(11)

Department of Energy
Washington, DC 20585

QA: N/A

DOCKET NUMBER
PROPOSED RULE PR 63
(70FR 53313)

December 7, 2005

Secretary
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001
Attention: Rulemakings and Adjudications Staff

DOCKET ID NO. RIN 3150-AH68

The U.S. Department of Energy (DOE) offers the following comments on the U.S. Nuclear Regulatory Commission (NRC) proposed rule, *Implementation of a Dose Standard After 10,000 Years*, published at 70 Fed. Reg. 53313 (2005). DOE believes that the proposed rule is an appropriate technical approach that reasonably implements the proposed revisions to the U.S. Environmental Protection Agency (EPA) rule, *Public Health and Environmental Radiation Protection Standards for Yucca Mountain*, published at 70 Fed. Reg. 49014 (2005), and satisfies NRC's obligation under the Energy Policy Act to adopt requirements and criteria consistent with EPA's standards. This letter summarizes DOE's comments on the proposed rule, and transmits a Supporting Document that provides further supporting details.

First, DOE supports NRC's proposed implementation of EPA's proposed rule to require that, except for the processes specified by EPA, the performance assessment through the time of peak dose will be subject to the current provisions of 10 CFR 63.114, as they apply to the 10,000-year compliance period, and will be based on the models as validated for that compliance period. This approach is consistent with the recommendations of the National Academy of Sciences Committee's *Technical Basis for Yucca Mountain Standards* (1995).

Second, although DOE concurs that it is appropriate for NRC to specify a range of deep percolation rates to implement the constant climate conditions indicated in 40 CFR 197.36 (c)(2), DOE believes that NRC should consider specifying deep percolation rates that are more representative of potential future climates in the region. The NRC has proposed deep percolation rates from 13 to 64 mm/yr and a mean rate of 32 mm/yr to represent the effect of climate change. These values appear to be more representative of the maximum deep percolation rate rather than of the full range of expected climates. Our assessment of deep percolation rates based on Nevada-specific observations provides an estimated range of recharge of 8 mm/yr to 22 mm/yr, and a mean value of deep percolation of 14 mm/yr. These results appear to be corroborated by the value for an average Late Pleistocene recharge rate of 15 ± 5 mm/yr for the Yucca Mountain, Nevada, region.

Template = SECY-067

SECY-02

Third, the definition of "weighting factor" in the NRC proposed rule specifies only tissue weighting factors. Radiation weighting factors are not specified, either explicitly or by reference. The definition of "weighting factor" in the proposed rule should be expanded to include radiation weighting factors. Alternatively, the NRC could simply require that the calculation of doses be consistent with International Commission on Radiation Protection 60/72 methodology and use current scientific methods.

Finally, because NRC must set licensing requirements and criteria that are consistent with the EPA standards, DOE recommends that NRC acknowledge that the reasonable expectation test allows for decreasing confidence in the numerical results of the performance assessments as the compliance period increases beyond 10,000 years.

DOE appreciates the opportunity to comment on the proposed rule. If you have questions concerning these comments or the supporting detailed comments that are enclosed, please contact me.

Paul M. Golan
Acting Director
Office of Civilian Radioactive
Waste Management

Enclosure:
DOE Comments on Proposed Revisions to
10 CFR Part 63, September 8, 2005

QA: N/A

December 7, 2005

Secretary
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001
Attention: Rulemakings and Adjudications Staff

DOCKET ID NO. RIN 3150-AH68

The U.S. Department of Energy (DOE) offers the following comments on the U.S. Nuclear Regulatory Commission (NRC) proposed rule, *Implementation of a Dose Standard After 10,000 Years,* published at 70 Fed. Reg. 53313 (2005). DOE believes that the proposed rule is an appropriate technical approach that reasonably implements the proposed revisions to the U.S. Environmental Protection Agency (EPA) rule, *Public Health and Environmental Radiation Protection Standards for Yucca Mountain*, published at 70 Fed. Reg. 49014 (2005), and satisfies NRC's obligation under the Energy Policy Act to adopt requirements and criteria consistent with EPA's standards. This letter summarizes DOE's comments on the proposed rule, and transmits a Supporting Document that provides further supporting details.

First, DOE supports NRC's proposed implementation of EPA's proposed rule to require that, except for the processes specified by EPA, the performance assessment through the time of peak dose will be subject to the current provisions of 10 CFR 63.114, as they apply to the 10,000-year compliance period, and will be based on the models as validated for that compliance period. This approach is consistent with the recommendations of the National Academy of Sciences Committee's *Technical Basis for Yucca Mountain Standards* (1995).

Second, although DOE concurs that it is appropriate for NRC to specify a range of deep percolation rates to implement the constant climate conditions indicated in 40 CFR 197.36 (c)(2), DOE believes that NRC should consider specifying deep percolation rates that are more representative of potential future climates in the region. The NRC has proposed deep percolation rates from 13 to 64 mm/yr and a mean rate of 32 mm/yr to represent the effect of climate change. These values appear to be more representative of the maximum deep percolation rate rather than of the full range of expected climates. Our assessment of deep percolation rates based on Nevada-specific observations provides an estimated range of recharge of 8 mm/yr to 22 mm/yr, and a mean value of deep percolation of 14 mm/yr. These results appear to be corroborated by the value for an average Late Pleistocene recharge rate of 15 ± 5 mm/yr for the Yucca Mountain, Nevada, region.

Third, the definition of "weighting factor" in the NRC proposed rule specifies only tissue weighting factors. Radiation weighting factors are not specified, either explicitly or by reference. The definition of "weighting factor" in the proposed rule should be expanded to include radiation weighting factors. Alternatively, the NRC could simply require that the calculation of doses be consistent with International Commission on Radiation Protection 60/72 methodology and use current scientific methods.

Finally, because NRC must set licensing requirements and criteria that are consistent with the EPA standards, DOE recommends that NRC acknowledge that the reasonable expectation test allows for decreasing confidence in the numerical results of the performance assessments as the compliance period increases beyond 10,000 years.

DOE appreciates the opportunity to comment on the proposed rule. If you have questions concerning these comments or the supporting detailed comments that are enclosed, please contact me.

/s/

Paul M. Golan
Principal Deputy Director
Office of Civilian Radioactive
Waste Management

Enclosure:
DOE Comments on Proposed Revisions to
10 CFR Part 63, September 8, 2005

bcc w/encl:
Janine Sweeney, DOE/HQ (GC-52), Las Vegas, NV
M. C. Urie, DOE/HQ (GC-52), Las Vegas, NV
M. L. Ulshafer, DOE/OQA (RW-3), Las Vegas, NV
R. M. Latta, NRC, Las Vegas, NV
J. D. Parrott, NRC, Las Vegas, NV
D. P. Irwin, Hunton & Williams, Richmond, VA
BSC CCU Administrator, BSC, Las Vegas, NV
Donald Beckman, BSC, Las Vegas, NV
CMS Coordinator, BSC, Las Vegas, NV
S. J. Cereghino, BSC, Las Vegas, NV
M. W. Pendleton, BSC, Las Vegas, NV
M. R. Wisenburg, BSC, Las Vegas, NV
R. B. Bradbury, MTS, Las Vegas, NV
Veronica Cornell, MTS, Las Vegas, NV
R. C. Murray, MTS, Las Vegas, NV
R. G. Gisch, Naval Reactors, Washington Navy Yard, DC
W. J. Arthur, III, DOE/ORD (RW-60), Las Vegas, NV
W. J. Boyle, DOE/ORD (RW-63), Las Vegas, NV
R. L. Craun, DOE/ORD (RW-65), Las Vegas, NV
J. R. Dyer, DOE/ORD (RW-60), Las Vegas, NV
A. V. Gil, DOE/ORD (RW-63), Las Vegas, NV
T. C. Gunter, DOE/ORD (RW-63), Las Vegas, NV
C. L. Hanlon, DOE/ORD (RW-63), Las Vegas, NV
P. G. Harrington, DOE/ORD (RW-65), Las Vegas, NV
C. M. Newbury, DOE/ORD (RW-63), Las Vegas, NV
K. W. Powers, DOE/ORD (RW-60), Las Vegas, NV
S. L. Rives, DOE/ORD (RW-60), Las Vegas, NV
P. F. Sanchez-Bartz, DOE/ORD (RW-60), Las Vegas, NV
G. L. Smith, DOE/ORD (RW-64), Las Vegas, NV
J. R. Summerson, DOE/ORD (RW-63), Las Vegas, NV
M. C. Tynan, DOE/ORD (RW-63), Las Vegas, NV
S. A. Wade, DOE/ORD (RW-64), Las Vegas, NV
M. H. Williams, DOE/ORD (RW-63), Las Vegas, NV
OLA&S Library
OLA&S Records Coordinator, Las Vegas, NV
Records Processing Center = "15"

Department of Energy Comments on Proposed Revisions to Nuclear Regulatory Commission Rule 10 CFR Part 63, September 8, 2005

Requirements for the performance assessment to time of peak dose, within the period of geologic stability

Comment:

The Department of Energy (DOE) supports the Nuclear Regulatory Commission's (NRC) proposed implementation of the Environmental Protection Agency's (EPA) proposed rule to require that, except for specific processes specified by EPA, the performance assessment through the time of peak dose will be subject to the current provisions of 10 CFR 63.114 as they apply to the 10,000-year compliance period, and will be based on the models as validated for that compliance period. This approach is consistent with the recommendations of the National Academy of Sciences Committee's *Technical Basis for Yucca Mountain Standards* (1995).

Supporting Information:

Extending the regulatory period to the time of peak dose has the potential to introduce arbitrary and unbounded speculation into the assessment of repository performance. EPA and NRC regulations require the use of a Total System Performance Assessment (TSPA) using probabilistic methods. However, the National Academy of Sciences Committee on Technical Bases for Yucca Mountain Standards noted that, "**Analyses using pessimistic scenarios and parameter values are more easily understood than Monte Carlo analysis. The results of these conservative calculations are then no longer estimates of likely behavior but rather bounding estimates. Bounding estimates can be criticized for compounding conservative assumptions, since they can easily produce consequences that are highly improbable. On the other hand, if compliance can be shown with a bounding estimate, then there is no need for a more complex analysis. Bounding estimates can thus be very useful, but care should be given as to how one could combine the robust, bounding-estimate type of assessment with a probabilistic analysis.**"[1] The National Academy of Sciences Committee noted that "**...the probabilities and consequences of modification by climate change, seismic activity, and volcanic eruptions at Yucca Mountain are sufficiently boundable that these factors can be included in performance assessments that extend over this time frame.**"[2]

The Department concurs with NRC's proposed implementation in 10 CFR 63.114(b) that, except for those processes specified by EPA, only those processes, conceptual models, numerical models, model parameters, and data considered in the 10,000-year compliance evaluation will be considered in the peak dose performance assessment. If a process is significant enough to be included in the 10,000-year compliance evaluation, it is reasonable to conclude that it should be included in the longer term dose projections. If a process is not significant enough to be included

[1] National Research Council. 1995. *Technical Bases for Yucca Mountain Standards.* Washington, D.C.: National Academy Press, page 79.
[2] *Id.* @ 9.

in the 10,000 year compliance evaluation, then two possible paths allow continued exclusion of that process from longer term assessments. Either the process has such a slow rate of occurrence that models and parameters for such processes are so speculative that the effects of these processes can not be reasonably bounded, or the process is not affected by coupled thermal-mechanical-hydrologic-chemical environmental effects that are more prevalent in the first hundreds to thousands of years of repository performance. In the former case, it is the extremely slow rate of occurrence that allows for the processes to continue to be excluded. In the latter case, it is the fact that with time transient coupled processes are less likely to occur and less significant in consequence. Both arguments lead to the conclusion that the processes and events included in the 10,000-year assessment of individual protection (as well as the conceptual models, numerical models, model parameters, and data for these processes and events) should remain the same for calculations of peak dose.

Effects of climate change and estimation of long term average infiltration rate

Comment:

Although DOE concurs that it is appropriate for NRC to specify a range of deep percolation rates to implement the constant climate conditions indicated in 40 CFR 197.36 (c)(2), DOE believes that NRC should consider specifying deep percolation rates that are more representative of potential future climates in the region. The NRC proposed specification of deep percolation rates from 13 to 64 mm/yr and a mean rate of 32 mm/yr to represent the effect of climate change appears to be skewed to a representation of the maximum deep percolation rate rather than a value that is representative of the full range of expected climates. Our assessment of deep percolation rates based on Nevada-specific observations provides an estimated range of recharge of 8 mm/yr to 22 mm/yr, and a mean value of deep percolation of 14 mm/yr. These results appear to be corroborated by the value for an average Late Pleistocene recharge rate of 15 ± 5 mm/yr for the Yucca Mountain, Nevada, region.

Supporting Information:

The National Academy of Sciences Committee on Technical Bases for Yucca Mountain Standards concluded that the probabilities and consequences of modifications by climate change are sufficiently boundable to be included in performance assessments that extend over the time frame of geologic stability (a time scale on the order of 10^6 years at Yucca Mountain).[3] The NRC proposes to specify an increased average value for "deep percolation of water" to be used to represent the effect of climate change in a TSPA for the period between 10,000 and 1,000,000 years (the period of geologic stability). This is a reasonable interpretation of the EPA rule, as this "deep percolation of water" would be equivalent to "net infiltration rate" or "recharge rate" and would represent increased water flow through the repository under wetter conditions expected in some future climate states.

[3] National Research Council. 1995. *Technical Bases for Yucca Mountain Standards.* Washington, D.C.: National Academy Press, page 9.

The NRC states that "[g]iven that average deep percolation at Yucca Mountain is about 4 percent of precipitation, under current conditions, and assuming between 5 to 20 percent for the fraction of precipitation that remains as deep percolation under intermediate/monsoon climates, one may estimate higher average water flow to the repository than observed today. ... On this basis, the NRC proposes that DOE represent the effects of climate change after 10,000 years by assuming that deep percolation rates vary between 13 to 64 mm/year (0.5 to 2.5 inches/year)." These values of deep percolation rates appear to be skewed to a representation of maximum deep percolation rate rather than a value that is representative of the full range of expected climates.

The NRC states that today "the mean precipitation, measured at Yucca Mountain, is 125 millimeters/year (mm/year) (4.9 inches/year)." NRC's support for this statement, a report by Thompson et al., did not measure modern precipitation at Yucca Mountain; the report only provided an estimate of modern mean annual precipitation (and mean annual temperature) for the vicinity of Yucca Mountain at an elevation of 5,000 ft (1,524 m).[4]

The NRC cites the estimated Holocene recharge rate provided by Zhu et al.[5] and states that it "corresponds to an estimated deep percolation rate of 5 mm/year (0.20 inches/year) when averaged over the repository footprint." Zhu et al. also provide an estimated average Late Pleistocene recharge rate of 15 ± 5 mm/yr. The proposed rule does not mention this value or discuss why this value is not considered applicable for an average value for deep percolation rate. The Zhu et al. estimate of recharge rate of 15 ± 5 mm/yr appears to provide a representative long-term average deep percolation rate that is based upon empirical data and upon a climate period that appears to be representative of the full range of climate change expected over the next 1,000,000 years.

The NRC also notes that "[e]xamination of locations in the United States, analogous to Yucca Mountain in some future intermediate and monsoon climates, suggests potential precipitation rates of between 266 and 321 mm/year [10.5 and 12.6 inches/year]." Thompson et al. (Tables 2 and 4) provide the precipitation estimates of 266 to 321 mm/year and specify that this is for the late glacial maximum and for an elevation of 5,000 ft.[6] The estimate of 266 to 321 mm/year for the late glacial maximum would be greater than precipitation expected for intermediate, monsoon, and present-day climates.

Generally, as elevation increases, annual precipitation increases. Elevated topography is associated with increased precipitation for three reasons: (1) more precipitation-bearing clouds are formed than over lower elevations, (2) clouds and storm systems that already exist are augmented and assisted in producing more precipitation, and (3) lower evaporation losses are associated with reduced fall distances. The maximum elevation of the land surface over the repository footprint is approximately 4,900 ft with most of the land surface at lower elevations,

---

[4] Thompson, R.S.; Anderson, K.H.; and Bartlein, P.J. 1999. *Quantitative Paleoclimatic Reconstructions from Late Pleistocene Plant Macrofossils of the Yucca Mountain Region.* Open-File Report 99-338. Denver, Colorado: U.S. Geological Survey.

[5] Zhu, C.; Winterle, J.R.; and Love, E.I. 2003. "Late Pleistocene and Holocene Groundwater Recharge from the Chloride Mass Balance Method and Chlorine-36 Data." *Water Resources Research, 39,* (7), SBH 4-1 - SBH 4-15. [Washington, D.C.]: American Geophysical Union.

[6] *Supra* note 4.

down to approximately 4,300 ft. This indicates that the Thompson et al. estimate for 5,000 ft provides an overestimate of precipitation.

Sharpe[7] indicates that over the next 1,000,000 years the climate is expected to be approximately: 3% monsoon (30,000 years), 12% interglacial (i.e., similar to present day; 120,000 years), 21% glacial (210,000 years), and 64% intermediate (i.e., similar to glacial-transition; 640,000 years). The proposed rule establishes precipitation and percolation estimates for the next 1,000,000 years based mostly upon late glacial maximum climatic conditions that will occur during only 21% of the million-year period and include the greatest precipitation. It would be more representative to take a value based upon the most prevalent climate stage or to weight the stages based upon their prevalence.

Additionally, Thompson et al. indicate, "For 5000 ft (1524 m) at the Yucca Mountain repository we estimate that mean annual temperature (MAT) and precipitation (MAP) differed from our modern baseline data as follows:

> 35 to 30 ka: MAT = ~4° C colder than today, MAP = 1.5X modern levels;
> 27 to 23 ka: MAT = ~5° C colder than today, MAP = 2.2X modern levels;
> 20.5 to 18 ka: MAT = ~8° C colder than today, MAP = 2.4X modern levels;
> 14 to 11.5 ka: MAT = ~5.5° C colder than today, MAP = 2.6X modern levels"[8]

Thus, over the period from 35,000 to 11,500 years ago, the mean annual precipitation varied from about 188 mm/yr (i.e., 125 mm/yr x 1.5) to about 325 mm/yr (i.e., 125 mm/yr x 2.6), rather than the 266 to 321 mm/yr indicated in the draft rule. It would appear that this lower bound of 188 mm/yr is more relevant to establishing a lower bound for the range of precipitation for future intermediate and monsoon climates and for calculation of the lower bound of the range of deep percolation rates.

The NRC also states that "[e]stimates of deep percolation rate as a fraction of precipitation have been calculated for various climate conditions. Between 5 to 20 percent of precipitation could reach the repository depth under intermediate/monsoon to 'full glacial' climate conditions. The larger percentage reflects 'full glacial' conditions" (Mohanty et al.[9]). The technical basis proposed for these estimates (5 to 20 percent) of deep percolation rate as a fraction of precipitation for various climate conditions is not apparent in the cited reference. A more detailed, transparent technical basis for these percentage values is needed along with the applicable references for this technical basis. Additionally, it would appear that interglacial climate conditions should also be considered in this evaluation as Sharpe indicates that these conditions will occur 12% of the time over the next 1,000,000 years.

---

[7] Sharpe, S. 2003. *Future Climate Analysis—10,000 Years to 1,000,000 Years After Present.* MOD-01-001 REV 01. [Reno, Nevada: Desert Research Institute].

[8] Supra note 4 @ p. 34.

[9] Mohanty, S.; Codell, R.; Menchaca, J. M.; Smith, M.; LaPlante, P.; Rahimi M.; and Lozano, A. 2004. *System-Level Performance Assessment of the Proposed Repository at Yucca Mountain Using the TPA Version 4.1 Code,* CNWRA 2002–05 Revision 2, San Antonio, Texas: Center for Nuclear Waste Regulatory Analyses.

The climate change for the time period from 10,000 years to 1,000,000 years in the future (the period of geologic stability) is expected to be similar to past climate changes during the Quaternary Period. Within this past period, climate oscillated between full glacial and interglacial states many times over a similar timeframe. This would indicate that the future time period will not just include intervals that will be wetter and colder, it will also include periods that will be similar to the present (hot and dry) as well as various intermediate climates. The NRC proposed values to represent climate change are skewed to a representation of maximum deep percolation rate expected under full glacial conditions rather than a value that is representative of the full range of expected climates. The proposed range of deep percolation rates should be re-evaluated by developing a long-term average climate rather than a less frequent, worst-case, wetter and colder climate.

Finally, an alternative method to estimate recharge based on the range of precipitation values is provided by Maxey and Eakin.[10] The Maxey-Eakin method of estimating recharge as a percentage of precipitation suggests that for annual precipitation greater than 20 inches (about 510 mm), 25% would become recharge; for precipitation from 15 to 20 inches (about 380 to 510 mm), 15% would become recharge; for precipitation from 12 to 15 inches (about 300 to 380 mm), 7% would become recharge; for precipitation from 8 to 12 inches (about 200 to 300 mm), 3% would become recharge; and for precipitation less than 8 inches (~200 mm), 0% would become recharge.

For 321 mm of annual precipitation, the Maxey-Eakin method indicates that 7% would become recharge, which would be about 22 mm/yr. For 266 mm of annual precipitation, the Maxey-Eakin method indicates that 3% would become recharge, which would be about 8 mm/yr. This would give a recharge range from 22 mm/yr to 8 mm/yr. Calculating the mean value of a log-uniform distribution of deep percolation that ranges from 22 mm/yr to 8 mm/yr (as was done on Page 53316 of the proposed rule):

$$(22 \text{ mm/yr} - 8 \text{ mm/yr})/[\text{Log}_e(22 \text{ mm/yr}) - \text{Log}_e(8 \text{ mm/yr})] = 14 \text{ mm/yr}.$$

This calculation for a range of recharge (8 mm/yr to 22 mm/yr) and the calculation of the mean value of deep percolation (14 mm/yr) compares well with, and appears to be corroborated by, the value for average Late Pleistocene recharge rate of 15 ± 5 mm/yr estimated by Zhu et al.[11] at Yucca Mountain using the chloride mass balance method and chlorine-36 data. This suggests that these values are more representative of the full range of climate change and should be considered as a value of long-term average deep percolation of water to represent climate change. The Department believes that NRC should consider specifying deep percolation rates such as these that are more representative of potential future climates in the region.

---

[10] Maxey, G.B. and Eakin, T.E. 1950. *Ground Water in White River Valley, White Pine, Nye, and Lincoln Counties, Nevada.* Water Resources Bulletin No. 8. Carson City, Nevada: State of Nevada, Office of the State Engineer.
[11] *Supra* note 5 at p. 1182.

Dosimetry

Comment:

The definition of "weighting factor" in the NRC proposed rule specifies only tissue weighting factors. Radiation weighting factors are not specified, either explicitly or by reference. The definition of "weighting factor" in the proposed rule should be expanded to include radiation weighting factors. Alternatively, NRC could simply require that the calculation of doses be consistent with International Commission on Radiation Protection (ICRP) 60/72 methodology and use current scientific methods.

Supporting Information:

There are two basic applications of dose assessments. The first one is the protection of workers from occupational exposures. For external exposures, this type of dose assessment relies on operational quantities used for area and individual monitoring. The other one is the prospective dose assessment for hypothetical future scenarios or for the situations where it is either impossible or impractical to rely on the measured quantities.

ICRP Publication 26[12], and thus 10 CFR 20 which is based on ICRP Publication 26, make no distinction between the dosimetric quantities used for these two applications. 10 CFR part 20 is concerned primarily with workplace protection, and the quantities defined in the rule reflect that. Both ICRP 26 and 10 CFR 20 define and give the values of organ weighting factors and also the values of quality factors, Q. The latter are used to account for the ability of different radiations to produce different biological effects, even if the amount of energy imparted to tissue per unit mass is the same.

In Publication 60, the ICRP started using different approaches to radiation weighting for the protection quantities (which are used to define dose limits and can also be used in prospective dose assessment, but are not measurable) and for the operational quantities used in measurements of external exposure (which are measurable). Radiation weighting for the protection quantities is accomplished by using a radiation-weighting factor. Radiation weighting for the operational quantities still uses the concept of quality factors, which is given as a function of the unrestricted linear energy transfer.

In the draft EPA standard, the EPA proposes, "to adopt updated scientific factors for calculating doses to show compliance with the storage, individual-protection, and human intrusion standards".[13] In the statement of considerations[14], EPA accepts the ICRP 60 factors and any factors that may be produced in the future that are incorporated by EPA into Federal guidance. (This currently points to Federal Guidance Report No. 13.) The EPA then proceeds to adopt the ICRP 60-based radiation and organ weighting factors and gives their values in Appendix A.

[12] ICRP 1977, *Recommendations of the International Commission on Radiological Protection.* Volume 1, No. 3 of *Annals of the ICRP.* ICRP Publication 26.
[13] 70 Fed. Reg. 49014, 49022 (2005) (Public Health and Environmental Radiation Protection Standards for Yucca Mountain, Nevada; Proposed Rule).
[14] *Id.* at 49047.

The set of tissue weighting factors that EPA proposes in Table A.2 represents the most current recommendations of ICRP. Table A.2 is based on recommendations of ICRP 60 with the addition of the extrathoracic region (ICRP Publication 66[15]) and the clarification of tissue weighting factor for colon and upper large intestine (ICRP Publication 69[16]). The potential problem is that dose coefficients (i.e., those given in ICRP Publication 72[17] and Federal Guidance Report 13[18]) consider a slightly different set of organs. The Department, therefore, has recommended that EPA not provide the list of tissues and organs but require that the calculation of doses be consistent with ICRP methodologies.

The proposed NRC rule states that the approach NRC is proposing with respect to dosimetry conforms to the definition of weighting factors provided in the EPA proposal. However, the weighting factors are limited to tissue-weighting factors. The radiation weighting factors are not specified – neither explicitly nor by reference. This omission could imply that the old quality factors of 10 CFR 20 should be used. This is conceptually inconsistent with the ICRP 60 methodology because when the ICRP defines their dosimetric quantities, it is implicit that these contain the values of radiation and tissue weighting factors recommended at the relevant time by the ICRP. Moreover, as noted previously, the ICRP made a distinction in Publication 60 between the protection quantities and operational quantities and the quality factors are relevant only to the operational quantities. The corresponding quantity used for the prospective dose assessment, which is applicable to both preclosure and postclosure dose assessment for the repository, is the radiation weighting factor.

For the reasons stated above, DOE recommends that NRC not list the values of weighting factors, but simply require that the calculation of doses be consistent with the ICRP 60 and 72 methodologies and use current scientific methods.

If the NRC determines that specification of weighting factors is necessary, then DOE offers the following comments regarding the proposed amendments to 10 CFR 63.2.

The proposed amendment to 10 CFR 63.2 adds the following definition of weighting factor: "*Weighting factor* for an organ or tissue is the proportion of the risk of stochastic effects resulting from irradiation of that organ or tissue to the total risk of stochastic effects when the whole body is irradiated uniformly. For calculating the effective dose equivalent, the values in Appendix A of 40 CFR part 197 are to be used."

The proposed definition should be expanded to include radiation weighting factors. A statement regarding the use of the radiation weighting factor should also be added, since radiation weighting factors and tissue weighting factors come together as a part of the methodology introduced in ICRP 60. The NRC should also add a definition of quality factor for use in

[15] ICRP 1994, *Human Respiratory Tract Model for Radiological Protection.* Volume 24, Nos. 1-3 of *Annals of the ICRP.* ICRP Publication 66.

[16] ICRP 1995, *Age-Dependent Doses to Members of the Public from Intake of Radionuclides: Part 3, Ingestion Dose Coefficients.* Volume 25, No. 1 of *Annals of the ICRP.* ICRP Publication 69.

[17] ICRP 1996, *Age-Dependent Doses to Members of the Public from Intake of Radionuclides: Part 5 Compilation of Ingestion and Inhalation Dose Coefficients.* Volume 26, No. 1 of *Annals of the ICRP.* ICRP Publication 72.

[18] EPA 2002, *Federal Guidance Report 13, CD Supplement, Cancer Risk Coefficients for Environmental Exposure to Radionuclides, EPA.* EPA-402-C-99-001, Rev. 1.

operational external dose calculations for workers. A suggested replacement definition of weighting factors is given below:

> *Weighting factors* include radiation weighting factors and tissue weighting factors. Radiation weighting factor is a factor by which the mean absorbed dose in any tissue or organ is multiplied to account for the detriment by the different types of radiation relative to photon radiation. Weighting factor for an organ or tissue is the proportion of the risk of stochastic effects resulting from irradiation of that organ or tissue to the total risk of stochastic effects when the whole body is irradiated uniformly. For calculating the effective dose equivalent, the values of weighting factors in Appendix A of 40 CFR part 197 are to be used.

In addition, the definition of the total effective dose equivalent should be modified to capture the NRC's Regulatory Issue Summary 2003-04 that provides for the use of effective dose equivalent in place of the deep dose equivalent in dose assessments. In the suggested replacement below the underlined words were added to the original definition:

> *Total effective dose equivalent (TEDE)* means, for purposes of assessing operational doses to workers, the sum of the deep-dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures). For purposes of assessing doses to members of the public (including the RMEI) and prospective doses to workers, TEDE means the sum of the effective dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures).

Consistency in Definition of Reasonable Expectation in EPA and NRC rules

Comment:

Because NRC must set licensing requirements and criteria that are consistent with the EPA standards, the Department recommends that NRC acknowledge that the reasonable expectation test allows for decreasing confidence in the numerical results of the performance assessments as the compliance period increases beyond 10,000 years.

Supporting Information:

In the proposed rule, EPA did not propose to expand or modify the definition of reasonable expectation in § 197.14 to account for the greater uncertainty between 10,000 years and the time of peak dose (within one million years of disposal). The EPA did note that the existing definition describes principles that are applicable for both shorter and very long time frames, but that the implications of these principles may be different, depending on the time frame. Specifically, they noted that they believe that reasonable expectation becomes even more important as the level of confidence that can be placed in numerical projections decreases over time. Further, EPA noted that the 10,000-year period is an indicator of times when uncertainties in projecting performance are more manageable and for which comparisons can be made with other regulated systems.

In the proposed rule, EPA referenced the 1999 preamble to proposed 40 CFR Part 197, wherein EPA said that if it were to regulate longer than 10,000 years, the EPA would expect the licensing judgment to be less strict in relying on dose projections compared to 10,000 years (64 FR 46998, August 17, 1999). Specifically, EPA noted "... that if the compliance period for the individual-protection standard extended to the time of peak dose within the period of geologic stability (which the National Academy of Sciences Committee estimated to be 1 million years for the Yucca Mountain site), this [reasonable expectation] test would allow for decreasing confidence in the numerical results of the performance assessments as the compliance period increases beyond 10,000 years. For example, this means that the weight of evidence necessary, based upon reasonable expectation, for a compliance period of 10,000 years would be greater than that required for a compliance period of hundreds of thousands of years."

Department of Energy Comments on Proposed Revisions to Nuclear Regulatory Commission Rule 10 CFR Part 63, September 8, 2005

Requirements for the performance assessment to time of peak dose, within the period of geologic stability

Comment:

The Department of Energy (DOE) supports the Nuclear Regulatory Commission's (NRC) proposed implementation of the Environmental Protection Agency's (EPA) proposed rule to require that, except for specific processes specified by EPA, the performance assessment through the time of peak dose will be subject to the current provisions of 10 CFR 63.114 as they apply to the 10,000-year compliance period, and will be based on the models as validated for that compliance period. This approach is consistent with the recommendations of the National Academy of Sciences Committee's *Technical Basis for Yucca Mountain Standards* (1995).

Supporting Information:

Extending the regulatory period to the time of peak dose has the potential to introduce arbitrary and unbounded speculation into the assessment of repository performance. EPA and NRC regulations require the use of a Total System Performance Assessment (TSPA) using probabilistic methods. However, the National Academy of Sciences Committee on Technical Bases for Yucca Mountain Standards noted that, "**Analyses using pessimistic scenarios and parameter values are more easily understood than Monte Carlo analysis. The results of these conservative calculations are then no longer estimates of likely behavior but rather bounding estimates. Bounding estimates can be criticized for compounding conservative assumptions, since they can easily produce consequences that are highly improbable. On the other hand, if compliance can be shown with a bounding estimate, then there is no need for a more complex analysis. Bounding estimates can thus be very useful, but care should be given as to how one could combine the robust, bounding-estimate type of assessment with a probabilistic analysis.**"[1] The National Academy of Sciences Committee noted that "**...the probabilities and consequences of modification by climate change, seismic activity, and volcanic eruptions at Yucca Mountain are sufficiently boundable that these factors can be included in performance assessments that extend over this time frame.**"[2]

The Department concurs with NRC's proposed implementation in 10 CFR 63.114(b) that, except for those processes specified by EPA, only those processes, conceptual models, numerical models, model parameters, and data considered in the 10,000-year compliance evaluation will be considered in the peak dose performance assessment. If a process is significant enough to be included in the 10,000-year compliance evaluation, it is reasonable to conclude that it should be included in the longer term dose projections. If a process is not significant enough to be included

[1] National Research Council. 1995. *Technical Bases for Yucca Mountain Standards.* Washington, D.C.: National Academy Press, page 79.
[2] *Id.* @ 9.

in the 10,000 year compliance evaluation, then two possible paths allow continued exclusion of that process from longer term assessments. Either the process has such a slow rate of occurrence that models and parameters for such processes are so speculative that the effects of these processes can not be reasonably bounded, or the process is not affected by coupled thermal-mechanical-hydrologic-chemical environmental effects that are more prevalent in the first hundreds to thousands of years of repository performance. In the former case, it is the extremely slow rate of occurrence that allows for the processes to continue to be excluded. In the latter case, it is the fact that with time transient coupled processes are less likely to occur and less significant in consequence. Both arguments lead to the conclusion that the processes and events included in the 10,000-year assessment of individual protection (as well as the conceptual models, numerical models, model parameters, and data for these processes and events) should remain the same for calculations of peak dose.

Effects of climate change and estimation of long term average infiltration rate

Comment:

Although DOE concurs that it is appropriate for NRC to specify a range of deep percolation rates to implement the constant climate conditions indicated in 40 CFR 197.36 (c)(2), DOE believes that NRC should consider specifying deep percolation rates that are more representative of potential future climates in the region. The NRC proposed specification of deep percolation rates from 13 to 64 mm/yr and a mean rate of 32 mm/yr to represent the effect of climate change appears to be skewed to a representation of the maximum deep percolation rate rather than a value that is representative of the full range of expected climates. Our assessment of deep percolation rates based on Nevada-specific observations provides an estimated range of recharge of 8 mm/yr to 22 mm/yr, and a mean value of deep percolation of 14 mm/yr. These results appear to be corroborated by the value for an average Late Pleistocene recharge rate of 15 ± 5 mm/yr for the Yucca Mountain, Nevada, region.

Supporting Information:

The National Academy of Sciences Committee on Technical Bases for Yucca Mountain Standards concluded that the probabilities and consequences of modifications by climate change are sufficiently boundable to be included in performance assessments that extend over the time frame of geologic stability (a time scale on the order of 10^6 years at Yucca Mountain).[3] The NRC proposes to specify an increased average value for "deep percolation of water" to be used to represent the effect of climate change in a TSPA for the period between 10,000 and 1,000,000 years (the period of geologic stability). This is a reasonable interpretation of the EPA rule, as this "deep percolation of water" would be equivalent to "net infiltration rate" or "recharge rate" and would represent increased water flow through the repository under wetter conditions expected in some future climate states.

[3] National Research Council. 1995. *Technical Bases for Yucca Mountain Standards.* Washington, D.C.: National Academy Press, page 9.

The NRC states that "[g]iven that average deep percolation at Yucca Mountain is about 4 percent of precipitation, under current conditions, and assuming between 5 to 20 percent for the fraction of precipitation that remains as deep percolation under intermediate/monsoon climates, one may estimate higher average water flow to the repository than observed today. ... On this basis, the NRC proposes that DOE represent the effects of climate change after 10,000 years by assuming that deep percolation rates vary between 13 to 64 mm/year (0.5 to 2.5 inches/year)." These values of deep percolation rates appear to be skewed to a representation of maximum deep percolation rate rather than a value that is representative of the full range of expected climates.

The NRC states that today "the mean precipitation, measured at Yucca Mountain, is 125 millimeters/year (mm/year) (4.9 inches/year)." NRC's support for this statement, a report by Thompson et al., did not measure modern precipitation at Yucca Mountain; the report only provided an estimate of modern mean annual precipitation (and mean annual temperature) for the vicinity of Yucca Mountain at an elevation of 5,000 ft (1,524 m).[4]

The NRC cites the estimated Holocene recharge rate provided by Zhu et al.[5] and states that it "corresponds to an estimated deep percolation rate of 5 mm/year (0.20 inches/year) when averaged over the repository footprint." Zhu et al. also provide an estimated average Late Pleistocene recharge rate of 15 ± 5 mm/yr. The proposed rule does not mention this value or discuss why this value is not considered applicable for an average value for deep percolation rate. The Zhu et al. estimate of recharge rate of 15 ± 5 mm/yr appears to provide a representative long-term average deep percolation rate that is based upon empirical data and upon a climate period that appears to be representative of the full range of climate change expected over the next 1,000,000 years.

The NRC also notes that "[e]xamination of locations in the United States, analogous to Yucca Mountain in some future intermediate and monsoon climates, suggests potential precipitation rates of between 266 and 321 mm/year [10.5 and 12.6 inches/year]." Thompson et al. (Tables 2 and 4) provide the precipitation estimates of 266 to 321 mm/year and specify that this is for the late glacial maximum and for an elevation of 5,000 ft.[6] The estimate of 266 to 321 mm/year for the late glacial maximum would be greater than precipitation expected for intermediate, monsoon, and present-day climates.

Generally, as elevation increases, annual precipitation increases. Elevated topography is associated with increased precipitation for three reasons: (1) more precipitation-bearing clouds are formed than over lower elevations, (2) clouds and storm systems that already exist are augmented and assisted in producing more precipitation, and (3) lower evaporation losses are associated with reduced fall distances. The maximum elevation of the land surface over the repository footprint is approximately 4,900 ft with most of the land surface at lower elevations,

---

[4] Thompson, R.S.; Anderson, K.H.; and Bartlein, P.J. 1999. *Quantitative Paleoclimatic Reconstructions from Late Pleistocene Plant Macrofossils of the Yucca Mountain Region*. Open-File Report 99-338. Denver, Colorado: U.S. Geological Survey.

[5] Zhu, C.; Winterle, J.R.; and Love, E.I. 2003. "Late Pleistocene and Holocene Groundwater Recharge from the Chloride Mass Balance Method and Chlorine-36 Data." *Water Resources Research, 39,* (7), SBH 4-1 - SBH 4-15. [Washington, D.C.]: American Geophysical Union.

[6] *Supra* note 4.

down to approximately 4,300 ft. This indicates that the Thompson et al. estimate for 5,000 ft provides an overestimate of precipitation.

Sharpe[7] indicates that over the next 1,000,000 years the climate is expected to be approximately: 3% monsoon (30,000 years), 12% interglacial (i.e., similar to present day; 120,000 years), 21% glacial (210,000 years), and 64% intermediate (i.e., similar to glacial-transition; 640,000 years). The proposed rule establishes precipitation and percolation estimates for the next 1,000,000 years based mostly upon late glacial maximum climatic conditions that will occur during only 21% of the million-year period and include the greatest precipitation. It would be more representative to take a value based upon the most prevalent climate stage or to weight the stages based upon their prevalence.

Additionally, Thompson et al. indicate, "For 5000 ft (1524 m) at the Yucca Mountain repository we estimate that mean annual temperature (MAT) and precipitation (MAP) differed from our modern baseline data as follows:

> 35 to 30 ka: MAT = ~4° C colder than today, MAP = 1.5X modern levels;
> 27 to 23 ka: MAT = ~5° C colder than today, MAP = 2.2X modern levels;
> 20.5 to 18 ka: MAT = ~8° C colder than today, MAP = 2.4X modern levels;
> 14 to 11.5 ka: MAT = ~5.5° C colder than today, MAP = 2.6X modern levels"[8]

Thus, over the period from 35,000 to 11,500 years ago, the mean annual precipitation varied from about 188 mm/yr (i.e., 125 mm/yr x 1.5) to about 325 mm/yr (i.e., 125 mm/yr x 2.6), rather than the 266 to 321 mm/yr indicated in the draft rule. It would appear that this lower bound of 188 mm/yr is more relevant to establishing a lower bound for the range of precipitation for future intermediate and monsoon climates and for calculation of the lower bound of the range of deep percolation rates.

The NRC also states that "[e]stimates of deep percolation rate as a fraction of precipitation have been calculated for various climate conditions. Between 5 to 20 percent of precipitation could reach the repository depth under intermediate/monsoon to 'full glacial' climate conditions. The larger percentage reflects 'full glacial' conditions" (Mohanty et al.[9]). The technical basis proposed for these estimates (5 to 20 percent) of deep percolation rate as a fraction of precipitation for various climate conditions is not apparent in the cited reference. A more detailed, transparent technical basis for these percentage values is needed along with the applicable references for this technical basis. Additionally, it would appear that interglacial climate conditions should also be considered in this evaluation as Sharpe indicates that these conditions will occur 12% of the time over the next 1,000,000 years.

---

[7] Sharpe, S. 2003. *Future Climate Analysis—10,000 Years to 1,000,000 Years After Present.* MOD-01-001 REV 01. [Reno, Nevada: Desert Research Institute].

[8] Supra note 4 @ p. 34.

[9] Mohanty, S.; Codell, R.; Menchaca, J. M.; Smith, M.; LaPlante, P.; Rahimi M.; and Lozano, A. 2004. *System-Level Performance Assessment of the Proposed Repository at Yucca Mountain Using the TPA Version 4.1 Code,* CNWRA 2002–05 Revision 2, San Antonio, Texas: Center for Nuclear Waste Regulatory Analyses.

The climate change for the time period from 10,000 years to 1,000,000 years in the future (the period of geologic stability) is expected to be similar to past climate changes during the Quaternary Period. Within this past period, climate oscillated between full glacial and interglacial states many times over a similar timeframe. This would indicate that the future time period will not just include intervals that will be wetter and colder, it will also include periods that will be similar to the present (hot and dry) as well as various intermediate climates. The NRC proposed values to represent climate change are skewed to a representation of maximum deep percolation rate expected under full glacial conditions rather than a value that is representative of the full range of expected climates. The proposed range of deep percolation rates should be re-evaluated by developing a long-term average climate rather than a less frequent, worst-case, wetter and colder climate.

Finally, an alternative method to estimate recharge based on the range of precipitation values is provided by Maxey and Eakin.[10] The Maxey-Eakin method of estimating recharge as a percentage of precipitation suggests that for annual precipitation greater than 20 inches (about 510 mm), 25% would become recharge; for precipitation from 15 to 20 inches (about 380 to 510 mm), 15% would become recharge; for precipitation from 12 to 15 inches (about 300 to 380 mm), 7% would become recharge; for precipitation from 8 to 12 inches (about 200 to 300 mm), 3% would become recharge; and for precipitation less than 8 inches (~200 mm), 0% would become recharge.

For 321 mm of annual precipitation, the Maxey-Eakin method indicates that 7% would become recharge, which would be about 22 mm/yr. For 266 mm of annual precipitation, the Maxey-Eakin method indicates that 3% would become recharge, which would be about 8 mm/yr. This would give a recharge range from 22 mm/yr to 8 mm/yr. Calculating the mean value of a log-uniform distribution of deep percolation that ranges from 22 mm/yr to 8 mm/yr (as was done on Page 53316 of the proposed rule):

$$(22 \text{ mm/yr} - 8 \text{ mm/yr})/[\text{Log}_e(22 \text{ mm/yr}) - \text{Log}_e(8 \text{ mm/yr})] = 14 \text{ mm/yr}.$$

This calculation for a range of recharge (8 mm/yr to 22 mm/yr) and the calculation of the mean value of deep percolation (14 mm/yr) compares well with, and appears to be corroborated by, the value for average Late Pleistocene recharge rate of 15 ± 5 mm/yr estimated by Zhu et al.[11] at Yucca Mountain using the chloride mass balance method and chlorine-36 data. This suggests that these values are more representative of the full range of climate change and should be considered as a value of long-term average deep percolation of water to represent climate change. The Department believes that NRC should consider specifying deep percolation rates such as these that are more representative of potential future climates in the region.

---

[10] Maxey, G.B. and Eakin, T.E. 1950. *Ground Water in White River Valley, White Pine, Nye, and Lincoln Counties, Nevada.* Water Resources Bulletin No. 8. Carson City, Nevada: State of Nevada, Office of the State Engineer.
[11] *Supra* note 5 at p. 1182.

Dosimetry

Comment:

The definition of "weighting factor" in the NRC proposed rule specifies only tissue weighting factors. Radiation weighting factors are not specified, either explicitly or by reference. The definition of "weighting factor" in the proposed rule should be expanded to include radiation weighting factors. Alternatively, NRC could simply require that the calculation of doses be consistent with International Commission on Radiation Protection (ICRP) 60/72 methodology and use current scientific methods.

Supporting Information:

There are two basic applications of dose assessments. The first one is the protection of workers from occupational exposures. For external exposures, this type of dose assessment relies on operational quantities used for area and individual monitoring. The other one is the prospective dose assessment for hypothetical future scenarios or for the situations where it is either impossible or impractical to rely on the measured quantities.

ICRP Publication 26[12], and thus 10 CFR 20 which is based on ICRP Publication 26, make no distinction between the dosimetric quantities used for these two applications. 10 CFR part 20 is concerned primarily with workplace protection, and the quantities defined in the rule reflect that. Both ICRP 26 and 10 CFR 20 define and give the values of organ weighting factors and also the values of quality factors, Q. The latter are used to account for the ability of different radiations to produce different biological effects, even if the amount of energy imparted to tissue per unit mass is the same.

In Publication 60, the ICRP started using different approaches to radiation weighting for the protection quantities (which are used to define dose limits and can also be used in prospective dose assessment, but are not measurable) and for the operational quantities used in measurements of external exposure (which are measurable). Radiation weighting for the protection quantities is accomplished by using a radiation-weighting factor. Radiation weighting for the operational quantities still uses the concept of quality factors, which is given as a function of the unrestricted linear energy transfer.

In the draft EPA standard, the EPA proposes, "to adopt updated scientific factors for calculating doses to show compliance with the storage, individual-protection, and human intrusion standards".[13] In the statement of considerations[14], EPA accepts the ICRP 60 factors and any factors that may be produced in the future that are incorporated by EPA into Federal guidance. (This currently points to Federal Guidance Report No. 13.) The EPA then proceeds to adopt the ICRP 60-based radiation and organ weighting factors and gives their values in Appendix A.

---

[12] ICRP 1977, *Recommendations of the International Commission on Radiological Protection.* Volume 1, No. 3 of *Annals of the ICRP.* ICRP Publication 26.

[13] 70 Fed. Reg. 49014, 49022 (2005) (Public Health and Environmental Radiation Protection Standards for Yucca Mountain, Nevada; Proposed Rule).

[14] *Id.* at 49047.

The set of tissue weighting factors that EPA proposes in Table A.2 represents the most current recommendations of ICRP. Table A.2 is based on recommendations of ICRP 60 with the addition of the extrathoracic region (ICRP Publication 66[15]) and the clarification of tissue weighting factor for colon and upper large intestine (ICRP Publication 69[16]). The potential problem is that dose coefficients (i.e., those given in ICRP Publication 72[17] and Federal Guidance Report 13[18]) consider a slightly different set of organs. The Department, therefore, has recommended that EPA not provide the list of tissues and organs but require that the calculation of doses be consistent with ICRP methodologies.

The proposed NRC rule states that the approach NRC is proposing with respect to dosimetry conforms to the definition of weighting factors provided in the EPA proposal. However, the weighting factors are limited to tissue-weighting factors. The radiation weighting factors are not specified – neither explicitly nor by reference. This omission could imply that the old quality factors of 10 CFR 20 should be used. This is conceptually inconsistent with the ICRP 60 methodology because when the ICRP defines their dosimetric quantities, it is implicit that these contain the values of radiation and tissue weighting factors recommended at the relevant time by the ICRP. Moreover, as noted previously, the ICRP made a distinction in Publication 60 between the protection quantities and operational quantities and the quality factors are relevant only to the operational quantities. The corresponding quantity used for the prospective dose assessment, which is applicable to both preclosure and postclosure dose assessment for the repository, is the radiation weighting factor.

For the reasons stated above, DOE recommends that NRC not list the values of weighting factors, but simply require that the calculation of doses be consistent with the ICRP 60 and 72 methodologies and use current scientific methods.

If the NRC determines that specification of weighting factors is necessary, then DOE offers the following comments regarding the proposed amendments to 10 CFR 63.2.

The proposed amendment to 10 CFR 63.2 adds the following definition of weighting factor: "*Weighting factor* for an organ or tissue is the proportion of the risk of stochastic effects resulting from irradiation of that organ or tissue to the total risk of stochastic effects when the whole body is irradiated uniformly. For calculating the effective dose equivalent, the values in Appendix A of 40 CFR part 197 are to be used."

The proposed definition should be expanded to include radiation weighting factors. A statement regarding the use of the radiation weighting factor should also be added, since radiation weighting factors and tissue weighting factors come together as a part of the methodology introduced in ICRP 60. The NRC should also add a definition of quality factor for use in

---

[15] ICRP 1994, *Human Respiratory Tract Model for Radiological Protection.* Volume 24, Nos. 1-3 of *Annals of the ICRP.* ICRP Publication 66.
[16] ICRP 1995, *Age-Dependent Doses to Members of the Public from Intake of Radionuclides: Part 3, Ingestion Dose Coefficients.* Volume 25, No. 1 of *Annals of the ICRP.* ICRP Publication 69.
[17] ICRP 1996, *Age-Dependent Doses to Members of the Public from Intake of Radionuclides: Part 5 Compilation of Ingestion and Inhalation Dose Coefficients.* Volume 26, No. 1 of *Annals of the ICRP.* ICRP Publication 72.
[18] EPA 2002, *Federal Guidance Report 13, CD Supplement, Cancer Risk Coefficients for Environmental Exposure to Radionuclides, EPA.* EPA-402-C-99-001, Rev. 1.

operational external dose calculations for workers. A suggested replacement definition of weighting factors is given below:

> *Weighting factors* include radiation weighting factors and tissue weighting factors. Radiation weighting factor is a factor by which the mean absorbed dose in any tissue or organ is multiplied to account for the detriment by the different types of radiation relative to photon radiation. Weighting factor for an organ or tissue is the proportion of the risk of stochastic effects resulting from irradiation of that organ or tissue to the total risk of stochastic effects when the whole body is irradiated uniformly. For calculating the effective dose equivalent, the values of weighting factors in Appendix A of 40 CFR part 197 are to be used.

In addition, the definition of the total effective dose equivalent should be modified to capture the NRC's Regulatory Issue Summary 2003-04 that provides for the use of effective dose equivalent in place of the deep dose equivalent in dose assessments. In the suggested replacement below the underlined words were added to the original definition:

> *Total effective dose equivalent (TEDE)* means, for purposes of assessing <u>operational</u> doses to workers, the sum of the deep-dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures). For purposes of assessing doses to members of the public (including the RMEI) <u>and prospective doses to workers</u>, TEDE means the sum of the effective dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures).

Consistency in Definition of Reasonable Expectation in EPA and NRC rules

Comment:

Because NRC must set licensing requirements and criteria that are consistent with the EPA standards, the Department recommends that NRC acknowledge that the reasonable expectation test allows for decreasing confidence in the numerical results of the performance assessments as the compliance period increases beyond 10,000 years.

Supporting Information:

In the proposed rule, EPA did not propose to expand or modify the definition of reasonable expectation in § 197.14 to account for the greater uncertainty between 10,000 years and the time of peak dose (within one million years of disposal). The EPA did note that the existing definition describes principles that are applicable for both shorter and very long time frames, but that the implications of these principles may be different, depending on the time frame. Specifically, they noted that they believe that reasonable expectation becomes even more important as the level of confidence that can be placed in numerical projections decreases over time. Further, EPA noted that the 10,000-year period is an indicator of times when uncertainties in projecting performance are more manageable and for which comparisons can be made with other regulated systems.

In the proposed rule, EPA referenced the 1999 preamble to proposed 40 CFR Part 197, wherein EPA said that if it were to regulate longer than 10,000 years, the EPA would expect the licensing judgment to be less strict in relying on dose projections compared to 10,000 years (64 FR 46998, August 17, 1999). Specifically, EPA noted "... that if the compliance period for the individual-protection standard extended to the time of peak dose within the period of geologic stability (which the National Academy of Sciences Committee estimated to be 1 million years for the Yucca Mountain site), this [reasonable expectation] test would allow for decreasing confidence in the numerical results of the performance assessments as the compliance period increases beyond 10,000 years. For example, this means that the weight of evidence necessary, based upon reasonable expectation, for a compliance period of 10,000 years would be greater than that required for a compliance period of hundreds of thousands of years."

From: <Jackie.Chestnut@rw.doe.gov>
To: <SECY@nrc.gov>
Date: Wed, Dec 7, 2005 5:02 PM
Subject: Comments on 10 CFR Part 63

The U.S. Department of Energy offers the following comments on the U.S. Nuclear Regulatory Commission proposed rule, Implementation of a Dose Standard After 10,000 Years, published at 70 Fed. Reg. 53313 (2005). (See attached file: Letter to NRC Secretary.pdf) (See attached file: NRC Rulemaking Cover Letter to Secretary.doc)(See attached file: NRC Rulemaking Final comment package.doc)

DOE appreciates the opportunity to comment on the proposed rule.

Thank you.

CC: <tjm3@nrc.gov>

Mail Envelope Properties (43975BD6.4E3 : 19 : 38115)

Subject: Comments on 10 CFR Part 63
Creation Date: Wed, Dec 7, 2005 5:01 PM
From: <Jackie.Chestnut@rw.doe.gov>

Created By: Jackie.Chestnut@rw.doe.gov

Recipients
nrc.gov
owf5_po.OWFN_DO
SECY (SECY)

nrc.gov
twf4_po.TWFN_DO
TJM3 CC (Timothy McCartin)

Post Office	**Route**
owf5_po.OWFN_DO	nrc.gov
twf4_po.TWFN_DO	nrc.gov

Files	**Size**	**Date & Time**
MESSAGE	472	Wednesday, December 7, 2005 5:01 PM
Letter to NRC Secretary.pdf	318917	
NRC Rulemaking Cover Letter to Secretary.doc		35328
NRC Rulemaking Final comment package.doc		61440
Mime.822	573416	

Options
Expiration Date: None
Priority: Standard
Reply Requested: No
Return Notification: None

Concealed Subject: No
Security: Standard