WASTE MANAGEMENT COST REDUCTION BY REGULATORY CHANGES

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ABSTRACT

Current regulatory standards for the various categories of radioactive waste, covering several management phases, are based upon the arbitrary Linear No-Threshold Hypothesis (LNTH) model for radiation dose effects. The LNTH implies that health effects are encountered all the way down to zero dose, and results in the fictitious use of the collective dose concept. Replacing the LNTH with a threshold dose-response model will introduce good science and justify relaxing exposure standards in regulatory changes. Preliminary estimates for only a few areas of interest, such as cleanup of nuclear facilities, nuclear power plant operation and decommissioning, and radon remediation, indicate potential cost savings of hundreds of billions of dollars.

INTRODUCTION

The categories of radioactive waste are: Low Level Waste (LLW), High Level Waste or Spent Fuel (HLW), Transuranic Waste (TRU), and mixed waste (radioactive plus hazardous chemical components). Management of these wastes divides into several phases: 1) characterization and classification of waste streams, 2) handling, packaging, and transport, 3) processing for disposal waste form and/or recovery of usable radionuclides and other components, and 4) disposal of residuals. Environmental management and cleanup of nuclear facilities can involve one or more of the waste categories, and up to all of the management phases, depending upon the site considered. Regulations, primarily by EPA, NRC and DOE govern these various categories and management phases. Current regulations are directly or indirectly based upon the Linear No-Threshold Hypothesis (LNTH). Replacing the LNTH with a threshold model for the effects of low-level radiation dose will justify a considerable relaxation of radiation protection regulations and lead to large cost reductions.

SUMMARY OF CURRENT REGULATORY STANDARDS

NRC and DOE

The standard basic limit of total body effective dose equivalent, for individual members of the general public, by the NRC (10 CFR 20) and the DOE (DOE Order No. 5400.5), is 100 mrem/y. The limit for individual occupational exposure by the NRC (10 CFR 20) and the DOE (10 CFR 835) is 5 rem/y. For land disposal of radioactive waste, the NRC limit for the public is dropped to 25 mrem/y (10 CFR 61). Appendix B of 10 CFR 20 tabulates, by radionuclide, values of limits for occupational annual ingestion and inhalation, air and water effluent concentrations, and sewer release concentrations. NRC external radiation standards for shipping packages (10 CFR 71) limit dose rate to 200 mrem/h at any point on the package surface and 10 mrem/h 1 m from the surface.

Uranium Mills and Tailings Disposition (NRC-10 CFR 40 App. A)

Maximum soil concentrations (NRC): Ra-226 and Ra-228, 5 pCi/g average in first 15 cm of depth, 15 pCi/g for layers below 15 cm depth. Maximum ground water concentrations: Ra-226 and Ra-228, 5 pCi/L, and gross alpha, 15 pCi/L (same as for EPA, 40 CFR 141 and DOE, 10 CFR 834.302).

NRC Soil Contamination Guidelines

Guidelines on acceptable contamination in soil on property to be released for unrestricted use, released in 1992 (Fed. Reg./Vol. 57, No.34, p.6140) list the following maximums in pCi/g: Co-60: 8, Sr-90: 5, Cs-137: 15, Pu-238, -239 (if found): 25, Am-241 (if found):30, Ra-226, -228: 5. The external exposure pathway, with contamination to infinite depth over an extensive area, for these Strontium, Cesium and Plutonium contamination levels is less than 0.01 mrem/y! The dose rates in mrem/y are 130 for Cobalt, 1.3 for Americium, and 0.16 for Radium.

EPA Standards

There is no EPA limit as high as 100 mrem/y. For nuclear power operations (40 CFR 190), and management and storage of spent fuel, HLW, and TRU (40 CFR 191), the limit is 25 mrem/y. Disposal of these wastes (10 CFR 191) lowers the limit to 15 mrem/y. In addition, containment requirements limit radionuclide releases over 10,000 y to tabulated values of Ci/1,000 MTHM (1 chance in 10), and 10 times these values (1 chance in 1,000), plus groundwater protection requirements: radionuclide release to underground drinking water sources must be within limits of 40 CFR 141.

EPA National Primary Drinking Water Standards (40 CFR 141)

Maximum Ra-226 and Ra-228, 5 pCi/L, gross alpha, 15 pCi/L. Beta and gamma emitter concentration limited to not producing greater than 4 mrem/y (at 2 L/day). Tabulated values assumed to produce this dose are: tritium (total body) 20,000 pCi/L, and Sr-90 (bone marrow) 8 pCi/L. These EPA standards are based upon outdated 1959 dose methodology.

Proposed Yucca Mountain HLW Standards

The NRC and DOE have proposed (64 Fed. Reg. 8640) a limit for all pathways of 25 mrem/y. The EPA has proposed (64 Fed. Reg. 46976) a limit of 15 mrem/y for all pathways, plus extra protection of groundwater to an equivalent of 4 mrem/y, within the 15 mrem/y total. This position imposes standards intended to apply "at the tap" to groundwater underlying the site. An impasse continues between the agencies.

Radon in Buildings

The EPA recommended action level for remediation is 4 pCi/L in buildings, though it is not set down as a regulation. The DOE calls for their facilities to meet this level.

REGULATORY GENESIS

Initially, most regulations begin with selection of limiting values for annual or lifetime risk of fatal cancer. The EPA generally sets a risk goal of one in 10^4 to 10^6. Then, using dose conversion factors obtained by applying a radiation effect dose model, the corresponding radiation dose or dose rate limits are calculated. It is in this step that the LNTH has been applied, implying that health effects are encountered all the way down to zero dose, and resulting in the fictitious use of the collective dose concept. In some cases, nominal limiting values for dose rates, such as 15, 25, or 100 mrem/y (0.15, 0.25, or 1.0 mSv/y) are selected directly (omitting the formality of the first step). Replacement of the LNTH by a threshold model in this step would appropriately cut off health effect occurrences at and below the applicable threshold value(s) of dose or dose rate. Corresponding to each limiting value of dose or dose rate, pathway models of varying complexity are used to calculate limiting quantities of released radionuclides, or maximum environmental concentrations. Resulting concentration limits in various regulations are expressed as activity per unit volume, mass, or area. The pathway models themselves are generally accepted, as are objectives for limiting annual and lifetime risk of fatal cancer. It is the arbitrary application of the LNTH, instead of a threshold model, in the intermediate step that causes controversy.

THRESHOLD MODEL JUSTIFIES CHANGES

Use of a threshold dose-response model, replacing the LNTH, will allow the genesis of regulations to follow the same general sequence as currently used, but only with application to individuals. A specified risk level will correspond to a dose level above the threshold level, not merely a point on an arbitrary linear line. This new dose level will be much greater than that from the LNTH. The collective dose concept becomes invalid. A large population of individuals, each exposed to a very low dose, suffers zero damage. For an individual and an annual or lifetime risk goal, the dose limit (or limits) is determined, considering the threshold level(s) along with an appropriate uncertainty factor. The corresponding radionuclide concentration limits then follow via pathway models, as before.

The effect of adopting a threshold model is that dose below some level, and the corresponding radionuclide concentrations, are of no concern. The impact of this propagates through all categories of radioactive waste and through all waste management phases. Revision of regulations to allow higher release rates and concentrations will shift classification such that some LLW will become exempt from regulation and the levels of packaging and disposal isolation will be reduced. Disposal waste form requirements can be relaxed in some instances. Processing for recovery of usable radionuclides, including reprocessing of spent fuel, and the acceptability for the applications of the products becomes enhanced. Cleanup and environmental restoration of nuclear facilities benefits from adoption of a threshold model. Some facilities or portions of those facilities may be exempted from restoration work or the levels of treatment may be reduced.

POTENTIAL COST REDUCTION

Detailed analyses of the potential cost reductions for each waste category and waste management phase are not yet available. The potential cost benefits that have been estimated are aggregated and intertwined through all aspects of waste management and environmental restoration such that allocation to each waste type or management phase becomes difficult. However, the overall total net costs are important at this time because they reveal the huge potential benefits of discarding the LNTH. A major area where this is true is in environmental management and cleanup of nuclear facilities, discussed below.

Cleanup of Nuclear Facilities

The DOE has spent $52 billion for cleanup of nuclear facilities from FY 1989 through FY1999 and projects funding for FY 2000 through FY 2070 to be $151-195 billion (1). The overall DOE environmental management and cleanup appropriations for years 1999 and 2000 were $5.8 billion each and the budget request for 2001 is $6.3 billion. In addition, $38 billion may be spent by operators for decommissioning 100 power plants in coming years. These costs are highly sensitive to the restrictiveness of the standards. The annual and total cleanup costs at each site will vary by multi-millions of dollars, depending upon the level of cleanup required by the regulations. This can be illustrated by examining costs to achieve different soil cleanup levels, which make up a portion of the overall environmental management and cleanup effort. A report by the General Accounting Office (GAO) to Senator Domenici (1) contains estimated soil cleanup costs from the DOE and NRC. The GAO report falls short of adequately considering refutation of the LNTH, but the reporting of agency activities and cost estimates is useful. The estimated soil cleanup costs listed in Table I indicate that the costs increase dramatically for cleanup to levels of 25 mrem/y or less, as compared to 100 mrem/y. The agencies have not presented data for costs of less restrictive cleanup to levels greater than 100 mrem/y. Figure 1 is a log-log plot for the Nevada Test Site and test ranges (NTS) and the Brookhaven National Laboratory waste facility (BNL). A linear plot for BNL in the GAO report implies that costs level off before the 100 mrem/y level is reached, but extrapolation on our log-log plot shows that continued cost savings may be achieved as the cleanup objective is relaxed to levels greater than 100 mrem/y. While the extrapolation may not be entirely valid in the absence of new detailed analysis, it does indicate the potential further reduction in costs as the cleanup objective is increased. Increasing to 1,000 mrem/y from the agency studies (limited to 100 mrem/y), indicates a further cost reduction for

BNL by a factor of 2.0, and for NTS by a factor of 15. Detailed analysis should be conducted for the less restrictive soil cleanup levels, but even the modest 100 mrem/y level, with corresponding relaxation of dose limits for other related restoration work, suggests a potential cost reduction that can reach more than $100 billion out of the projected $151-195 billion total.

Table I. Estimated Costs to Achieve Different Soil Cleanup Levels, in Millions of Dollars

	Soil Cleanup Level, mrem/y			
Agency/Site/Date	100	25	15	less than 10
DOE/NTS/1995	35	131	240	1003 (5 mrem/y)
DOE/BNL/1995	15.9	24.4	28.2	64.5 (1 mrem/y)
NRC/Power Plant/1997	0.17	0.31	0.41	1.44 (3 mrem/y)
NRC/Metal extraction facility/1997	5.30	6.21	7.33	13.86 (3 mrem/y)

A preliminary examination of areas of potential cost savings was presented in our earlier paper (2). Excerpts from that paper for nuclear power plants and radon remediation follow.

Nuclear Power Plants

The major radiation protection costs associated with nuclear power operations are for: 1) management of low-level radioactive wastes, 2) compliance with ALARA guidelines, and 3) waste management at time of decommissioning. If radioactive waste categories are relaxed commensurate with changed dose limits, quantities of waste designated as "radioactive" or "mixed" will be reduced and degrees of disposal isolation for some classifications may change.

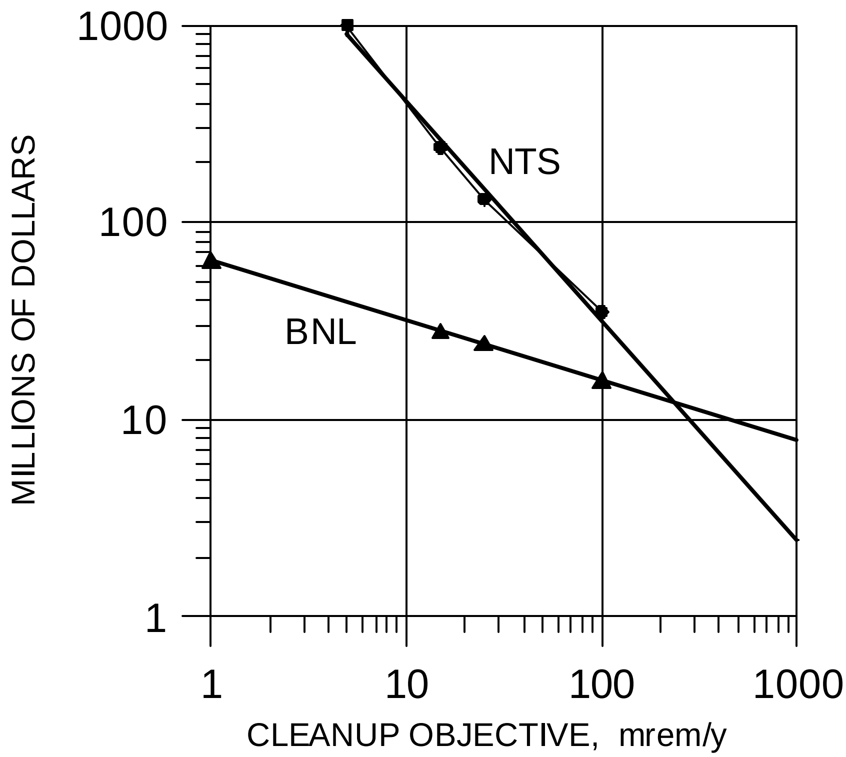

Fig. 1. Estimated costs to achieve different soil cleanup levels at NTS and BNL.

Preliminary estimates made at two nuclear power plant sites indicate that if regulations were changed to permit 5 rem/y (50 mSv/y) and concentrations in waste streams were correspondingly relaxed, compliance costs could be reduced by a value in excess of $10 million per year per plant. Extrapolation of this preliminary estimate to 109 plants in the United States leads to an estimated potential saving of more than $1 billion per year.

Decommissioning costs estimated for one plant are a little over $500 million, with about 25% of this ($125 million) being for burial costs. If relaxed regulations permitted much of the decontaminated debris to be buried on site and transportation and burial costs to be reduced by only one-half, the $60 million savings per plant would project to a potential savings for all current plants of over $6 billion.

Radon Remediation

The average concentration of ^{222}Rn in outdoor air in the United States is about 0.25 pCi/L (10 Bq/m^3), and the average concentration inside homes is about 1.5 pCi/L (55 Bq/m^3) (3). Using a nominal equilibrium factor of 0.5, the average concentration of radon decay products in homes becomes about 0.75 pCi/L (27.5 Bq/m^3). The concentration of ^{222}Rn proposed by the NCRP and recommended by the EPA as the action level for remediation is 4 pCi/L (150 Bq/m^3). The conversion factor between radon gas concentration in a home, averaged over a year, and the annual effective dose equivalent to full-time occupants is 185 mrem/y per pCi/L (50 µSv/y per Bq/m^3) (3). Thus, the guidance action level corresponds to a dose rate of 750 mrem/y (7.5 mSv/y). The distribution of airborne ^{222}Rn concentrations in homes in the United States is reported by Nero et al. (4). Among the estimated 60 million single-family homes in the U.S. (estimated 70% of the U.S. housing stock), 7.0% (4.2 million) exceed the 4 pCi/L guidance action level, and 2.1% (1.3 million) exceed 8 pCi/L.

Mossman and Sollitto (5) state that the estimated total cost to reduce and maintain indoor radon levels at or below 4 pCi/L (150 Bq/m^3), including installation and annual operational and maintenance fees is about $5,600 per home. For 4.2 million homes, this becomes $23.5 billion. A revision in the allowable dose rate to 5 rem/y (50 mSv/y) corresponds to increasing the action level for radon by a factor of almost seven, to 27 pCi/L (1000 Bq/m^3). For this concentration, very few homes would require remediation. Thus, most of the currently indicated remediation costs **can be avoided** by increasing the action level in accordance with adopting a threshold dose model.

CONCLUSIONS

Current regulatory standards for radiation protection are directly and indirectly based upon the LNTH. Replacing the LNTH with a threshold dose-response model will introduce good science and justify relaxing exposure standards in regulatory changes. The preliminary estimates presented here for only a few areas of interest indicate that the monetary value of potential benefits can reach hundreds of billions of dollars. These savings estimates include: more than $100 billion less over several decades for environmental management and cleanup of nuclear facilities, $1 billion/y during operations and $6 billion for decommissioning existing nuclear power plants, and more than $20 billion for avoidance of unneeded radon remediation in homes. Further, in addition to these and other direct benefits, there is the promise of unlimited benefits from intangible benefits. Eliminating the common myth that "there is no safe level of radiation" will overcome objections held by some persons and unleash the broad benefits of nuclear science.

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