ECONOMIC ASPECTS OF EPA'S HLW DRAFT PROPOSED REGULATION

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ABSTRACT

Since 1987, when Subpart B of 40 CFR 191 was remanded by the Court back to EPA, the Agency has been in the process of reproposing these disposal standards. Concomitantly with this reproposal, the EPA has been developing an augmented Economic Impact Assessment in an attempt to further define costs and benefits of this draft proposed rulemaking. This paper abstracts from this analysis to remark on the stringency of the revised standard from a purely economic perspective. At the same time, the opportunity is taken to mention some larger, quasieconomic issues encountered, but not necessarily addressed, in performing the analysis.

INTRODUCTION AND BACKGROUND

The Environmental Protection Agency's (EPA) standards are intended to be the lead standards regarding the environmental effects of nuclear waste management and disposal. As such the EPA is responsible for developing and promulgating, "generally applicable standards for protection of the general environment from offsite releases from radioactive material in repositories" (1). This includes spent nuclear fuel and high-level waste (HLW) and transuranic radioactive wastes.

In 1982, Congress passed the Nuclear Waste Policy Act (NWPA) to set up a comprehensive program for development of geologic repositories for spent fuel and HLW (2). It divided responsibilities among the Nuclear Regulatory Commission (NRC), Department Of Energy (DOE) and EPA for waste disposal. EPA was to develop environmental standards, NRC was to devise licensing criteria, and DOE was to select disposal sites and demonstrate compliance. In 1983, anticipating EPA's release limits, NRC promulgated 10 CFR 60, which, among other things, set requirements that high-level and spent fuel waste form leach rates not exceed 10^{-5} and canisters have a minimum life expectancy of 300 to 1000 years(3). Transuranic wastes are to be considered for disposal in the Waste Isolation Pilot Plant (WIPP). The Nuclear Energy Authorization Act of 1980 specifies WIPP as a research and development project to demonstrate the safe disposal of radioactive wastes that result from defense activities(4). DOE has constructed WIPP in compliance with orders developed by DOE and a working agreement with the State of New Mexico. Although development of the first stage of WIPP is complete and it is ready to start receiving wastes, its use has been delayed for some time while its safety is demonstrated. The NWPA and NRC regulations do not apply to transuranic wastes to potentially be placed at WIPP. EPA's regulation will.

EPA promulgated standards on August 15, 1985 (40 CFR Part 191) (5). However, those parts of the standards dealing with disposal (Subpart B) were vacated by a U.S. Appeals Court on July 17, 1987, and were remanded to the Agency for further consideration(6). EPA is again examining the potential environmental and economic impacts from disposal of these materials, preparing to publish another proposed rule for public review and comment, and will again consider these comments in developing and re-promulgating environmental standards for disposal.

The Rule's Requirements

The focus for the EIA has been primarily with Subpart B, "Disposal", of the proposed 40 CFR 191, draft #3 (Subpart B of the regulation originally promulgated was specifically remanded to EPA) and Subpart C, which was newly created in the process of reproposing the rule(7). Basically, Subpart B has three major components. The first component, a containment requirement, includes numeric limits on the cumulative releases of radionuclides to the environment for the first 10,000 years after disposal (intended to allow less than 1000 premature deaths per 100,000 MTHM over that period). The second component consists of qualitative assurance requirements that, among other things, require that both natural and engineered barriers be used. The third part consists of a standard for protection of the individual. Working draft 3 of the rule may propose options of 10 and 25 millirem annual committed effective dose equivalent to the individual for the time period options of 1000 and 10,000 years, for all exposure pathways.

Subpart C contains the fourth component of the rule that has been studied for its impact. It contains, again in the latest working draft, groundwater protection requirements which are consistent with EPA's drinking water standards, 40 CFR 141(8). Compliance with the individual and ground water requirements assumes only that "expected" processes occur, such as the normal flow of ground water, and that intrusion, seismic, and volcanic events do not occur.

Purpose

The purpose of this paper is to discuss the economic impact assessment (EIA) done for the draft proposed rule and how the results can be used to remark on the stringency of 40 CFR 191 using economic criteria. Included also is a discussion of some of the more philosophical economic issues encountered in the process.

Caveat

We also note here that we have not yet incorporated the possibility of gaseous releases from tuff repositories. Insufficient information currently exits as far as releases; technological and geological solutions and the associated mitigation costs; and potential regulatory approaches to address the issue. All modeling results are for generic geological repositories.

ASSESSING THE STRINGENCY OF 40 CFR 191

The issue of the stringency of EPA's rule has been raised in some quarters based on the general features of the rule or methodologies EPA used in its development. These appear to include, but are not limited to: EPA modeling techniques and assumptions; the probability form of the rule and the use of release limits; the 10,000 year time horizon, and the difficulty of demonstrating compliance. If EPA's assumptions and the form of the standard are taken as givens and the question of stringency is then posed, placing the standard in an economic context sheds a different light on 40 CFR 191.

Criteria for Stringency

For the purpose of this discussion five criteria are proposed to judge the stringency of a standard. Multiple criteria are proposed to view the rule in a number of ways and to provide a broader gauge by which to judge the rule. Those criteria offered are 1) the implementation flexibility allowed by the rule 2) the 'tightness' of the standard, that is, the reduction of contaminants from current or baseline levels 3) the cost effectiveness of and cost per averted health effect implied by the standard 4) the ability of current engineering and technology to meet the standard and 5) the impact of the standard on consumers and producers.

Criterion 1, flexibility, considers how much the rule constrains the choice between options by eliminating easier options that would have been acceptable otherwise. That is, the more flexible the rule, in terms of preserving options for meeting it, the less binding it is, and the less costly it should be on average to implement. In this regard, note that 40 CFR 191 relies on performance standards rather than technological requirements. The rule does not rule out any category of geological formation *a priori*. It does not require any specific engineered barrier, only that some form of engineered barrier be used. Hence the rule allows flexibility to choose the most cost-effective alternative and allows for whatever technological developments may follow the rule. As a contrast a prescriptive rule such as 10 CFR 60 requires that leach rates be less than 10^{-5} and canisters last at least 300 to 1000 years. This is not to suggest a defect with 10 CFR 60. In this case the two forms of rules are appropriate to the complementary roles of the Agencies. But from a purely economic view of rule making, the less explicit the form of the technology and the more degrees of freedom given for implementation of a rule, the more cost-effective, on average, it will be.

Criterion 2, the tightness of the rule, is frequently described in terms of its requirements for the reduction of pollution, emissions, releases, etc. from current levels. A rule that requires that pollution be reduced by 99 percent is more demanding than one that requires only a 95 percent reduction. The question then becomes "What reduction from current levels is EPA requiring?" The minimally acceptable disposal scenario for large volumes of High-level and transuranic waste (acceptable to both the scientific community, many in the disposal community, and the general public) appears to be geologic. Therefore, for large volumes of radioactive waste the listing of possible disposal scenarios would start with geologic and become increasing stringent from there. To buttress this argument we note the following: 1) Geologic disposal has been recommended by several scientific bodies, including the National Academy of Sciences/National Research Council (NAS-NRC) Advisory Committee in 1957, the NAS-NRC Advisory Committee on Radioactive Waste Management (CRWM) in 1968, the Federal Energy Resources Council (FERC) in 1976, the Interagency Review Group in 1980, and the Board On Radioactive Waste Management(9). For HLW waste Congress has decreed that geologic repositories be evaluated and has specified locations for those repositories(10). And lastly, it is noted that for water releases tuff, while being the cheapest disposal medium is also the most protective of the three we have examined. In short, 40 CFR 191 requires no further reduction of waterborne releases from those shown (by modeling) to be associated with a well-designed HLW geologic repository in tuff or salt with some engineered barriers.

Criterion 3, the cost per averted health effect is, in general, related to the effects of the first two. The per health effect cost generally increases and the rule becomes less cost-effective as a rule's flexibility is decreased and as the standard it implies is tightened. Cost per averted health effect has an advantage over the first two criteria in that it can typically be stated in more concrete terms. Comparing the cost per averted health effect of the possible options to a base case or to each other allows for a discussion of the cost-effectiveness of the options. This is the basic approach economists use: to compare the incremental cost of moving to the next most stringent option to the incremental benefits realized from such a move.

This cost-effectiveness comparison is used here rather than the more familiar cost-benefit analysis. The reason for this is several-fold. It allows a comparison of several different disposal options so that the cost-effectiveness and stringency of the preferred standard may be placed in context. Cost-effectiveness analysis is also appropriate when the costs and benefits are measured in different ways. In the HLW analysis two factors prohibit the direct comparison of costs and benefits in a formal cost-benefit framework. The first is that the costs are discounted but the benefits are not. Discounting of benefits over the long time-frames involved (10,000 years for the health effects in this case) or even over a relatively short period such as several hundred years, will give a present value of zero, for any reasonable discount rate. The second is that the costs and benefits are expressed in different terms, costs in dollars, benefits in averted health effects. There is no monetization of health effects that would be lost or saved with the choice of options. And lastly, the costs and benefits of the least stringent option, tuff with no canisters, are not known. What is known are the absolute costs of such a repository, but not the costs incremental to what may have occurred in the absence of 10 CFR 60 or 40 CFR 191. The same applies for the health effects. To somewhat surmount this problem the various options are compared to suggest what the most cost-effective level of stringency might be.

In the analysis that follows, the costs and benefits of the standard were examined for a number of options that might meet it. These options were combinations of three variables: geologic media, container, and waste form. There were three choices of geologic media for the HLW analysis: basalt, salt, and tuff. For transuranic waste only salt disposal was studied. There were a variety of waste forms and their associated leach rates for HLW. Waste form leach rates considered ranged over a continuum of rates from 10^{-3} to 10^{-6}. Finally, there were two canister lives to consider: 300 and 1,000 years. These options reflect both the choices of studies performed by EPA to evaluate 40 CFR 191 and 10 CFR 60 requirements. For transuranic waste no canisters or leach rates limits are assumed. All results are from the Background Information document for HLW, currently internal draft #3 (11).

For HLW, Fig. 1 shows the large number of options that exist for meeting the containment requirements for the HLW repository and the number of health effects associated with each option, assuming the emplacement of 100,000 MTHM of HLW (the actual figure for the Congressionally mandated HLW disposal site is 70,000 MTHM). These health effects range from about 2 in the most protective case to approximately 2,200 for the worst case for the 10,000 year period of the analysis. Basalt has the worst performance under all options with a health effects range of from about twenty to the worst case of approximately 2,200 mentioned above. Of the three media, basalt relies most on low waste form leach rates to keep health effects to acceptable levels. The smallest number of health effects, approximately 2, is associated with tuff, a 1,000 year canister and a waste form leach rate of 10^{-6}.

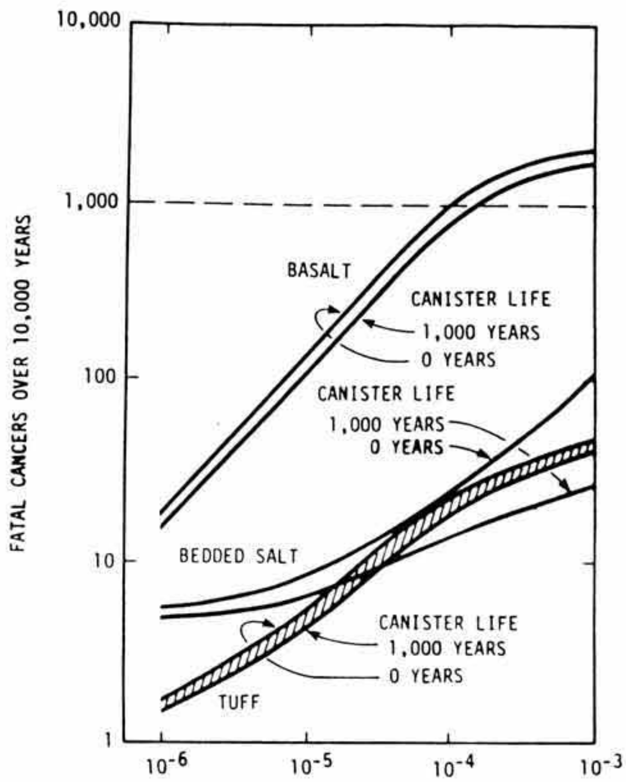

Fig. 1. The effect of canister life and waste form on population risks for three repository media.

The choice of geologic media has a much larger impact on expected health effects than do engineering features in EPA's modeling results. In basalt, a waste form with a leach rate of less than 10^{-4} would meet the rule with less than 1,000 health effects, but a faster leach rate would be allowed if some other option, such as a hypothetical 10,000 year super canister, were available (health effects start up dramatically at the end of the life of the 1,000 year canister so that if 10,000 canister were to be used basalt, and a faster leach rate, would meet 10 CFR 60). Any of the points shown on Fig. 1 for either salt or tuff keep health effects below approximately 100.

Figure 1 also illustrates the effect of 10 CFR 60. It requires that minimum canister life be somewhere between 300 and 1,000 years and waste form leach rates be less than 10^{-5}. If the NRC requirements are met, 40 CFR 191 is complied with in all three media studied. Figure 1 also shows that the highest number of health effects expected from HLW in any media and complying with 10 CFR 60 is approximately 130. This result is for basalt with a leach rate of 10^{-5} and a 300 year canister. The highest number of health effects for a salt media would be 9 and for tuff, 5. In the absence of NRC's rule, tuff and salt would continue to meet the EPA standard with health effects a little below 100 for salt and below 50 for tuff. For basalt, EPA's standard could be just barely met with zero year canisters and leach rates between 10^{-4} and 10^{-5}. These parameters would not satisfy the NRC rule. The discovery of potential gaseous releases to the atmosphere may change this picture but the many possible options have not yet been evaluated. In any case, the analytic approach would be the same.

At a salt repository for transuranic wastes, which is not subject to NRC's rule, no special canister or waste forms are necessary to meet 40 CFR 191 according to EPA modeling. For transuranic wastes, studies show that if the equivalent of 100,000 MTHM of waste were stored in a salt repository, about 9 health effects would occur. No studies were performed with regard to alternative waste forms or canister types so the effect of these mitigation technologies is not known. DOE is known to be conducting such an evaluation, however, and EPA is very much interested in the results. The requirement for an engineered barrier might be met through technologies for sealing the storage vaults. The costs for such a facility would be expected to increase if the requirements of 10 CFR 60 were applied.

Table I shows both the costs and health effects associated with the disposal of 70,000 MTHM. It assumes the use of those options for HLW that meet the requirements of both 10 CFR 60 and the containment requirement of 40 CFR 191 part B. The largest cost is associated with the preparation of the geologic media. Of the three media, basalt is most expensive with a present value of $7.4 billion (discounted at 2 percent to attain a present value). This is followed by salt, with a present value cost of $5.5 billion and tuff, with a present value cost of $3.6 billion. It is also noted that a salt repository meeting only 40 CFR 191 has a present value cost of $3.6 billion.

Costs for different waste forms and canisters are also shown. Due to the different timing of activities in the different media, the present values of using a particular canister type or waste form varies by a small amount, although the undiscounted values are not different. The cost of using a 300 year canister is around $400 to $500 million while the cost of a 1,000 year canister adds about $200 million over the life of the project. The cost of a waste form with a leach rate of 10^{-5} is around $600 million. Switching to a waste form with a release rate of 10^{-6} adds $200 to $300 million.

A comparison of the options for which modeling results are available allows a comparison of the cost-effectiveness of the options. Of course, to make a comparison of stringency an option must be compared to options preferably both less and more stringent. An analytic problem that exists in evaluating the simplest case, tuff in combination with a zero canister life, which is the lowest cost option that would comply with 40 CFR 191. We have nothing less stringent, insofar as costs, with which to compare. We can, however, compare it to more stringent options and use the comparison to judge the cost-effectiveness of becoming more stringent.

The move from the least stringent option to meet 40 CFR 191 to one that would comply with 10 CFR 60 can be looked at. To set up the scenario for 40 CFR 191, a repository in tuff is used and no restriction on waste form or canister life are used. This would cost $3.6 billion, the cost of repository development for tuff. The number of deaths attributable to the highest leach rate for which we have data is approximately 55 per 10,000 years. 10 CFR 60 at a minimum cost would require construction of the repository in tuff, using a minimal (300 year) canister, and a waste form with a leach rate of 10^{-5}. This would result in about 6 deaths in 10,000 years and cost $4.6 billion. This suggests that a reduction in health effects is achieved in moving from 40 CFR 191 to 10 CFR 60 at $20 million per health effect. This is the least cost-effective 10 CFR 60 would be compared to the minimum requirements of 40 CFR 191.

Other comparisons are possible and are shown in Table II. It is possible to decrease the number of statistical health effects by using waste forms with reduced leach rates or longer lasting canisters. Table II shows the cost of and statistical health effects averted attributed to moves from one option to another. Option 1 is the least costly option in tuff that meets the NRC rule; it consists of using a 300 year canister and a waste form with a leach rate of 10^{-5}. It was used as the least costly 10 CFR 61 complying option above. Option 2 consists of using a 1,000 year canister. Option 3 consists of reducing the waste form leach rate by a factor of 10. Option 4 consists of improving both the canister and the leach rate. Tuff is the media used here in all cases due to its dominating performance.

As Table II shows, moving from option 1 to option 3 is the most cost-effective move. This option consists of reducing the waste form leach rate to 10^{-6}. Moving from option 1 to option 3 would cost $254 million and save 4 statistical lives implying a cost of $63 million per statistical health effect averted. Moving to option 2 or to option 4 are both much more costly per statistical health effect averted. While the move to option 3 is the cheapest way to purchase additional protection, the move would produce no net benefits unless the reduction of a health effect was considered to be worth $63 million or more.

The individual and ground-water requirements provide an extra protection to populations living near the repositories, but they do not add to the cost of compliance. EPA generic modeling suggests, for a tuff repository with characteristics similar to Yucca, zero discharge of radiation to ground water during the period of undisturbed performance in 10,000 years. The analysis for salt shows the same, even when no special canisters or waste forms are used. These modeling results support the case that the requirements of 40 CFR 61 for management and storage of radioactive waste shall prevent any increase in the levels of radioactivity in any underground source of drinking water

TABLE I

Costs and Risks for Alternative Configurations of HLW Management System

Geologic Media	Leach Rate	Longevity of Canister See note*	Number of Deaths in 10,000 yr	Present value of costs in billions of 1988 dollars discounted at 2%: Repository Development	Alternative Leach Rate	Aternative Canister	Total for Alternative Configuration
BASALT	1E-05	0	150.0	7.4	0.6	0.5	8.5
BASALT	1E-05	1000	110.0	7.4	0.6	0.7	8.7
BASALT	1E-06	0	30.0	7.4	0.9	0.5	8.8
BASALT	1E-06	1000	20.0	7.4	0.9	0.7	9.0
SALT	1E-05	0	9.0	5.5	0.6	0.4	6.6
SALT	1E-05	1000	7.0	5.5	0.6	0.7	6.8
SALT	1E-06	0	6.0	5.5	0.9	0.4	6.8
SALT	1E-06	1000	5.0	5.5	0.9	0.7	7.1
TUFF	1E-05	0	6.0	3.6	0.6	0.4	4.6
TUFF	1E-05	1000	5.0	3.6	0.6	0.6	4.8
TUFF	1E-06	0	2.0	3.6	0.8	0.4	4.9
TUFF	1E-06	1000	1.6	3.6	0.8	0.6	5.1

*The minimum canister life in cost estimates is 300 yr.

TABLE II

Cost-effectiveness of options for meeting 40 CFR 191*

From Option	Million $ per Life Saved (to option)			Total Incremental Cost in Millions of $ (to option)			Incremental Lives Saved (to option)		
	2	3	4	2	3	4	2	3	4
1	212	63	106	212	254	466	1.00	4.00	4.40
2	--	14	75	--	42	254	--	3.00	3.40
3	--	--	530	--	--	212	--	--	0.40

* Option 1 - tuff, 300 yr. cannister, 10^{-5} leach rate
Option 2 - tuff, 1000 yr. cannister, 10^{-5} leach rate
Option 3 - tuff, 300 yr. cannister, 10^{-6} leach rate
Option 4 - tuff, 1000 yr. cannister, 10^{-6} leach rate

outside the controlled area which may cause a violation of any primary drinking water regulation under 40 CFR Part 141.

An option in the individual protection requirement may require that exposure to individuals through all pathways not exceed 10 millirems per year. As has been shown, ground-water has been determined to have zero discharge in the modeling results. There is, therefore, no impact of moving the limit from 25 millirem down to 10 or even zero.

Criterion 4 is the ability of current engineering and technology to meet the standard. According to EPA's generic modeling all geologic media, tuff, salt, and basalt meet EPA's containment standard. Geologic vaults are not technologically daunting. EPA modeling shows that a more sophisticated approach such as canisters or engineered barriers provide additional assurance of containment but are not necessary to meet the release limits of the standard in its simplest form.

Criterion 5, the last criterion to be applied in this stringency assessment, is the impact the rulemaking has on producers and consumers. In other words, the impact on the economy itself and on the standard of living, the burden it places on those who must pay for it. This is not a measure of efficiency and simply by virtue of its size does not justify an action. However, in the face of uncertain benefits it is important to be aware of the relative size of the effort being imposed by a regulation in relation to the economy or a sector of the economy.

For analysis of economic impact, the costs of the options are converted from present values to annual payments. The parameters used in this conversion are the real interest rate, assumed to be 2 percent, and the term -- that is the number of years of payment, assumed to be 85 years which is approximately the expected emplacement lifetime of the proposed repository.

The least costly option that meets the NRC rule is to construct the repository in tuff using a 300 year canister and limiting the leach rate to 10^{-5}. This would cost \$4.6 billion in present value terms and has an annual payment of \$113.5 million. This annual payment constitutes an increase in utility rates of 0.00000440 cents/kwh and would cause a decline in sales of electricity of 0.000073 percent. Consumers would bear the entire \$113.5 million cost; it would cost each utility customer \$1.06 per year. Producers would experience no change in profit as it is assumed that utility rates are set to maintain a constant profit. However, producers would find their annual revenues had declined by \$5.238 million.

Were the most protective option chosen, tuff with a 1000 year canister and a leach rate limit of 10^{-6}, it would cost \$5.1 billion in present value terms. The annual payment would be \$124.9 million. The increase of electric rates would be 0.00000484 cents/kwh while purchases of electricity would decline by 0.000080 percent. Consumers would pay \$124.9 million, or \$1.17 per customer, annually. Although their profits would not change, producers would loose \$5.764 million in revenue per year. The economic impacts of moving to the more stringent configuration appears to the authors to be small based on these data.

INTRACTABLE ECONOMIC ISSUES ASSOCIATED WITH 40 CFR 191 ANALYSIS

Discussions remarking on the economic aspects of environmental regulations and actions dealing with radioactive waste are an all-to-rare phenomena at these symposia. Rarer still are discussions of some of the larger, more intractable economic issues facing economists engaged in preparing regulatory impact analyses for radioactive waste regulations. Several of these 'quasieconomic issues' have been encountered in the preparation of the EIA for 40 CFR 191. Four of the more interesting are discussed here.

Discounting and Intergenerational Problems

Income to be received at some future date is discounted to discover the value of that income today. Why should it be the case that a tomorrow dollar is worth less than a today dollar? Because the possibility of earning interest on the income is forgone between now and the time when it will be received. Thus, there is an opportunity cost of not having the money now. A dollar of costs that occur in the future likewise are, in real terms, lesser than those occurring today as are future benefits that occur in monetary terms, e.g. profits. Extending the notion of discounting from dollars to health effects is perhaps one of the more contentious issues associated with radioactive waste disposal and the collateral economics.

Economists do not have a solid economic foundation for agreeing on applying the rationale for discounting future dollars to future health effects. Lives are not dollars and economics can deal only with the real and the physical, not the metaphysical.

However, some economists might make the claim that no reduction in the value of a life/health effect is suggested by discounting, only an intertemporal comparison to establish societal priorities. Many in the health professions believe, however, that a life in the future is equivalent to one now and so should not be discounted because there are no intertemporal priorities to be set. This may or may not be to confuse the moral value of life, which many believe to be infinite, with the social value of a life, which is the amount that society is willing to pay or is able to pay to save a life.

Still, the question is unsettled. In the Office of Radiation Programs discounting of health effects, particularly over very long time periods, is typically done only as a contrasting informational analysis shown together with the undiscounted results in the primary analysis.

For a regulation such as 40 CFR 191, an additional complicating factor is the very long time period over which the health effects could occur. In this instance discounting has the effect of transferring health effects from disposal from the present and near future generations to far future generations. This effect, the transfer of health effects to the future generations, occurs as those health effects farther out are discounted even more heavily (discounting is an exponential function). In a rational decision making context, if one accepts discounting, those technological and/or engineering options that push health effects out in time (and onto future generations) are seen as equally effective for health protection as those that reduce health effects absolutely (because with discounting, pushing them out further does reduce them). All things considered, it is probably cheaper to push health effects out in time than it is to reduce them absolutely. Of course, with radionuclides and decay, time also equates with decreased risk so these are not totally incongruous.

The issue of intergenerational equity arises from the argument that we should not push the health effects resulting from our power generation and other activities onto future generations by way of discounting. Therefore, the question of whether to discount is not one without a large impact. Intergenerational equity is the rationale for indirectly (by way of release limits) limiting health effects in the absolute and providing that the limitation on radiation exposure for future generations is at least as stringent as for the current generation. But again, it is one to be weighed heavily for in seeking to protect our heirs we will have to spend a portion of their inheritance.

Lifecycle Approach

Simply put, in conducting a cost-benefit analysis the question is asked, "Is the social cost of the activity being analyzed outweighed by the social benefits to be gained from it?" In the instance of HLW disposal, the situational framework for the analyst does not exist in such a way as to answer this question. On the one hand we have HLW that has already been generated--so the question of whether it should be generated (do the benefits exceed the costs) is moot. On the other hand, the process of ongoing radioactive waste generation is so difficult to evaluate from a cost-benefit standpoint as to make conventional economic analysis, for all practical purposes, useless.

In a strictly formal sense conducting such a cost-benefit analysis would look at the total life-cycle of radioactive waste, from generation to disposal. It would start with the benefits to be accrued through the use of nuclear power: the value of energy independence; the reduction in the price of other energy sources due to reduced demand; the relative cost of the energy source and net savings that accrue through use; the value of reduction of acid rain due to decreased use of fossil fuels; the value of reductions in CO_2 emissions and the impact on global warming, etc. The costs might include the capital and operating costs of a plant, the probabalistic cost of release events, the true social cost of the fuel cost including the clean up of uranium mill tailings, the cost of decontamination and decommissioning, and, of course, radioactive waste disposal. Only a few of these can readily be calculated.

In the current analysis the position is taken that a political/societal decision has been made for activities generating the waste, based upon an implicit understanding of the costs and benefits or ignorance of them, and so both past waste generation and future waste generation questions are moot. We can only, after the fact, offer the optimum disposal solution premised on the costs and benefits of disposal alternatives alone. This is known as the 'it fell from the sky' approach. Such a truncated analysis does not allow an answer to the question of whether the waste should have been generated. It does allow discovery of the optimum method of disposal given that it has been generated (at least, within the economic framework). In the EIA conducted by the EPA on HLW, a differential impact analysis is conducted to provide more information. In this analysis the cost of disposal and how it is spread among the elements in society are described together with the impact on electrical usage. These impacts were discussed in the second part of this paper.

The Concept of Protection of the Individual and Its Inclusion Into Economic Analysis

The concept of setting a health protection standard in terms of a limitation on the dose that the maximum exposed individuals (MEI) of a population group may receive has two supporting bases. There is derivation from health protection theory that protection of the most exposed individuals is a method of conferring some protection on both individuals and the general population. It is also an egalitarian concept in that it reduces the unevenness of the burden that any one group of the population may have to bear. Setting a standard in terms of the MEI (or similar concepts such as the Critical Population Group (CPG) or the Maximum Individual Dose (MID)) as EPA did in its proposed LLW and HLW standards still allows for the calculation, through modeling, of health effects or averted health effects. The economics of the rulemaking can then be done in terms of these averted general population health effects, they being the expressed benefits of the rule and juxtaposed with the costs of different levels of stringency of disposal. We can then express a cost per health effect averted or something akin to it. Decision makers then have some additional information to help with the regulatory process. Note, however, that a rule phrased in terms of individual dose in and of itself may not be very protective of the population. An example of this might be a dose per individual at or slightly below the individual dose limit but given to a very large number of individuals over a long period of time. This would result in a large number of health effects.

In current forms of economic analysis the calculation of benefits that accrue from the protection given from a millirem reduction to unspecified numbers of individuals through probabalistic scenarios is not and cannot be made. There is no way of placing a valuation on this 'burden sharing insurance' nor is there any idea what the balance should be between a millirem reduction to such a group and the dollars necessary to offer this type of protection, as is sometimes implicit with an averted population health effect. Instead, the general population protection this individual protection translates into is used to provide benefits in the cost-benefit calculations. Since protection of the individual, in addition to the population, is predicated on the supposition that there is a limitation on the impact of any specific group and this is of value, the economic impact analysis understates the benefits that accrue as a result of that rulemaking.

No Advancement Assumptions

The ability to predict what advances in science and technology there will be or when or where they will occur is not yet with us; nor what cultural and societal changes will take place over what intervals. This is true even in the short term. As one begins to contemplate time periods of thousands of years or 10,000 years, recognition is given to the limits of the imagination. Given this, it is understandable and perhaps prudent when attempting to predict future health effects from disposal to make assumptions of stasis: no change from the present in the future ability to avoid or inhibit nuclide releases or to prevent health effects from such releases. Indeed, in some ways it is assumed that future civilizations will be less advanced than ours. This is implied with the doses given to the large populations who have no way to detect the nuclide contaminants or, if so, no way to prevent their release and consumption. The same can be said for the individual.

Still, to the science of economics, somewhat predicated on the ability of incentives to invoke solutions, either societal or technical, and of growth and development as the norm, it is a difficult assumption to have to make--that there will be no advances in the sciences and the medical arts in the 10,000 year period of performance for disposal or, that for some reason, they will not have an impact. To some observers of advances in recent years it would seem a good possibility that a treatment for malignant neoplastic cellular processes (cancer) would occur within the next several decades, certainly within the next hundred years. This counterassumption would call the benefits of restrictive disposal over thousands of years into question--but does not and cannot change the way we perform our analysis. And certainly one will win no friends within the environmental community to assume away our radioactive waste disposal problems in the belief that future societies will be able to take care of them. We are today spending billions to deal with contamination form only a few decades in the past.

CONCLUSIONS

Based on the economic criteria applied to the rule, 40 CFR 191 does not appear to be an overly stringent rule. This conclusion is based on the fact that the data developed in assessing the rule show compliance with the individual protection requirement, the ground-water protection requirement, and the containment requirement can be achieved by virtue of the properties of the proper geologic media alone. This is true for a salt, basalt, or tuff geologic facility. Thus, once it has been decided that the waste is to be put in a well designed geologic repository, EPA's rule, according to our modeling results, should no additional cost over those for the least stringent (in terms of cost) geological conditions.

Furthermore, the data is rather clear as to the best option to choose for those that meet the criteria of the rule. Salt and tuff clearly dominate basalt in that less health effects can be attributed to them and they are both clearly less costly to develop and use. Tuff is also shown to be superior to salt in these ways, but not quite as dramatically. Increasing the stringency of control, even to the most stringent one studied, has only a small impact on the economy. The least stringent option was shown to cost $1.06 per year to the average utility customer, the most stringent (most protective) $1.17 per year. This implies that each utility customer depending on electricity from a nuclear plant would pay about 11 additional cents per year at the very most to go from the least to the most stringent form of containment possible. The least costly option for meeting it would be expected to contribute to far fewer deaths than the rule implicitly allows for; a more stringent option costs only slightly more.

Any precise economic attribution to a regulation, either 10 CFR 60 or 40 CFR 191, of the economic impact of HLW and transuranic disposal, while expected, is not relevant in this instance. And while the issue might be raised that 40 CFR 191 Subpart B imposes no cost on and provides no benefit to society over and above ongoing radwaste disposal efforts, that is not the proper perspective of the rule making. Two points are worth mentioning on this score. The first is that something of a chicken and egg problem exists with regard to the relationship between 10 CFR 60 and 40 CFR 191. Because EPA's environmental standard was to be implemented by 10 CFR 60, the NRC tried to anticipate EPA rule making in promulgating 10 CFR 60 and therefore its requirements can be said to be influenced by EPA actions and not totally preempting the impact of 40 CFR 191. Thus, in effect, there did not exist a total environmental standard prior to 40 CFR 191 and EPA's requirements become NRC's as NRC implements EPA's Standard. Both EPA and NRC have acknowledged that further actions by the NRC will be needed to fully implement 40 CFR 191 when it is repromulagted.

Even if 40 CFR 191 were seen as duplicative of NRC's disposal regulation, there would still be very strong arguments for its promulgation. The first is that the NWPA requires it. Secondly, while 10 CFR 60 appears to meet EPA's standard under present repository designs, it may not under all disposal conditions. 40 CFR 191 provides the assurance that disposal of HLW and transuranic waste will be carried out in an environmentally protective manner for the near term and far into the future. And lastly, there is the certainty that 40 CFR 191 provides to those in the regulatory community as to what, in EPA's judgement, is the prudent level of protection to be offered. Planning can therefore go forward on disposal sites without waiting for the other shoe to drop at EPA.

What conclusions can be drawn from the discussion of intractable economic issues? Only that the inability to resolve these issues in a definitive way will continue to create differences among analysts as to the value of geologic disposal for HLW and the value of the nuclear power that produces (at least some) of the radioactive waste as a byproduct. At some point a mandate should be sought on how, in a societal fashion, these questions should be answered and remove them as a policy issue. This might remove some conservatism in current assumptions.

REFERENCES

1. Nuclear Waste Policy Act of 1982, Public Law 97-425, January 7, 1983.
2. Nuclear Waste Policy Act of 1982, Public Law 97-425, January 7, 1983.
3. U.S. Nuclear Regulatory Commission, "Disposal of High-Level Radioactive Wastes in Geologic Repositories," Code of Federal Regulations, Title 10, Part 60.
4. U.S. Department of Energy. National Security and Military Applications of Nuclear Energy Authorization Act of 1980, Public Law 96-164, December 29, 1979.
5. Environmental Protection Agency, Office of Radiation Programs. "Final Regulatory Impact Analysis". 40 CFR Part 191--Environmental Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Waste. EPA 520/1-85-027, August 15, 1985.
6. First Circuit Court, Natural Resources Defense Council, Inc. v. United States Environmental Protection agency, Environmental Law Reporter, Litigation, 18:20088-20106 (1988).
7. Environmental Protection Agency, Work Group. Working Draft 1 of 40 CFR Part 191. June 2, 1989.
8. Environmental Protection Agency, 40 CFR Part 141: Water Pollution Control; National Primary Drinking Water Regulations; Radionuclides, Fed. Regist., 51(189): 34836-34862 (Sept. 30, 1986).
9. BRWM 1990: Rethinking High-Level Radioactive Waste Disposal, Board on Radioactive Waste Management, Commission on Geosciences, Environment, and Resources, National Research Council, 1990, p. vii.
10. Nuclear Waste Policy Amendments Act of 1987, Public Law 100-203, December 22, 1987.
11. Environmental Protection Agency, Office of Radiation Programs. "Background Information Document for the Repromulgation of 40 CFR Part 191". Environmental Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes. (Chapters 1 to 4) Internal Draft. EPA 520/X-89-XXX, September 1989.