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IEER Comments on the Nuclear Regulatory Commission's Proposed Rule on Low-Level Radioactive Waste Disposal (10 CFR Part 61; Docket NRC-2011-0012)[1]

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The following are the Comments of the Institute for Energy and Environmental Research concerning the Nuclear Regulatory Commission's Proposed Rule on Low-Level Radioactive Waste Disposal as it appeared in the *Federal Register* on March 26, 2015.

1. I have made a number of comments formally and informally on elements of NRC 2011[2] on many occasions, including at the invitation of the NRC staff. By-and-large, the proposed revisions ignore essentials of my comments at best. The NRC has ignored sound science and common sense in many aspects of the proposed rule.

2. The proposed rule revisions constitute a major federal action. For instance, the revisions would potentially allow large amounts of extremely long-lived radionuclides, including hundreds of thousands of tons of depleted uranium from enrichment plants and possibly even wastes currently defined as Greater-than-Class-C waste, to be disposed of in shallow land facilities. It is therefore incumbent on the NRC to prepare an Environmental Impact Statement on the proposed revisions, setting forth and analyzing reasonable alternatives as well as a no-action alternative.

3. A definition of the term "member of the public" should be provided in the rule. It should explicitly include people of all ages, including infants and children, and including males

[1] U.S. Nuclear Regulatory Commission, "10 CFR Parts 20 and 61 [NRC–2011–0012; NRC–2015–0003] RIN 3150–AI92. Low-Level Radioactive Waste Disposal; Proposed Rule," *Federal Register* v.80, no.58 (March 26, 2015), pages 16081-16125, on the Web at www.gpo.gov/fdsys/pkg/FR-2015-03-26/pdf/2015-06429.pdf, hereafter 80 FR 16081-16125 (2015-03-26).
[2] NRC 2011

as well as females. Annual dose compliance should be explicitly assessed to the member of the public who is estimated to get the largest dose according to this definition. Specifically, for the purposes of 10 CFR 61, the term "member of the public" should be defined as

> A member of the public is (i) a male or female of any age affected by the operations of a facility covered by this rule except during a period when he or she is carrying out any operation which is part of management or disposal of low-level radioactive waste, nuclear fuel cycle or (ii) a male or female of any age affected by the facility covered by this rule and/or the waste disposed of in it after the closure of the facility into the indefinite future.

4. The definition of "inadvertent intruder" in the proposed rule is absurd. How can a person be an "intruder" if they engage in normal activities, such as agriculture, after all institutional controls have expired and after all passive barriers are assumed to no longer be effective? An "intruder" by definition is someone who is not authorized to be on the site but enters anyway. After 500 years, people who enter the site will be members of the public who may gain access by purchasing land, by using in a manner that may then be authorized, or may simply be using land that has been opened up to the public by design or lapse of institutional memory. At that time, anyone on the former disposal site is simply a member of the public as defined in paragraph #3 above. We therefore suggest that the term "intruder" be confined to those entering the site without authorization or by crossing barriers for the first 500 years, as follows:

   > *Intruder*: Any person who enters the site inadvertently or deliberately without authorization or in violation of barriers during the 100-year period of institutional control after closure or during the 400 years after that when manmade barriers are expected to be effective.

   Dose limits for intruders should be applied only to persons fitting this description.

5. The proposed revised language of 10 CFR 61.41 (the proposed 10 CFR 61.41(a)) drops organ doses altogether from the rule on the grounds that equivalent dose, calculated using organ weighting factors is a "modern" approach because such weighting factors did not exist at the time of the publication of ICRP 2 (in the late 1950s) on which the current rule is based. This is disingenuous and misleading. It would also cause a massive relaxation of allowable pollution and organ doses from many radionuclides, including all actinides, strontium-90, and various radioiodines.

   While the ICRP has created a methodology for calculating effective dose using organ weighting factors, it has not done away with organ doses. *Indeed, organ dose calculations are the foundation of committed effective dose.* In other words, organ doses must first be calculated before effective dose can be calculated; *they remain the most fundamental quantity in estimating internal dose.*

   The calculation of effective dose from organ doses requires the interposition of "weighting factors" whose crude nature and even arbitrariness is evidenced, among other

things, by the fact that they have changed greatly in several ways since ICRP 60 was published in 1991. Table 1 shows the weighting factors in ICRP 60 published in 1991 and in ICRP 103 published in 2007.

Table 1: Organ or Tissue weighting factors in ICRP 60 (1991) and ICRP 103 (2007)

Organ or Tissue	**ICRP 60**	**ICRP 103**
Gonads	0.20	0.08
Bone marrow (red)	0.12	0.12
Colon	0.12	0.12
Lung	0.12	0.12
Stomach	0.12	0.12
Bladder	0.05	0.04
Breast	0.05	0.12
Liver	0.05	0.04
Oesophagus	0.05	0.04
Thyroid	0.05	0.04
Skin	0.01	0.01
Bone surface	0.01	0.01
Brain	N/A	0.01
Salivary glands	N/A	0.01
Remainder (Notes 1 and 2)	0.05	0.12

Source: ICRP 60 (1991) p. 8 and ICRP 103 (2007) p. 65. “N/A” means" not applicable.”
Notes: 1. Remainder in ICRP 60: adrenals, brain, upper large intestine, small intestine, kidney, muscle, pancreas, spleen, thymus, and uterus.
2. Remainder in ICRP 103: adrenals, extrathoracic (ET) region, gall bladder, heart, kidneys, lymphatic nodes, muscle, oral mucosa, pancreas, prostate (males), small intestine, spleen, thymus, uterus/cervix (females).

Note the large differences in the weighting factors for gonads (down by 60 percent in ICRP 103), breast (up by 140 percent in ICRP 103) and the “remainder” (up by 140 percent in ICRP 103).
The list of radiosensitive organs that had individual weighting factors is longer in ICPR 103; the list of organs in the “remainder” also increased in ICRP 103. For instance the lymphatic nodes were not included in weighting factors at all in ICRP 60. *Indeed, seven new organs appeared in ICRP 103 that were not mentioned at all in ICRP 60*: salivary glands, the ET region, gall bladder, heart, lymphatic nodes, oral mucosa, and prostate (males). *One organ was eliminated*: upper large intestine, which, in ICRP 60 was part of the “remainder”; this was in addition to the colon being listed as a separate organ.

The averaging of male and female gonads (testes and ovaries, respectively) also does not make sense in the context of the rule of protecting the most exposed member of the public. It is also highly prejudicial to women and to future generations. Specifically, primary oocytes are formed in utero; females are typically born with a million or more of them. Sperm, in contrast, are continuously created. Moreover, the contribution of the

ovum to a person is far greater than that of the sperm; for one thing, all mitochondria, which are the foundation of the human energy system, come from the ova. In contrast, radiation damage to an embryo arising from damaged sperm would typically occur due to exposure in the weeks just before conception; moreover sperm contribute no mitochondria.

Similarly, averaging the male and female breast makes no sense from the point of view of a rule seeking to protect all members of the public to a standard that is equal to or better than that of the most exposed member of the public. Female breast cancer is 100 times more common than the male breast cancer.[3] The risk factors for breast cancer incidence in BEIR VII show the female breast to be a highly radiosensitive organ; the male breast cancer risk was low enough that it was lumped together with the remainder of the cancers not explicitly listed. Female infants have a risk of 0.117 cancers per sievert for breast cancer alone. This risk is about the same as the lifetime average for all cancers (male and female average risk). In contrast, the prostate cancer risk for male infants is more than ten times lower – 0.0093 cancers per sievert. A weighting factor that averages male and female breasts therefore is highly stacked against females, especially female children who are highly vulnerable to breast cancer risk compared to almost all other cancers except non-fatal skin cancers, for which male infants have the greatest radiosensitivity, according to the EPA.[4]

It is clear that sex averaging of weighting factors is unjustified for a dose-based rule that seeks to protect "any member of the public."

Averaging organ weighting factors by age also makes no sense in a regulatory context in which the aim is to limit dose to the most exposed member of the public, who will often be a child. Children's organs are still developing; for some organs that process extends through puberty. Averaging them with adult organ weighting factors is scientifically unacceptable in a dose-based standard.

The NRC's argument that organ dose should be eliminated because the ICRP 2 approach was based on an obsolete "critical organ" approach is specious. Organ dose is still fundamental to internal dosimetry. There is nothing obsolete about this approach. Moreover, current science continues to show that many radionuclides target specific organs like the thyroid or bone surface. This means that limiting organ doses is the most protective way to limit harm to public health.

The organ dose approach is entirely modern; as noted, organ doses are the basis for effective dose estimates. The method of calculating organ doses has been updated, and the updated dose conversion factors have been published by the EPA in Federal Guidance Report 13. This new method of calculation should be adopted. That is the proper way

[3] American Cancer Society 2014

[4] NAS/NRC 2006 Table 12-D1 (p. 311); units converted to risk per sievert. The EPA estimates female breast cancer incidence risk as 0.126 cancers per Sv (EPA 2011 Table 3-12b (p. 54)). It is the most radiosensitive cancer of all excluding non-fatal skin cancers, for which male infants have the greatest radiosensitivity at 0.172 cancers per Sv (EPA 2011 Table 3-12a and Table 3-12b (p. 54)).

to update the rule to reflect recent scientific understanding. For internal dose this will mean limiting the committed equivalent organ dose due to intake in one year to any member of the public plus the external dose to that organ to a specified limit.

As further evidence of the current validity of organ dose, we note that U.S. government is implementing a large compensation program for current and former nuclear weapons complex workers stricken with cancer likely caused by radiation exposure at work based entirely on organ dose calculations. Internal doses to a specific target organ (relevant for a particular cancer) from a multiple radionuclides are calculated; external organ doses are added to them. Effective doses are not involved in determining probability of causation or in compensation decisions.

Further, the ICRP itself has explained that effective dose, while convenient for regulatory purposes and for estimating risk to the public on some aggregated basis, is not intended for individual protection:

> Effective dose is an *indicator for stochastic risk* but it is *not intended for the assessment of risks of individuals*.[5]

The reason is that there are "uncertainties in the low-dose range, underlying approximations, simplifications, sex and age - averaging)."[6] While the uncertainties and the degree of arbitrariness in weighting factors and the variable grouping of organs under the rubric of "remainder" of the body is not explicitly mentioned in this quote, any reasonable understanding of current dose estimation methods and of cancer induction points to organ doses as the most fundamental quantity in radiation dosimetry and the protection of public health if a dose-based standard is used.

ICRP 103 explains that the weighting factors are averages over populations do not apply to particular individuals:

> They represent mean values for humans *averaged over both sexes and all ages* and thus do not relate to the characteristics of particular individuals.[7]

10 CFR 61 and other basic radiation protection rules, like 40 CFR 190, are fundamentally about the limitation of *individual* dose. By limiting the dose to "any member of the public" to a specified value, the rule ensures that all members of the public are protected to the same or higher levels than the most exposed member of the public (that is, to a level of dose or risk that is lower than the most exposed member of the public). *This goal is substantially compromised when average weighting factors are used. It is utterly compromised when male and female weighting factors for all age groups are averaged, as is the case with present weighting factors in both ICRP 60 and ICRP 103.* This is because current understanding of radiation risk shows that females and children face substantially higher risk for most cancers than adult males for the same radiation dose.

[5] Menzel 2011 Slide 20, italics added
[6] Menzel 2011 Slide 20
[7] ICRP 103 (2007) p. 68, italics added

Children also generally get higher committed equivalent organ doses than adults per unit of radioactivity inhaled or ingested.[8] *These understandings of the higher risk faced by females and children and the higher doses experienced by children represent the most fundamental updating of the science that needs to be reflected in the revised rule. Effective dose, which uses average weighting factors, does not and cannot do that job.*

It would be unacceptable and unscientific to drop organ doses; it is all the more egregious that the NRC is proposing to do so on the grounds of modernizing and updating the science. As I have pointed out more than once, both to the NRC and to the EPA, we still have organs. Organ doses are still calculated in the most up-to-date science, though somewhat differently than before. The present science still shows that many radionuclides preferentially target certain organs, as a simple fact of human biology. *Organ doses are the most fundamental quantities in modern internal radiation dose estimation.* It is the weighting factors that are used to calculate effective dose that add a large element of uncertainty and even arbitrariness to the process. As they currently stand, they also obliterate essential differences between males and females and between children and adults. Effective dose may be convenient for regulators and licensees because it enables them to roll everything into a single number. *But regulation is not for the convenience of licensees and regulators. It is for the protection of the public.*

Modernizing and updating the science points in the direction of dropping effective dose and limiting the rule to organ doses, including internal doses from combinations of radionuclides added to the external dose. It is also relevant in this context to note that whole bodies do not get cancer (though, once contracted, it can spread throughout the body). Cancer initially affects a particular organ or system. Even circulatory and lymphatic system cancers have target organs, like the bone marrow and lymph nodes.

In sum, the most reliable current science points in the direction of focusing 10 CFR 61 on organ dose alone and rejecting committed effective dose.

Finally, it is important to note that dropping organ doses from the rule in favor of effective dose alone would substantially relax the implicit permissible concentrations of all radionuclides that preferentially target certain organs. Examples include all actinides and strontium-90, which target the bone surface, and radioactive isotopes of iodine which target the thyroid. This was pointed out in a study commissioned by the EPA as long ago as 1997.[9] It would be completely unacceptable to relax radiation protection under the guise of modernizing and updating the science, especially when recent science, including the risks published by the EPA in 2011,[10] has concluded that the cancer risks of radiation are far greater than those estimated when 40 CFR 190 was first promulgated.

In light of the above, we recommend that 10 CFR 61.41 be revised to read:

[8] FGR 13 CD Suppl. (2002)
[9] SC&A 1997
[10] EPA 2011

> Concentrations of radioactive material which may be released to the general environment in ground water, surface water, air, soil, plants, or animals must not result in an annual dose exceeding an equivalent of 25 millirems to the whole body or to any organ of any member of the public, with annual internal dose being defined as committed equivalent dose to any organ due to intakes of radionuclides in one year; all pathways are included in the estimation of dose, including the drinking water pathway from all sources of drinking water affected by the facility. Drinking water concentrations specified in or implicit in 40 CFR 141.66 must not be exceeded in surface water or groundwater at any point on or beyond the site boundary due to operations of the facility or disposal of radionuclides at the facility. Reasonable effort should be made to maintain releases of radioactivity in effluents to the general environment as low as is reasonably achievable.

We have reduced the allowable dose to the thyroid from 75 millirem per year in the existing rule to 25 millirem per year. The BEIR VII risk assessment for thyroid cancer shows that 75 millirem per year to the thyroid of female children from infancy to five years of age would by itself produce a thyroid cancer risk of about 2 in 10,000.[11] Exposures after that would further increase the risk. The new assessment of this disease and of sex differences in risk requires a lowering of the allowable thyroid organ dose to 25 millirem per year at most.

Note that the doses from all sources of drinking water should be included in the revised 10 CFR 61.41. One way to ensure protection of offsite water resources to the drinking water standard would be for the NRC to require groundwater and surface water at or beyond the site boundary to comply with EPA's drinking water limits. Even Milton Friedman, an eminent apostle of the free market and limited government, noted that the freedom of individuals should be limited in a variety of ways. Among other things he noted that "one man's freedom to murder his neighbor must be sacrificed to preserve the freedom of the other man to live." He noted this in the context of determining the "appropriate activities of government." In the same general context, he also opined that they should not be free to pollute the water flowing through their property because that action "in effect forc[es] others to exchange good water for bad" involuntarily: that is, an exchange when people are in situations where "it is not feasible for them, acting individually, to avoid the exchange or to enforce appropriate compensation."[12] This precisely describes the situation in which neighbors of NRC licensees find themselves. It is therefore the responsibility of the NRC, even in a minimalist interpretation of the appropriate role of government, to prevent that enforced exchange of good water for bad.

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[11] Calculated from NAS-NRC 2006 Table 12D-1 (p. 311). EPA 2011 estimates thyroid cancer risks to be somewhat lower at 1.4 in 10,000 (calculated from EPA 2011, Table 3-12b). In any case, even with the lower thyroid cancer risks in EPA 2011, the life risks from thyroid cancer alone at 75 millirem per year would exceed 3 in 10,000 were exposure at 75 millirem per year permitted. This clearly points to a lowering of the annual thyroid exposure limit by at least a factor of three, which is the recommendation in these comments.

[12] Friedman 1962 Chapter 2, on web at http://books.cat-v.org/economics/capitalism-and-freedom/chapter_02 the rule.

As noted above, the structure of the drinking water rule was originally meant to protect individuals and small water systems from possible large expenditures of a federal mandate. This was reasonable enough; but the same structure has, all too often, allowed corporate polluters to force their neighbors to involuntarily exchange good water for bad. It is time to plug this hole in the drinking water rule. The free pass that the EPA and the NRC have given to licensees to pollute their neighbors' water supplies must be revoked.

6. External dose calculations should take into account that children are smaller and hence their various organs are closer to the ground (and hence to contamination that is present on the ground). These organs include their reproductive organs. This is especially important for female children.

7. The proposed language of 10 CFR 61.41(a) does not specify what guidance document will be used for dose calculations. It should specify that the EPA's current guidance – Federal Guidance Report 13 – will be used. At present FGR 13 does not contain separate dose conversion factors[13] for males and females. Therefore, the rule should also specify that when the EPA publishes separate dose conversion factors for males and females that they will be automatically incorporated into compliance assessment.

8. One thousand years as a compliance period is both too short and too long. It is too long because the proposed rule makes no provisions for any barriers to be effective in ensuring that compliance can be achieved for beyond 500 years. It is too short because some radioactive materials have half-lives that are far longer. For instance, the half-life of uranium-238, the main constituent of depleted uranium, is over 4.4 billion years. Its specific activity grows over hundreds of thousands of years due to the growth of progeny (uranium-234, thorium-230, and radium-226). The proposed rule recognizes this problem but it unacceptably increases doses to the public to 500 millirem for a "protective assurance" period defined as the period from 1,000 years to 10,000 years.

   There is no basis on which to relax the protection of people far into the future compared to those alive today or those in the next 500 or 1,000 years. As noted above, doses to any organ of any member of the public should be limited to 25 millirem per year.

   While the rule proposes that analysis of shallow land burial performance can be done for 10,000 years, this is unrealistic. From what we know about the past, 10,000 years is a very long-time for analysis of performance of shallow land systems. Ice ages can occur and have occurred on time scales that are similar. Severe climate disruption due to warming is already occurring, according to the best available scientific evidence and analysis. The NRC's own invited experts to the 2009 depleted uranium workshop considered 10,000 years far too long for reasonable modeling of shallow land facilities. Specifically, Peter Burns, a geochemist, stated "I was **particularly amused** by the climatic divisions, none of which can be relied on, even perhaps at 1,000 but certainly not in 10,000 or 100,000 [years]. As an example, I am a geoscientist. **So I have this rare**

[13] Dose conversion factors for internal dose convert an intake (inhalation or ingestion) of a unit of radioactivity of a particular radionuclide into an organ dose.

ability to see into the far distant past. (Laughter.) And I know, for example, that Death Valley was filled with about 1,000 feet of water 10,000 years ago. And that tells you how much the climate can change in the arid regions."[14] The NRC has ignored this advice and the underlying science. No scientifically sound calculation for shallow land disposal can be done over such a long period; the uncertainties would be huge even for parameters that one might foresee, not to speak of those that one cannot. The uncertainty in the dose calculations could easily be several orders of magnitude. The proposed 10 CFR 61.13 would require that "uncertainties" be taken into account (at (a)(8)) in providing the "reasonable assurance" of compliance. But it provides no clue as to how climate disruption would be taken into account. Indeed, the word "climate" does not even appear in the proposed text, let alone a definition of climate change or climate disruption. The language regarding uncertainties in the proposed 10 CFR 61 is clearly *pro forma*; as it currently stands it would have little scientific connection to the real world over thousands of years.

At the same time, a 10,000 year time frame for reasonable assurance of limiting doses is not enough for certain radionuclides. IEER has shown that disposal of depleted uranium even in the very dry climate of southwestern Texas (Andrews County) can result in doses that would be thousands of times the 25 millirem limit, dependent on assumptions about erosion rate. At an erosion rate of 0.01 cm per year, the dose from grouted depleted uranium disposal at 100,000 years would be essentially zero; however, at an erosion rate of 0.032 cm per year, the peak external dose, (occurring at about 78,000 years) would be about 121 rem, or almost 5,000 times the 25 millirem annual limit.[15]

These are heuristic calculations (done with the DOE-created computer program RESRAD). They do not estimate dose in the future in any realistic sense, since erosion is only one parameter to be taken into account. But they do show that the doses from very long-lived radionuclides can be huge and that the uncertainties are also enormous. Both are irremediable problems of shallow land burial of large amounts of depleted uranium and other very long-lived wastes.

9. The rule should acknowledge that the risks from disposal of long-lived radionuclides, like plutonium-239 or the constituents of depleted uranium over time in shallow land facilities, are too uncertain to be accurately modeled. It is unacceptable to dispose of large total amounts of long-lived radionuclides even in low concentrations or long-lived radionuclides in high-concentrations in shallow land facilities. This means that long-lived radionuclides must have both total radioactivity and concentration limits. Examples include depleted uranium from enrichment plants, recycled uranium, and other such waste streams that resemble Greater-than-Class-C waste or transuranic waste. They should be banned from shallow land facilities and be explicitly designated for deep disposal without exception and without any loopholes.

10. It is acknowledged here that wastes containing mainly short-lived radionuclides cannot exclude every iota of long-lived material. This is the reason for having concentration

[14] NRC 2009, pp. 94-95. Emphasis added.
[15] Makhijani and Smith 2005, table on p. 16

limits. The current GTCC limits should be maintained. Table 1 in the present rule at 10 CFR 61.55(a) should be amended by dropping the word "transuranic." This simple change would limit the concentrations of a number of long-lived alpha-emitting radionuclides that are not covered by the present rule, including uranium-238, thorium-232, thorium-230, and radium-226.

11. Long-lived radionuclides should be defined as those having half-lives of more than 10 years, which is compatible with an institutional control period of 100 years (ten half-lives). The definition of long-lived waste in the proposed rule at 61.2 is far too expansive in the context of shallow land burial.

12. Total curie limits are needed, in addition to concentration limits in 10 CFR 61.55 and those recommended just above. For instance, Class C waste containing less than a hundred curies of carbon-14 (half-life 5,730 years), even under the current Class C concentration limits, can pollute groundwater (at least at Hanford) to levels exceeding safe drinking water standards as well as the 10 CFR 61 dose limits. This was the result as estimated by the Department of Energy's calculations for the reactor graphite disposal at the Hanford site.[16] Hundreds of curies disposed of in similar conditions would violate the present 10 CFR 61.41 without violating Class C concentration limits. The depleted uranium example discussed above provides another example.

13. The above considerations indicate that a method must be found to protect the public without crossing the boundaries of scientific reasonableness and common sense. The current rule does not do that; the proposed rule would make the problem a lot worse. This requires a multi-pronged approach that *must be adopted as a whole* given the complexity and variety of waste streams that are included under the unfortunate rubric of "low-level waste."

14. First, the compliance period should be limited to 500 years.

15. Second, for long-lived radionuclides that do not have decay products that build up beyond 500 years, curie limits could be set by examining a hypothetical pulse release of the entire inventory of long-lived radionuclides into the environment in various ways immediately after the end of the compliance period. The limits for long-lived radionuclides could be set so that the dose criteria would not be exceeded with any combination of long-lived radionuclides or release modes. This could allow upper curie limits to be derived in a scientifically reasonable way that would also ensure compliance with dose criteria. This is a reasonable approach for radionuclides such as carbon-14.

16. Third, a modified approach is needed for radionuclides that have build-up of decay progeny, such as uranium-238. In such cases, the peak inventory should be assumed to

[16] The DOE calculated that disposing of 37,000 curies of carbon-14 on the Central Plateau would cause a contamination of 1.3 million picocuries per liter, or 650 times the drinking water limit of 2,000 picocuries per liter. See Yakama Nation ERWM 2010, Attachment 3, pages 13 and 14. Assuming the same concentration and environmental conditions, a total source term of 57 curies would produce contamination to the drinking water limit. Adding pathways other than drinking water would of course add to the dose.

be released instantly at the end of the compliance period. For instance, in case of depleted uranium disposal, the peak future inventory of radium-226 would be assumed to be exposed to the surface at 500 years; external doses would be calculated based on that. In the case of internal dose. The equilibrium mixture of uranium-238 and its progeny would be assumed to be deposited in groundwater instantly and doses to a resident farmer family estimated on that basis. This would not be modeling in the conventional sense of choosing parameters such as erosion for the long-term. It would be a heuristic calculation that would indicate maximum conceivable dose without involving methods of estimating shallow land burial performance that are technically indefensible for periods of thousands of years. The goal would be to assure protection of the public according to the same standards we expect for ourselves today. Wastes exceeding the concentrations ***or*** quantities as discussed above should be slated for deep geologic disposal, as is the case for DOE transuranic waste.

17. The proposed "intruder" dose limit of 500 millirem per year is unacceptably high. There is no moral rationale for allowing doses to future generations beyond 500 years, the proposed period of barrier life after which "intruders" could come into the site unrestricted, to be greater than those for those of the present public or the public in the coming decades. The proposed limit is five times bigger than the 10 CFR 20 limit for members of the public from *all sources* of man-made radioactivity (except medical and sewer). Intruder doses should be limited to the same doses as for the present and immediate future. Only the method of calculating them after the formal modeling performance period would change.

18. With the above provisos, *and only with the above provisos*, the compliance calculations done by formal modeling such as by the use of RESRAD or similar approaches, can be limited to 500 years. This is a reasonable period, especially in view of the NRC proposed requirement for the durability of intruder barriers of 500 years. While the proposed rule states the requirement as "at least 500 years" (at 61.7(f)(3)), there is no regulatory mandate for durability beyond that time. If the NRC does not adopt total radionuclide and concentration limits as above and the calculation methods for long-term public health protection along the lines suggested above, then the present language of 10 CFR 61, Subpart C, which does not have a time limit of compliance, should be maintained. This would not be a very good result but greatly preferable to the proposed changes to 10 CFR 61 regarding compliance period.
19. The revised rule should address how the NRC is going to assure the scientific soundness of the modeling. It should also create a process for making corrections of errors if and when they occur in licensing-related technical documents along with license amendments as needed in such cases. I have pointed out the problem of some specific egregious errors and their persistence over many years in a number of forums. It is important for the NRC to have a formal external, independent review procedure in done through blind contracts awarded from an escrow fund not controlled by the industry or by the NRC. The NRC should also have a procedure for promptly addressing technical errors pointed out by the public as part of the rule and for making the needed corrections should they be verified. Verification calculations should be published promptly.

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