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The NRC's September 2-3, 2009, workshop on Depleted Uranium Waste Rulemaking
Arjun Makhijani's notes
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The NRC held a two day workshop on a proposed change in the low-level waste disposal regulation, 10 CFR 61.55, to accommodate large amounts of depleted uranium (DU) from uranium enrichment plants and other "unique" waste streams. I participated in this workshop, at the invitation of the U.S. Nuclear Regulatory Commission (NRC). The proceedings were transcribed. The transcript and slide presentations have been posted on the NRC's website.[1]

The reader should remember that these are my notes on the workshop discussion. They include my notes on what was said as well as my own observations and conclusions. Others will undoubtedly have their own conclusions. The last section represents my conclusions alone.

The notes are preceded by some background information. The NRC is preparing its own minutes of the meeting, which will be published. The NRC staff expressed the hope that these minutes would be available before the next workshop in Salt Lake City, to be held on September 23 and 24, 2009.

NRC staff person Chip Cameron, who moderated the workshop, said that the conclusions of the workshops would be brought to the attention of the Commissioners. Public comment on the course of the rulemaking is open until October 30, 2009.

A. Background

In March 2009, the Commission directed the staff to proceed in a rather specific investigation pursuant to a recommendation in an October 2008 NRC staff paper, SECY-08-0147.[2] That staff paper was prepared pursuant to a Commission finding three years prior, in October 2005, known

[1] The transcripts, slide presentations, and background documents are available on the NRC's web page: *Unique Waste Streams*, at http://www.nrc.gov/about-nrc/regulatory/rulemaking/potential-rulemaking/uw-streams.html. The Transcripts are hereafter cited as NRC DU meeting transcript, September 2, 2009 and NRC DU meeting transcript September 3, 2009.

[2] R.W. Borchardt (Executive Director for Operations), to the Commissioners [of the NRC], *Response to Commission Order CLI-05-20 Regarding Depleted Uranium*, Rulemaking Issue, SECY-08-0147, October 7, 2008, on the Web at http://www.nrc.gov/reading-rm/doc-collections/commission/secys/2008/secy2008-0147/2008-0147scy.pdf.

as CLI-05-20,[3] that large amounts of depleted uranium had not been analyzed in the low-level waste Environmental Impact Statement (EIS), which, in turn, was prepared a decade-and-a-half earlier. The present low level waste classification scheme, specified in regulations at 10 CFR 61, is derived from the EIS analysis. The Commission's recognition of the fact that the EIS did not contain an analysis of the impacts of disposal of large amounts of depleted uranium, such as those from uranium enrichment plants, was a determination long sought by intervenors in enrichment plant proceedings, first during a proposed plant in Louisiana in the 1990s (which was never built) and then during the license proceedings for the National Enrichment Facility, which is being built in New Mexico. The Commission's order, CLI-05-20, came in that context and the October 2008 staff paper, SECY-08-0147, was prepared as a result.

SECY-08-0147 developed four options:

- *Option 1*: This would follow a January 2005 Commission finding[4] that DU was low-level waste within the meaning of the low-level waste regulations, but without further sub-categorization of DU within the Class A, B, C, and Greater Than Class C scheme. Option 1 would publish guidance stating that whatever disposal method was adopted, a demonstration of compliance with the radiation protection part of the low-level waste rule (10 CFR 61 Subpart C) would be required. Licensees proposing to dispose of DU could not assume that it would be Class A low-level waste. Such a classification for DU from enrichment plants has been suggested by the nuclear industry in the past in the context of enrichment plant licensing proceedings, whereas IEER has argued that DU is akin to GTCC waste and should be classified as such within the low-level waste rule.
- *Option 2*: SECY-08-0147 did some generic analysis, based on a model that has not been published, and a number of assumptions, indicating that shallow disposal of DU was (i) unsuitable at humid sites, and (ii) may be suitably disposed of, if meeting the requirements of 10 CFR 61 Subpart C, at arid sites, even if the period of performance (dose estimation) is extended to one million years. This is the order of magnitude of time at which a peak dose from DU disposal might be expected. Since shallow land disposal was indicated to be unsuitable at some sites, and may be suitable at others, Option 2 was to modify 10 CFR 61.55(a)(6) to allow disposal of large amounts of DU and other "unique" waste streams by adding a new paragraph to the disposal rule. This new paragraph, to be numbered 61,55(a)(9) would require a site specific analysis for shallow land disposal of such waste streams. Disposal of such waste at low-level waste sites (including those licensed only for Class A waste) would be allowed if the site specific analysis met the performance objectives of the low-level waste regulation, specified at 10 CFR 61 Subpart C.
- *Option 3*: This option would be to analyze the characteristics of large amounts of DU to determine its classification within the Class A, B, C, or GTCC framework. This would

[3] U.S. Nuclear Regulatory Commission, *Memorandum and Order, In the Matter of Louisiana Energy Services, L.P. (National Enrichment Facility) Docket No. 70-3103-ML*, CLI-05-20, October 19, 2005, on the Web at http://www.nrc.gov/reading-rm/doc-collections/commission/orders/2005/2005-20cli.pdf.

[4] U.S. Nuclear Regulatory Commission, *Memorandum and Order: In the Matter of Louisiana Energy Services L.P. (National Enrichment Facility)*, CLI-05-05, January 18, 2005, on the Web at http://www.nrc.gov/reading-rm/doc-collections/commission/orders/2005/2005-05cli.pdf.

essentially amount to filling the gap left behind by the omission in the low-level waste Final EIS.

- *Option 4*: This option would be to go back to the drawing board and reevaluate the whole low-level waste classification framework, "using updated modeling and performance assessment techniques to evaluate and revise the existing waste classification tables for all radionuclides, if necessary, not just for DU.

In March 2009, after reviewing SECY-08-0147, the Commissioners chose Option 2:

> Previously, in the adjudicatory proceeding for the Louisiana Enrichment Services (LES) license application, the Commission determined that depleted uranium is properly classified as low-level radioactive waste. Although the Commission stated that a literal reading of 10 CFR 61.55(a)(6) would render depleted uranium a Class A waste, it recognized that the analysis supporting this section did not address the disposal of large quantities of depleted uranium. Outside of the adjudication, the staff was tasked to evaluate this complex issue and provide specific recommendations to the Commission. SECY-08-0147 is the result of the Commission's direction and provides recommendations for a path forward.
>
> As an initial approach to addressing this complicated issue, the Commission has approved the staff's recommended Option 2 to 1) proceed with rulemaking in 10 CFR Part 61 to specify a requirement for a site-specific analysis for the disposal of large quantities of depleted uranium (DU) and the technical requirements for such an analysis; and 2) to develop a guidance document for public comment that outlines the parameters and assumptions to be used in conducting such site-specific analyses.[5]

However, the vote was not unanimous. Commissioner Jaczko, who has since been appointed the Chairman of the NRC, voted against Option 2, having earlier stated his preference for Option 3:

> In my original vote on SECY-08-0147, I approved Option 3 (determine classification for depleted uranium within existing classification framework) and I disapproved the staff's recommendation for Option 2 (rulemaking to specify requirement for site-specific analyses for the disposal of large quantities of depleted uranium). Since that vote, which was dated November 3, 2008, more information has come to light that I would like to address in my vote.
>
> The disposal of large quantities of depleted uranium (DU) is a unique challenge because, unlike typical low-level waste, the doses increase over time rather than decrease. The technical analysis included with SECY-08-0147 indicates that additional requirements are likely needed for disposal of large quantities of DU in order to protect public health and safety; for example, increased waste disposal depth or robust radon barriers may be required. However, Option 2 does not explicitly change the classification of DU as presently provided for in 10 CFR 61.55 and therefore the waste would remain classified as Class A. I do not

[5] Annette L. Vietti-Cook (Secretary [of the Commission])**,** Memorandum to R. W. Borchardt (Executive Director for Operations), *Staff Requirements – SECY-08-0147 – Response to Commission Order CLI-05-20 Regarding Depleted Uranium*, Nuclear Regulatory Commission, March 18, 2009, on the Web at http://www.nrc.gov/reading-rm/doc-collections/commission/srm/2008/2008-0147srm.pdf.

believe that it is logical to argue that that waste that requires additional requirements for disposal (similar to those required for Class C waste) can still be labeled as Class A waste.[6]

B. Arjun Makhijani's workshop notes

There were three broad topics discussed;

1. Narrow rule changes for disposal of large amounts of DU from enrichment plants and from other waste streams, since DOD and DOE have non-enrichment DU waste streams.
2. A long term process for a "risk-informed" review of low-level waste regulations.
3. Other "unique" waste streams besides DU that are not now covered explicitly in the low-level waste rules.

Most of the discussion was on the first topic.

1. NRC staff presentations on the Commission's order and SECY-08-0147.

a. Larry Camper

The initial NRC staff presentation was by Larry Camper, who noted that only small quantities were considered in the low-level waste EIS: about 6 metric tons were considered at a concentration of 0.05 microcuries per cc. Large amounts of DU were a new issue.

He stated that DU is currently Class A waste by default since it captures all radionuclides not specified explicitly in 10 CFR 61.55. As regards performance assessment for demonstrating compliance with 10 CFR 61 Subpart C, he stated that it was a "living tool."

b. Dr. David Esh

Dr. Esh reiterated that large amounts of DU were not analyzed in the final low level waste EIS: the draft of that EIS only considered 17 curies of U-238 (about 5 metric tons of pure depleted uranium or about 6 metric tons of DU in oxide form by my calculation) or 3 curies of U-235. This amount of DU is far lower than the amounts produced by uranium enrichment plants. Dr. Esh laid out some of the technical details of the modeling of disposal of large amounts of DU that form the basis of the analysis in SECY-08-0147, which was the technical background to the Commission's (divided) decision to pursue Option 2.

The following are features of the analysis:

- It considers sites in various climatic zones, but is not site specific.

[6] *Commissioner Jaczko's Revised Comments on SECY-08-0147 Response to Commission Order CLI-05-20 Regarding Depleted Uranium*, March 6, 2009, on the Web at http://www.nrc.gov/reading-rm/doc-collections/commission/cvr/2008/2008-0147vtr.pdf. See pdf pages 7 and 8.

- It assessed doses for one million years – the approximate period during which the decay products of U-238, the main ingredient of DU, continue to build up. This approximates a peak dose calculation.
- As radium-226 builds up over thousands of years, radon-222 emissions increase. Radon-222 doses were included in the analysis. A clay layer that would inhibit radon migration was included. Given the assumption of no erosion, this layer would essentially stay intact over a million years.
- Shallow burial (defined as less than 30 meters depth) at various depths was considered.
- Chronic intruder as well as offsite resident doses were considered.
- Various exposure pathways were considered.
- Both air and water induced erosion were assumed to be zero for one million years.
- An ad hoc model, consisting of a commercial Monte Carlo package and an in-house spreadsheet was developed.
- The dose assessment was based on TEDE, which is Total Effective Dose Equivalent (defined as the sum of deep external dose and committed effective dose equivalent for internal dose).
- For the offsite resident a 25 millirem TEDE dose limit was applied as the performance objective. For the chronic intruder who builds a house above the disposal site, a 500 millirem dose limit (TEDE) was applied as the performance objective.[7]

The following limitations of the analysis should be noted (most came up during the presentations or the discussion):

- Climate change was not considered – that is, a constant climate was assumed for one million years.
- Colloidal transport of radionuclides was not included.
- The clay barrier to radon migration into a home built over or near the disposal area was assumed to stay intact over a million years (e.g., no cracks would develop that may allow more migration of radon into the house).
- Changes to the chemical form of uranium over one million years were not considered.
- Disposal in above-ground structures, such as those used by EnergySolutions at its Clive, Utah, site, was not analyzed.
- Organ doses, which are required under 10 CFR 61 Subpart C to be limited (25 millirem per year to any organ except for 75 millirem to the thyroid) were not evaluated.

The results were as follows:

- Using the TEDE approach, the analysis concluded that shallow land burial, less than 3 meters deep, was not suitable for DU, except for "small quantities" defined as 1 to 10 metric tons.[8]

[7] It should be noted that 10 CFR 61 requires assurance that an inadvertent intruder be protected after institutional control expires, but does not specify a dose limit. 10 CFR 61.42 states in its entirety: "Design, operation, and closure of the land disposal facility must ensure protection of any individual inadvertently intruding into the disposal site and occupying the site or contacting the waste at any time after active institutional controls over the disposal site are removed." A figure of 500 mrem per year is often used for performance assessment.
[8] SECY-08-0147 2008, Enclosure 1, p. 16.

- Disposal of DU in large amounts at humid sites "with viable water pathways is probably not appropriate."[9]
- For disposal at 5 meters or deeper, up to 30 meters, SECY-08-0147 concluded that disposal at arid sites could meet performance criteria:

> Depleted uranium can be disposed of under arid conditions and meet the Part 61 performance objectives for 1,000 to 1 million years performance periods, if the waste disposal depth is large, or robust barriers are in place to mitigate radon.[10]

There were also other technical presentations on details of some issues. Specifically, there was consideration of:

- Site specific geochemistry issues
- Site specific radon issues

These were presented by Dr. Karen Pinkston.[11]

Finally, there were legal and regulatory framework discussions on topics such as:

- What changes should be in the rule versus what should be just in the guidance document.
- Compatibility between federal regulations and regulations adopted by Agreement States. This is connected to the question of guidance and rule changes.

2. Discussion

There were invited panelists around the table as well as members of the public who were asked for comment. Invited panelists included other federal government entities (DOE, DOD), state regulators, representatives of waste companies (EnergySolutions and Waste Control Specialists), academics, consultants, and NGO representatives. Diane D'Arrigo and Arjun Makhijani were present representing Nuclear Information and Resource Service and IEER, respectively.

a. Performance issues – 10 CFR 61 Subpart C

SECY-08-0147 concluded that shallow land burial (at five meters or more) of large amounts of DU could meet the performance criteria of 10 CFR 61 (see above). However, the analysis does not actually correspond to the performance criteria in 10 CFR 61, which requires an organ dose annual limit of 25 millirem (except for the thyroid, which has a 75 millirem limit).[12] For instance, the bone surface dose from drinking water contaminated with lead-210 (a decay product of radon-222) is more than 30 times bigger than the committed whole body dose.[13]

[9] SECY-08-0147 2008, Enclosure 1, p. 16.
[10] SECY-08-0147 2008, Enclosure 1, p. 16. Emphasis in the original.
[11] Slides were co-authored by Karen Pinkston and Christopher Grossman.
[12] 10 CFR 61.41 (2008)
[13] Lead-210 would be inhaled since it is present in the air as a result of radon-222 seepage into a house. It is a decay product of radon-222. Dose conversion factors in these comments are from EPA's *Federal Guidance Report 13,* supplement CD published in 2002.

Similarly, the bone surface dose from ingestion of U-238 (the main radionuclide in DU) is about 16 times bigger than the committed effective dose equivalent. When I asked about why the performance assessment was not according to the criteria in 10 CFR 61 Subpart C, Dr. Esh stated that the NRC staff had used a "modern" approach and used TEDE as the performance criterion:

> Primarily because in more recent evaluations; in particular, for waste incidental to reprocessing, we have had direction from the Commission to use more modern methods, instead of those old methods. So we followed that direction. [14]

I pointed out that human beings still have organs, and Subpart C requires organ dose calculations, so it is not a question of modern methods of calculation or not, but whether Subpart C was on the table and whether the Commission had authorized it to be on the table in this particular proceeding rather than the long-term proceeding to review the whole low-level waste rule. Dr. Esh's answer indicates that somewhere, in some document, the Commission had indeed given direction to the staff to not calculate organ dose but only the TEDE. I have been unable to find any such direction. On the contrary, SECY-08-0147 itself sets out to show whether compliance with 10 CFR 61 Subpart C can be achieved with shallow land burial:

> The technical analysis addressed whether amendments to § 61.55(a) are necessary to assure large quantities of DU are disposed of in a manner that meets the performance objectives in Subpart C of 10 CFR Part 61.[15]

The issue of changing the dose criteria or ignoring organ doses or "modern methods" of dose calculation does not appear at all in either SECY-08-0147 or the Commission's decisions and orders. As part of this discussion, Dr. Esh explicitly stated that the NRC was not proposing to modify Subpart C.[16]

Yet, a review of the numbers and results in SECY-08-0147 leads me to conclude that its conclusion that shallow land burial could in some cases meet the 10 CFR 61 performance criteria is premature at best, since the analysis did not actually address a critical aspect of those criteria. Indeed, the graphs for resident doses (Figures 7a and 7b) in SECY-08-0147 indicate that doses to the most exposed organs could very well exceed 25 millirem per year over the period of performance evaluated (one million years). In effect, the staff eliminated an essential performance criterion and the Commissioners made their decision to pursue Option 2 based on a potentially false reassurance that shallow land burial could meet the regulatory performance criteria of Subpart C under some circumstances, even if the shortcomings of the analysis are ignored.

Other participants indicated that Subpart C may need to be on the table in this rulemaking. The facilitator, Mr. Chip Cameron, stated in summing up the discussion that

> I think we know that Subpart C could be on the table in this proposed rule….[17]

[14] NRC DU meeting transcript, September 2, 2009, p. 104.
[15] SECY-08-0147 2008, p. 1.
[16] NRC DU meeting transcript, September 2, 2009, p. 105.
[17] NRC DU meeting transcript, September 2, 2009, p. 237.

Dr. Esh raised a question as to whether the regulatory limit for radon dose for an intruder from DU disposal could be set at a small fraction of natural radon dose. An industry representative stated that exposure scenarios should be site specific. For instance, water at the EnergySolutions Utah site is saline and so it is unreasonable to assume that anyone would drink it.

An industry representative suggested that the radon standard should not be dose based. Rather the same standard as is now applied to mill tailings could be used.

I argued for a federal NRC specification of the general types of scenarios to be considered, with common sense constraints. In the absence of this, states may allow exclusion of even realistic scenarios, such as hunters going on to the site.

I asked whether the performance part of the low-level waste rule was on the table in this proceeding. The indicated answer both in regard to the dose limits and period of performance was that it was indeed on the table. I suggested that in that case the NRC should go back to the drawing board and publish a new notice in the *Federal Register* stating the 10 CFR 61 Subpart C was going to be revised.

b. Is the analysis conservative?

SECY-08-0147 and its Enclosure 1, state that the staff developed a "screening model" to do a "screening analysis" whose purpose "was to evaluate key variables such as disposal configurations (disposal depth and barriers), performance periods, institutional control periods, waste forms, site conditions, pathways, and scenarios."

I asked whether the term "screening" was being used to indicate a conservative analysis – that is an analysis that would give an upper bound for the dose estimate, so that one could be reasonably assured that a more realistic analysis would yield a lower dose estimate. In other words, such a screening analysis would lead to an assurance that the conclusion that DU could be disposed of in shallow land burial and meet specified performance criteria was robust.

Dr. Esh indicated that the term screening was not used in that sense in the paper. He agreed with the suggestion that the screening model in SECY-08-0147 "wasn't conservative."[18]

c. Climate and long-term modeling

The failure to consider erosion and climate change are among the non-conservative elements in the NRC staff analysis. Dr. Peter Burns, a geoscientist from the University of Notre Dame, noted that climate projections cannot be relied on for 10,000 or 100,000 or 1 million years. As an example he stated that Death Valley was deep under water 10,000 years ago. There was also wider discussion on the problems of modeling for long time frames and the period for which performance would be evaluated (see below). The terms "silly" and "silliness" came up in the context of trying to describe attempts to model shallow land burial for a million years, but it was

[18] NRC DU meeting transcript, September 2, 2009, p. 83.

suggested by the moderator, Chip Cameron, that this was perhaps not the best language to use in a regulatory context.[19]

d. Geochemistry

Shallow land burial above the water table with a soil cover for the waste is by its nature an oxidizing environment. Uranium can be quite mobile over the long term in such an environment, especially if it is also humid. A reducing environment for DU disposal could be created by choosing the right chemical form and providing reducing engineered barriers. Three factors need to be considered together in any assessment:

- The waste form,
- The nature of the engineered barriers, and
- The geology of the site.

In this context, Peter Burns noted that using existing sites would pose problems. It would be a better solution to take a fresh site and match the waste form to the geology.

It should be noted that the generic analysis in SECY-080-0147 did not do the analysis in this way since it was admittedly a generic rather than site-specific analysis and since no chemical changes to the form of the uranium were taken into account. Dr. Burns pointed out that some clay deposits in Tennessee that are now mined for various purposes, such as use in food additives, appeared to be very stable and might provide a natural analog for future investigations.

e. Stability and erosion

The analysis in SECY-08-0147 assumed that the site would be stable for the period of performance evaluated – that is, for one million years. Zero erosion was assumed for this period. This is one of the non-conservative aspects of the analysis. Zero fluvial or aeolian erosion means that there would be no uncovering of the waste and direct external radiation dose would therefore be low. There would be essentially no dose from radium-226, a powerful gamma emitter, since this was assumed to remain well below the surface and therefore shielded.

The analysis did not consider disposal in above-ground structures, which, by their very nature are vulnerable to fluvial and aeolian erosion over long periods of time.

Further, the assumption of long term cover stability means that there would be no large cracks that would develop in the clay, for instance, through wet and dry cycling especially in periods of extreme weather conditions. Such cracks would greatly enhance the mobility of the radon through the clay cover and hence greatly increase doses to a resident at the site boundary or to an intruder with a house above the disposal location.

[19] NRC DU meeting transcript September 2, 2009, at various places in pp. 98 to 116 and also pp. 185, 195, and 251.

f. Long term modeling of shallow land disposal

The above factors all point to the problem of modeling DU disposal in shallow land burial facilities over long periods of time. Dr. Burns pointed out that there was no way in which one could show quantitatively that there would not be a problem with shallow land disposal over periods like one-and-a-half million years. There was no dispute on this point from the NRC staff.

g. Period of performance

My impression was that the following was generally agreed regarding DU and long-term performance assessment

- Uncertainties become very large over periods as long as 10,000 to one million or more years,
- Modeling shallow land burial over periods as long as a million years or more appeared infeasible quantitatively, and
- The main radiological problems in dry areas other than those that might be associated with uncovering the waste, appear over the long term (thousands of years or more), presuming the areas remain dry.

There was considerable discussion of what to do as a result of the above realities. Precedents were discussed. Yucca Mountain standard is the only one that goes out to a million years. The WIPP standard (40 CFR 191) requires performance assessment for 10,000 years. Tailings for 1,000 years. (40 CFR 192) There was also a comment that beyond 100 years the performance has to be assessed in the context of intruders. There was a suggestion, from Bill Dornsife of WCS,that an endpoint of dose for radon may not be suitable and that a mill tailings standard of radon emanation rate might be considered instead.[20]

Industry representatives, among others, wanted a limitation on period of performance – that is, the period over which doses would be estimated. This would evidently bypass the difficulty that scientifically defensible modeling shallow land disposal for a period corresponding to peak radiation dose from DU disposal appears to be unfeasible.

However, a difficulty with such an approach is that 10 CFR 61 Subpart C does not contain a time limitation. There is therefore a requirement to protect whoever is most exposed in the future in a manner that does not exceed the dose limits specified there.

Limiting the period of performance would mean a change to 10 CFR 61 Subpart C. I suggested that instead of doing that, the NRC consider adopting the modeling approach of the French high-level waste rule. That rule recognizes that the uncertainties increase greatly beyond 10,000 years. But instead of changing the dose performance standard, it changes the method by which the modeling is done:

[20] NRC DU meeting transcript, September 2, 2009, p. 251.

- For up to 10,000 years, the uncertainties in the parameters are specified explicitly and probability distributions are provided. This gives a realistic set of estimates of what the performance would be, assuming the parameters are well characterized.
- Beyond 10,000 years the conservative, fixed values are used for parameters so as to calculate an upper limit of the dose. The same dose reference number is maintained but now we have what would be a bounding value for the long term, presuming the upper bound parameters:climate, geological, and others can be specified in a scientifically defensible way.

I provided a copy of the French regulation to the NRC staff and also to the DOE staff.

The staff's position in SECY-08-0147 is possibly along these lines, though more ambiguous:

> Considering the technical aspects of the problem, the performance assessment staff recommends a performance period of *10,000 years* for the analysis of *DU* disposal. However, analyses should be performed to peak impact, and if those impacts are significantly larger than the impacts realized within 10,000 years, then the longer term impacts should be included in the site environmental evaluation.[21]

It is unclear from this whether or not the staff proposes to require that the requirements of 10 CFR 61 be met up to the peak time of dose.

h. Existing and interim waste disposal

DOD, DOE, as well as private disposal companies have been disposing of some DU. They may also want to dispose of DU from enrichment plants in the interim – that is, before a rule for that waste stream is finalized. The question arose as to whether such disposal would be "grandfathered in" or would the waste have to be dug up if prior disposal did not conform to the rule. There was considerable sentiment from several quarters that it should be grandfathered in.

I pointed out that the DOE was recovering buried waste at a transuranic waste site in Idaho. This waste had been disposed of prior to the creation of a TRU waste category in 1970, but now is being recovered anyway.

i. Classification of DU

This tangled issue came up again. Larry Camper of the NRC staff said that DU was Class A waste. This derives from 10 CFR 61.55(a)(6) that states that waste not specifically defined in the tables of the rule is Class A. However, the whole proceeding for rulemaking is happening because the NRC recognized in October 2005 that the final EIS for low-level waste had not analyzed large amounts of DU for disposal. I repeatedly asked Mr. Camper whether he considered DU from enrichment plants as Class A waste. He did not directly reply, but repeated that DU was Class A waste.

[21] SECY-08-0147 2008, Enclosure 1, p. 21. Emphasis in original.

j. The Rights of Agreement States

States that regulate civilian nuclear licensees under agreement with the NRC ("Agreement States") are required to meet a complex set of "compatibility" requirements to ensure that NRC requirements are being met. The regulation and enforcement is done at the state level in such cases. But the NRC has the responsibility to ensure that there is compliance with applicable federal regulations. There was a presentation on compatibility issues in regard to DU disposal. One important procedural issue is what items should be in the new rule and what items should be in the guidance. The industry and state regulator sentiment is for the NRC to give the maximum possible leeway to state authorities. States can generally set more conservative standards than those at the federal level.

I expressed concerns as to whether there was adequate oversight regarding the two sites that may, in the near future, dispose of DU from enrichment plants – Utah (EnergySolutions site) and Texas (WCS site). Specifically, I raised the issue of whether the NRC was adequately exercising its oversight responsibilities. I had raised the same issue during my testimony as an expert witness for the intervenors in the National Enrichment Facility licensing case.

Specifically, I found that some of the results of the modeling done in a performance assessment underlies the EnergySolutions license contained physically impossible numbers. For instance, more uranium-238 was proposed to be disposed of per gram of Utah soil than the weight of the Earth. I was asked whether I was comfortable with the State of Texas agreeing to a DU concentration limit for the WCS site. I said that the last time I looked at the WCS issue, which was four years ago, I was not convinced that WCS was even qualified to receive radioactive waste – since, among other things, their license application at that time proposed to dispose of more U-235 as waste than had ever been mined.

If the NRC and the state of Utah have failed to require a correction of such evident scientific problems, even though they have been formally put on the table, how could one be confident of the process for licensing and enforcing DU disposal regulations?

I also pointed out that IEER has done the only independent site specific analysis of DU disposal by shallow land burial for the WCS site and of a site with parameters corresponding to the Utah site. Our analysis had shown that doses would be exceeded at both sites by large margins in well under one million years and in most cases on times scales on the order of 10,000 years. I was told, informally, that NRC staff would look into the record of the LES proceeding. In response, I told them I would supply the IEER LES reports to the staff. IEER has sent the URLs for the reports to the moderator, Chip Cameron.[22]

[22] IEER's LES reports: Arjun Makhijani and Brice Smith, *Costs and Risks of Management and Disposal of Depleted Uranium from the National Enrichment Facility Proposed to be Built in Lea County New Mexico by LES*, Institute for Energy and Environmental Research, Takoma Park, MD, November 24, 2004, and the *Update* to this report, July 5, 2005. Redacted versions for public release are on the Web at http://www.ieer.org/reports/du/lesrpt.pdf and http://www.ieer.org/reports/du/LESrptupdate.pdf.

k. Other issues

There was some discussion of whether there should be a discussion of what "significant" quantities of DU were. Some suggested that this was not needed, if performance was going to be the key.

A number of other issues were discussed, including defining what other "unique" waste forms there might be. There seemed to be a general agreement that there was no point in trying to define "unique" waste forms at this time.

It was also stated that it would not be appropriate to try to consider reprocessing waste streams as part of the current rulemaking.

l. Overall low-level waste rule changes

The commission is currently on a path to a two-step low level waste rulemaking. The first is for large amounts of DU and other "unique" waste forms that may allow shallow land disposal if a site specific analysis shows compliance with performance criteria. The second would be a revamping of the whole low-level waste rule on a "risk-informed" basis. It was not clear to me from the meeting discussion whether the revamping of the rule would be retroactively applied.[23] Some statements from the NRC staff indicated that the rule change would not be retroactive. But other statements were more ambiguous.

C. Bottom lines for Arjun Makhijani

1. There was some excellent technical discussion during the workshop. I appreciate that and learned a great deal.
2. Doing quantitative analysis of shallow land burial over a period of a million years is not reasonable. Yet the NRC staff did it.
3. The NRC staff's assumptions are admittedly not conservative. Some of the assumptions, such as no erosion, no chemical changes in an oxidizing environment, site stability, and no climate change for a million years are not scientifically defensible. While the word "silliness" that was used to describe the modeling assumption in regard to climate was later retracted, it seems to me that it is perhaps the most apt term under the circumstances. Whatever the term, the Commission based its decision (with one dissenting vote) on an analysis that has several scientifically indefensible assumptions in it. This indicates to me that the process should start over, with a defensible modeling exercise.
4. The Commission asked only that a revision to 10 CFR 61.55(a)(6) be considered – a new paragraph 10 CFR 61.55 (a)(9) would be added requiring site specific analysis for DU disposal. SECY-08-0147 states that

> The technical analysis addressed whether amendments to § 61.55(a) are necessary to assure large quantities of DU are disposed of in a manner that meets the performance objectives in Subpart C of 10 CFR Part 61.

[23] See, for instance, NRC DU meeting transcript September 2, 2009, pp. 49-51.

However, as a matter of fact, the technical analysis did not estimate organ doses and therefore failed to address whether disposal of large amounts of DU would meet the requirements of Subpart C of 10 CFR 61. It is quite possible that, even without any other changes, evaluation of organ doses would materially change the conclusions of the paper. It is therefore also possible that Commission's decision may also have been different.

5. ***A change to the performance standard – either for period of performance (no limit now) or for dose (25 millirem to the whole body per year, or 25 millirem to the most exposed organ, except 75 millirem to the thyroid) was not proposed in the present rulemaking. Yet it seems clear that revisions to the performance criteria are being considered both in regard to period of performance and dose limits. This is inappropriate. If such revisions are to be considered, the rulemaking must be started all over again, with a proper notice of the extent of the proposed rule changes.***
6. While a change in performance standards is not appropriate in the context of this limited rulemaking, since it was not included in the description of the rulemaking by the NRC, I do think that it is reasonable to define the way modeling is done beyond 10,000 years. In this regard, the French high-level waste regulation seems appropriate. In other words, the dose limits 10 CFR 61 should be maintained, and the indefinite time period should also be maintained, but modeling approach can be modified beyond 10,000 years to take account of much greater uncertainties.
7. All said and done, there was no scientific material at the workshop that would cause IEER to revisit its conclusion, based on lengthy analysis, including site-specific analysis, that DU should be classified as Greater Than Class C waste under 10 CFR 61.55. On the contrary, all of the evidence, including that put forth by the NRC staff as explanations of their modeling as well as other expert discussion from invited participants confirmed that DU is not suitable for shallow land burial.
8. Prior to the workshop, IEER asked for the model that was used in SECY-08-0147 before the workshop, but was refused. During the workshop Larry Camper stated that the model was not subject to the Freedom of Information Act since it was used for a pre-decisional matter. However, he stated that he would see what he could do to release as much material as possible to IEER. I appreciate the spirit of openness in which that commitment was made. IEER will keep the public informed if and when it receives the model and/or model-related materials.