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BIOSPHERE MODELING AT YUCCA MOUNTAIN, NEVADA

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I. INTRODUCTION

The objectives of the biosphere modeling efforts are to assess how radionuclides potentially released from the proposed repository could be transported through a variety of environmental media. The study of these transport mechanisms, referred to as pathways, is critical in calculating the potential radiation dose to man. Since most of the existing and pending regulations applicable to the Project are radiation dose based standards, the biosphere modeling effort will provide crucial technical input to support the Viability Assessment (VA), the Working Draft of License Application (WDLA), and the Environmental Impact Statement (EIS).

In 1982, the Nuclear Waste Policy Act (NWPA) was enacted into law. This federal law, which was amended in 1987, addresses the national issue of geologic disposal of high-level nuclear waste generated by commercial nuclear power plants, as well as defense programs during the past few decades. As required by the law, the Department of Energy (DOE) is conducting a site characterization project at Yucca Mountain, Nevada, approximately 100 miles northwest of Las Vegas, Nevada, to determine if the site is suitable for the nation's first high-level nuclear waste repository.

II. WORK DESCRIPTION

Due to the different potential release mechanisms in different phases of the Project, the biosphere modeling efforts are divided into two sub-tasks, i.e., preclosure and postclosure. The preclosure is defined as the time period from the beginning of the operation to the permanent closure of the repository, whereas the postclosure is the time period after the permanent closure of the repository. Scenarios for potential releases of radionuclides are very different for these two time periods. The biosphere modeling efforts take the postulated releases from these scenarios and follow them through various pathways until they result in a dose to humans.

During the preclosure time period, radionuclides are projected to be released into the atmosphere from surface facilities. These radionuclides could be transported downwind from the point of release by atmospheric dispersion mechanisms. The preclosure assessment employs a atmospheric transport model to project radionuclide concentrations in air at specific downwind locations. The concentrations in air can then be used as input data in a terrestrial transport and bioaccumulation model to calculate radiation dose to a receptor of interest.

The postclosure biosphere modeling estimates the radiation dose to a member of a critical population due to the radionuclides released from the repository during the postclosure time period. After the engineered systems within the repository begin to lose their abilities to contain radionuclide inventory, migration of radioactive elements through the geosphere begins, eventually entering the local water table and moving toward inhabited areas. The biosphere modeling addresses the pathways from the groundwater to humans, through various pathways. The primary release scenario may be a groundwater well used for drinking water supply and irrigation. This scenario would result in potential doses through inhalation, ingestion, or direct exposure pathways.

The biosphere is a complex system, and numerous and diverse factors must be considered to model the movement of radionuclides through the biosphere to

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man. First, the Features, Events, and Processes (FEP) applicable to the Yucca Mountain environment are identified, and the site-specific assessment context is developed to define the assessment framework for the biosphere modeling. A conceptual environmental pathway model is then developed, and a computer code, GENII-S,[1] is selected to carry out the computation. Sensitivity analysis is performed to identify important input parameters for best allocating resources in data collection activities.

The computation of radiation dose is performed using unit radionuclide release rates and groundwater concentrations for the preclosure and postclosure, respectively. For each radionuclide of interest, radiation dose resulting from a unit release rate or groundwater concentration under a specific exposure scenario is calculated and defined as the Biosphere Dose Conversion Factor (BDCF). As a result, the BDCF carries a unit of annual dose per unit release rate or groundwater concentration, i.e., mrem/yr per pCi/sec release rate or mrem/yr per pCi/L groundwater concentration. By multiplying the release rate or groundwater concentration of a radionuclide and its BDCF for a specific exposure scenario, the radiation dose resulting from that particular radionuclide and exposure scenario can be calculated. The sum of the radiation doses from all the radionuclides released into the environment will be used to determine whether or not the repository could meet the performance standards in terms of environmental radiation protection.

III. RESULTS AND DISCUSSIONS

For the preclosure, eight radionuclides of interest are considered,[2] whereas for the postclosure, thirty-nine radionuclides are identified as having some potential for release through the groundwater pathway.[3] For each of these radionuclides of interest, BDCFs are calculated for different receptor scenarios and precipitation states. Three receptors are considered in this assessment: a subsistence farmer, a residential farmer, and an average individual in Amargosa Valley. For each receptor scenario, three precipitation states, current (1x), twice (2x), and three times (3x) the current precipitation rate, are used for the development of the BDCFs.

It is very important to understand the reliability and accuracy of these dose projections in order to determine whether or not the repository can meet the regulations and standards. Uncertainty analyses are performed to disclose the reliability and accuracy of these dose assessment results.

Two types of uncertainties are being addressed in the biosphere modeling assessment. The first type is due to the stochastic variability of each model input parameter. This type of uncertainty analysis is essential to quantify the numerical dispersion in the output due to the uncertainty in the model input parameters. Temporal and spatial variations are typical in nature systems, and the true values can not be known. Therefore, a single, point value may not be adequate to represent a parameter, and it is often necessary to described the parameter by a frequency distribution to account for the variation. As a result, each of the parameter uncertainty is propagated into the assessment endpoint (i.e., radiation dose) by using analytical or numerical methods, and the uncertainty of the assessment endpoint is described in terms of a probability or confidence interval. The analysis on this type of uncertainty also reveals the relative importance of each input parameter based on its contribution to the overall uncertainty.

The second type of uncertainty is due to a "lack of knowledge" with regard to the exact specification of the assessment, e.g., decisions involving judgment of future states of environment where data and knowledge are not known to any degree of precision. This type of uncertainty is evaluated by performing a large number of "what-ifs," i.e., different exposure scenarios as described previously.

The biosphere modeling effort delivers crucial technical input for the Viability Assessment, the Working Draft of License Application (WDLA), and the Environmental Impact Statement (EIS). The developed BDCFs and their uncertainties, when combined with the release quantities, project the potential radiation dose to humans from the repository, which will be used to determine how the repository can meet the environmental radiation protection standards.

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