Comments on the draft EPA standards for a Yucca Mountain high-level radioactive waste repository

by Arjun Makhijani November 23, 1999

The Draft EPA [Environmental Protection Agency] standard for the proposed Yucca Mountain repository, while containing some aspects that are in the direction of environmental protection, is fundamentally deficient in a number of procedural as well as substantive aspects. A final standard along the lines of the present draft will fail to ensure the protection of health and the environment for the time during which wastes disposed of in the repository will remain a hazard to public health. IEER's main recommendations are:

- The EPA's choice of "reasonably maximally exposed individual" is fundamentally flawed. It should be replaced by a critical group of subsistence farmers, as discussed in Appendix D of the 1995 National Research Council Report entitled *Technical Bases for Yucca Mountain Standards* (the TBYMS report).

- EPA should discard its proposed time limit of 10,000 years for radiation dose protection. The time at which the dose limit must be met should be the time of estimated peak dose, whenever that might occur, as recommended in the TBYMS report.

- The EPA's choices of location for withdrawal of groundwater are too far (at least several kilometers) from the repository footprint. The assumed location of groundwater withdrawal should be at the downgradient edge of the repository footprint, unless the estimated contaminant concentration due to all sources, including Yucca Mountain is greater at another location.

- EPA should take into account all relevant non-cancer and synergistic health and ecological risks from repository construction and waste disposal in it, even if the National Academy of Sciences has not so far evaluated these risks. Specifically, EPA should evaluate non-cancer risks from carbon-14 releases.

- The suggested limit of 15 millirem per year is not protective enough. It has been set without taking due account of potential future groundwater contamination from radionuclides left in the ground due to past nuclear testing, future "sub-critical" tests, which are expected to continue indefinitely, some other potential radionuclide sources in the region, and some non-cancer risks that may be relevant in the context of the Yucca Mountain repository.

- EPA should specify that groundwater protection requires that the dose limit of 4 millirem not be exceeded taking into account the cumulative contamination from all potential radionuclide contaminant sources, including but not limited to the Yucca Mountain repository alone. The final Yucca Mountain standard should require strict conformity with the Safe drinking Water Act.

- EPA should require that the dose limit to the critical group correspond to the 99 percent upper confidence bound based on quantifiable parameters. This will build some room for unanticipated

problems in a project whose performance assessment is likely to contain uncertainties and omissions that cannot be quantified.

- The EPA's inadvertent human intrusion scenario should be based on technology, such as laser drilling, which is foreseeable but which may not be commercial today.

Detailed comments and recommendations

1. The 1995 report of the National Research Council on Yucca Mountain Standards (TBYMS report)

The EPA was right to state that it not be completely bound by the TBYMS report. However, it is not sufficient to use this report merely as a "starting point." (F.R. page 46982). It is not, as the EPA has claimed, a question of following the National Research Council advice "mechanically" (F.R. page 46982), but using its "expert scientific guidance" with due consideration as Congress intended.

IEER believes that the EPA must treat the TBYMS report as authoritative unless:

- there was an internal disagreement on the panel, in which case the EPA must exercise its own well-considered scientific judgment,
- there are clear scientific, environmental or health protection grounds to reject the TBYMS report's analysis or recommendations and adopt a different approach, or
- the TBYMS report did not take into account certain health or environmental factors, thereby leaving open the door for the EPA to use its own scientific judgment.

2. Time for assessing dose limit compliance

The EPA's time limit of 10,000 years for assessing doses and risks is arbitrary. It is also contrary to the scientific advice in the TBYMS report that the EPA is mandated to take into account. Further, the TBYMS report's conclusion in this regard has precedent in an earlier report by a 1983 National Research Council panel on geologic isolation. One of the EPA's principal justifications, reference to 40CFR191, can be rejected out of hand. If 40CFR191 were a reliable guide to standards in the present case, new standards would not be needed for Yucca Mountain at all. Further, the quantity of long-lived radionuclides is far greater and the specific mix of radionuclides at Yucca Mountain is different from that in the Waste Isolation Pilot Project in New Mexico, where 40CFR191 is being used as the governing rule.

The EPA's reason that uncertainties beyond 10,000 years become unacceptably large is not a reason to stop at that time. On the contrary, it should be a reason to set a more stringent standard and to seek ways which uncertainties can be reduced. Present inadequacy of Yucca Mountain models is not an argument to abandon health protection of future generations. Making modeling uncertainties small enough is task of the Department of Energy (DOE). It is the job of the Nuclear Regulatory Commission to ensure that DOE

has done it well. It is EPA's job to ensure that health and environment are protected.

The EPA's other argument for not extending the time frame beyond 10,000 years is that "[t]here are likely to be no exceptionally large geologic changes during that time" of 10,000 years (F.R. page 46994). In fact, this is an argument to extend the time frame and assess what the effect of such geologic changes might be, if the area is actually susceptible so such change during the anticipated period of risk.

Moreover, the EPA's requirement that events that have more than a 1 in 10,000 chance of occurring in the 10,000 years after disposal be considered is tantamount to requiring an examination of the effect of events that may occur millions of years after disposal (with higher expected values during these longer periods). Thus, the EPA is essentially agreeing with the TBYMS report that assessments of events for a time period on the order of a million years could be done, though with increasing uncertainty. It is generally acknowledged that estimates for long time periods are one of the most difficult aspects of repository performance assessment. But within that context, the choices should not be arbitrary, but rather geared to performance criteria for the period over which the repository might substantially affect the human environment (defined by the peak dose in this instance).

The bottom line is that the time of peak dose is the relevant time frame from the point of view of public health and environmental protection. The EPA's arguments are not based on sound environmental reasoning and are internally inconsistent. The EPA has not provided sufficient grounds to reject the TBYMS report's conclusion that estimates could be made for up to one million years. Its rejection of the TBYMS report's recommendation regarding compliance at the time of peak dose is scientifically and environmentally inappropriate. The final standard should be revised to so that the maximum allowable dose is not exceeded at the time of estimated peak dose.

3. Choosing the critical group

The EPA's evaluation of the relative merits of the two approaches to choosing the critical group described in the TBYMS report is sound. The EPA correctly notes that the method in Appendix D of that report, which identifies subsistence farmers as the critical group, is both more straightforward and is better founded in precedent and current practice, including recommendations of the International Commission on Radiological Protection. However, the EPA has then illogically rejected the subsistence farmer critical group approach in favor of its own "reasonably maximally exposed individual" who would be "representative of a future population termed 'rural-residential.'" This is an inappropriate extension to populations far into the future of present-day rules that define hypothetical maximally exposed individuals relative to presently operating facilities. It is speculative and scientifically unsound.

Moreover, the EPA's implicit assumption that a part-time farmer of the future would not grow all his/her own food (F.R. page 46989) is an unwarranted extension into the long-term future of the present-day idea that subsistence farming has relatively low labor productivity. People in the future might choose to grow most or all of their own food in highly productive ways for health reasons, and have plenty of time for other income-producing or leisure activities. *The term "subsistence farming" in radiation protection should be interpreted solely as a person (or household) growing most or all of the food that they consume, without regard to the amount of time or income involved in farming and non-farming activities*.

One of the main reasons to use the subsistence farmer critical group is that it eliminates speculation about future lifestyles. Trying to define future population characteristics introduces unacceptable elements of

speculation into dose estimates, vitiating the estimates to the point that they may have little value for protecting future populations. The EPA therefore should adopt the subsistence farmer approach to the critical group recommended in Appendix D of the TBYMS report. Its rejection of this approach in favor of a "reasonably maximally exposed individual" is not appropriate on scientific and environmental grounds.

4. Risk versus dose

The risk-based approach recommended in the TBYMS report needs to be translated into a dose-based approach for cancer risk in order to be given practical effect. Since the probability of cancer cannot be calculated using present techniques except through a risk coefficient or coefficients, setting a dose limit is a reasonable way for the EPA to incorporate cancer risk into the regulation. However, it is not sufficient for other risks (see below), for which different risk measures are likely to be needed. Specifically, the EPA should evaluate whether the health risk from non-cancer effects may be comparable to or greater than that proposed in its 15-millirem limit for radiation exposure set mainly by using cancer risk coefficients (apart from very limited consideration of some mental retardation effects of radiation exposure). A method for evaluation of all relevant non-cancer risks, such as birth defects or miscarriages, should be published for public comment, since the TBYMS report provided no guidance for such risks. The limits for radiation exposure should be reduced to reflect non-cancer risks and uncertainties in these risks at the present time.

5. Location of water resources relative to the repository footprint

The location for the source of the water used by the subsistence farmer critical group should be at the downgradient edge of the footprint of the repository, where the maximum radionuclide concentration can be expected. There is no scientific basis for the assumption that residences far into the future would not be closer than several kilometers away from the edge of the repository footprint (F.R. page 46989), or that water would not be drawn from near Yucca Mountain, even if they were. For instance, if the terrain at the foot of Yucca Mountain is hospitable enough to accommodate a tunnel-boring machine, it can also accommodate a well-drilling machine for drinking and irrigation water. Transport of irrigation water for several kilometers is well within the bounds of current practice. Moreover, it is possible that the amount of groundwater available in the vicinity of Yucca Mountain may increase greatly in geologic time frames (see below).

6. Small incremental risks

The EPA should be more firm and explicit that it is rejecting the concepts of "negligible incremental dose" and "negligible incremental risk." The TBYMS report's recommendation of this concept for the specific example of carbon-14 was based essentially on cancer risk considerations. The TBYMS report did not consider many kinds of non-cancer risks that could arise from exposure to carbon-14 (see below). Hence, the EPA should explicitly reject the use of this concept.

Exposure to carbon-14 should be considered as an explicit problem for individual and population protection in the standard since there are non-cancer risks that may arise in certain groups from exposures that have hitherto been considered a very small. Further, the calculated population doses to the global population from a Yucca Mountain repository have been estimated to be very high – large enough in fact to result in an estimated 4,000 excess cancer fatalities over 10,000 years. This estimate was made by the EPA's own Science Advisory Board in 1993.

The EPA should use the linear, no-threshold hypothesis even for very small doses. The fact is that all incremental doses are above a considerable background radiation dose. Therefore, even very small doses may produce proportionate effects, since any threshold that might exist may already be exceeded by the biological damage caused by natural background radiation and other background carcinogenic risk factors. The linear no-threshold hypothesis is the best public health and environmental approach available. It is standard practice in radiation protection throughout the world. Ignoring supposedly small incremental risks introduces an unacceptable element of arbitrariness into the standard setting process.

7. Dose to the critical group

The suggested EPA standard of 15 millirem is not protective enough since it allows very little margin for exposures from other nuclear fuel cycle activities. Even leaving aside new activities in the future, extensive underground nuclear testing at the Nevada Test Site has left behind a vast potential source term of long-lived radionuclides.

The potential source term for future groundwater contamination in the area is increasing. The Department of Energy is now conducting sub-critical tests, which do not create vitrified rock that might contain a part of the plutonium. Hence, sub-critical tests are likely to pose disproportionately large risks of groundwater contamination per unit of unfissioned plutonium involved.

The EPA should also estimate the potential plutonium burden in the underground environment from such tests and factor in plausible exposure pathways prior to setting a limit for Yucca Mountain exposures. Two other sources of potential exposure need to be taken into account – that from “low-level” waste disposal at Beatty as well as from “low-level” waste disposal on the Nevada Test Site by DOE. Given that groundwater is likely to continue to play a central role in the economic development of the region, the dose limits from a Yucca Mountain repository should be set low enough so that there is still room for economic development that may involve commercial nuclear activities.

The EPA should take other sources and pathways of exposure into account in a scientifically rigorous manner before deciding how much below a 25-millirem dose limit to set the Yucca Mountain standard. For instance, until recently, it had been the general assumption, based on official assurances, that these radionuclides would remain sealed in the vitrified rock created by the test explosions. The recent discovery that plutonium in colloidal form left over from one of the tests has migrated a mile from the test location, should cause a re-evaluation of the potential long-term doses to the public in the region.

In this context, it is worth noting some of the findings of an external peer-review of DOE’s modeling of contamination migration from one area of the test site. The review was commissioned by DOE. Here are some of its findings:

- “Of greatest concern to us is the virtual absence of site-specific data from the underground nuclear test areas where most of the contaminant release and migration are expected to take place. Such an absence of data is unusual for sites of suspected or potential groundwater contamination. This data deficiency throws into question the validity of the analysis of the fate of pollutants, and required corrective action at Frenchman Flat.” (page 5)

- “…we do not feel that the actual uncertainty in the predictions [of contaminant transport] is adequately evaluated….The actual uncertainty is likely to be much larger than that calculated

because a number of factors have not been adequately addressed or impose limitations on the analysis." (page 9)

- Official studies have considered "[o]nly radionuclides with unclassified source term data….We suspect that inclusion of these [long-lived] radionuclides [from classified source terms] will almost certainly increase predicted radionuclide doses from groundwater." (page 10)

The EPA's process for setting the maximum allowable dose should explicitly take into account these issues. Consideration of these sources is also important for groundwater protection (see below).

8. The maximum dose and the upper confidence bound

The maximum allowable dose in the draft EPA standard does not have confidence limit specified with it. A failure to specify the confidence level leaves the issue inappropriately ambiguous. The EPA's approach that there should be a "reasonable expectation" that the standard will be met is vague and unenforceable.

The EPA should use an approach of specifying that the dose limit to the critical group limit should be the 99 percent upper confidence bound, based on those parameters that can be quantified. An upper confidence bound requirement is appropriate because Yucca Mountain dose calculations will most likely have significant uncertainties associated with them that cannot be quantified. One way to deal with some of the uncertainty that cannot be resolved by present-day knowledge is to require that the dose limit to the critical group correspond to an upper confidence bound rather than the mean value for the critical group.

Given the unprecedented nature of high-level repository dose estimation, a 99 percent confidence bound is more appropriate than the usual 95 percent bound often used in statistical computations. Using an upper confidence bound as the critical group dose estimate for assessing compliance is especially important for Yucca Mountain.

The performance of Yucca Mountain, as currently estimated by the Department of Energy, depends mainly on a single feature – a metal canister in an oxidizing environment. There is essentially no back-up feature that would provide a comparable level of containment. This is a huge vulnerability that must be recognized and factored into the health and environmental protection standard setting process of the EPA. IEER does not agree with the EPA that the corrosion rates of the canister and other metal components "may be quantified with a high degree of accuracy and precision" (F.R. page 46998). Based on present data, it is not even clear whether the repository will remain unsaturated for a few hundred thousand years. There is considerable evidence that the repository horizon has been flooded with hot water rising from below in the geologic past, with the time of such flooding being uncertain.

9. Use of expert opinion

In making dose computations, the DOE and NRC may use expert opinion and advice, but they should not exclude public opinion and advice on this account. "Expert elicitation" (F.R. page 46997) done with "Delphi" studies in which experts are polled about parameters that cannot be well-quantified based on real world data is often little more than a compilation of opinions dominated by an insiders' club. Expert elicitation should not be used to estimate parameters using Delphi surveys or similar techniques. This restriction should be specified in the EPA standard because Delphi type of techniques can create more problems than they solve and, moreover, exclude the public from vital areas of debate. Expert opinion

provided in the context of open scientific and public debate in public hearings is greatly preferable to Delphi type approaches, especially for the most difficult questions. IEER recommends that all expert opinion and the documents on which it is based should be public.

10. Non-cancer risks

EPA has not given appropriate consideration to non-cancer risks and has failed to take into account the limitations of the 1990 National Academy of Sciences report (the BEIR V report), which is the principal basis for its discussion on this subject. The BEIR V study omitted most non-cancer effects and even omitted consideration of a variety of genetic effects. It acknowledged these limitations.

While the NAS may or may not consider all relevant effects in a specific scientific study, the EPA must take into account all relevant non-cancer effects. For instance, since carbon-14 may be released from an unsaturated repository at Yucca Mountain (in contrast to estimated releases from saturated repository locations), its non-cancer effects should be taken into account.

The National Academy of Sciences Committee on the Effects of Ionizing Radiation is due to re-study the effects of low-level radiation (the BEIR VII committee). The chairman of the BEIR VII panel, Dr. Monson, assured IEER during the public comment period on the second day of the first meeting that the issues raised in an IEER letter (see below), will be considered as seriously as if they had been raised by a member of the committee. The letter raises health issues that were ignored in the BEIR V report. The letter, along with the list of signatories, is attached as an integral part of these comments. The EPA should consider all non-cancer and synergistic effects relevant to Yucca Mountain. All radioactive and non-radioactive toxic materials that may be released into the human environment from a Yucca Mountain repository should be evaluated. These include greater than Class C wastes, highly enriched naval spent nuclear fuel, foreign research reactor spent fuel, and materials that are expected to be used in repository construction, canisters, and other engineered barriers.

11. Groundwater resource protection

The EPA has proceeded appropriately in including the groundwater sub-limit of 4 millirem in its proposed standard. IEER strongly supports this inclusion. However, the proposed 10,000-year time limit on this protection should be discarded in favor of time of peak dose, as discussed above for the overall dose limit. An approach using effective dose equivalents can be used to set combined limits for beta- and alpha-emitters in a conservative way, so that all plausible combinations of releases of radionuclides would result in drinking water doses less than 4 millirem per year.

The 4 millirem sub-limit is an essential element in the broader goal of protecting drinking water supplies. However, the EPA has left the NRC and DOE with a loophole in that it would allow these agencies to consider the maximum contaminant levels (MCLs) to apply to a “representative amount of groundwater” (F.R. page 47002). In the four scenarios that the EPA considers, the closest point for determining groundwater purity is 5 kilometers from the repository. The others are 18, 20, and 30 kilometers from the repository.

The controlled area for the repository can extend at most 5 kilometers from the repository. The Safe Drinking Water Act (SDWA) therefore applies at all locations more than 5 kilometers from the repository and to many locations that are closer. Therefore, the EPA must discard scenarios at distances greater that 5 kilometers, unless it can be shown that they would have higher concentrations of radionuclides. Further,

even a distance of 5 kilometers is unacceptably far from the repository footprint. The DOE cannot reasonably claim to maintain such a large "controlled" area after repository closure. The assumed withdrawal point should be at the downstream edge of the repository footprint, which at the present time is projected to be about 1 kilometer from the center of the repository. There is not and cannot be a rational basis for violating the requirements of the SDWA. A Yucca Mountain standard that is inconsistent with the SDWA is necessarily arbitrary and capricious.

The EPA has assumed that the water withdrawal scenarios should "reflect the current, general lifestyles and demographics of the area, but not be rigidly constrained by current activities " (F.R. page 47002). The EPA's assumptions are arbitrary and speculative in that they constrain future lifestyles. Given mounting evidence that groundwater has risen and flooded the repository level in the geologic past, the EPA should factor in the potential that there may be a large volume of highly contaminated water at the edge of the repository footprint. This is because a flooded repository could cause a far more rapid and extensive release of radionuclides than is now projected for an unsaturated repository. Moreover, given the uncertainty about future climate, the current availability of water near Yucca Mountain should not constrain the standard setting process for groundwater protection. The MCLs should be determined at the downgradient edge of the repository footprint and not several kilometers away. Modeling considerations based on low water volume available today should not be a principal factor in decision-making on the withdrawal point for the water.

The requirement in the draft standard of a "representative amount of groundwater" appears to be inconsistent with the SDWA. The smallest public water system whose groundwater is protected under the SDWA may have as few as 15 connections or supply 25 people. The EPA should make its Yucca Mountain standard fully consistent with the SDWA. The final rule should protect the smallest potential public water supply as defined in the SDWA.

Finally, the EPA should specify that the sub-limit of 4 millirem for drinking water refers to all sources of man-made radionuclides, including any radionuclides that might migrate to the edge of the repository footprint from the Nevada Test Site (see discussion above about overall dose limit). If the migration of radioactivity from other sources combined with the Yucca Mountain source term is estimated to produce higher concentrations of radionuclides in groundwater at another location, then that location should be chosen for application of groundwater protection standards. Any other approach would not be consonant with the SDWA, which aims to protect groundwater as a resource.

12. Deliberate human intrusion

The EPA has not considered the risks of deliberate human intrusion following the TBYMS report advice that "it makes no sense…to try to protect against risk arising from conscious activities of future human societies" (cited on F.R. page 46999). This reasoning omits one very crucial consideration. Current US policy is that such intrusion would be highly undesirable. Therefore, the EPA should specify that the repository should have features that would reduce, to the extent possible, the likelihood of deliberate human intrusion.

13. Inadvertent human intrusion

The EPA's assumption that technology similar to present-day commercial technology would be used for drilling in case of inadvertent human intrusion is inappropriate. Technologies currently under development include cutting of rock with high-powered lasers. Such technologies would greatly change

the economics and feasibility of drilling in many areas and are also likely to result in far easier penetration of engineered barriers than is assumed in the EPA scenario for inadvertent human intrusion. The EPA should assume that the costs of drilling to the repository level in the not too distant future (a few decades) will be far lower than those at present and, moreover, that it will not be difficult to penetrate the canister. In other words, the EPA's scenario for inadvertent human intrusion should be based on technologies, such as laser rock cutting, that are foreseeable but not necessarily economical today.

Attachment: Letter to the BEIR VII (Biological Effects of Ionizing Radiation) Committee of the National Academy of Sciences, September 3, 1999 (including signatures added after September 3)

Additional Resources and Information:

- IEER's Comments on the Draft Nuclear Regulatory Commission Rule on Disposal of High-Level Radioactive Wastes
- IEER's Plan for Management of Highly Radioactive Waste (*SDA* v7n3, May 1999)
- WANTED: Sound Radioactive Waste Management Policy (*SDA* v6n1, May 1997)