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RECENT BIOSPHERE WORK FOR IPA PHASE 3

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INTRODUCTION

The Energy Policy Act of 1992[1] directed a National Academy of Sciences (NAS) committee to advise the U.S. Environmental Protection Agency (EPA) on the technical bases for certain aspects of standards to be developed by EPA for use by the Nuclear Regulatory Commission (NRC) to license a potential geologic high-level radioactive waste repository at Yucca Mountain (YM). The resulting NAS recommendations favor the application of a risk-based standard and adoption of the critical group approach for estimating potential doses[2] from the disposal facility. If such a standard was adopted, compliance demonstration by the Department of Energy (DOE) would include evaluation of doses or risks to potentially affected individuals in a performance assessment for submission to NRC.

In Phase 3 of their Iterative Performance Assessment (IPA) studies, the NRC Division of Waste Management and the Center for Nuclear Waste Regulatory Analyses (CNWRA) further developed the NRC capability to calculate individual doses in IPA analyses. This capability was included in the TPA Version 3.1 code through the use of dose conversion factors (DCFs) that convert estimated concentrations of individual radionuclides in groundwater and soil to total effective dose equivalents (TEDE). The calculation of DCFs utilized information from previous efforts to define site specific dose parameters[3,4] and recommendations from the NAS Committee on high-level waste (HLW) standards[2]. Experience gained from these IPA biosphere analyses supported staff participation at the international workshop on biosphere modeling and assessment methods known as BIOMASS. This paper summarizes the results of NRC/CNWRA efforts to provide a dose calculation capability in the TPA Version 3.1 code.

WORK DESCRIPTION

Following the release of the NAS recommendations for HLW standards[2], IPA Phase 3 dose assessment analyses focussed on providing the capability to calculate annual individual TEDEs. Objectives of this work included (i) use of site-specific information and results from sensitivity analyses to determine receptor and biosphere parameters, (ii) use of a biosphere based on present YM climate conditions, (iii) allowance for long-term changes from existing biosphere conditions to a cooler and wetter climate (i.e., pluvial period), and (iv) development of a capability to calculate doses from both groundwater and direct releases for all radionuclides in the TSPA-93[5] inventory. Use of DCFs supported these objectives.

The DCFs were calculated deterministically using the GENII-S dose assessment code[6]. A deterministic (rather than stochastic) calculation was used to reduce the complexity of implementation in the TPA Version 3.1 code. Parameter selections were based on a review of available information[7]. For consistency with NAS recommendations for calculating the dose to the average member of a critical group, the average member of the receptor group was approximated by considering the current population that would be expected to be most-highly exposed (i.e., nearest the site engaging in practices involving the greatest number of applicable exposure pathways), and by selecting parameters that describe the behavior of an average member of this group. Two receptor groups were used (i) a resident farmer based on conditions in the Amargosa Valley and (ii) a nonfarming resident located closer to the repository site. Most parameters for the average member were taken to be median values from known or estimated probability distributions. Pluvial period biosphere parameters were estimated by using information relevant to an existing farming area with mean annual temperature and precipitation conditions similar to those expected under pluvial conditions at YM. The YM pluvial conditions were estimated using data from the paleontological record[8,9,10,11].

Input parameters were based on site-specific information, when available, and supplemented by generic parameter sources when site-specific information was not available. A sensitivity analysis was conducted to focus the parameterization effort. Stochastic dose calculation results from a previous analysis[4] were analyzed using multiple regression statistics to identify important processes and parameters in the dose calculation. These processes and parameters included crop interception, resuspension, food and water consumption rates, plant and animal uptake factors, and irrigation. Particular attention was focussed on these parameters to ensure the best available information was used.

RESULTS

DCFs were calculated for each unique combination of radionuclide, climate (current or pluvial conditions), receptor group (resident farmer or nonfarming resident), transport pathway (groundwater or air deposition of direct release to soil), and exposure pathway (all pathways, animal product ingestion, drinking water, external plume and groundshine, inhalation, or terrestrial crop ingestion). Results were included in a previous CNWRA report[7]. A sample of the all-pathway DCF results stratified by transport pathway and climate is provided in figure 1. These results show that the groundwater source DCFs for the pluvial period climate conditions are approximately 30 to 40 percent of the DCFs for the current climate. This percentage is attributable to a decrease in the irrigation rate under estimated pluvial conditions. For the groundwater transport pathway, a comparison of exposure pathway-specific DCFs with the all pathway DCFs shows that terrestrial crop ingestion and drinking water pathways comprise a majority of the all-pathway DCFs for most radionuclides, followed by the animal product ingestion pathway (which is important for 10 elements) with relatively small contributions by the external exposure and inhalation pathways. A similar comparison of direct release DCFs (i.e., for soil contamination) shows inhalation to be a major contributor to the all pathway DCFs for many radionuclides.

CONCLUSION AND DISCUSSION

IPA Phase 3 biosphere analyses have generated site-specific DCFs and supported the capability to calculate annual individual TEDEs in the NRC TPA Version 3.1 code. This implementation of individual dose capability is an initial effort, however the dose modeling builds on earlier work and includes available site-specific information and a capability to account for biosphere changes to pluvial conditions with time. This improved dose calculation capability has enhanced NRC/CNWRA expertise to conduct biosphere analyses and to review DOE performance assessments for the U.S. repository program.

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