methodology, but will draw no conclusions regarding regulatory compliance.

The risk methodology had previously been presented assuming point-estimates for all parameters. This paper will use probability distributions to propagate uncertainty through the risk calculation and will ultimately generate a complementary cumulative distribution function for risk as its final result.

The identification and evaluation of structures, systems, and components (SSC) that are important to safety are important preclosure aspects of a geologic nuclear waste repository. Results of this risk assessment methodology can be applied, in conjunction with a hypothetical "take-away" analysis that assumes the failure of a SSC to perform its function, to rank SSC importance with respect to safety. The presented risk assessment methodology investigates risk-based importance measures by incorporating consequence into the analysis to yield risk information. The resulting importance measure for a SSC is the risk increase resulting from its failure. The resulting risk insights can serve as valuable information for highlighting aspects of facility design, applying quality controls, and focusing regulatory reviews.

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## KEYWORDS

probabilistic risk assessment, risk-based importance measures, uncertainty propagation, nuclear waste, handling operations, geologic repository