NOTATION VOTE

RESPONSE SHEET

TO: Annette Vietti-Cook, Secretary

FROM: Commissioner Baran

SUBJECT: SECY-17-0017: Proposed Revision to NUREG-1530, "Reassessment of NRC's Dollar Per Person-Rem Conversion Factor Policy"

Approved X Disapproved ____ Abstain ____ Not Participating ____

COMMENTS: Below ____ Attached X None ____

Entered in "STARS"
Yes X
No ____

Jeff Baran
SIGNATURE

6/12/17
DATE

Commissioner Baran's Comments on SECY-17-0017, "Proposed Revision to NUREG-1530, 'Reassessment of NRC's Dollar Per Person-Rem Conversion Factor Policy'"

In this paper, the staff recommends updating NRC's guidance on the "dollar per person-rem conversion factor," which is the agency's monetary valuation of the cancer mortality risk of radiation exposure. This proposed revision is one component of the agency's broader effort to update its cost-benefit guidance.

The dollar per person-rem conversion factor is comprised of two elements: (1) the value of a statistical life (VSL), and (2) the cancer mortality risk coefficient. The VSL represents how much society is willing to pay for small reductions in a particular risk of death. The cancer mortality risk coefficient reflects the probability of cancer mortality from radiological exposure. These two elements are multiplied to generate the dollar per person-rem conversion factor.

The conversion factor used by NRC is important because it represents the dollar value of the health benefits of an action that reduces radiological exposure. A credible and up-to-date dollar per person-rem conversion factor is essential for an accurate cost-benefit analysis of potential regulatory requirements. A dollar per person-rem conversion factor that is too low would result in the agency underestimating the benefits of proposed regulatory requirements, which could inappropriately skew the agency's regulatory decisionmaking.

The staff's proposed revision would increase NRC's VSL from the current $3 million to an updated $9 million and would adopt EPA's latest cancer mortality risk coefficient of 5.8×10^{-4}, which was published in 2011. Based on these changes, NRC's dollar per person-rem conversion factor would increase from $2,000 to $5,200.

I agree with the NRC staff that the agency's dollar per person-rem conversion factor needs to be updated and find the staff's proposed changes to the VSL and cancer mortality risk coefficient to be thoughtful and well-supported. NRC's dollar per person-rem conversion factor and VSL have not been updated since 1995 and are woefully out of date. Because NRC has gone 22 years without updating these values, the agency has become a notable outlier among federal agencies. For example, EPA has updated its VSL several times since 1999 and currently uses a value of $8.7 million. The U.S. Department of Transportation has updated its VSL at least three times since 1993 and is currently using a value of $9.3 million. The Department of Homeland Security and Food and Drug Administration both use a VSL of $8.6 million, while the Occupational Safety and Health Administration uses a VSL of $9 million. Thus, NRC's current VSL of $3 million is a fraction of what other agencies across the federal government are using. Updating NRC's VSL and dollar per person-rem conversion factor will both improve our regulatory decisionmaking and foster greater consistency among federal agencies.

The staff also proposes a methodology for keeping the conversion factor up-to-date by (1) maintaining the VSL in current dollars to reflect annual changes in inflation and real income growth, (2) establishing a trigger for re-evaluating the elements of the dollar per person-rem conversion factor if developments would be expected to change the conversion factor by more than $1,000, and (3) informing the Commission if EPA further updates its cancer mortality risk coefficient. I support this reasonable approach for maintaining a credible and reliable dollar per person-rem conversion factor.

For these reasons, I approve the revised guidance, subject to the attached edits. One of my edits relates to the statement in the proposed guidance that applicants for reactor licenses under Parts 50 and 52 will still be required to use the old conversion factor of $1,000 per total body man-rem and $1,000 per man-thyroid-rem because it appears in NRC's regulations. However, the regulatory language in Section II.D of Appendix I, Part 50, states that this conversion factor will be used "[a]s an interim measure and until establishment and adoption of better values (or other appropriate criteria)." This rule language clearly contemplates and provides for the use of an updated value when one is available. By approving the updated conversion factor in the revised guidance, the Commission is establishing and adopting the "better values" envisioned by the rule. My proposed edits reflect that a rulemaking is not needed to use the updated conversion factor in the context of Part 50 and 52 license applications.

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

NUREG-1530
Revision 1

JMB Edits

Reassessment of NRC's Dollar per Person-Rem Conversion Factor Policy

Final Report

Office of Nuclear Reactor Regulation

ABSTRACT

The U.S. Nuclear Regulatory Commission (NRC) uses the dollar per person-rem conversion factor in developing cost-benefit analyses to determine the monetary valuation of the consequences associated with radiological exposures. In 1995, the NRC issued NUREG-1530, "Reassessment of NRC's Dollar per Person-Rem Conversion Factor Policy," which updated the dollar per person-rem conversion factor from $1,000 to $2,000 (in constant dollars) (NRC, 1995a). The $2,000 per person-rem conversion factor serves only as a proxy for the health effects associated with a person-rem of dose. This number resulted from the multiplication of the value of a statistical life (VSL) ($3 million in 1995) by the risk coefficient for stochastic health effects (7.3×10^{-4} per person-rem), rounded to the nearest thousand. The continued validity of the $2,000 per person-rem conversion factor has been questioned because estimates and bases for the VSL and cancer mortality risk coefficients have changed since the NRC published NUREG-1530 in 1995.

Revision 1 to NUREG-1530 incorporates updates to the dollar per person-rem conversion factor and establishes a method for keeping this factor up-to-date. The dollar per person-rem conversion factor has been updated from $2,000 (in constant dollars) to $5,200 in 2014 dollars based on the application of an updated best estimate VSL of $9.0 million and the U.S. Environmental Protection Agency's cancer mortality risk coefficient of 5.8×10^{-4} per person-rem. Revision 1 to NUREG-1530 uses a directs the NRC staff to round the conversion factor withto two significant figures instead of rounding to the nearest $1,000 value and provides guidance to the staff on when to use a higher dollar per person-rem conversion factor.

1 REGULATORY BACKGROUND

For all activities regulated by the U.S. Nuclear Regulatory Commission (NRC), the Commission has the authority to take action it deems necessary to ensure adequate protection of public health and safety. Additionally, for NRC-regulated activities, the Commission has discretionary authority to require safety improvements, beyond those necessary to achieve adequate protection, that will increase the protection of public health and safety. The NRC uses various tools to determine whether such a safety improvement is justified, including a cost-benefit analysis. To compare the incremental costs and benefits, all monetized attributes considered in the cost-benefit analysis must be expressed in common units, typically dollars. Therefore, person-rems of averted exposure, a measure of safety value, is converted to dollars by monetizing the health detriment of radiation exposure. The NRC monetizes the cancer mortality risk of radiation exposure as dollars per person-rem of collective dose.

The NRC establishes the dollar per person-rem conversion factor by multiplying a value of a statistical life (VSL) coefficient by a cancer mortality risk coefficient. The U.S. Environmental Protection Agency's (EPA) summary cancer mortality risk coefficient is a gender-averaged value, calculated for a stationary U.S. specific population (defined by the 2000 U.S. vital statistics) (EPA, 2011b). The VSL is not a value placed on a human life, but a value that society would be willing to pay for reducing health risk. The concept of a VSL is used throughout the Federal government to monetize the health benefits of a safety regulation.

For approximately the last two decades, the NRC has used a conversion factor of $2,000 per person-rem (in constant dollars) as the monetary valuation of the consequences associated with radiological exposure. That is, an increase or decrease in person-rem is valued at $2,000 per person-rem to allow a quantitative comparison of the costs and benefits associated with a proposed regulatory decision. In the initial publication of NUREG-1530, "Reassessment of NRC's Dollar per Person-Rem Conversion Factor Policy," in 1995, the NRC established this conversion factor from the multiplication of the VSL ($3 million) by the risk coefficient for stochastic health effects (7.3×10^{-4} per person-rem) (NRC, 1995a). Stochastic health effects are health effects that occur by chance and may occur without a threshold level of dose, whose probability is proportional to the dose and whose severity is independent of the dose.

This conversion value has been used as a reference point in NRC regulatory analyses including: (1) evaluation of routine liquid and gaseous effluent releases; (2) evaluation of accidental releases; (3) evaluation of radiation protection practices, as provided for in Part 20 of Title 10 of the *Code of Federal Regulations* (10 CFR), "Standards for Protection Against Radiation"; (4) backfit analyses; and (5) environmental analyses.

The NRC prepares regulatory analyses for proposed actions that would impose requirements on NRC licensees. The analyses include an examination of the benefits and costs associated with alternative approaches to meeting the particular regulatory objectives. The NRC requires a regulatory analysis for a broad range of regulatory actions. In general, all mechanisms used by the NRC staff to establish or communicate generic requirements, requests, or staff positions, that would effect a change in the use of resources by the licensees will include an accompanying regulatory analysis. These mechanisms include rules, bulletins, generic letters, regulatory guides, orders, standard review plans, branch technical positions, and standard technical specifications. The conclusions and recommendations included in a regulatory analysis are neither final nor binding, but rather are intended to inform decisions made by the NRC staff and the Commission.

The NRC believes a reevaluation ~~continued validity~~ of the $2,000 per person-rem conversion factor is appropriate ~~has been questioned~~ because estimates and bases for the VSL and cancer mortality risk coefficients have changed since the NRC published NUREG-1530 in 1995 (NRC, 1995a).

Revision 1 to NUREG-1530 incorporates updates to the dollar per person-rem conversion factor and establishes a method for keeping this factor up-to-date. The dollar per person-rem conversion factor has been updated from $2,000 (in constant dollars) to $5,200 (in 2014 dollars) based on the application of an updated best estimate VSL of $9.0 million and the EPA's cancer mortality risk coefficient of 5.8×10^{-4} per person-rem. Revision 1 to NUREG-1530 directs the staff to round the conversion factor to two significant figures instead of rounding to the nearest $1,000 value and provides guidance to the staff on when to use a higher dollar per person-rem conversion factor.

The NRC's Revision 1 to NUREG-1530 continues the practice of calculating a dollar per person-rem conversion factor based on the VSL and a cancer mortality risk coefficient that establishes the probability for cancer mortality health effects attributable to radiological exposure. The resulting dollar per person-rem conversion factor is expected to apply to situations where populations are exposed to low doses that collectively result in calculated excess cancers.

also applied the $1,000 per person-rem value. ~~In both contexts, the $1,000 per person-rem value has been the figure of merit and one of the factors in the respective assessments.~~

In February 1981, President Ronald W. Reagan issued EO 12291, which directed executive agencies to prepare a regulatory impact analysis for all major rules and stated that regulatory actions should be based on adequate information concerning the need for and consequences of any proposed actions. Moreover, EO 12291 directed that actions were not to be undertaken unless they resulted in a net positive benefit to society. As an independent agency, the NRC was not required to comply with EO 12291. The Commission, however, noted that its established regulatory review procedures included an evaluation of proposed and existing rules in a manner consistent with the regulatory impact analysis provisions of EO 12291. The Commission determined that clarifying and formalizing the existing NRC cost-benefit procedures for the analysis of regulatory actions would advance the purposes of regulatory decisionmaking. EO 12291 was later superseded by EO 12866 in October 1993, which did not affect NUREG-1530.

The NRC published NUREG/BR-0058, Revision 0, "Regulatory Analysis Guidelines of the U.S. Nuclear Regulatory Commission," in January 1983 and published Revision 1 in May 1984 (NRC, 1983a and 1984, respectively). The NRC then published NUREG/CR-3568, "A Handbook for Value-Impact Assessment" in December 1983 (NRC, 1983b). These documents were issued to formalize the NRC's policies and procedures for analyzing the costs and benefits of proposed regulatory actions. These initial revisions of NUREG/BR-0058 did not mention the $1,000 per person-rem figure; however, NUREG/CR-3568 recommended that the analyst use a range of values, one of which should be the $1,000 per person-rem value. As NUREG/CR-3568 provides the implementation guidance for performing regulatory analyses, it became standard practice of the NRC staff to apply this guidance whenever a quantitative regulatory analysis or cost-benefit analysis was performed.

In May 1983, the NRC issued an interim policy statement on "Safety Goals for Nuclear Power Plant Operation" for use during a 2-year trial period (NRC, 1983c). In this policy statement, the Commission adopted qualitative and quantitative design goals for limiting individual and societal risks from severe accidents. Also in this policy statement, the Commission stated that the benefit of an incremental reduction of societal mortality risks should be compared with the associated costs on the basis of $1,000 per person-rem averted as one consideration in decisions on safety improvements. The value proposed was in 1983 dollars and was to be modified to reflect general inflation in the future. At the end of the 2-year interim period, a number of comments were received on this value. These comments proposed values ranging from $100 per person-rem to values exceeding $1,000 per person-rem. Respondents who believed the $1,000 value was too low did not provide another number, but merely indicated that the value should be raised. As a result, the $1,000 per person-rem value was deleted in the final policy statement, "Safety Goals for the Operations of Nuclear Power Plants," when published in August 1986 (NRC, 1986).

In 1985, the staff revisited the $1,000 per person-rem valuation and its use in regulatory analyses of nuclear power plant improvements designed to enhance safety. Although the monetary value of averted person-rem of radiation exposure up to that time referred only to averted health effects (such as averted latent cancer fatalities), the use of $1,000 per person-rem was evaluated and defined at that time as a surrogate for all averted offsite losses, such as health and property. The basis for this determination is in an October 1985 memorandum from the NRC Executive Director for Operations to the Commissioners (NRC, 1985a).

An example of the use of value-impact analysis occurred in February 1982, as part of the Three Mile Island Action Plan. The Commission promulgated 10 CFR 50.34(f)(1)(i), which requires certain nuclear power plant reactor license applicants to prepare a plant-specific probabilistic risk assessment (PRA) to identify significant and practical improvements in the reliability of core and containment heat removal systems that do not impact excessively on the plant (NRC, 1982a). As a result of this rule, cost-benefit analyses were prepared in 1985 for the U.S. Advanced Boiling Water Reactor design and reported in the General Electric Standard Safety Analysis Report (NRC, 1985b). These cost-benefit analyses analyzed 80 design-specific enhancements using $1,000 per person-rem. PRAs are now widely used for existing operating nuclear power plant licensing actions and are required for new reactor designs and licenses issued under 10 CFR Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants."

In a February 1989 decision, the U.S. Third Circuit Court of Appeals directed the NRC to consider severe accident mitigation design alternatives (SAMDAs) as part of the NRC's environmental review process under the National Environmental Policy Act (NEPA) before granting reactor operating licenses to owners of nuclear power plants (Limerick Ecology, 1989). The staff subsequently evaluated SAMDA analyses for Limerick, Comanche Peak, and Watts Bar nuclear power plants before issuing operating licenses (NRC, 1996a). The economic consequences of severe accidents and the need for SAMDAs were evaluated for the "Generic Environmental Impact Statement for License Renewal of Nuclear Plants," originally issued in 1996 (NRC, 1996b). In each of these instances, the staff used the $1,000 per person-rem value as a screen to compare costs and benefits.

In October 1993, President William J. Clinton issued EO 12866 requiring all executive branch agencies to perform regulatory analyses for all significant rules. A significant (or major) rule is defined by EO 12866 as:

> … any regulatory action that is likely to result in a rule that may: (1) have an annual effect on the economy of $100 million or more or adversely affect in a material way the economy, a sector of the economy, productivity, competition, jobs, the environment, public health or safety, or State, local, or tribal communities; (2) create a serious inconsistency with an action taken or planned by another agency; (3) materially alter the budgetary impact of entitlements, grants, user fees, or loan programs or the rights and obligations of the recipients thereof; or (4) raise novel legal or policy issues arising out of legal mandates, the President's priorities, or the principles set forth in this Executive order.

The NRC, as an independent agency, is not required to comply with EO 12866. However, Revision 1 to NUREG/BR-0058 already reflected the intent of the EO~~, in part because of the Commission's previously expressed desire to meet the spirit of EOs related to regulatory reform and decisionmaking~~. Revision 2 to NUREG/BR-0058 reflected the experience accumulated by the NRC in implementing Revision 1 to NUREG/BR-0058 and changes to the NRC's regulations since 1984 (NRC, 1995b).

In 1995, the NRC revisited the $1,000 per person-rem value and issued NUREG-1530 (NRC, 1995a). This report updated the dollar per person-rem conversion factor to $2,000 per person-rem. The $2,000 per person-rem conversion factor served only as a dollar proxy for the health effects associated with a person-rem of dose. Offsite property damage costs were no longer included within the $2,000 per person-rem value. Separate estimates of the offsite costs

3 REGULATORY APPLICATIONS

The U.S. Nuclear Regulatory Commission (NRC) applies the dollar per person-rem conversion factor in a variety of regulatory applications that require the determination of the monetary valuation of the consequences associated with radiological exposures. This includes the evaluation of routine effluent releases from nuclear power plants, accidental releases, and radiation protection practices, as well as regulatory analyses, backfit analyses, and environmental analyses. Details of each of these regulatory applications are addressed below.

3.1 Routine Liquid and Gaseous Effluent Releases from Nuclear Power Plants

The dollar per person-rem conversion factor value appears in the NRC's regulations only in Title 10 of the *Code of Federal Regulations* (10 CFR), Part 50, "Domestic Licensing of Production and Utilization Facilities," Appendix I, "Numerical Guides for Design Objectives and Limiting Conditions for Operation To Meet the Criterion 'As Low as Is Reasonably Achievable' [ALARA] for Radioactive Material in Light-Water-Cooled Nuclear Power Reactor Effluents" (Section II, Paragraph D), in a paragraph related to items to be included in a license applicant's radioactive waste system. That regulation states, in part:

> As an interim measure and until establishment and adoption of better values (or other appropriate criteria), the values $1,000 per total body man-rem and $1,000 per man-thyroid-rem (or such lesser values as may be demonstrated to be suitable in a particular case) shall be used in this cost-benefit analysis.

The terminology for population dose was changed in the 1980's from "man-rem" to "person-rem" to be more in line with societal expectations. The conversion factor cited in this regulation has not been updated since the rule was promulgated in 1975 (NRC, 1975a). The NRC staff and licensees have historically ~~are required~~ used this conversion factor of $1,000 per total body person-rem and $1,000 per person-thyroid-rem in applying for design approvals for radioactive waste systems, and not the values discussed in this report and in NUREG/BR-0058. The NRC has now adopted a better and more current conversion factor of $5,200, and this value should be used in applications for design approvals and radioactive waste systems.

~~In designing radioactive waste processing systems, licensees and applicants are not required to install additional effluent controls to reduce routine effluent releases below 3 millirem per year for liquid effluents and 5 millirem per year for gaseous effluents, if the cost of the resultant reduction in the population exposure within 50 miles of the reactor is greater than $1,000 per total body person-rem and $1,000 per person-thyroid-rem (NRC, 1975a).~~ In considering the installation of additional radioactive waste processing equipment, licensees and applicants must include all items of reasonably demonstrated technology that can affect reductions in population doses.

3.2 Accidental Releases

The dollar per person-rem conversion factor value is used frequently when considering accidental radiological releases ~~are a consideration~~. Accidental releases are factored into safety enhancement considerations. When calculating accident-related attributes, the NRC staff draws from risk and reliability assessments or statistically-based analyses (NRC, 1997). As further discussed in the Regulatory Analyses and Backfit Analyses sections below, the NRC staff calculates the incremental change in public risk that would result from the proposed regulatory action and converts it to a dollar per person-rem value using discounted factors.

3.3 10 CFR Part 20 ALARA Program

As required by 10 CFR 20.1101(b), licensees should make every reasonable effort to keep radiation exposures and releases of radioactive materials ALARA. This regulation applies to all the NRC licensees and is concerned with the release of radioactive material and associated occupational and public dose incurred as a result of normal licensee activities.

ALARA, as defined at 10 CFR 20.1003, "Definitions," means making every reasonable effort to maintain radiation exposure as far below the dose limits set forth in 10 CFR Part 20, "Standards for Protection against Radiation," as is practical, taking into account the current state of technology, the economics of improvements in relation to benefits to the public health and safety, and other societal and socioeconomic considerations, and the utilization of nuclear energy in the public interest. Given this definition, it would appear that a dollar per person-rem value should be an important factor in cost-benefit tradeoffs used in establishing reasonableness under the ALARA program. In this regard, the NRC is aware that current industry practice, particularly within power reactors, is to voluntarily value an averted person-rem at a higher dollar value owing to manpower constraints and other labor cost considerations that are integral to licensees' cost-benefit tradeoffs.

Regulatory Guide (RG) 8.37, "ALARA Levels for Effluents from Materials Facilities," advises materials licensees that they should consider engineering options to achieve ALARA goals in the release of effluents and that modifications should be implemented unless an analysis indicates that a substantial reduction in collective dose would not result or the costs are considered unreasonable. One basis for reasonableness identified in this regulatory guide is a quantitative cost-benefit analysis, which requires the use of a dollar value per unit dose averted. RG 8.37 currently recommends the use of $1,000 per person-rem, and acknowledges that a wide range of values could be justified (NRC, 1993).

3.4 Regulatory Analyses

The NRC staff guidance for preparing regulatory analyses is discussed in Revision 4 to NUREG/BR-0058. When preparing regulatory analyses, Revision 4 to NUREG/BR-0058 instructs the NRC staff to use a conversion factor that can place all values and impacts (i.e., benefits and costs) on a common basis (NRC, 2004).

Revision 4 to NUREG/BR-0058 discusses the policy concepts for regulatory analysis and instructs the NRC staff to use the dollar per person-rem conversion factor to calculate a common monetary value of radiation exposure. This value captures the health effects attributable to radiological exposure and does not capture other consequences, such as non-health impacts and offsite property damage (NRC, 2004).

In NUREG/BR-0184, the NRC expanded upon policy concepts included in NUREG/BR-0058 and provided data and methods to support regulatory analyses. NUREG/BR-0184 instructed the NRC staff to use the $2,000 per person-rem value to convert person-rem exposure to a monetary value. This value is then discounted for the purpose of calculating net benefits (NRC, 1997).

characterization, and analysis of both monetized costs and benefits (e.g., those measured in dollars) and qualitative costs and benefits (e.g., functional or non-monetized) are essential for the evaluation and selection of the preferred alternative. Unless exempted in 10 CFR 51.71, "Draft environmental impact statement—contents," or 10 CFR 51.75, "Draft environmental impact statement—construction permit, early site permit, or combined license," the NEPA requires NRC staff to include an analysis that considers "the economic, technical, and other benefits and costs of the proposed action and alternatives" in an environmental impact statement (EIS). In addition, current NRC policy developed after the decision in Limerick Ecology Action, Inc. v. NRC ~~decision~~ (869 F.2d 719, 1989) requires consideration of alternatives to mitigate the consequences of severe accidents in an EIS prepared at the operating license stage.

The NRC staff reviews and evaluates severe accident mitigation alternatives (SAMAs) to ensure that changes that could improve severe accident safety performance are identified and evaluated. Severe accidents are those that could result in substantial damage to the reactor core, whether or not there are serious offsite consequences. Potential improvements could include hardware modifications, changes to procedures, and changes to the training program (NRC, 2006). A SAMA analysis is included as part of the environmental review conducted for license renewal if a site-specific SAMA analysis had not been previously performed. For new reactors, a severe accident mitigation design alternative (SAMDA) analysis, which is a subset of the SAMA analysis, is also included as part of the environmental review for construction permits, design certifications, and combined licenses.

Section 7.3 of NUREG-1555, "Standard Review Plans for Environmental Reviews for Nuclear Power Plants" (NRC, 2007), for new reactors; and Section 5.2 to NUREG-1555, Supplement 1, Revision 1 (NRC, 2013c), for license renewal, provide guidance on the analysis and assessment of SAMAs. The guidance instructs the NRC staff on how to evaluate the estimated cost, risk reduction, and dollar benefits for SAMAs and the assumptions used to make these estimates. The cost-benefit comparison is further evaluated to determine if it is consistent with the cost-benefit balance criteria and methodology given in NUREG/BR-0184 (NRC 1997) and Revision 4 to NUREG/BR-0058 (NRC 2004). In addition, during license renewal reviews, any SAMA with estimated implementation costs within a factor of 2 to 5 of the estimated dollar benefits is further analyzed to ensure that a sufficient margin is present to account for uncertainties in assumptions used to determine the cost and benefit estimates (NRC, 2013c). To evaluate each cost-benefit criterion, the NRC staff uses the NRC's current dollar per person-rem averted amount for health effects.

The NRC's regulations~~,~~ (10 CFR 51.71(d))~~,~~ require~~s~~ the NRC staff to include an analysis that considers the economic, technical, and other benefits and costs of the proposed licensing action and alternatives in an EIS. ~~However, supplemental EISs prepared at the license renewal stage are not required to discuss the economic or technical benefits and costs of either the proposed action or alternatives unless benefits and costs are either essential for a determination regarding the inclusion of an alternative in the range of alternatives considered or relevant to mitigation as required by 10 CFR 51.95(c).~~

Environmental reviews conducted for new reactors use the dollar per person-rem factor in cost-benefit analyses to obtain the averted costs of postulated accidents (NRC, 2004 and NRC, 2007). The factor is used because the offsite radiological impact upon persons is calculated as a cost component in the SAMA and SAMDA analyses, which are part of the EIS.

estimates this value to be $6.7 million in 2014 dollars using CPI to inflate the value) per fatality averted (i.e., VSL) as a default value when agencies had not supplied any value (OMB, 2002).

In September 2003, the OMB issued Circular A-4 that reported VSL estimates between $1 million to $10 million per statistical life in 2001 dollars (the NRC staff estimates these values to be $1.3 million to $13.3 million in 2014 dollars using CPI to inflate the value). The OMB drew on two journal articles and an analysis prepared by the EPA's SAB in selecting these values (Viscusi and Aldy, 2003 and Mrozek and Taylor, 2002). Circular A-4 replaced both the 1996 "best practices" (OMB, 1996) and the 2000 guidance (OMB, 2000).

4.3 VSL Values Based on Radiation Protection Activities in Other Countries

The NRC studies and considers the approaches used by other countries to inform the NRC decisions on regulatory activities and agency guidance. The discussion in this section provides information on other countries' best practices. In addition, the studies authored by Viscusi and Aldy, which are used by other countries, were used in the NRC's new VSL calculations. Therefore, it is beneficial to consider how other countries use these studies.

In the United Kingdom (U.K.), the National Radiological Protection Board approved the recommendation to set a VSL between $3 million and $4.5 million in 1990 dollars (between approximately $5.4 million and $8.2 million in 2014 dollars using CPI to inflate this value), using the WTP approach.

Viscusi and Aldy (2003) analyzed approximately 20 labor market studies, published since 1990, for both developed and developing countries. They analyzed studies in labor markets in Australia, Austria, Canada, Japan, the U.K., Hong Kong, India, South Korea, and Taiwan. The authors noted that VSLs range from U.S. currency values of $200,000 to $69 million in 2000 dollars ($275,000 to approximately $95 million in 2014 dollars using CPI-U to inflate this value) depending on the risk to workers, the country's income levels, and the methodologies performed in the studies analyzed. Viscusi and Aldy note that the higher numbers tend to come from studies performed in the U.K. The authors noted that they suspected the large numbers come from risk measures and other unobservable factors plus large worker compensation differences.

Viscusi and Aldy (2003) also noted that Canada has placed a significant focus on hedonic labor market analyses. They also noted that the Canadian analyses tend to be similar to those analyzed in the U.S. labor markets as opposed to those in the U.K. labor markets. The majority of VSLs tend to fall between $3 million and $6 million in 2003 dollars (between $4.1 million and $9.7 million in 2014 dollars using CPI to inflate the values).

4.4 Representative VSL for NRC Activities

Given the lessons learned from this literature review and outreach, the NRC staff will update its VSL base year value best estimate to $9.0 million (2014 dollars). ~~Given the extensive resources spent by~~ O~~o~~ther Federal agencies ~~on this topic~~, specifically the EPA and the DOT, have expended significant resources on developing their approaches. T~~t~~he NRC staff believe it is prudent to leverage the work done by these agencies~~se resources~~ and align its VSL recommendations with those of its Federal counterparts. This estimate is derived from the average of the DOT's VSL ($9.3 million) and the EPA's VSL ($8.7 million) in 2014 dollars. The NRC staff believe that averaging DOT's VSL and EPA's VSL produces a balanced and reliable VSL.

In order to align with practices of other Federal agencies, the NRC will adopt a low and a high VSL estimate for use in sensitivity analyses. Each Federal agency identified in this report has adopted VSL estimates, in 2014 dollars, based on that agency's mission and within its own processes. The staff recognizes that if it performed similar research as other Federal agencies, the staff's estimates likely would be roughly similar. Therefore, the staff will adopt the a low and high VSL values (in 2014 dollars) that envelop the DHS values and are bounded by the OMB values as shown in Table 1 for use in sensitivity analyses as discussed further in Section 6.

Table 1 Low and High VSL Values in 2014 Dollars

Agency	Low	High
DOT	$5.3 million	$13.2 million
DHS	$6.8 million	$10.8 million
OMB	$1.3 million	$13.3 million

As discussed above, the DOT and the DHS low and high estimates are inflated using those agencies' formulas for keeping their VSL estimates up to date. The OMB does not have a systematic method of updating their formula, and therefore, the NRC staff inflated the OMB's values using the CPI.

reductions in the probability of total detriment for a given population. From a practical perspective, the NRC believes that regulatory issues involving deterministic effects and/or early fatalities would be very rare and can be addressed on a case-specific basis, as the need arises.

Consistent with best practice, the NRC staff provides a range of dollar per person-rem conversion factors for use in sensitivity analyses. These analyses are performed to evaluate the impact on cost-benefit analysis results of using plausible alternative values for this conversion factor. For this purpose, the NRC staff recommends varying the dollar per person-rem conversion factor by plus or minus 50 percent. This results in a range of conversion factors with a low value of $2,600 per person-rem and a high value of $7,800 per person-rem. When applying an alternative dollar per person-rem value, the analyst must document the reasons and basis for using the alternative.

These lower and upper bound estimates for the dollar per person-rem conversion factor can be used in sensitivity analyses to evaluate the impact of variability in the conversion factor that can arise from two independent sources: (1) use of plausible alternative values for the VSL or (2) uncertainty about the cancer mortality risk coefficient. Varying the conversion factor by 50 percent in each direction is equivalent to independently varying the VSL estimate or cancer mortality risk coefficient by 50 percent in each direction for one-way sensitivity analyses. For the VSL estimate, this is equivalent to using low and high VSL estimates of $4.5 million and $13 million (2014 dollars), respectively, based on a cancer mortality risk coefficient of 5.8×10^{-4} per person-rem. This range of VSL values is nearly the same as the low and high VSL estimates the NRC staff identified from other Federal agency practices of $5.3 million and $13.2 million (2014 dollars), respectively. For the cancer mortality risk coefficient, this is equivalent to using low and high risk coefficients of 2.9×10^{-4} per rem and 8.7×10^{-4} per rem, respectively. By comparison, the 90 percent confidence interval for the EPA cancer mortality risk coefficient is 2.8×10^{-4} per rem and 1.0×10^{-3} per rem.

The NRC staff has thus determined that using a low value of $2,600 per person-rem and a high value of $7,800 per person-rem in sensitivity analyses is reasonable for evaluating the impacts of using plausible alternative values for the VSL estimate or the cancer mortality risk coefficient (see Table 3).

Table 3 The NRC Dollar per Person-Rem Summary Inputs

Estimate	Dollar per Person-Rem (2014 dollars)	VSL Sensitivity Values (2014 dollars)[a]
Best	$5,200	$9.0 Million
Low	$2,600	$4.5 Million
High	$7,800	$13 Million

[a] The VSL sensitivity values are calculated by dividing the dollar per person-rem value by the cancer mortality risk coefficient of 5.8×10^{-4} per person-rem.

6.1 Number of Significant Figures

Historically, the NRC has rounded the dollar per person-rem conversion factor to the nearest thousand dollars for the purposes of estimating monetary valuation. Given the large uncertainties inherent in this approach, annual updates would have little to no impact on this value between periodic baseline reviews because a change could not be made until there was the need for a $1,000 step change. To properly account for updated values in the conversion

Step 4: MUWE data is reported quarterly. The MUWE factors are found in the economic news release (http://www.bls.gov/bls/newsrels.htm). In the usual weekly earnings of wage and salary workers, go to Table 1, which is the MUWE table. The column that contains the MUWE data for this calculation is the "Total $" column, in current dollars (BLS, 2014c). Collect the most recent four quarters of MUWE and calculate the average.

Most recent Quarter MUWE (2Q 2016)	828
First Previous Quarter MUWE (1Q 2016)	823
Second Previous Quarter MUWE (4Q 2015)	820
Third Previous Quarter MUWE (3Q 2015)	811
Current Year MUWE (average)	**820.5**

Step 5: Calculate the real income growth from base year to current year.

$$Real\ Income\ Growth = \frac{MUWE_{current\ year}}{MUWE_{base\ year}}\ x\ 100\%$$
$$= \frac{820.5}{791} = 103.729\%$$

Step 6: Calculate the adjusted dollar per person-rem for Low, Best, and High values. The calculated dollar per person-rem conversion factors are rounded to two significant figures.

$$\text{Dollar per Person} - \text{Rem}_{\text{Current year}} = \text{Dollar per Person} - \text{Rem}_{\text{base year}} \times (Inflation) \times (Real\ Income\ Growth)^{income\ elasticity}$$

Low: $\text{Dollar per Person} - \text{Rem}_{current} = \$2{,}600 \times (1.0065032) \times (1.03729)^{0.5} = \$2{,}700$

Best: $\text{Dollar per Person} - \text{Rem}_{current} = \$5{,}200 \times (1.0065032) \times (1.03729)^{0.5} = \$5{,}300$

High: $\text{Dollar per Person} - \text{Rem}_{current} = \$7{,}800 \times (1.0065032) \times (1.03729)^{0.5} = \$8{,}000$

7.2 Updating the Cancer Mortality Risk Coefficient

The NRC staff will inform the Commission if the EPA adopts a new cancer mortality risk coefficient and make a recommendation whether to adopt this coefficient in establishing the NRC's dollar per person-rem conversion factor. Following Commission direction, the NRC staff would update the cancer mortality risk coefficient used in the dollar per person-rem conversion factor policy.

7.3 Re-Baselining Dollar per Person-Rem Conversion Factor

Although accounting for changing economic conditions (e.g., inflation and income growth) can provide a more realistic estimate of VSL (and, therefore, the dollar per person-rem conversion factor), economic adjustments alone do not account for the full change in VSL over time. Therefore, the NRC staff will periodically ~~consider~~ reevaluate~~ing~~ its baseline values for VSL and the cancer mortality risk coefficient, and will update guidance and regulations if the conversion factor would change by more than $1,000 per person-rem. This practice is consistent with other Federal agencies' initiatives to establish formalized processes for re-baselining VSL (and,

8 IMPLICATIONS OF REVISED CONVERSION FACTOR POLICY

The $5,200 per person-rem conversion factor in 2014 dollars discussed in this report reflects an increase of a factor of approximately 2.6 from the $2,000 per person-rem conversion factor that has been used by the U.S. Nuclear Regulatory Commission (NRC) since 1995.

As part of the NRC's update of the dollar per person-rem conversion factor, the NRC staff considered the potential impact of any change from the $2,000 per person-rem factor on current regulations and past regulatory decisions. In the introductory sections of this report, the staff describes how the dollar per person-rem conversion factor is used in NRC regulatory decisions.

First, with regard to regulatory decisions concerning radioactive waste system design alternatives for nuclear power plants (Title 10 of the *Code of Federal Regulations* (10 CFR), Part 50, "Domestic Licensing of Production and Utilization Facilities," Appendix I, "Numerical Guides for Design Objectives and Limiting Conditions for Operation To Meet the Criterion 'As Low As Is Reasonably Achievable' for Radioactive Material in Light-Water-Cooled Nuclear Power Reactor Effluents"), the staff involved in those assessments has indicated that increases in the conversion factor of at least an order of magnitude would be necessary to justify any reassessment of those decisions. Therefore, the changes in the conversion factor policy, as considered in this report, would not impact ~~bring into question~~ those past decisions. ~~Moreover, applicants for reactor licenses under 10 CFR Part 50 and 10 CFR Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants," and the NRC staff in its review of such applications, are still required to use the current conversion factor ($1,000 per total body man-rem and $1,000 per man-thyroid-rem) in Section II.D of 10 CFR Part 50, Appendix I, until it is formally changed through a rulemaking.~~

Second, for all other regulatory applications where $2,000 per person-rem has been used by the NRC, the staff is not proposing that previous decisions be reviewed or updated based on this revision~~ed~~ to the conversion factor~~ policy~~. Furthermore, even for regulatory decisions involving safety enhancements for severe power reactor accidents proposed following the accident at Fukushima Dai-ichi where the potential difference in total dollar valuation could be large, the staff used $4,000 per person-rem as an alternative value estimate (NRC, 2012b). The NRC staff does not propose revisiting those past regulatory decisions. There are several reasons for this position. First, the $2,000 per person-rem value has historically been used by the staff ~~as a figure of merit~~, but only ~~and~~ as one input among many in the regulatory decision. Second, ~~in~~ recognizing that there will be inherent uncertainties with any value selected for use ~~tion of the uncertainties inherent in such a figure of merit~~, the NRC would typically rely more heavily on other considerations when the break-even cost-beneficial determination was close (e.g., within a factor of five). ~~Finally, the factors that justify an increase in the dollar per person-rem conversion factor have had a similar effect on increasing the cost of modifying a licensed facility.~~ In conclusion, updated cost-benefit analyses would most likely result in little, if any, change to past regulatory decisions.

9 PROCESS TO INCORPORATE THE REVISED DOLLAR PER PERSON-REM VALUE AS NRC POLICY

The $5,200 per person-rem conversion factor in 2014 dollars and related changes in the U.S. Nuclear Regulatory Commission's (NRC) conversion factor policy will be incorporated into Revision 5 of NUREG/BR-0058. This is in accordance with the plan discussed in SECY-14-0002, "Plan for Updating the U.S. Nuclear Regulatory Commission's Cost-Benefit Guidance" (NRC, 2014). ~~The deletion of all references to the present $1,000 and $2,000 per person-rem values in existing regulations and guidance is planned with the exception discussed below~~.

The NRC staff recognizes that updating the dollar per person-rem conversion factor may be appropriate in the future. The value should be updated using the process discussed in this Revision 1 to NUREG-1530 under Section 7, "Methodology for Maintaining the Conversion Factors Current."

With respect to implementation, the NRC staff shall, and licensees~~,~~ and applicants may, begin using the revised conversion factor in all regulatory applications discussed in Section 3 of this document~~, other than the exception discussed below~~. Licensees may propose using other dollar per person-rem factors than the factor presented in this guidance.

~~For example, regulatory applications discussed in Section 3.1, "Routine Liquid and Gaseous Effluent Releases from Nuclear Power Plants," the values discussed in Title 10 of the *Code of Federal Regulations* (10 CFR), Part 50, "Domestic Licensing of Production and Utilization Facilities," Appendix I, "Numerical Guides for Design Objectives and Limiting Conditions for Operation To Meet the Criterion 'As Low As Is Reasonably Achievable' for Radioactive Material in Light-Water-Cooled Nuclear Power Reactor Effluents," must be used until they are changed through rulemaking. If a licensee or applicant chooses to use values other than those provided in 10 CFR Part 50, Appendix I, for radioactive waste system designs, they must request an exemption under 10 CFR 50.12 or 52.7, both titled "Specific Exemptions."~~