# GTCC WASTE MANAGEMENT

Arjun Makhijani, Ph.D.
President, IEER
At the Nuclear Regulatory Commission
August 13, 2015

# OVERVIEW

- The current 10 CFR 61 revision proposal, to have a period of performance of 10,000 years and allow site-specific performance-based evaluation in place of conformance to waste concentration limits, is fundamentally deficient, made much worse by the potential inclusion of GTCC waste in shallow land burial, including potentially large amounts of depleted uranium.
- 10 CFR 61.55(a)(3)(iii) and (a)(4(iv) should be tightened to require that all wastes with concentrations greater than Tables 1 and 2 (column 3) **SHALL *be disposed of in deep geologic burial without exception. The word "transuranic" should be removed from Table 1.***
- 10 CFR 61.55(a)(3)(iii) should be expanded to include curie and concentration limits for ALL long-lived radionuclides (half-lives >10 years). Depleted uranium and recycled uranium are like transuranic waste (or GTCC) for disposal purposes and should be governed by a requirement for repository disposal.
- The NRC proposal to revise 10 CFR 61.41 to eliminate organ doses under the guise of modernizing the science is a disingenuous deception of the public. It is nothing less than an egregious relaxation of the standards. The current dose standards should be tightened by the incorporation of drinking water rules by reference.
- My comments on the proposed LLW rule revisions are the basis of a large part of my presentation here and should be referred to as you review my remarks. They are at http://ieer.org/wp/wp-content/uploads/2013/01/IEER-Comments-on-NRC-LLW-disposal-7January2013-Docket-NRC-2011-0012-1.pdf.

# PERFORMANCE PERIOD (SLIDE 1)

1. In 2009, Peter Burns, an NRC-invited 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 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."
2. The draft LLW rule has completely ignored this advice and set a performance period of 10,000 years.
3. The draft rule also ignores specifics related to the added complexity that anthropogenic climate disruption is adding to the problem of long-term performance assessment of LLW sites.
4. The proposed rule also allows radionuclides whose concentrations build even after that time to be disposed of in low-level waste facilities. No computer program or performance assessment can remedy the risks of near-surface disposal of very long-lived radionuclides.

# PERFORMANCE PERIOD (SLIDE 2)

1. Shallow land burial should be confined to amounts and concentrations that would not exceed dose limits (10 CFR 61.41 with a drinking water sublimit) at 500 years (intruder barrier time) if the entire amount of waste were released into the groundwater at that time or if performance assessment indicates that doses may be exceeded during that period.
2. In the case of radionuclides with daughter products that build up, a "Gedanken" calculations of doses resulting from release of peak amounts, whenever they occur, should be done; they should be used to set curie limits, assuming a resident farmer scenario.
3. The calculations in 1 and 2 above should be used to set curie limits for long-lived radionuclides, including carbon-14, Sr-90, Cs-137, Ni-59, and Ni-63, as well as all radionuclides in Table 1 that do not fall into the GTCC category. Deep geologic disposal rules should govern GTCC.
4. After 500 years, there are no "intruders." That word applies only to persons entering prohibited areas, often with criminal intent. If barriers are not required to persist beyond that time, all people on the site are simply members of the public. Their doses should be limited to the current 10 CFR 61.41 and to the drinking water limits if by that pathway. These is no scientific or etymological basis for a regulatory idea that a person could be an "intruder" after institutional controls and barriers are presumed to be gone.
5. Using this method and with the above rule changes, the performance period should be limited to 500 years. This is the longest that is reasonable for low-level waste facilities. But without the accompanying restrictions described above on long-lived radionuclides outlined here, a short performance period would simply allow a radiological ambush of unsuspecting future generations.

# GTCC WASTE CONCENTRATIONS

- Long lived waste should be defined as having half-lives >10 years. Rationale: decay time, ~10 half-lives, is greater than the required period of institutional control.
- The term “transuranic” should be removed from Table 1 in 10 CFR 61.55. This will then accommodate thorium and uranium, including depleted uranium and recycled uranium in the present rule so far as concentrations are concerned.
- As described in the previous slide, there should be curie limits in addition to concentration limits for long-lived radionuclides. This is a way to reduce uncertainties and have better assurance that future generations doses will not exceed 10 CFR 61.41 in the period beyond 500 years.
- Dilution of waste that results in a lower classification (e.g., C to A, or GTCC to C) should be prohibited.

# COMMENTS RE: 10 CFR 61.41 ALSO RELEVANT FOR GTCC WASTE (SLIDE 1)

- The argument that updating the dosimetric basis of the standards requires or even implies going from organ doses and the equivalent dose to the whole body in the current rule to committed effective dose is an egregious misrepresentation of the science and the ICRP's work at best and sophistry at worst. It disguises a large relaxation of radiation protection, especially in regard to radionuclides with target organs, including all actinides and Sr-90. The ICRP has updated its organ dose methodology. My arguments are stated in detail in my comments to the EPA's ANPR for 40 CFR 190, which I incorporate here by reference. http://ieer.org/wp/wp-content/uploads/2014/08/IEER-Comments-on-EPA-ANPR-40cfr190.pdf.
- **Organ doses remain the fundamental scientific basis of internal dosimetry**. Committed effective dose is a derivative quantity that requires organ weighting factors, which have changed in odd ways in the past.
- The proposed 10 CFR 61.41(a) and (b) would result in a large relaxation of contamination limits and organ dose limits, especially with respect to waste containing transuranic radionuclides, any other actinides, including depleted uranium and other similar wastes and any other radionuclides like Sr-90 that have target organs. This includes much GTCC waste and the waste we propose be treated like GTCC (like depleted uranium).

# COMMENTS RE: 10 CFR 61.41 (SLIDE 2)

- Organ weighting factors are averages over all ages and over males and females. Given that we know (BEIR VII, EPA Blue book, Table 3-12a and 3-12b), this is unacceptable for protecting individuals. 10 CFR 61 seeks to protect "any member of the public." This means the most exposed member of the public. It is rendered meaningless when organ dose weighting factors for children, males, and females are averaged.
- The ICRP has itself has explained that "Effective dose is an indicator for stochastic risk but it is *not intended for the assessment of risks of individuals*" (italics added). And 10 CFR 61 limits individual dose -- not population dose.

# COMMENTS RE: 10 CFR 61.41 (SLIDE 3)

I conclude, therefore, that whole body dose can be eliminated from 10 CFR 61.41. The following paragraph can replace the existing 10 CFR 161.41. It is sound, updated science, including BEIR VII and EPA's Blue book and would protect females, children, and males :

- Concentrations and total amounts of radioactive materials which may be released to the general environment in groundwater, surface water, air, soil, plants, or animals must not result in an annual organ dose (external plus internal) to any organ exceeding 25 millirem. Annual internal organ dose is defined as the 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. Drinking water concentrations specified in or implicit in 40 CFR 141.66 shall not be exceeded in surface water or groundwater at any point on or beyond the site boundary. Reasonable effort should be made to maintain releases of radioactivity in effluents to the general environment as low as reasonably achievable.

# MEMBER OF THE PUBLIC, INTRUDER

- The term intruder should be defined to be any person who enters the site during the 100-year period of institutional control or during the 400 years after that when barriers are expected to be operational.
- During the 500-year period, all persons outside the site not acting in an official capacity are “members of the public.” After 500 years all persons are members of the public and 61.41 should apply to them.
- A suitable definition of member of the public should be included: Member of the public means any individual that can receive a radiation dose in the general environment, whether she/he may or may not also be exposed to radiation as part of an occupation associated with the low-level waste facility. However, an individual is not considered a member of the public during any period in which she/he is engaged in carrying out any operation which is part of the low-level waste facility.

# GTCC WASTE IMPLICATIONS

- The above general comments on 10 CFR 61.41 and on definitions of members of the public would also apply to GTCC waste.
- The EPA can be asked to issue a new rule for the ensemble of wastes, including GTCC waste, that should go into a deep geologic repository.
- The rule would resemble 40 CFR 191, though dose limits would be in terms of organ doses only, as described above.
- Given the volume of GTCC and other wastes that should be disposed of in deep geologic repository, it is desirable to evaluate a repository process separate from the spent fuel disposal process to deal with these wastes. This is for both economic and environmental reasons.

# SLIDES NOT TO BE PRESENTED BUT ARE PART OF MY COMMENTS

- The slides that follow are part of my comments but I do not plan to present them. They describe the inventories of various materials that should be disposed of in a deep geologic repository. They includes both civilian and DOE waste. This is apt since DOE is responsible for GTCC waste as well as its own GTCC-like waste. There are, moreover, vast quantities of other long-lived wastes that are estimated to utterly destroy groundwater's usability over the long-term. The carbon-14 inventory of the Hanford graphite moderator blocks is one important example.
- If they are not doing so already, I recommend that the NRC and DOE coordinate their activities and proposals in regard to GTCC waste, related DOE waste as described in the following slides, the NRC LLW rule revision, and related matters to ensure that the GTCC wastes and other similar wastes (enumerated in slides below) are slated for deep geologic disposal.
- The inventories below do not constitute and an exhaustive list.

# SHOULD BE DISPOSED IN DEEP GEOLOGIC DISPOSAL ALONG WITH GTCC

- Depleted uranium
- Recycled uranium
- Pre-1970 Buried TRU waste
- Hanford graphite moderator blocks
- ILAW (immobilized low-activity waste) at Hanford
- Sr-90 and Cs-137 capsules at Hanford.

# DEPLETED URANIUM AS GTCC-LIKE

- Uranium is not a transuranic (TRU) element, yet it has all the physical, chemical, and radiological characteristics of TRU radionuclides.
- The specific activity of uranium oxides, the chemical form for disposal, is well above 100 nanocuries per gram.
- The specific activity increases with time

# INVENTORY OF EXISTING DEPLETED URANIUM

- About 700,000 metric tons stored in steel cylinders in the form of uranium hexafluoride ($UF_6$) at Paducah (KY), Portsmouth (OH), and Oak Ridge (TN).
- Will become 558,000 metric tons once turned into $U_3O_8$.
- This is the equivalent of about 190,000 curies.

# ACTUAL AND ESTIMATED PROJECTED (IN 2011) INVENTORY OF DU3O8

| | Current/Projected | Metric tons | Cubic meters | Curies |
|---|---|---|---|---|
| DOE complex | Current | 5.58E+05 | 6.72E+04 | 1.90E+05 |
| LES | Projected | 3.09E+05 | 3.72E+04 | 1.05E+05 |
| Areva | Projected | 3.46E+05 | 4.16E+04 | 1.17E+05 |
| Total | Current and Projected | 1.21E+06 | 1.46E+05 | 4.12E+05 |

# RECYCLED URANIUM

- 250,000 metric tons in the DOE complex with various degrees of enrichments.
- Contains transuranic radionuclides (mainly plutonium and Np-237), fission products (mainly Tc-99), and activation products (mainly U-236).

# PRE-1970 BURIED TRU WASTE

- DOE is planning to leave it in the soil.
- It is greater than class C under NRC rules and TRU under EPA rules.

| | Volume $m^3$ | Curies | nanocuries/g |
|---|---|---|---|
| Total DOE sites (including Hanford) | 138,000 | 48,510 | 195 |
| Hanford | 82,800 | 42,651 | 286 |

# REACTOR GRAPHITE WASTE AT HANFORD

- The radionuclide of concern is carbon-14. The concentration is slightly less than GTCC definition but potential groundwater contamination, if buried at Hanford, would be much greater than drinking water standard.
- The total C-14 radioactivity is 37,400 curies in the graphite reactor blocks of all 8 reactors. Total release would likely be greater than allowed for spent fuel from a deep geologic repository under 40 CFR 191 (100 curies per 1,000 metric tons of spent fuel for a total of 10,000 to 15,000 curies from all U.S. reactor spent fuel, already generated and projected from existing reactors).
- This could be released as radioactive carbon dioxide to the air or to water from shallow land burial. It is not suitable for shallow land burial. The curie amounts are too large.

# IMMOBILIZED LOW ACTIVITY WASTE (ILAW) AT HANFORD

- Volume: 160,000 cubic meters
- Activity: 476,000 curies (Tank EIS, Alternative 2A)

# INVENTORY OF GTCC AND OTHER WASTES THAT SHOULD BE SLATED FOR DEEP GEOLOGIC DISPOSAL

| | Volume $m^3$ | Curies |
|---|---|---|
| DU ($DU_3O_8$) | 146,000 | 412,000 |
| RU | 13,200 | 250,000 (1) |
| TRU | 138,000 | 48,510 |
| ILAW | 160,000 | 476,000 |
| Graphite moderators | 5,690 | 37,400 |
| GTCC LLRW and GTCC-Like | 7,710 | 1,790,000 |
| Total | 470,000 (rounded) | 3,000,000 |

(1) Assuming an average activity of 1,000 nanocuries per gram

# SR-90 AND CS-137 CAPSULES

- Extracted from high-level liquid waste to reduce radioactivity

| | MCi in 2001 | MCi in 2011 | Volume $m^3$ | MCi/$m^3$ in 2011 |
|---|---|---|---|---|
| Sr-90 | 20 | 16 | 1.5 | 11 |
| Y-90 | 20 | 16 | | |
| Cs-137 | 47 | 37 | 3.5 | 5 |
| Ba-137m | 47 | 37 | | |
| Total | 134 | 106 | 5 | not applicable |