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Dave Morey
Vice President
Farley Project

Southern Nuclear Operating Company
the southern electric system

December 16, 1993

Rules Docket Clerk
U. S. Environmental Protection Agency
Mail Stop LE-131
Air Docket No. A-93-27
Room M-1500
401 M Street, SW
Washington, D. C. 20460

Comments on Advanced Notice of Proposed Rulemaking
"Radiation Site Cleanup Regulations"
(58 Federal Register 54474 of October 21, 1993)

Dear Sir:

Southern Nuclear Operating Company has reviewed the advance notice of proposed rulemaking "Radiation Site Cleanup Regulations," published in the Federal Register on October 21, 1993. In accordance with the request for comments, Southern Nuclear Operating Company is in total agreement with and endorses the NUMARC comments which are to be provided to the EPA.

Should you have any questions, please advise.

Respectfully submitted,

D. Morey

Dave Morey

DNM/JDK

250001

DF03 1/1 Per B. Siegel
Add: B. Siegel Hi Smil 1/1

cc: Southern Nuclear Operating Company
R. D. Hill, Plant Manager

U. S. Nuclear Regulatory Commission, Washington, D. C.
T. A. Reed, Licensing Project Manager, NRR

U. S. Nuclear Regulatory Commission, Region II
S. D. Ebneter, Regional Administrator
G. F. Maxwell, Senior Resident Inspector

Route: BJG/CRP/WEB/KWM/LBL
File: M.04.01 (cover letter)
G.02.10

NUMARC

Jerri Krienke will coordinate comments.

NUCLEAR MANAGEMENT AND RESOURCES COUNCIL

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cc: JDW
DNM
JTB
CKM

Thomas E. Tipton

G. Bockhold S. Bethay
J. Krienke J. Bailey
B. Moore

November 29, 1993

LCV-0233
HL-4

TO: NUMARC Administrative Points of Contact

SUBJECT: Draft Industry Comments to EPA on ANPR on Site Cleanup

The purpose of this letter is to transmit for your review the draft industry comments (Enclosure 1) to the EPA on site cleanup and restoration criteria to be used in decontaminating and decommissioning nuclear facilities. The draft comments respond to an advance notice of proposed rulemaking (Enclosure 2) requesting input in developing generally applicable cleanup levels for sites contaminated with radioactive material, a related issues paper (Enclosure 3), and a meeting of EPA's newly created advisory committee on site cleanup (a subcommittee of their National Advisory Council for Environmental Policy and Technology, NACEPT). This draft should be helpful if you choose to prepare utility-specific comments to the EPA. **If you have comments on this draft, please send them to Lynnette Hendricks by December 15, 1993.** The comments are due to the EPA December 20, 1993.

EPA intends to formally issue a proposed rule for public comment sometime in the summer of 1994. Both EPA and NRC may make drafts of their proposed rules available to the public in early 1994. If so, we will also prepare industry comments on these. As a part of the rulemaking process EPA will determine whether the proposed NRC rule achieves a sufficient level of protection of public health and the environment and if so, NRC licensees will be exempted from the EPA radiation site cleanup regulations.

If you have any question regarding the enclosures or if we can be of any further assistance to you regarding this issue, please call Lynnette Hendricks, John Schmitt or me.

Sincerely,

Thomas E. Tipton

TET:LH
Enclosures

c: NUMARC Board of Directors (w/o enclosures)
NUMARC Executive Points of Contact (w/o enclosures)

ENCLOSURE 1

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November 30, 1993

U.S. Environmental Protection Agency
Mail Stop LE-131
Air Docket No. A-93-27
Room M-1500
401 M St. SW
Washington, D.C. 20460

ATTENTION: Docketing and Service

SUBJECT: Advanced Notice of Proposed Rulemaking on Radiation Site Cleanup Regulations

To Whom it May Concern:

These comments are submitted by the Nuclear Management and Resources Council (NUMARC)[1] on behalf of the nuclear power industry in response to the U.S. Environmental Protection Agency's (EPA's) Federal Register Notice (58 Fed. Reg. 54474, October 21, 1993) announcing the availability of an Issues Paper, and requesting input to assist EPA in developing proposed regulations that will set cleanup levels for sites contaminated with radionuclides. The nuclear power industry fully supports EPA in its efforts to develop generally applicable cleanup levels for sites contaminated with radionuclides. NUMARC also strongly encourages EPA to coordinate very closely with NRC, and to make full use of NRC's parallel efforts to develop comparable standards for NRC-licensed facilities. If EPA and NRC standards differ in approach or format, we strongly encourage EPA to base their assessment of whether NRC's standard achieves a sufficient level of protection of health and safety on a careful in-depth review of all the

[1] NUMARC is the organization of the nuclear power industry that is responsible for coordinating the combined efforts of all utilities licensed by the NRC to construct or operate nuclear power plants, and of other nuclear industry organizations, in all matters involving generic regulatory policy issues and on the regulatory aspects of generic operational and technical issues affecting the nuclear power industry. Every utility responsible for constructing or operating a commercial nuclear power plant in the United States is a member of NUMARC. In addition, NUMARC's members include major architect/engineering firms and all of the major nuclear steam supply system vendors.

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factors affecting the level of cleanup that will actually be achieved under the different formats, i.e., different dose limits or risk goals can lead to the same degree of cleanup. NRC oversight of implementation details for NRC-licensed facilities (e.g., scenarios chosen, inputs to models, land use considerations and site specific evaluations of additional cleanup actions to reduce contaminants to levels that are as low as reasonably achievable) have an enormous impact on actual degree of cleanup achieved.

The nuclear power industry fully supported the NRC's series of enhanced participatory workshops around the country. This included (1) submitting comments to NRC on their Issues Paper and the outcome of those workshops, (2) participating in public hearings held by NRC to gather public input in preparation for drafting a Generic Environmental Impact Statement on radiological criteria for decommissioning NRC-licensed facilities, (3) submitting written comments to NRC on their plans to develop a GEIS, and (4) participating as a member of the public in EPA's recent meeting of the newly formed National Advisory Council for Environmental Policy and Technology, NACEPT, subcommittee on site cleanup. NUMARC commends both agencies for the steps being taken to enhance public participation in this important rulemaking. We believe that these extra efforts to include the public in the development of the rulemaking will result in greater public understanding and ultimately acceptance of protective, reasonable cleanup standards. These comments specifically address what transpired at the NACEPT subcommittee meeting and the questions posed by EPA in the ANPR. Also, since many of the issues are identical and because we encourage the agencies to work very closely together, we are attaching our comments previously submitted to NRC and request that they be made a part of this docket.

Although NUMARC felt the NACEPT subcommittee meeting achieved an effective dialogue among its members, the subcommittee lacks balance in that its constituency lacks representation by any entity that owns and operates commercial nuclear facilities or other facilities that will be affected by the standard and that is directly responsible for performing, and funding cleanups. This important perspective, different from that of others who have less direct responsibility for cleanup, is necessary to the committee's advisory role to EPA. The lack of such representation skews the subcommittee's advice. It should be factored into EPA's usage of the subcommittee's initial recommendations and the omission should be remedied in the future by adding representation with such qualifications. Representatives responsible for cleanup, for example, would be deeply engaged on the issues of measurability and impact of lower standards in terms of waste volumes.

takes an integrated approach in setting the standard which considers naturally occurring radioactive material and naturally occurring and accelerator produced radioactive materials, NORM/NARM issues, waste management issues and future land use, rational public policy and implementable standards will not likely result from EPA's efforts.

Contamination is already in place, consequently a standard that lacks appropriate flexibility could result in some cases in extreme measures being required to achieve cleanup at costs and impacts that are far out of proportion to benefits achieved by cleanup to those levels. This potential underlines the need for permitting flexibility in evaluating appropriate actions. NUMARC believes a successful standard assures public health and safety while allowing site cleanup and restoration for future beneficial use in a cost effective manner.

To determine cost effectiveness of cleanup standards the EPA must be able to accurately evaluate impacts and costs associated with different levels of cleanup. One of the greatest challenges in developing an accurate data base for reliably assessing impacts is estimating reasonable and realistic volumes of contaminated soils. Soil volume estimates are very important to valid impacts evaluation because at the lower dose levels being considered for formulating the standards, soil volume will be a principal determinant of the overall cost and alternative risk impacts. As EPA is aware there is a tendency to "miss" soil contamination and thereby grossly underestimate volumes of contaminated soils when estimates are based on scanty or preliminary site characterization data. For example, in June, 1993, GAO submitted a report to Congress where inadequate site characterization led to two failed cleanup attempts at a site, "Nuclear Regulation, Cleanup Delays Continue at Two Radioactive Waste Sites in Ohio."

Full scale site characterizations are necessary to provide valid estimates of the amounts of waste created, especially at the lower dose levels being considered. EPA's efforts to characterize model sites will provide some insight into the shape of the cost benefit curve to aid the risk management decisions associated with development of the clean-up standards. However, ultimately the rule must accommodate the need to use site specific information to evaluate potential cleanup activities on the basis of their providing overall risk reduction, i.e., to avoid spending inordinate sums for marginal reductions in hypothetical exposures in the future at the cost of actual detriment to workers, the public and the environment in the near term. The cleanup criteria should employ an upper limit on dose to an individual based on generally acceptable risk. The recommendations of nationally and internationally recognized experts in radiation protection -- the National Council on Radiation Protection and Measurements and the International Commission on Radiological Protection provide such criteria. Additionally, a process should be

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The absence of industry representation that will fund and carry out a cleanup was apparent in the NACEPT subcommittee's discussions on finality of cleanup activities. Recognizing limitations of technology and cost to achieving ideal risk goals, some members implied revisiting the site in the future for further cleanups was a way to address not meeting ideal goals. In fact, cleanups are occurring today under RCRA and Superfund, and under NRC and state programs. These cleanups often recognize practical limitations of technology and cost and apply realistic considerations of future land uses without being open-ended. This approach encourages and helps achieve cleanups, which are the ultimate goals sought. It is fiscally imprudent for private industry to initiate cleanups if standards are likely to change and result in the need to redo cleanups, thereby costing rate payers, stockholders and members of the public additional unnecessary expenditures. There is no finality and therefore no incentive for the private sector to proceed with site cleanups.

Some prevalent themes in the constructive discussion between participants at the EPA's NACEPT site cleanup subcommittee meeting related to the overarching significant point that the standard should be implementable, i.e., measurable, and verifiable with due consideration of practicalities. Some of the themes supporting this very important point were: cost, waste management implications, environmental impacts, non-radiological risks associated with cleanups and transferring minor radiological risks by relocating slightly contaminated material to a new site. NACEPT advised the EPA to not permit striving for perfection in cleanups and in the process grid locking the system, preventing accomplishment of cleanup. NUMARC strongly supports this advise and recommends EPA make use of actual measurements at sites to determine what is measurable with proper consideration given to the practicalities of making hundreds of those measurements in conjunction with ongoing cleanup activities. Carefully documenting the basis for the value selected with actual site data will be important for helping public understanding and gaining public acceptance of realistic protective cleanup standards.

NUMARC recommends that EPA look carefully at ongoing cleanup programs administered by the states and NRC for working models of how best to implement practicality in cleanup standards, and to avoid derailing efforts the states and NRC already have underway. Careful review of details of ongoing programs will also facilitate cleanups at sites with multiple contaminants, chemical as well as radiological. EPA has stated it intends to address waste management and recycle/reuse issues at a later time after development of cleanup standards. NUMARC recognizes that the technical basis needed to support cleanup, waste management and recycle standards differ, however we endorse the NACEPT subcommittee's apparent consensus that waste management implications of any cleanup standards must be considered in setting the cleanup standards. Unless EPA

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employed to optimize risk reduction activities below the limit using site specific information. Such a standard permits doing the most overall good by employing a limit and using ALARA below the limit to optimize risk reduction activities to provide further protection. Alternatively, arbitrarily setting a limit based solely on risk without accurate knowledge of other impacts and cost effectiveness is not good public policy. It can result in spending inordinate sums for marginal reductions in hypothetical exposures in the future at the cost of actual detriment to workers, the public and the environment in the near term.

EPA stated at the NACEPT subcommittee meeting that it is inclined to include something in the cleanup standards regarding the structure of public involvement in the cleanup process. NUMARC supports local involvement in verifying sites are being cleaned up to appropriate standards and recognizes local representatives have a role for input in carrying out decisions on future land use. However, local involvement is not a health and safety issue. Consequently, it would be inappropriate to make it a requirement in the regulation. In addition, due to the varied nature and complexity of facility decontamination, the varied composition of communities in the vicinity of the sites, and the different history of community/industry relations on issues prior to site cleanups, it is neither desirable nor feasible to delineate in either EPA's or NRC's rules the form or scope of community involvement. Flexibility and freedom for the decommissioning entity to approach local involvement on a case-specific basis will be enhanced by the lack of regulatory prescription.

Nuclear power industry responses to questions posed in the ANPR are enclosed. NUMARC appreciates this opportunity to provide this input as part of EPA's rulemaking to establish radiological cleanup standards. If we can be of further assistance as you review our comments, please do not hesitate to contact Lynnette Hendricks, John Schmitt or me.

Sincerely,

Thomas E. Tipton

TET/LH:cma
Enclosures

c: Robert Bernaro, NRC

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Frances X. Cameron, NRC
Don Cool, NRC

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NUCLEAR POWER INDUSTRY COMMENTS ON EPA RADIATION SITE CLEANUP ANPR

A. **Level of Protection**

What level or levels of risk should the proposed regulation(s) achieve to ensure protection of human health and the environment after cleanup? Should the level apply to a maximally exposed individual, the average member of the most exposed group, or to some other entity?

NUMARC recommends establishing site cleanup standards based on the risk limit for members of the public contained in recommendations of the National Council on Radiation Protection and Measurements (NCRP) and the International Commission on Radiological Protection (ICRP). The requirement should be that cleanup be achieved such that exposures to the public are kept as low as reasonably achievable, economic and social factors being taken into account. NUMARC recommends a 100 mrem total effective dose equivalent (TEDE) limit to any member of the public, above background from all man-made sources, excluding medical, in any one year. NUMARC recommends a compliance screening level of 25 mrems applied to the mean annual TEDE to the critical population, the most highly exposed homogeneous group affected by the restored site. If the mean TEDE to the critical group is likely to exceed 25 mrem, an evaluation should be made to ensure that no individual is likely to receive an annual TEDE exceeding 100 mrem from all man-made sources, excluding medical sources. The position of the commercial nuclear power industry agrees with the position of the Health Physics Society.

A consistent dose standard that can be applied to all facilities ensures a uniform, equitable, predictable approach to site cleanup. ICRP and NCRP make use of the best consensus science on health effects of radiation, the United Nations Scientific Committee on the Effects of Atomic Radiation, composed of experts in radiation protection worldwide, and the National Academy of Science's Committee on the Biological Effects of Ionizing Radiation, which is composed of independent experts in a variety of specialties. Below the limit, which ensures protection of all individuals to science based safe levels of risk, flexibility needs to be provided to accommodate site specific factors so the total risk, including radiation risk, can be reduced as far as reasonable and practical. This means costs and other non-radiological impacts, e.g., ecological damage, industrial and transportation risks, and waste management implications be considered when deciding on actions to further reduce potential radiation doses to the public below the protective limit. Alternatively, if the rule making approach attempts to set lower limits that factor in cost effectiveness generically, even if done on a facility type or industry bases. EPA would need to accurately evaluate impacts and costs associated with different levels of cleanups for different types of facilities in order to develop an appropriate rule. One of the greatest challenges in developing an accurate data base for reliably assessing impacts is estimating reasonable and realistic volumes of contaminated soils at the various dose levels being considered. The full scale site characterizations that would be necessary to provide valid estimates of the amounts of waste created, especially at the lower dose levels being considered are not likely to be available as EPA is developing the standards. As EPA is aware from its experience with Superfund cleanups, there is a tendency to "miss" soil contamination and thereby grossly underestimate volumes of contaminated soils when estimates are based on scanty or preliminary site characterization data, qualitative assessment, or inference from other facilities. Consequently, the best approach to establishing cleanup standards is to apply a generally applicable dose limit with ALARA utilized below the limit so that costs and other impacts can be considered on a site-specific basis when reliable data is available. This ensures cleanups will be accomplished in a protective, reasonable manner that optimizes cost-effective overall risk reduction.

Should there be different levels of cleanup for different land use scenarios?

Yes. In order to minimize total risk (occupational radiation dose and non-radiological risks to workers), protect the environment, and achieve cost-effectiveness, NUMARC believes the future use of the facility should be taken into account in the methodology for dose estimation. As the NACEPT subcommittee discussion indicated, industrial sites are very valuable assets especially due to the difficulty in zoning new areas for industrial uses. This is especially true for nuclear power plant sites because the access to transmission lines and sources of cooling make the sites extremely valuable. A utility may decide to use the site for future elective generation after the nuclear power plant is decommissioned. If the site is going to be retained for industrial uses the scenario used to determine compliance should be an industrial use scenario, not an unrestricted residential use scenario. Likewise, if the area is going to be turned into a park, recreational type scenarios should be used to determine compliance with the dose limit. If a "conservative" use scenario is prescribed, it may force actions which increase overall risk because the regulation requires calculation of unrealistic hypothetical doses.

Should members of future generations be protected at the same level as members of the current generation?

Yes, under ideal circumstances where it is possible to reliably predict future exposures and take reasonable actions to prevent them. Without certainty and finality, the industrial sector's future financial exposure and the public's confidence are unnecessarily undermined. Individual members of future generations should be protected at a level of protection that is commensurate with internationally recommended dose limits for members of the public, and the cumulative exposure over many generations should be considered in efforts to reduce levels of contaminants left on site. However, efforts to further reduce exposures must address the considerable uncertainty inherent in predicting exposure to populations out in the future beyond a few generations. Changing demographics make such predictions highly uncertain. In addition, an accurate cost-benefit analysis will first place the costs and benefits on an equivalent basis by monetizing the benefits and after selecting an appropriate discount rate (the time value of money), comparing the cost effectiveness of benefits today.

B. Consistency with Existing Regulations

In what manner and to what degree should the proposed cleanup regulation(s) be consistent with existing Federal, state and local cleanup statutes, regulations, requirements, and guidance?

The EPA should strive for maximum consistency with those existing Federal, state and local cleanup programs that have been successful in accomplishing practical timely cleanups. The experience gained from these programs on how to input flexibility and practicality into cleanups and how to avoid grid locking the system should be carefully reviewed and used by EPA in formulating generally applicable standards. This is necessary because the goal of these standards is to ensure cleanups will be accomplished in a protective, reasonable manner that optimizes cost-effective overall risk reduction.

Use of internationally recognized dose limits for members of the public provides a mechanism for establishing a consistent dose standard that can be applied to all facilities in a uniform, equitable manner. A review of site-specific factors can lead to reduction of total risk, including radiation risk as far as reasonable and practical. This approach also provides opportunities to implement lessons learned from other programs in accomplishing practical, timely cleanups. Conversely, NUMARC does not believe EPA has sufficient data and information for all types of facilities to be covered by the standard to establish cleanup standards that have adequately considered cost effectiveness and practicalities.

C. Regulatory Approaches and Type of Regulation(s)

What regulatory approaches should be considered? Should the regulation(s) include a single dose or risk limit, or a range of limits? Should the regulations contain a table or tables of default media- and radionuclide-specific concentration limits based on generic site conditions? Should the regulation(s) correspond to site-specific concentration limits derived from an Agency-approved pathways model based on actual site conditions? Should the proposed regulation(s) be technology based linked to an acceptable risk level?

NUMARC believes the optimum regulatory approach is a single dose limit, based on the risk limit for members of the public contained in recommendations of the National Council on Radiation Protection and Measurements (NCRP) and the International Commission on Radiological Protection (ICRP), combined with the requirement that cleanup be achieved such that exposures to the public are kept as low as reasonably achievable (ALARA), economic and social factors being taken into account (including social factors like future land use). A screening level to address exposures from multiple sources is also recommended (see comments under A. Level of Protection). Pathway models based on actual site conditions and uses should be employed to translate from concentration to dose in determining compliance with the limit and ALARA requirements.

Tables of default media- and radionuclide-specific concentration limits based on generic site conditions are likely to be grossly inaccurate for most conditions at actual sites for certain media, e.g., ground water. These values would likely incorporate "conservative" assumptions which could force actions to be taken which increase overall risk. A table of default concentration limits for dose from buildings (which would not be expected to vary much by site) for two different rehabilitation scenarios, i.e., NRC's NUREG/CR 5512, could be meaningful and useful. However, this information is probably better contained in regulatory guidance where it can be updated when necessary without the need for formal rulemaking.

NUMARC sees no advantage in tying technology to an acceptable risk limit. NUMARC doubts whether the EPA will have the information necessary to prescribe optimum technology for various cleanup applications and even if this information was available today, advances in technology would warrant continuing changes in the regulations. Such regulatory instability may discourage timely commitment to cleanup based on valid economic exposure considerations. Changing the regulations frequently is also a resource drain on the agency staff and the public that must participate in the rulemaking process. The site-specific evaluations required under the ALARA approach that we recommend would consider available technology in determining cost effective reductions in dose below the dose limit.

D. Practicality Issues

How should the availability, development, advantages and limitations of current remediation technologies, fate and transport models, exposure and risk assumptions, detection limits, and site characterization techniques be considered?

These practicality considerations are very necessary and appropriate to EPA's developing protective, reasonable cleanup standards. These practicality issues are dynamic, for example remediation technologies development. Certainty and stability in cleanup standards is needed to ensure timely cleanups. EPA can develop a stable regulation that will encourage timely use of developing advancements by formulating the rule with a limit to protect individuals and a requirement that cleanup be achieved such that exposures to the public be kept as low as reasonably achievable, economic and social factors taken into account.

With such a rule in place, those parties responsible for the cleanup would make realistic assessment of feasibility of remediation technologies, based on actual experience with use of technologies in full scale projects and of the costs, risks and impacts of applying the technology to their cleanup. Uncertainties regarding the efficacy of technologies would also be addressed on a site-specific basis within the scope of the margin of cleanup needed to make the application effective. This would include considering the risks that application of the technology would pose to the public and workers, other impacts on the environment, and cost.

Fate and transport models used would be the best available at the time. Exposure assumptions should be based on realistic values for the critical group of the population that receives the highest dose. Risk assumptions used should be the latest recommendations from the national and international bodies of experts, NCRP and ICRP, responsible for reviewing consensus science recommendations.

EPA should carefully document practical limits on measurability, considering the variation in background among the nuclear facility sites affected by the standards and the variability of background at any location. This is necessary to ensure the practicality of the standards based on technical considerations and to aid public understanding and public acceptance of realistic, protective cleanup criteria. Detection limits should be evaluated in the context of site characterization and compliance survey performance under actual site cleanup project conditions. In the case of large sites cleanup involves collecting hundreds of actual measurements of very low levels of contamination in the field and then comparing them to the limit using statistical analyses. By evaluating the detection limits at sites under cleanup conditions, EPA would also be able to document when increases in assessment difficulties occur over the range of cleanup levels evaluated and include those impacts in their rulemaking cost/benefit analyses. Examples of these significant added impacts are costs in sample analyses and the added labor and overhead to account for time delays that reoccur between each cleanup/assessment iteration. EPA should carefully consider these impacts because impractical requirements would result in an inability to perform cleanups or resources being ineffectively spent on compliance demonstration rather than risk reduction.

How should cleanup costs and financial responsibilities be assessed? What weight should be placed on these considerations in developing the regulation(s), and in what order of importance should they be addressed? What liability issues arise? How can pollution prevention considerations be incorporated?

Currently planning and funding for cleanups at commercial nuclear power plants is carried out prior to the plants being shut down, in accordance with NRC regulations, and is usually included in the rate base with approval of state public utility commissions. The cleanup criteria contained in the final EPA standards could have an impact on the adequacy of current funding if the criteria are significantly lower than the safe cleanup criteria in NRC's current program.

Consideration of cost effectiveness is required in setting federal regulations. Cost effectiveness considerations are closely related to other practicality issues contained in this section. Executive Order 12866 of September 30, 1993, Regulatory Planning and Review, stipulates that:

> "(5) When an agency determines that a regulation is the best available method of achieving the regulatory objective, it shall design its regulations in the most cost-effective manner to achieve the regulatory objective. In doing so, each agency shall consider incentives for innovation, consistency, predictability, the costs of enforcement and compliance (to the government, regulated entities, and the public), flexibility, distributive impacts, and equity.
>
> (6) Each agency shall assess both the costs and the benefits of the intended regulation and, recognizing that some costs and benefits are difficult to quantify, propose or adopt a regulation only upon a reasoned determination that the benefits of the intended regulation justify its costs."

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The President clearly intends for agencies to exercise cost accountability on a regulation-by-regulation basis. This can be done by comparing the cost of this regulation to the amounts spent in other federal or state programs to reduce risks and avoid detriment. In addition, it is prudent for the agency to identify points of diminishing return where further expenditures result in little or no reduction in detriment (detriment in this case would be a function of the number of people exposed) and specifically avoid situations that are not cost-effective, as prescribed in the Executive Order. The President also clearly intended for the agencies to consider costs of compliance. This highlights the importance of establishing standards that are readily and realistically measurable. Several state representatives participating in NRC's series of public workshops around the country indicated they had very limited resources. They implored the agencies to set standards that were readily verifiable so their limited resources could be devoted to other duties that provided real reduction in risk. If the standards are not readily verifiable, it may result in increased risk in another area. NUMARC recommends EPA pay close attention to where the costs of compliance demonstration start to rise. It is fiscally imprudent to spend large portions of site restoration resources on compliance demonstration rather than cleanup.

The lower end of the range of cleanup criteria considered by EPA should be based on contamination levels below which it is not feasible or practical to demonstrate compliance. EPA should not waste resources considering hypothetical costs or impacts of alternatives that cannot be employed in a practical sense. Accordingly, actual measurements should be made at sites to determine what is measurable with proper consideration given to the practicalities of making those measurements in conjunction with ongoing cleanup activities. Above the level of measurability, cost effectiveness of cleanup standards can only be evaluated by accurately establishing impacts and costs associated with different levels of cleanup. Waste management implications and disposal costs are probably the most significant impacts of site cleanups.

One of the greatest challenges in developing an accurate data base for reliably assessing impacts is estimating reasonable and realistic volumes of contaminated soils. Full scale site characterizations are necessary to provide valid estimates of the amounts of waste created, especially at the lower end of the dose range. EPA's efforts on characterizing model sites may provide some insight into shape of the cost benefit curve. There will still be a need to use site-specific information to evaluate potential cleanup activities on the basis of their providing overall risk reduction, i.e., to avoid spending inordinate sums for marginal reductions in hypothetical exposures in the future at the cost of actual detriment to workers, the public and the environment in the near term. A standard employing an upper limit on dose to an individual with ALARA below this limit to optimize risk reduction activities ensures adequate public health and safety and permits doing the most overall good.

Liability for cleanups remains with the owner of the site if new information or changes in knowledge of risk indicate a site now poses a substantial risk to public health and safety. However, NUMARC believes any decision to revisit should be based on : (1) a demonstration based on peer reviewed scientific information (e.g., recommendations of NCRP and ICRP) that a substantial increase in overall public health and safety would be obtained through additional cleanup efforts, and (2) the benefits of the additional cleanup efforts would outweigh the costs and non-radiological impacts. Marginal improvements in safety would not be adopted even if benefits outweigh the costs.

NUMARC sees no need for inclusion of any prescriptions in the regulations to encourage pollution prevention activities for future uses of radioactive materials at commercial nuclear power reactors and fuel fabrication facilities. It must be kept in mind that contamination of soil and structures at these sites largely occurred with facilities operating in full compliance with any release or containment standards in effect at the time. Pollution prevention is incorporated in operating philosophy for these facilities and the liability for cleanups and new standards for cleanup provide more than sufficient incentive for companies to make every effort to prevent contamination of sites. For example, utilities are planning and funding today for cleanups that will occur years in the future. Attempts to further drive efforts beyond those present in the economic realities and liabilities of today's cleanup standards are unwarranted. The uncertainty associated with attempts to establish even lower standards for future operations could amount to a defacto moratorium on any uses of radioactive material: depriving members of the public from its beneficial uses and perhaps forcing usage of alternative technologies that result in larger detriment to society.

E. NARM/NORM Issues

Should naturally occurring and accelerator-produced radioactive material (NARM), and in particular diffuse naturally occurring radioactive materials (NORM), be included in the proposed cleanup regulations(s)? If so how should they be included?...How would Federal NORM requirements affect existing state regulations?

Rational public policy and risk harmonization dictate that the degree of protection provided to individual members of the public should not vary depending on the source of the contaminant. Otherwise it may be considered acceptable to spend inordinate sums in one case to avoid a small risk from one source of material, for example, material that happens to be licensed under NRC regulations, whereas no resources would be spent to correct a situation that potentially poses orders of magnitude greater risk to a much larger number of individuals, for example, NORM material that is not licensed by any agency.

Consequently, EPA's cleanup standards should be consistent with the risk management being implemented for NARM/NORM. Diffuse naturally occurring radioactive materials, like contamination from licensed facilities, is already in place. Recommendations of the NCRP and ICRP recognize the differences between controlling materials at the source, e.g., during facility operations, and taking action to remediate contamination once it is already in place, referred to by them as programs requiring "intervention." ICRP Publication 60 states, "The countermeasures forming a program of intervention, which always have some disadvantages, should be justified in the sense that they should do more good than harm. Their form, scale and duration should then be optimized so as to maximize the net benefit." These facts underline the need for EPA to regulate all radioactive materials under a program which permits evaluation of potential cleanup activities on the basis of their providing overall benefit and risk reduction using case-specific information. NUMARC recommends EPA establish standards based on ICRP and NCRP recommended dose limits for members of the public to ensure adequate protection of all individuals, with ALARA below the limit to optimize risk reduction activities to provide further protection.

F. Mixed Waste Issues

Should mixed AEA radioactive and Resource Conservation Recovery Act (RCRA) hazardous waste be addressed in the regulations? Should the regulation(s) address only the radioactive component of the waste? What is the current nature and extent of mixed waste contamination at Superfund sites and, in particular, at Federal Facilities?

Yes, the mixed waste issue should be addressed in the regulations. The cleanup standards and waste management issues are very interdependent. Reasonable cleanup standards with flexibility to do the most practical good to prevent creation of large volumes of radioactive and mixed wastes, i.e., by not requiring cleanup to arbitrary risk levels which merely transfer minimal risks from the cleanup site to the public in new locations where the material will be disposed. Furthermore, in the process added risk is incurred to the public along the route, to workers in moving and transporting the waste, and detrimental impacts on the environment could occur. Currently there are no levels in the regulations for radioactivity or for toxicity or for listed hazardous wastes below which they do not require treatment as hazardous, radioactive or mixed waste, even if the levels are so low that they are comparable to levels of radioactivity or similar toxics in common materials that the public encounters routinely without any regard for their toxicity or radioactivity. NUMARC believes EPA should establish acceptable risk levels (and supporting methodology to convert from concentration to risk), for releasing materials from a cleanup site for waste disposal and for recycle without regard to their radioactivity. EPA should develop similar standards for the hazardous component which would apply to the hazardous component alone or in combination with radioactivity, e.g., mixed waste. These standards are desperately needed to permit redirecting valuable resources towards more productive societal uses, and in the process reduce the significant risks that result from current approaches which inappropriately cause materials to be treated as hazardous, radioactive, or mixed waste.

A. Waste Management Issues

How should the management of radioactive waste generated during cleanup be addressed? Should separate rules and guidance be developed to deal with waste handling, treatment, storage, transportation, and disposal activities? How should the availability of waste disposal sites and their capacities be factored into decisions concerning protection level(s) of the regulation(s)? How should the corresponding volumes of waste and cleanup costs anticipated with each protection level be considered?

NUMARC believes EPA should take an integrated approach to setting cleanup standards which considers all benefits and costs, i.e., radiological and non-radiological risks to workers, and the public, waste management implications, and environmental impacts. Contamination is already in place. Actions taken to clean up sites are in the form of interventions which will pose their own risks on the public and workers and could be detrimental to the environment. All the risks and impacts should be integrated into the cost benefit assessment for setting the standard.

Waste disposal will be a major component of cleanup costs for most sites. Using a valid database to compare volumes of wastes and cleanup costs to cleanup levels and health detriment (which considers numbers of persons exposed) EPA will be able to identify cleanup levels where costs rise steeply and cleanup levels where significant reduction in detriment does not occur in spite of more cleanup and the associated increases in costs and risk impacts. In this manner EPA can estimate cleanup levels where risk reduction and costs and other impacts are optimized.

Planned low level waste disposal facilities are highly engineered structures not intended to handle enormous volumes of slightly contaminated soil or other building materials. As discussed under "F. Mixed Waste" NUMARC believes EPA should establish a lower end to the definition of what must be treated as radioactive, hazardous or mixed waste if it is removed from the site. Currently materials that contain levels of radioactive or hazardous contaminants in levels comparable to those found in many routinely used products must be subjected to the same controls as materials that could pose significant risks in their handling, storage and disposal.

If EPA sets reasonable cleanup standards that are protective of individuals in the public with flexibility below the limit to ensure cleanup costs and impacts do not outweigh benefits achieved on a site specific basis, and if EPA establishes lower limits for the definition of radioactive, hazardous and mixed wastes, there should be no need to establish separate standards to address waste handling, treatment, storage, transportation or disposal in the context of site cleanup.

Given the potential inadequacy of existing licensed disposal sites to accommodate the volumes of radioactive waste anticipated from cleanups, should one waste management option be partial site cleanups with above-ground onsite retrievable storage? Should another waste management option be the cleanup and consolidation of wastes from multiple sites with the storage or disposal of these wastes at another contaminated site? How should NORM and mixed radioactive and non radioactive hazardous wastes be addressed?

Onsite retrievable storage of cleanup waste and /or consolidation of wastes from other contaminated sites should be considered if the retrievable storage or consolidation is effective at reducing the risk of exposure to future users of the site versus leaving the contamination in place, and if the risk to consolidate the material does not result in risk to workers or the public that exceeds the cost and risk reduction of the consolidation. This could be evaluated using the ALARA process to review the option of such storage. In addition, it would be necessary to demonstrate that proper controls are in place, e.g., institutional controls or other controls on future land use to reduce the probability that future users will inadvertently use that portion of the site in such a manner that unacceptable exposure could occur.

B. Recycle/Reuse Issues

Should decontaminated structures, equipment, and metal be reused or recycled? What level or levels of residual radioactivity contamination should be set for these materials, and how should the levels(s) be established? How would these materials be used and what potential public health impacts would they pose?

Valuable resources, raw materials, energy, labor and cost that went into their production, are tied up in these materials. NUMARC believes structures, equipment and metal should be reused or recycled wherever it is possible to do so without subjecting potential users to unacceptable radiological risks. The levels of radiological contamination and the ability to accurately predict future uses determines the ability to reuse and recycle them and the degree of restrictions on reuse and recycle that will be necessary to ensure the public is adequately protected.

Establishing proper controls for recycle/reuse falls into three cases. The first case, the same use of slightly contaminated material, is for structural materials that have been determined to meet cleanup standards. The residual radioactivity remaining on these structures would not be significant enough to warrant any restrictions on subsequent removal of materials for disposal or other uses. Scenarios used to determine compliance with cleanup standards would assume long periods of occupancy and exposure to these materials. Consequently, it is difficult to envision a reuse of building materials that could expose people in other locations to unacceptable doses. For example, even if the material were reused, it is unlikely that the combination of amount of contaminated building materials and the occupancy times could exceed those used to meet original cleanup standards.

The second case, unknown uses of slightly contaminated materials, is for materials of high recycle value like metals for which the future use is more difficult to predict. For this case it would be necessary to determine acceptable concentrations of radioactive material that are likely to result in acceptably safe exposures. Germany has done a great deal of work in this area that uses multivariate analysis using weighted probabilities for reuses, e.g., metal ends up in a frying pan versus in an industrial plant, and dose scenarios for those reuses to establish acceptable concentration limits. NUMARC believes EPA should examine the German's work in this area for accuracy and applicability to recycle and reuse in this country. Essentially the United States is participating in the programs of other countries today anyway since we live in a world economy and materials released for recycle/reuse freely end up in our products today regardless of actions taken or not taken by EPA. If EPA sets standards that are much more stringent than those of other countries in the world, our industries and government are put at an unnecessary economic disadvantage. If the overall percentage of world recycled metal is large, then EPA's lower standard merely determines that the source of recycled metals are from other countries. The lower standards might have no effect on lowering the amount of radioactivity in those recycled products.

The third case, restricted recycle/reuse, applies to materials that have concentrations of radionuclides that are too high to result in acceptable public dose under conservative use scenarios, but the degree of contamination is low enough that they can be reused in nuclear applications, for example as containers or shielding for radioactive materials, because they result in insignificant doses in these very controlled uses. It should be relatively straightforward to establish concentration limits for these uses based on external dose rates.

DRAFT

What potential liabilities exist for future distributors or sellers of these materials, and what notice to buyers should be required?

The liabilities should be minimal because the degree of contamination for unrestricted uses has already been restricted to levels which could result in only minimal exposures even under very conservative use scenarios. These materials would be no more radioactive than many common materials containing comparable amounts of natural radioactivity.

For restricted uses the liability would also be minimal or nonexistent because the materials fall back into a regulatory system which exercises extreme controls over radioactive materials. No notice to buyers should be required because EPA would have determined that the materials pose a deminimus risk. Also it would be illogical to notify buyers that these materials contain radioactive materials when it is not currently required to notify buyers that all materials contain some radioactive materials , and some contain much more than the amounts that would probably be permitted under this recycle/reuse program (e.g., camping lantern mantels). Finally, a notice to buyers would be illogical and a competitive disadvantage to sellers in this country because other countries materials would not be so labeled and yet might contain higher levels of radioactive material from nuclear uses.

ENCLOSURE 2

ENVIRONMENTAL PROTECTION AGENCY

40 CFR Part 195

[FRL-4792-8]

Radiation Site Cleanup Regulations

AGENCY: Environmental Protection Agency.

ACTION: Advance notice of proposed rulemaking.

SUMMARY: The U.S. Environmental Protection Agency (EPA) is developing regulations that will set forth requirements for cleanup levels for sites contaminated with radionuclides. These regulations will be designed to protect human health and the environment from exposure to ionizing radiation, and will be applicable to sites contaminated with radioactive material subject to the Atomic Energy Act (AEA) and to sites covered under the authority of the Comprehensive Environmental Response, Compensation and Liability Act (i.e., Superfund sites), including but not limited to Federal facilities.

The purpose of this action is to solicit general comments, information and data that are applicable to the broad issues identified in the Supplementary Information section and which will shape the overall scope and direction of this rulemaking. In addition to this early request for input, EPA will announce additional opportunities for public participation as this rulemaking progresses.

In a separate rulemaking, EPA will also develop regulations for the management and disposal of radioactive waste generated during site remediation and will explore the feasibility of recycling or reusing site structures, equipment, and metals after cleanup. Comments on waste management and recycle/reuse issues are also being solicited at this time. However, it is important to note that the current rulemaking effort focuses on development of the radiation site cleanup regulations.

DATES: Comments and information are requested on or before December 20, 1993.

ADDRESSES: Comments should be submitted, in duplicate, to the docket clerk at the following address: U.S. Environmental Protection Agency, Mail Stop LE-131, Air Docket No. A-93-27, room M-1500, First Floor Waterside Mall, 401 M Street, SW., Washington, DC 20460. The Docket is open from 8:30 a.m. to 12 noon and from 1:30 p.m. to 3:30 p.m., Monday through Friday, excluding Federal holidays. A reasonable fee may be charged for copies of docket material.

FOR FURTHER INFORMATION CONTACT: Ms. Barbara Hostage, Chief, Radiation Studies Branch, Radiation Studies Division, Office of Radiation and Indoor Air, U.S. Environmental Protection Agency, Washington, DC 20460, (202) 233-9237.

SUPPLEMENTARY INFORMATION: On June 18, 1986, EPA published an Advance Notice of Proposed Rulemaking (ANPR) titled "Radiation Protection Criteria for Cleanup of Land and Facilities Contaminated with Residual Radioactive Materials" (51 FR 22264). Many of the issues and discussions presented in the 1986 ANPR are similar to those considered in the current rulemaking effort and may be consulted for additional background information.

Statutory Authority

Under the Atomic Energy Act (42 U.S.C. 2201/AEA 161; 42 U.S.C. 2021/AEA 274) and Reorganization Plan No. 3 of 1970 (5 U.S.C. Appendix 1), EPA is authorized to develop Federal guidance and regulations to protect public health and the environment from the effects of radiation. The Comprehensive Environmental Response, Compensation, and Liability Act (42 U.S.C. 9601) authorizes the President to take response action whenever there is a release or threat of a release of hazardous substances, which includes radionuclides.

Current Approach to Site Cleanup

Progress to date in cleaning up radiation sites has, in general, been limited and slow. The total number of sites eventually requiring cleanup may number in the thousands and may cost hundreds of billions of dollars to remediate. In the absence of promulgated standards that specifically address cleanup requirements, the majority of these sites have been and continue to be cleaned up using a variety of criteria. EPA believes that the lack of specific cleanup standards has led to confusion and public concern, increased costs with marginal increases in protection levels, and delays in accomplishing necessary cleanups.

Proposed Regulatory Strategy

The Agency recognizes that the selection of a regulatory approach and the choice of cleanup levels involve many difficult technical and policy decisions with wide-ranging economic and environmental implications. EPA believes that the development of regulations that specifically address cleanup requirements will assist in ensuring that radioactively contaminated sites are cleaned up in a consistent, protective and cost-effective manner. To this end, EPA is proposing a comprehensive regulatory strategy. As an initial step in this strategy, the Agency is developing cleanup levels for soil and groundwater contaminated with radionuclides. These will correspond to an acceptable risk limit and may be based on different land use scenarios, such as residential or commercial/industrial use. EPA is currently exploring several different approaches for deriving these levels and has not yet selected a specific approach or type of regulation (or a combination).

As future steps in the regulatory strategy, EPA will develop waste management regulations that will include standards for the handling and disposal of radioactive waste generated during cleanup. As a component of this, EPA will also examine the feasibility of recycling or reusing site structures, equipment and metals contaminated with low levels of radioactivity after cleanup. EPA is not including the development of waste management regulations in its current rulemaking effort on radiation site cleanup regulations. The waste management regulations will be developed in a separate rulemaking.

Cleanup Issues Under Consideration

To assist in shaping its regulatory strategy for cleanup, EPA has prepared an Issues Paper to present issues, alternative regulatory approaches, and preliminary analyses that are relevant to the development of radiation site cleanup regulations. A copy of this paper may be obtained by calling the Superfund/RCRA Hotline at 1-800-424-9346 (TDD 1-800-553-7672). In the Washington DC area, dial 703-412-9810. Interested parties can also contact the Cleanup Regulation Electronic Bulletin Board at 1-800-700-STDS (dial 703-790-0825 in the Washington, DC area) for information on rulemaking activities and available documents.

Currently, EPA is evaluating several important issues related to the cleanup regulations, including but not limited to the following:

A. Level of Protection

What level or levels of risk should the proposed regulation(s) achieve to ensure protection of human health and the environment after cleanup? Should the level apply to a maximally exposed individual, the average member of the most exposed group, or to some other entity? Should there be different levels of cleanup for different land use scenarios? Should members of future generations be protected at the same level as members of the current generation?

B. Consistency with Existing Regulations

In what manner and to what degree should the proposed cleanup regulation(s) be consistent with existing Federal, state, and local cleanup statutes, regulations, requirements, and guidance?

C. Regulatory Approaches and Type of Regulation(s)

What regulatory approaches should be considered? Should the proposed regulation(s) include a single dose or risk limit, or a range of limits? Should the regulations contain a table or tables of default media- and radionuclide-specific concentration limits based on generic site conditions? Should the regulation(s) correspond to site-specific concentration limits derived from an Agency-approved pathways model based on actual site conditions? Should the proposed regulation(s) be technology-based linked to an acceptable risk level?

D. Practicality Issues

How should the availability, development, advantages and limitations of current remediation technologies, fate and transport models, exposure and risk assumptions, detection limits, and site characterization techniques be considered? How should cleanup costs and financial responsibilities be assessed? What weight should be placed on these considerations in developing the regulation(s), and in what order of importance should they be addressed? What liability issues arise? How can pollution prevention considerations be incorporated?

E. NARM/NORM Issues

Should naturally occurring and accelerator-produced radioactive material (NARM), and in particular diffuse naturally occurring radioactive materials (NORM), be included in the proposed cleanup regulation(s)? If so, how should they be included? What is the current nature and extent of NORM contamination at Superfund sites and Federal facilities? Would future legislation be useful and, if so, what legislation would be most effective in regulating the cleanup of NORM sites? How would Federal NORM requirements affect existing state regulations?

F. Mixed Waste Issues

Should mixed AEA radioactive and Resource Conservation and Recovery Act (RCRA) hazardous waste be addressed in the regulation(s)? Should the regulation(s) address only the radioactive component of the waste? What is the current nature and extent of mixed waste contamination at Superfund sites and, in particular, at Federal facilities?

EPA is also considering a number of waste management and recycle/reuse issues that may have a significant impact on the development of the cleanup regulations:

A. Waste Management Issues

How should the management of radioactive waste generated during cleanup be addressed? Should separate rules and guidance be developed to deal with waste handling, treatment, storage, transportation, and disposal activities? How should the availability of waste disposal sites and their capacities be factored into decisions concerning protection level(s) of the regulation(s)? How should the corresponding volumes of waste and cleanup costs anticipated with each protection level be considered? Given the potential inadequacy of existing licensed disposal sites to accommodate the volumes of radioactive waste anticipated from cleanups, should one waste management option be partial site cleanups with above-ground onsite retrievable storage? Should another waste management option be the cleanup and consolidation of wastes from multiple sites with the storage or disposal of these wastes at another contaminated site? How should NORM and mixed radioactive and nonradioactive hazardous wastes be addressed?

B. Recycle/Reuse Issues

Should decontaminated structures, equipment, and metal be reused or recycled? What level or levels of residual radioactivity contamination should be set for these materials, and how should the level(s) be established? How would these materials be used and what potential public health impacts would they pose? What potential liabilities exist for future distributors or sellers of these materials, and what notice to buyers should be required?

Coordination With Interested Parties

EPA is committed to moving forward with the rulemaking expeditiously while coordinating with all interested parties, as follows:

A. Public Participation

EPA strongly encourages public participation throughout the rulemaking process to ensure that all interests are adequately represented. EPA will provide opportunities for the public to review and comment on supporting rulemaking documents.

B. NACEPT

EPA is establishing a subcommittee under the auspices of the National Advisory Council for Environmental Policy and Technology (NACEPT). Chartered under the Federal Advisory Committee Act, NACEPT provides extramural environmental policy information and advice to the Administrator of EPA and other Agency officials. Membership of this subcommittee will consist of individuals from a wide variety of governmental agencies, industry, and public interest groups so as to ensure a balanced representation.

C. Other Interested Parties

EPA will also coordinate with the following groups: other Federal agencies; state and local governmental agencies; Indian Nations; environmental groups; and industry and trade associations.

Relationship of EPA Cleanup Standards to NRC Decommissioning Standards

On March 16, 1992, EPA and the Nuclear Regulatory Commission (NRC) signed a Memorandum of Understanding (MOU) to "establish a basic framework within which EPA and NRC will endeavor to resolve issues of concern to both agencies that relate to the regulation of radionuclides in the environment." This MOU governs these proposed EPA regulations and the proposed NRC decommissioning standards. It formally defines the roles, responsibilities, and separate rulemaking activities of each agency concerning regulations that affect NRC licensees and NRC-licensed facilities and radioactive materials.

Under the MOU, if EPA determines that NRC's regulatory program achieves a sufficient level of protection of the public health and the environment, EPA will propose in the **Federal Register** that NRC licensees be exempted from the EPA radiation site cleanup regulations. EPA believes that this dual track approach provides the best means to help ensure that EPA cleanup regulations and NRC decommissioning standards are consistent.

Coordinated Implementation of Regulations

EPA is also coordinating with the Department of Energy (DOE), Department of Defense (DOD), and NRC on technical implementation issues for the cleanup of radioactive contamination at Federal facilities. EPA, DOE, DOD, and NRC face several of the same steps during cleanup, such as initial site characterization, exposure and risk modeling, remedial design and action, onsite radiation monitoring, and compliance sampling and analysis. Each step presents many technical challenges, and all four agencies understand the clear advantages of meeting these challenges with a unified Federal approach that combines the best scientific and technical resources and real-world experiences of each agency. It is EPA's intent to coordinate this Federal effort and to ensure all facets of the technical implementation guidance are based on scientifically sound and technologically feasible principles and methods.

List of Subjects in 40 CFR Part 195

Environmental protection, Cleanup standards, Decommissioning, Decontamination, Intergovernmental relations, Radiation protection, Radioactive contamination, Recycle-reuse, Site remediation, Waste management standards.

Dated: October 15, 1993.

Carol M. Browner,

Administrator.

[FR Doc. 93-25928 Filed 10-20-93; 8:45 am]

BILLING CODE 6560-50-P

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Environmental Protection
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ENCLOSURE 3

EPA

Issues Paper on Radiation Site Cleanup Regulations

Recycled/Recyclable
Printed on paper that contains at least 50% recycled fiber

Contents

List of Tables and Figures

Chapter 1
Introduction

No one knows exactly how many sites in the U.S. are contaminated with radionuclides, but the number may run in the thousands. Sites range from corners of laboratories contaminated with small amounts of short-lived, low-level wastes to sprawling former nuclear weapons facilities replete with long-lived transuranic and high-level wastes. Buildings and equipment often are contaminated along with soil, water, and other environmental media. Many sites also are contaminated with nonradioactive hazardous chemicals. Cleaning up these sites to protect human health and the environment from exposure to ionizing radiation poses complex scientific and technical challenges; it will require novel approaches and will be very expensive.

Progress in radiation site cleanups in general has been limited and slow. This has been due to uncertainties about the nature and extent of contamination and the lack of specific cleanup standards. The result has been confusion, public consternation, and costly delays. Congress, federal agencies, state governments, the regulated community, and the public are concerned about, among other issues, the difficulties in identifying consistent cleanup requirements for radioactive sites. To remedy the lack of consistent cleanup standards, the U.S. Environmental Protection Agency (EPA) is developing regulations that will establish cleanup levels for radioactive sites. This paper identifies many of the issues related to that effort, which will include numerous opportunities for public involvement both during the rulemaking and during site-by-site cleanup deliberations.

1.1 Purpose and Scope of the Cleanup Regulations

EPA believes that developing specific cleanup standards for radioactive sites will ensure consistent, protective, and cost-effective site remediation. To that end, EPA is pursuing a comprehensive regulatory strategy. First, the Agency is developing cleanup regulations for soil and groundwater contaminated with radionuclides. Under a separate rulemaking, EPA will develop waste management regulations which will include requirements for handling and disposing of radioactive waste generated during remediation. The Agency also will explore the feasibility of recycling or reusing site structures, equipment, and metals after cleanup. The cleanup and waste management regulations will apply to all sites contaminated with radioactive material subject to the Atomic Energy Act (AEA) and to sites covered under authority of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

1.2 Interagency Coordination and Public Participation

The EPA regulations will apply to a broad range of site types, so the Agency is coordinating its regulatory development activities with numerous interested parties, including other federal agencies such as the Department of Energy (DOE), Department of Defense (DoD), and the Nuclear Regulatory Commission (NRC). (EPA is coordinating with NRC, which is developing regulations that will govern the decommissioning of NRC-licensed facilities.) The Agency also is involving state and local governments, Native American tribes, environmental groups, industry and trade associations, and the general public.

The Agency strongly encourages members of the public to participate throughout the process to ensure that their concerns are understood and addressed. EPA will establish a computerized Cleanup Regulation Electronic Bulletin Board (800 700-STDS outside the Washington, DC area, and 703 790-0825 locally) to answer questions and provide information on rulemaking activities and available documents.

1.3 Purpose and Organization of the Issues Paper

EPA prepared this document to present issues, approaches, and preliminary analyses related to its development of radiation site cleanup regulations. It focuses exclusively on issues and approaches related to developing *cleanup regulations*; it does not address issues specific to waste management regulations, which will be addressed in a separate document.

The three chapters that follow discuss Significant Issues, Regulatory Approaches, and Summary and Next Steps. Appendix A presents background information on radioactive waste and provides additional details of EPA coordination of its rulemaking effort. Appendix B discusses statutory authorities upon which EPA may base its cleanup regulations. Appendix C is a copy of the EPA/NRC MOU. Appendix D discusses the issues raised in NRC's Enhanced Participatory Rulemaking on Radiological Criteria for Decommissioning, in which EPA participated. Appendix E is a list of acronyms, and Appendix F is a glossary of terms used throughout this document.

Chapter 2
Significant Issues

Before EPA can adopt a strategy for developing radiation site cleanup regulations, the Agency must evaluate a number of significant issues. These issues, which are discussed in this chapter, include:

- Which statute, or combination of statutes, should be used as the basis for Agency radiation site cleanup regulations?
- What is an acceptable cleanup level and how should it be determined?
- What consideration should be given to future land use when specifying cleanup levels?
- How should additive risks be handled?
- Who should the regulations protect:
  - — Individuals, whole populations, or both?
  - — Populations especially sensitive to radiation?
  - — The general public, remediation workers, or both?
- How should the regulations ensure that people *and* the environment are protected?
- What time frame should be considered when calculating individual doses?
- Are available measuring and modeling techniques adequate to support the regulations?
- Are technologies available to achieve specified cleanup levels?

2.1 Selecting a Statutory Authority

Selecting one or more statutory authorities on which to base the radiation site cleanup regulations is fundamental to the rulemaking process. The statutory authorities that underlie the rule will determine such issues as which sites and radionuclides will be covered by the rule and how the rule will be enforced.

Under the Atomic Energy Act and Reorganization Plan No. 3 of 1970, EPA is authorized to develop federal guidance and to establish standards to protect health and the environment from the effects of radiation. The Comprehensive Environmental Response, Compensation, and Liability Act authorizes the President to take response action whenever there is an actual or threatened release of hazardous substances, including radionuclides.

A variety of other federal laws authorize the regulation of radionuclides. Appendix A discusses the major relevant federal statutes. Appendix B discusses, evaluates, and compares four major statutory authorities upon which EPA could draw, alone or in combination, as it develops the radiation site cleanup regulations. The statutory authorities evaluated in Appendix B are the:

- Atomic Energy Act (AEA)
- Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA)
- Resource Conservation and Recovery Act (RCRA)
- Toxic Substances Control Act (TSCA)

Many environmental statutes (e.g., RCRA, the Safe Drinking Water Act, and the Clean Water Act) allow EPA to delegate program enforcement authority to the states through a lengthy and exacting process—so long as they meet certain criteria. One general criterion is that states must adopt regulations at least as stringent as EPA's. But if some states were to adopt more stringent radiation regulations, the Agency goal of consistent radiation site cleanup standards might be undermined. Delegation also poses implementation issues that the Agency probably would want to consider. For example, the drinking water program expends much effort to ensure the effectiveness of state enforcement programs and that states report complete and accurate information to EPA. Among the problems the drinking water program faces are inconsistent definitions, inconsistent interpretations of program requirements, and inconsistent data reporting formats.

On the other hand, delegation of program enforcement to states gives more authority to officials closer to local concerns and conditions. It also gives states more say in determining which sites are cleaned up first and how they are addressed.

2.2 Determining Acceptable Cleanup Levels

Ionizing radiation causes cancer and other health problems in people. When EPA develops regulations that cover carcinogens, the Agency assumes that any exposure, no matter how small, to a carcinogen poses some risk.[1] People are exposed to radiation from a variety of natural sources, so it is impossible to eliminate this risk. The Agency can, however, set radiation site cleanup levels to limit exposure and reduce radiation concentrations to what are considered acceptable levels. Several approaches are available for doing so:

- Requiring cleanup to the lowest levels of radiation that instruments can detect.
- Requiring cleanup to levels equal to background, or natural, radiation levels.
- Requiring cleanup to a radiation level that corresponds to a risk level or a range of risk considered protective of human health and the environment.
- Requiring cleanup to a level based on the performance of the Best Demonstrated Available Technology (BDAT).

Each approach is explored in greater detail in the subsections that follow.

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[1]"Risk Assessment Guidance for Superfund: Volume I — Human Health Evaluation Manual (Part A, Baseline Risk Assessment)," Interim Final, EPA Office of Emergency and Remedial Response, EPA/540/1-89-002, December 1989.

2.2.1 Clean up to Detection Limits

EPA could set the cleanup level equal to the detection limit for radionuclides, or, the Agency could require additional cleanup to bring radiation levels below currently detectable levels. EPA might adopt the latter approach if it thought that new technologies might be able to detect lower levels of radioactivity and that additional site cleanup would be effective in reducing radionuclide concentrations.

Detection limits for radiation at the surface and below ground can be difficult to define in a scientifically defensible manner, and they do not relate directly to protection of human health and the environment. In addition, it is often technically impractical or infeasible to reduce radionuclide concentrations to detection limits. Furthermore, implementing standards that are below the quantifiable levels of detection cannot be justified scientifically. For these reasons, EPA determined in the proposed RCRA Subpart S corrective action rule (40 CFR Part 264, Subpart S) that it could not set media cleanup standards below detectable limits.[2]

2.2.2 Clean up to Background

The Agency could require that radioactive contamination of environmental media be reduced to background levels. Typically, this involves measuring radiation concentrations in relatively undisturbed, offsite soils or up-gradient groundwater to establish background levels at individual sites. Adoption of this approach would require EPA to develop statistical procedures for sampling and for calculating background levels of radionuclides. The Agency also would need to consider how to handle situations in which the background radiation levels are quite high (for example, because of localized concentration of radon) or influenced by contamination in adjacent sites.

The RCRA Subpart F groundwater monitoring program provides a precedent for this approach—although it is one that EPA has moved away from in recent years. Subpart F requires the cleanup of groundwater contamination to background levels, to maximum contaminant levels for 14 constituents, or to alternate concentration limits.[3] EPA promulgated these requirements in the early 1980's as part of the initial set of RCRA regulations. In developing more recent RCRA regulations, the Agency moved away from background levels toward risk-based levels. According to the preamble discussion:

> Experience in the Subpart F program has demonstrated that the determination of background levels can be a lengthy, controversial process. Furthermore, background levels will often be much lower than [risk-based] levels. Thus, this alternative was rejected, since it might delay [ultimate cleanups] and might often require [studies] even where levels were significantly below health- and environmental-based standards.[4]

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[2]55 FR 30828

[3]40 CFR 264.94

[4]55 FR 30815

2.2.3 Clean up to Risk-Based Levels

The long-term effects of exposure to ionizing radiation "manifest themselves in human populations simply as a statistical increase in the incidence of certain already existing conditions."[5] Consequently, cleanup levels can be linked to likely exposures that will result in a statistical increase in cancer cases: the more protective the cleanup regulations, the fewer the additional statistical cancer cases from exposure to ionizing radiation.

The primary objective of a risk-based approach would be to establish cleanup levels that ensure a specified level of protection for human health and the environment. If EPA were to promulgate a risk-based cleanup regulations for radionuclides, the Agency would have to determine an acceptable level of cancer risk on which to base them.

As Table 1 shows, a wide range of dose limits and corresponding estimated risk levels have been specified by several agencies under a number of radiation protection regulations. In addition to these radiation protection standards, the revised National Contingency Plan (NCP) has established an acceptable lifetime risk range for carcinogens of 10^{-4} to 10^{-6} for site cleanups under CERCLA. (That corresponds to a statistical increase in the cancer incidence rate ranging from one case for every 10,000 people to one case for every million people exposed.)

RCRA Subpart S adopted the NCP risk range largely to achieve substantial consistency with the Superfund cleanup program; media cleanup standards specified in Subpart S are potential applicable or relevant and appropriate requirements (ARARs) for the Superfund program. ARARs can affect the cleanup levels Superfund site remediations must achieve. EPA did not want regulated entities to "program shop" for the least stringent standards, so the Agency adopted the NCP risk range for Subpart S.[6]

Several, often competing, factors may influence the determination of an acceptable risk level for radiation site cleanup regulations. Lower risk levels would be more protective of human health and the environment, would be more likely to permit the release of cleaned-up sites for residential use (see section 4.2, below), and may be more acceptable to the public. They also could lead to costlier cleanups, higher radiation exposures to cleanup workers, and more remediation waste that also will require disposal.

Specifying a risk range as the NCP does may strike an acceptable balance between these competing factors. A range of 10^{-4} to 10^{-6} could be, in most situations, a convenient and practical level for radiation site cleanup regulations—especially if CERCLA provides at least part of the statutory authority for this rulemaking. And since the RCRA corrective action program already has adopted the CERCLA risk range, this approach would be familiar to the RCRA-regulated community that handles mixed waste. (The radioactivity associated with such a risk range, however, often is a small percentage of the background radiation.)

If the Agency were to adopt a risk range, it would need to determine whether the specific exposure assumptions used by the RCRA and CERCLA programs are appropriate for radiation exposures at contaminated sites. For example, the RCRA and CERCLA risk range considers fatal and nonfatal cancers, but international and NRC radiation protection guidance considers only fatal cancers. EPA also would have to develop guidance on how such factors as current and future uses of a site would influence the

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[5]Mackenzie L. Davis and David A. Cornwell, *Introduction to Environmental Engineering* (New York: McGraw-Hill, Inc., 1991), 743.

[6]55 FR 30852

cleanup level achieved at a site. The sensitivity of available methods for measuring radioactivity is another important consideration; it is not clear whether current measurement techniques are sufficiently

Table 1
Selected Annual Dose Limits for Exposure to Ionizing Radiation[a]

Dose Limit (mrem/yr)	Corresponding Estimated Lifetime Excess Cancer Risk[b]	Citation
100	2×10^{-3}	NRC: 10 CFR Part 20, Standards for Protection Against Radiation - applies to all radioactive sources and all exposure pathways.
		DOE: Proposed 10 CFR 834, Radiation Protection of the Public and the Environment - applies to all radioactive sources and all exposure pathways.
25	5×10^{-4}	NRC: 10 CFR Part 61, Licensing Requirements for Land Disposal of Radioactive Waste - applies to all radioactive sources and all exposure pathways.
		DOE: Proposed 10 CFR Part 834, Radiation Protection of the Public and the Environment - applies to all radioactive sources and all exposure pathways associated with waste management.
		EPA: 40 CFR Part 190, Environmental Radiation Protection Standards for Nuclear Power Operations - applies to all radioactive sources and all exposure pathways.
15	3×10^{-4}	EPA: Proposed 40 CFR Part 191, Environmental Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Waste - applies to all radioactive sources and all exposure pathways.
10	2×10^{-4}	DOE: Proposed 10 CFR Part 834, Radiation Protection of the Public and the Environment - applies as a reporting requirement for all radioactive sources and pathways, and as a limit for all radionuclide sources via air emissions.
		EPA: 40 CFR Part 61, National Emission Standards for Hazardous Air Pollutants — applies as a limit for all radionuclide sources via air emissions.
4	7×10^{-5}	EPA: 40 CFR Part 141, Interim Primary Drinking Water Regulations (1976) — applies as a limit on anthropogenic radionuclides in drinking water.
		EPA: 40 CFR Parts 141 and 142, proposed rule for National Primary Drinking Water Regulations - Radionuclides — applies as a limit for all beta-gamma emitting radionuclides in drinking water.

[a] Excludes annual radiation doses from natural background and medical sources. According to the National Council on Radiation Protection and Measurements Report No. 94 ("Exposure of the Population in the United States and Canada from Natural Background Radiation," published in 1987), background radiation exposure results in a dose of approximately 300 mrem/yr, or an estimated lifetime cancer risk of about 1×10^{-2}.

[b] Includes fatal and non-fatal cancers (i.e., cancer incidence). Calculated assuming a 30-year residential exposure duration consistent with EPA OSWER Directive 9285.6-03[7] and a cancer incidence risk conversion factor of 6×10^{-7} per millirem, taken from EPA's "Risk Assessments Methodology, Environmental Impact Statement, NESHAPS for Radionuclides, Background Information Document — Volume I," EPA/520/1-89-005, September 1989.

[7]Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors," Interim Final, OSWER Directive 9285.6-03.

sensitive to determine compliance with a more stringent (e.g., 10^{-6}) radiation risk limit. For example, a 10^{-6} lifetime excess cancer risk level corresponds to an external exposure rate of about 0.003 microroentgens per hour (μR/hr). Typical field survey instruments can measure no less than 1μR/hr, which corresponds to a lifetime excess cancer risk level of 3×10^{-4}. Risk-based approaches other than the one adopted by CERCLA are also possible. For example, the Agency might consider the risk goal approach discussed in the NRC rulemaking issues paper[8] or in DOE Order 5400.5 and proposed 10 CFR 834. This approach includes a constraint on radiation doses below the 100 mrem per year limit[9] for all radiation sources and pathways and the application of requirements to reduce dose, and risk, "as low as is reasonably achievable" (ALARA) below the dose constraint level. In this situation, the dose constraint would ensure that minimum requirements for individual risk are achieved and population risk (collective dose) and other factors (including cost, social concerns, and ecological considerations) are used to reduce risk to an optimum level of protection.

Because NRC and DOE already have adopted less than 100 mrem/year plus ALARA for their current radiation protection regulations, this approach would be familiar to the regulated community that handles radioactive waste. It is unclear, however, how far below the dose constraint additional cleanup would be considered practical, what dose/risk goal would ultimately be achieved, and how ALARA would be applied to reach this goal.

2.2.4 Clean up to Technology-Based Levels

Cleanup regulations could base cleanup levels on the performance of the Best Demonstrated Available Technology (BDAT). Requirements could be expressed as radionuclide-specific concentrations (i.e., numerical performance standards) or as specified technologies to be employed at site cleanups. In the former case, the rule would allow the use of any technology, so long as it could be shown that the chosen technology achieves cleanup levels specified by EPA and attainable by BDAT. In the latter case, the rule would specify a technology, or combination of technologies, to be used depending on the nature of contamination at a site. In either case, however, EPA would write the regulations to ensure that sites were cleaned up in a manner that protects human health and the environment.

One example of technology-based regulations is the RCRA land disposal restrictions (LDR) program, which requires the treatment of as-generated hazardous wastes prior to land disposal. The LDR framework rule[10] contains the following definitions:

- "Best" means technologies that yield the most effective results from well-designed and well-operated systems.
- "Demonstrated" means technologies currently in use on a full-scale, as opposed to a pilot- or bench-scale, basis.

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[8] "Proposed Rulemaking to Establish Radiological Criteria for Decommissioning: Issues for Discussion at Workshops," Nuclear Regulatory Commission, November 30, 1992.

[9] A millirem, or mrem, is one one-thousandth of a rem (see glossary).

[10] 51 FR 40572

- "Available" means available for lease or purchase, as opposed to a patented process that could not be licensed outside a firm.

It should be noted that previous applications of technology-based standards, such as the Clean Air Act requirements, frequently require future re-evaluations of the residual risks associated with the standards.

2.3 Future Uses of Cleaned-up Sites

Contaminated sites subject to the radiation cleanup regulations may be found in industrial parks, commercial developments, agricultural areas, residential settings, mixed-use zones, and other settings. Land uses, however, may change drastically over time. For example, with the end of the Cold War, dozens of military bases nationwide are being converted to nondefense uses, possibly including housing and recreation. The prospect of such widespread base closings was unseen just a few years ago. The considerable uncertainty in forecasting uses of radioactive sites—even those in heavily industrialized areas—must be considered in the selection of a protective cleanup standard.

Given this uncertainty, EPA recognizes the importance of tailoring cleanup levels to particular land uses and of involving the public—which likely will have a strong interest in establishing future uses—in the process of determining appropriate cleanup levels site by site. Public involvement in radiation site cleanup decisions also will help focus the process on environmental justice concerns.

The linkage of cleanup levels with land use is nothing new. When proposing RCRA Subpart S soil cleanup levels, for example, EPA recognized that using exposure assumptions tailored to industrial land uses might be appropriate when facilities were located in areas likely to remain industrial for the foreseeable future. The Agency "Draft Contaminated Media Principles" also suggests that cleanup levels should consider reasonably expected uses of environmental media, as well as the costs and technical limitations associated with their cleanup.[11] The Superfund program also has developed guidance[12] on identifying future land uses at NPL sites and procedures[13] for assessing human health risks associated with alternate land-use scenarios, including residential and commercial/industrial land uses.

Consistent with these EPA initiatives, NRC guidance for cleaning up sites contaminated with uranium and thorium establishes different cleanup levels for different land uses. In particular, the guidance defines five disposal and storage approaches, each with increasingly higher permissible concentrations of

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[11] "Draft Contaminated Media Principles," Contaminated Media Cluster, EPA Office of Solid Waste and Emergency Response, August 12, 1993.

[12] "Risk Assessment Guidance for Superfund: Volume I — Human Health Evaluation Manual (Part A, Baseline Risk Assessment)," Interim Final, EPA Office of Emergency and Remedial Response, EPA/540/1-89-002, December 1989. Also, "Human Health Evaluation Manual, Supplemental Guidance: Standardized Default Exposure Factors," EPA Office of Solid Waste and Emergency Response, Toxics Integration Branch, OSWER Directive 9285.6-03, March 25, 1991.

[13] "Risk Assessment Guidance for Superfund: Volume I — Human Health Evaluation Manual (Part B, Development of Risk-based Preliminary Reduction Goals)," Interim Final, EPA Office of Emergency and Remedial Response, Publication 9285.7-01B, October 1991.

uranium and thorium in soil and correspondingly stringent land-use restrictions.[14] A 1992 NRC document, "Action Plan to Ensure Timely Cleanup of Site Decommissioning Management Plan Sites," however, notes that only the first two approaches remain viable; the remaining three are inconsistent with decommissioning requirements.[15]

To help maintain current land use patterns, restrictions on future site uses could be part of EPA's cleanup regulations. (Such restrictions would help ensure that cleanup levels appropriate for current land uses would not become inappropriate because the use of the land has changed.) EPA has explored the use of institutional controls on land uses at RCRA and CERCLA sites undergoing cleanup. (Institutional controls include fences to restrict access to contaminated areas, deed restrictions or laws and ordinances limiting site access or resource use, and techniques such as providing alternative water supplies or prohibitions against the use of onsite groundwater for drinking.[16]) RCRA Subpart S, for example, proposes the use of institutional or other controls to prevent any significant exposure to hazardous wastes at RCRA facilities that use "conditional" remedies. The rule also indicates that institutional controls may play a role in final remedies.

The NCP discourages the use of passive institutional controls, such as deed restrictions, in favor of active measures, such as security patrols, unless active measures are found to be impractical. For example, the final remedial action at the Maxey Flats Disposal Site left hazardous and radioactive materials on site; consequently, institutional controls are being used to restrict site use and to ensure that the site is monitored and maintained in perpetuity.[17] Such "perpetual" active measures, however, may face difficulties gaining acceptance by the public, which may view them as neither practical nor protective.

Considering Agency approaches in the programs just discussed, EPA may want to develop radiation site cleanup regulations for a range of future uses, from residential and recreational to agricultural to commercial/industrial. For example, regulations might allow some low level of residual radioactivity to remain after cleanup so long as institutional controls are employed to ensure that a site is not used for an unsuitable purpose, such as a school. On the other hand, EPA also may have to consider that some heavily contaminated sites, such as the Nevada Test Site or Hanford nuclear site, may never be available for public use under any circumstances. Less restrictive cleanup criteria may be appropriate at such sites simply to ensure that contamination does not migrate off site or that workers are not exposed to unacceptably high levels of radioactivity.

Cultural resource management may also play a role in future land-use decisions involving cleaned up sites. Historic sites and national landmarks or sites sacred to Native Americans, for example, may affect cleanup decisions and influence the acceptability of certain regulatory approaches.

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[14]"Disposal or On-site Storage of Thorium or Uranium from Past Operations," Branch Technical Position, 46 FR 52061, October 23, 1981.

[15]57 FR 13389

[16]55 FR 30833-34

[17]Draft "Maxey Flats Disposal Site Remedial Action Fact Sheet," EPA/OSWER, December 16, 1992.

2.4 Additive Effects

In developing and implementing cleanup regulations, the additive risks associated with exposure to multiple radionuclides from multiple sources via multiple pathways must be considered. Many health-based radiation protection regulations define acceptable concentrations or quantities for individual radionuclides and individual exposure pathways; they then provide a "sum of the fractions" procedure for estimating the effects of simultaneous exposure to multiple radionuclides.

An individual's total exposure and risk is determined by adding exposures from disparate sources at a site, such as contaminated soil and groundwater. While such an approach is routinely used, it may result in levels of individual radionuclides that are below current detection limits. In such cases, compliance with cleanup regulations might be difficult to demonstrate.

Sources and pathways of exposure to ionizing radiation will not be limited to those found at a contaminated site. EPA will have to decide how its cleanup regulations should handle the risks arising from indoor exposures to radionuclides—including elevated radon levels caused by technologically enhanced sources of indoor or outdoor radium contamination. And depending on the scope of the cleanup regulations, the additive risks from exposure to naturally occurring radionuclides (i.e. NARM/NORM) and other radionuclides (i.e., source, byproduct, and special nuclear material) may be an issue. For example, if the cleanup regulations do not include NARM/NORM, EPA would need to consider adding the risks associated with NARM/NORM exposures to the exposures to radionuclides included within the scope of the regulations.

Ionizing radiation is not the only carcinogenic contaminant at many sites. A significant fraction of radioactive sites also contain hazardous chemical wastes. Therefore, the risk to the public from these sites derives from exposure to ionizing radiation and exposure to hazardous chemicals. Although radiation site cleanup regulations may be intended to protect against harmful exposures to ionizing radiation, cleanup activities at mixed-waste sites also might have to address the risks posed by hazardous chemicals. EPA will examine such situations during development of the radiation site cleanup regulations. The procedures used by other Agency programs should prove instructive. For example, CERCLA cleanup guidance provides suggestions for summing such risks to determine baseline risk conditions at Superfund sites.[18]

2.5 Target Individuals/Populations to be Protected

The EPA risk assessment approach assesses exposure to a "reasonably" exposed maximum individual. EPA standards always include an individual risk limit, but population risk may dictate more control than would individual risk alone. Although NRC also assesses exposure to a "reasonably" exposed maximum individual, public exposure is generally limited by individual risk; population risk may be used in conjunction with individual limits.[19]

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[18] "Risk Assessment Guidance for Superfund: Volume I — Human Health Evaluation Manual (Part A, Baseline Risk Assessment)," Interim Final, EPA Office of Emergency and Remedial Response, EPA/540/1-89-002, December 1989.

[19] NRC-EPA Risk Harmonization, Phase I: Risk Assessment, Briefing Document, November 25, 1992.

If EPA decides to employ a risk-based approach to radiation cleanup standards, the Agency will have to decide whether the regulations should be applied to individuals or total populations, or both. Standards that apply to populations (i.e., collective dose standards) sum all of the individual doses received by population members over a designated period of time.[20] If a collective dose is used, EPA will have to consider (1) how small a dose should be included in the summation of individual doses, (2) the time frame for the population's exposure, (3) how the dose might be limited by the location of receptor populations relative to the source(s) of contamination, and (4) how to include the entire population or ensure that a representative portion of the population is used to determine collective exposure.

Which individuals should be considered in risk calculations also will have to be determined. Among the questions to be answered are: Should the regulations protect the average person, or persons such as children who are most sensitive to radiation exposure? Should the regulations be designed to protect members of the general public during and after remediation, workers who perform the cleanups, and/or workers employed at a site after it is cleaned up?

Workers engaged in hazardous waste operations and emergency responses, including workers employed in hazardous waste site cleanups,[21] are protected under identical standards promulgated by EPA and the U.S. Occupational Safety and Health Administration (OSHA) under section 126 of the Superfund Amendments and Reauthorization Act. (OSHA defers to NRC on radiation protection matters under the terms of an MOU.[22]) The applicability of these standards to remediation workers at radioactive sites would have to be considered if the radiation cleanup regulations are designed to limit remediation worker exposures.

Agency guidance promotes the use of a range of descriptors to characterize the results of a risk assessment.[23]Risk descriptors include total population risk; average and/or maximum individual risk; and risk to sensitive or highly exposed segments of the population. Presentation of the results of the risk assessment in terms of one or more risk descriptors provides insight on the range of different exposure concentrations encountered in the risk assessment. The regulations could specify risk levels for a range of risk descriptors based on specific exposures.

Individual levels could be based on either the average person's risk or that of the most exposed person in the population to be protected. Population risk is calculated by summing individual risks for all individuals in the exposed population. (Or, if the average individual risk is used, multiplying that risk by the size of the population.) Determining population risk, however, is not always possible due to data limitations.

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[20]The radiation protection standards contained in DOE's proposed 10 CFR Part 834 regulations are individual dose levels. These regulations, however, specify reporting requirements on individual and collective dose bases to "provide timely notification before collective doses become substantial." NRC's 10 CFR Part 20 specifies provisions on collective dose.

[21]The EPA regulations, published on June 23, 1989 at 54 FR 26654, incorporate the Occupational Safety and Health Administration standards by reference and are codified at 40 CFR Part 311.

[22]53 FR 43950

[23]"Guidance on Risk Characterization for Risk Managers and Risk Assessors." Memorandum from EPA Deputy Administrator F. Henry Habicht II to Assistant Administrators and Regional Administrators, February 26, 1992.

Using a variety of risk levels describes the variability in exposures, lifestyles, and other factors that lead to a distribution of risk across a population.[24] For meaningful interpretation of a risk level, the exposed population, or target population, must be defined clearly with respect to location relative to the site, activity patterns, and the presence of sensitive groups.[25] In many cases, determining the cut-off between exposed and nonexposed individuals can be technically challenging.

2.6 Protection of the Environment in Addition to Human Health

Most research on the harmful effects of radiation has focused on people. EPA, however, also is concerned with the broader issue of potential harm to the environment. The effects of ionizing radiation on the environment as well as on people are a concern at many NPL sites.[26] In developing its cleanup regulations, therefore, EPA also must consider cleanup levels that provide ample protection for plants and animals as well as for people.

National and international radiation protection advisory committees have concluded that levels protecting human health should be sufficient to protect the environment as well. The National Academy of Science, for example, states:

> The principal potential impact of radioactive effluents on the biosphere is the induction of deleterious health effects in [people]. Comparable levels of impact undoubtedly exist in other biota, but there is no present evidence that there is any biological species whose sensitivity is sufficiently high to warrant a greater level of protection than that adequate for [people].[27]

Similarly, the International Commission on Radiological Protection (ICRP) has stated as part of its recommended objectives that:

> Although the principal objective of radiation protection is the achievement and maintenance of appropriately safe conditions for activities involving human exposure, the level of safety required for the protection of all human individuals is thought likely to be adequate to protect other species, although not necessarily individual members of those species. The Commission therefore believes that if [people are] adequately protected then other living things are also likely to be sufficiently protected.[28]

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[24] Habicht (1992)

[25] "Risk Assessment Guidance for Superfund: Volume I—Human Health Evaluation Manual (Part A, Baseline Risk Assessment)," Interim Final, EPA Office of Emergency and Remedial Response, EPA/540/1-89-002, December 1989.

[26] Memorandum from John Thomas, DynCorp-Viar, to Jim Konz, EPA/Toxics Integration Branch, March 26, 1993.

[27] "The Effects on Population Exposure to Low Levels of Ionizing Radiation," Report of the Advisory Committee on the Biological Effects of Ionizing Radiation, National Research Council, National Academy of Sciences, November 1972.

[28] "Recommendations of the International Commission on Radiological Protection," ICRP Publication 26, January 1977.

In a more recent study requested by DOE, the National Council on Radiation Protection and Measurements (NCRP) reviewed the literature on how radiation affects aquatic organisms. Based on this review, and on estimates of radiation dose rates to aquatic biota calculated using a combination of aquatic pathways for the total exposures of 100 mrem per year, NCRP concluded:

> [Our] estimates indicate that the ICRP statement, "if man is adequately protected then other living things are also likely to be sufficiently protected," is reasonable, at least within the generic scenario considered here.[29]

Based on these conclusions, there may be a technical basis for focusing on human health risks in the development and implementation of the radiation site cleanup regulations.

This is not necessarily the case, however, for nonradioactive chemicals. In the proposed RCRA corrective action rule, for example, EPA took a different position for nonradioactive hazardous wastes by stating that:

> There may be instances where adverse environmental effects may occur at or below levels that are protective of public health. Sensitive ecosystems (e.g., wetlands) or threatened or endangered species or habitats that may be affected by releases of hazardous waste or constituents should be considered in establishing media cleanup standards. The Agency plans to develop guidance on evaluating ecological impacts. Until more substantive guidance is developed, the Agency intends to determine on a case-by-case basis when standards must be established at lower concentrations [e.g., at the lower end of the risk range] to protect sensitive ecosystems or environmental receptors.[30]

2.7 Time Frame to be Considered

In calculating individual doses to verify compliance with regulations, the radiation community traditionally has assumed that an individual is exposed to the source of radiation over his or her entire lifetime (approximately 70 years, on average). The EPA Superfund program, however, recognizes that individuals do not spend their entire lives living at the same location. Accordingly, the Superfund risk assessment guidance[31] recommends that, in lieu of site-specific information to the contrary, risk assessors assume that members of the general public are exposed for 350 days per year for 30 years when evaluating future residential, agricultural, and recreational land use scenarios for contaminated sites. For future commercial/industrial scenarios, the guidance recommends that risk assessors assume a worker is exposed for 250 days per year for 25 years. Should an approach that considers different exposure time frames for different land use scenarios be used in developing and implementing the radiation site cleanup regulations?

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[29] "Effects of Ionizing Radiation on Aquatic Organisms," Recommendations of the National Council on Radiation Protection and Measurements, NCRP Report No. 109, August 30, 1991.

[30] 55 FR 30827

[31] "Human Health Evaluation Manual, Supplemental Guidance: Standardized Default Exposure Factors," EPA Office of Solid Waste and Emergency Response, Toxics Integration Branch, OSWER Directive 9285.6-03, March 25, 1991.

Another time frame-related issue is whether multiple-generation exposure to radiation should be considered and, if so, how. When developing regulations to protect entire populations, it may be appropriate to consider exposures to multiple generations—especially for sites contaminated with long-lived radionuclides. Given the residual levels of long-lived radionuclides and the growth of their decay products, the health of several successive generations may be affected; and it may be appropriate to protect them. Some radiation protection regulations (such as the EPA proposed high-level waste regulations in 40 CFR Part 191) are designed to protect human health and the environment for 10,000 years. Of course, uncertainty increases significantly as the time frame extends so far into the future.

2.8 Measurement and Modeling Techniques

The availability of measurement and modeling techniques to demonstrate compliance with cleanup levels is an important consideration. As noted above, it is not clear that available measurement techniques are sufficiently sensitive to demonstrate compliance with a 10^{-6} radiation risk limit.

Selecting appropriate models to determine the extent of cleanup required to achieve desired cleanup levels also is important. Several models (e.g., PRESTO[32] and RESRAD[33]) are available for direct use or adaptation to the requirements of radiation cleanup regulations. Because different models are based on different assumptions regarding exposure levels and pathways of concern, their results can vary significantly. Developing procedures and criteria to help standardize dose and risk estimates may be necessary. Key questions to be addressed include: How would uncertainties be handled? Should site owners/operators have the freedom to choose and apply pathway models on their own, or should EPA prescribe models and procedures?

2.9 Technological Feasibility

The feasibility of any cleanup approach will depend on the availability of technologies that can achieve the desired cleanup levels. In 1990, the EPA Office of Emergency and Remedial Response (OERR) and the Office of Radiation and Indoor Air (ORIA) jointly reviewed technologies that could be used to remediate soil, water, and structures at 25 Superfund sites contaminated with radioactive materials.[34] They evaluated the reliability, effectiveness, and development status of the technologies. Their review showed that a number of technologies show potential for addressing radioactive contamination and merit further study. The remediation technologies include soil washing, chemical extraction, physical screening, classification, gravity concentration, flotation, vitrification, and solidification. In addition, a joint ORIA - EPA Control Technology Center report indicates that

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[32] "Low-Level and NARM Radioactive Wastes, Model Documentation, PRESTO-EPA-CPG, Methodology and Users Manual," EPA Office of Radiation Programs, EPA 520/1-87-026, December 1987.

[33] Gilbert, T.L., M.J. Musko, K.F. Eckerman, W.R. Hanson, W.E. Kennedy, Jr., B.A. Napier, and J.K. Soldat. "A Manual for Implementing Residual Radioactive Material Guidelines," January 1988. For U.S. Department of Energy.

[34] "Assessment of Technologies for the Remediation of Radioactively Contaminated Superfund Sites," EPA Office of Solid Waste and Emergency Response and Office of Radiation Programs, EPA/540/2-90/001, January 1990.

incineration of radioactive and mixed waste, used as a volume-reduction process, is a viable treatment technology.[35]

DOE and EPA continue to test and evaluate the applicability of a number of technologies for radioactive contamination problems. As EPA develops its radiation site cleanup regulations, additional data on the performance and cost of technologies appropriate for addressing different types of radioactive contamination problems will become available.

[35] "Background Document on Radioactive and Mixed Waste Incineration: Volume I - Technology," EPA 520/1-91-010-1, May 1991.

Chapter 3
Regulatory Approaches

EPA is considering four basic approaches for the cleanup regulations:

1. Establishing a dose or risk limit.

2. Requiring the use of a "lookup table" of radionuclide- and medium-specific concentrations that would specify cleanup standards applicable to all sites.

3. Requiring the use of a lookup table and a pathway model to calculate cleanup levels site by site in response to site-specific conditions.

4. Recommending specific technologies to be employed in radiation site cleanups.

From a site owner's point of view, the four approaches span a range from flexible to restrictive. Figure 1 shows the relative flexibility of each approach. A dose or risk limit would be the least prescriptive; it would define an overall health-based goal to be achieved, but would provide site owners with complete flexibility in deciding how to meet that goal. At the other end of the spectrum, the regulations could specify the technologies that must be used in radiation site cleanup. This approach would leave little room for flexibility in cleanup work.

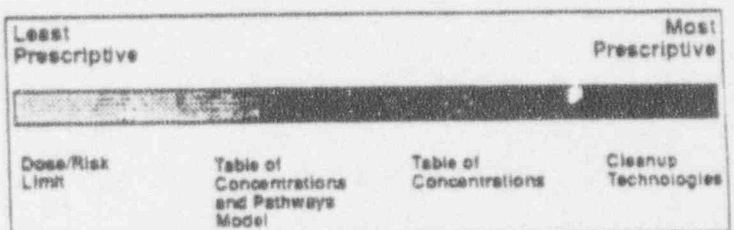

Figure 1 Spectrum of Regulatory Approaches

Whatever approach the Agency finally chooses will be used to achieve risk- or health-based cleanup levels designed to protect the public and the environment. The Agency also will provide opportunity for the public to participate in the approach selection process because public acceptance of, and support for, the selected approach is critical.

To provide a framework in which to begin considering the approaches, Table 2 presents six preliminary evaluation criteria. At this early stage, rigorously evaluating each approach against each criterion is difficult; the approaches need to be refined, and more information needs to be gathered. Once EPA has resolved such outstanding issues as the acceptable risk level, the expected future uses of remediated sites, and the particular radionuclides and pathways to be considered, the Agency will continue its analysis and will consider additional criteria as appropriate.[36] Until then, tradeoffs between the

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[36]The Agency plans to evaluate potentially favorable approaches against criteria in addition to those listed in Table 2. Examples include exposures to remediation workers and waste management implications (i.e., the different types and quantities of wastes that may be generated under different clean-up

approaches can be evaluated only in a general way to support preliminary decisions and the selections of promising approaches that warrant further analysis.

Table 2
Preliminary Criteria for Evaluating Regulatory Approaches

Criterion	Description
Ability to promulgate	There may be important tradeoffs between the approaches in terms of the availability of information and models needed to develop technically sound regulations.
Ability to implement and enforce	Once cleanup regulations are promulgated, the government and regulated community must be able to implement and enforce it effectively. Major issues that have a bearing on the ability to implement and enforce a given regulatory approach include technical feasibility (such as the suitability of available technologies, measurement techniques, and risk models) and resource demands (such as required personnel skills and the need for training, guidance, and outreach).
Compatibility with current environmental regulations	Compatibility with other environmental radiation protection regulations and programs is desirable, because EPA cleanup regulations would apply to NRC licensees, DOE installations, and additional sites under the purview of other government agencies.
Costs	The potential economic costs associated with each regulatory approach will vary considerably depending on the levels of protection. Costs may be defined in terms of human and monetary resources, the time required to clean up sites, or the technical effort required to achieve the desired cleanup objectives. In general, as cleanup levels are reduced, costs increase.
Coverage of NARM/NORM-contaminated waste	Existing regulatory controls for NARM/NORM-contaminated waste are inconsistent and non-uniform. Covering NARM/NORM-contaminated waste in the cleanup regulations, therefore, may provide an opportunity to standardize radiation protection in this area.
Coverage of mixed waste	Mixed waste is of special interest because a large fraction of the radioactive waste at sites that require cleanup is mixed with non-radioactive hazardous waste. The combined radiation and chemical threat associated with mixed waste is also a special concern that could be addressed in the cleanup regulations.

Table 3 compares each of the four approaches EPA is considering with the six evaluation criteria presented in Table 2. The following sections discuss each approach in turn. They cover the major issues that would have to be resolved if an approach were selected and its major advantages and disadvantages. Although not explicitly addressed in this paper, EPA could choose to combine two or more approaches to create additional ones.

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approaches). Insufficient information is currently available to evaluate the approaches against these other criteria.

Table 3
Comparison of Regulatory Approaches

Regulatory Approach	Criterion					
	Ability to Promulgate	Ability to Implement and Enforce	Compatibility With Current Environmental Regulations	Costs	Coverage of NORM*	Coverage of Mixed Waste*
Dose or Risk Limit	Easy	Most Difficult	Most Consistent	Most Expensive	Yes	No (if dose) Yes (if risk)
Look-Up Table	Difficult	Easy	Consistent	Expensive	Yes	No
Look-Up Table & Pathways Model	More Difficult	Difficult	Consistent	More Expensive	Yes	No
Technology Requirement	Most Difficult	Easy	Least Consistent	Least Expensive	Yes	Yes

* "Yes" means an approach could easily accommodate NORM contaminants and/or non-radioactive chemicals if such contaminants are to be included within the scope of the cleanup regulations. "No" means that an approach could not easily accommodate such contaminants, even if they are covered by the regulations.

3.1 Dose or Risk Limit

EPA's cleanup regulations could take the form of a dose or risk limit. For example, the regulations could require that land be cleaned up in a manner that ensures people will not receive a given radiation dose, expressed in millirems per year and that a given radiation dose would correspond to an acceptable lifetime cancer incidence risk. Or, since for regulatory purposes EPA assumes a simple linear relationship between radiation dose and cancer risk, the regulations could express the allowable exposure level in terms of a lifetime cancer incidence risk, such as 1×10^{-4}. The Agency could specify a single dose or risk limit or a range of limits, like the 1×10^{-4} to 1×10^{-6} used in Superfund. Having specified a dose or risk limit, the regulations would leave open-ended the exact nature and extent of cleanup activities—so long as compliance with the limit could be demonstrated.

Three major issues are associated with this approach. First, EPA would have to determine the appropriate dose or risk level. As discussed in section 2.1, there are several precedents for dose limits, ranging from 4 mrem/year (2×10^{-4} cancer risk) to 100 mrem/year (4×10^{-3} cancer risk). The risk levels used in selecting remedies under CERCLA are lower, ranging from 1×10^{-6} to 1×10^{-4} excess lifetime cancer incidence risk.

Second, EPA would have to decide whether the dose or risk limit would apply to individuals, entire populations, or both. (Issues associated with these choices were discussed in section 2.5.) Third, the Agency would have to consider whether to express the limit as a radiation dose or a cancer risk. Radiation standards traditionally have been expressed as an acceptable dose rather than a risk; most RCRA and CERCLA standards for protection from exposure to hazardous substances, however, are expressed in terms of acceptable risk or risk range.

A risk limit offers two important advantages over an acceptable limit on dose:

- If dose-to-risk conversion factors change, as they have in the past, a future revision to the standard would not be necessary.

- A risk limit could be applied to mixed-waste sites to limit the combined cancer risk from exposure to radiation and to nonradioactive chemicals, since exposure to radiation and to chemical carcinogens is additive.[37]

An issue unique to a risk-based approach is whether to consider nonfatal as well as fatal cancers when determining an acceptable risk level. The precedents regarding this issue are varied. International and NRC radiation protection guidance consider only fatal cancers; CERCLA considers both types.

A dose or risk limit approach to regulation has a number of advantages:

- The process of developing regulations consisting of only a dose or risk limit would be straightforward. EPA simply would have to determine an acceptable level or range of risk based on the available evidence. No pathway modeling or other detailed analyses would be required to determine the level. (Such analysis, however, would still be necessary for purposes of predicting regulatory impact.)

- Most current radiation standards are expressed in terms of radiation dose, therefore, a dose limit would be consistent with other radiation regulations. A risk limit would be consistent with the approach taken under CERCLA and would be generally consistent with existing dose standards since radiation dose can be easily related to risk.

- A dose or risk limit could be applied to all types of radioactive contamination, including naturally occurring or accelerator-produced radioactive material (NARM) and naturally occurring radioactive material (NORM).

The primary disadvantages of this approach include:

- There are potential difficulties in implementing and enforcing regulations that specify only a dose or risk limit. Estimating dose and risk at a specific site often requires substantial technical understanding and resources. Also, dose or risk modeling requires making numerous assumptions, and the results may vary significantly under different assumptions. This potential variability may make enforcement difficult.

- Difficulties in implementation also may make demonstrations of compliance difficult.

- Implementation costs for site owners may be highest under this approach. The process of estimating doses and risks, translating dose/risk limits into medium- and radionuclide-specific concentrations, and selecting remedial alternatives can be resource-intensive and can require substantial technical skills. In addition, the process would have to be performed for every site.

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[37]Addressing the combined risks of radionuclides and chemicals would delay promulgation of the cleanup regulations and would make the regulations more difficult and expensive to implement. This is because a combined-risk approach would be more complex technically and would require significant input from other EPA offices. An approach that attempts to address the combined cancer risk posed by radionuclides and nonradioactive chemicals at cleanup sites likely would require CERCLA authority.

3.2 Table of Radionuclide Concentrations

This approach involves development of default exposure scenarios for a generic radioactive site and the use of an exposure pathways model to "back calculate" medium-specific radionuclide concentrations that correspond to an acceptable dose or risk. Site owners/operators would determine what radionuclides are present at their sites, then look up the corresponding required cleanup levels in a table. Depending on the types of sites and number of exposure scenarios and land-use assumptions considered, EPA might have to generate several radionuclide concentration tables to match different site situations.

There is considerable precedent for such an approach. In EPA regulations, 40 CFR Part 192 establishes acceptable concentrations of radium in soil at uranium mill tailings sites; 40 CFR Part 141 specifies maximum levels for contaminants, including radionuclides, in drinking water; and 40 CFR Part 302 lists quantities of radionuclides reportable under CERCLA, which are based on medium-specific pathway modeling conducted by EPA. In its hazardous waste program, EPA has proposed contaminant-specific concentrations in land, water, and air for corrective action at RCRA facilities.[38] NRC radiation protection regulations in 10 CFR Part 20 (Appendix B) also list radionuclide-specific reference levels for air and water. Similarly, NRC Regulatory Guide 1.86[39] provides a lookup table of surface contamination limits for classes of radionuclides.

EPA selection of appropriate exposure scenarios and models to derive radionuclide concentrations is a major issue associated with this approach. The scenarios and models would have to be reasonable, yet protective of human health and the environment across the wide range of contaminated sites. (See Appendix A for a discussion of the various site-specific conditions and expected exposure pathways.)

Because radionuclide concentration limits are used in other regulatory programs inside and outside the Agency, EPA plans to examine the underlying assumptions and methods used in such rules and guidance to ensure appropriate consistency. For example, the Agency could develop radionuclide concentrations for the cleanup regulations by using current concentration-to-dose conversion factors developed for other programs. EPA could, for example, combine the dose conversion factors listed in Federal Guidance Report No. 11[40] with appropriate exposure assumptions, or it could consider adopting NRC draft factors for converting radionuclide concentrations to dose.[41]

Advantages of this approach include:

- EPA could develop and use conservative exposure scenarios and default parameters to derive radionuclide- and medium-specific concentrations that would be protective of human heath and the environment in most, if not all, circumstances.

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[38]Corrective Action for Solid Waste Management Units at Hazardous Waste Management Facilities, Proposed Rule, 55 FR 30798, July 27, 1990.

[39]"Termination of Operating Licenses for Nuclear Reactors," June 1974.

[40]"Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion," Federal Guidance Report No. 11, Prepared for the EPA Office of Radiation Programs by Oak Ridge National Laboratory, EPA-520/1-88-02, September 1988.

[41]"Residual Radioactive Contamination from Decommissioning, Technical Basis for Translating Contamination Levels to Annual Dose," Draft Report for Comment, Prepared for NRC Office of Nuclear Regulatory Research by Pacific Northwest Laboratory, NUREG/CR-5512, PNL-7212, August 1992.

- It would be easier to implement than would a dose or risk limit. Radiation site cleanups would have to attain concentrations clearly specified in a table, regardless of individual site characteristics. Environmental sampling would be necessary to demonstrate attainment of the required concentrations, but pathway modeling and numerous assumptions at individual sites would be unnecessary.

- This approach would be consistent with many current radiation protection standards.

- EPA could use this approach to address all categories of radioactive materials and wastes at sites, including naturally occurring radionuclides and radionuclides controlled under the Atomic Energy Act (AEA).

- This approach could be incorporated into the current CERCLA process without reducing its flexibility.

Disadvantages of this approach include:

- The conservative hypothetical modeling required to develop concentration limits for a diverse range of sites could result in limits that may be unnecessarily low for some sites (i.e., the hypothetical modeling exposure conditions used in the modeling might be very different from the actual conditions at some sites).

- A table of radionuclide concentrations that would apply to all sites would be more difficult for the Agency to develop than would a dose or risk limit.

- A look-up table would not cover the combined cancer risks of radionuclides and chemicals at mixed-waste sites. To address this combined risk, a parallel table of chemical-specific concentrations also would have to be adapted or developed.

3.3 Table of Radionuclide Concentrations Combined With a Pathway Model

This regulatory approach combines a table of generic radionuclide- and medium-specific concentrations as described above with a standardized pathway model to derive concentrations site by site. Under this approach, EPA would develop equations and initial exposure assumptions and parameters that site owners/operators could use to derive site-specific cleanup levels. The table and pathway model could be used in a tiered fashion: either the standard default concentrations in the table could be used or the pathway model could be used to calculate site-specific concentrations.

Pathway models have been used in radiation protection. The airborne emission limits for radionuclides (40 CFR Part 61), for example, allow the use of a table of release quantities and specify the use of the COMPLY model in demonstrating compliance.[42] Several NRC regulations are implemented using Regulatory Guides that recommend procedures and equations for calculating site-specific doses and

[42] "User's Guide for the COMPLY Code," EPA Office of Radiation Programs, EPA/520/1-89-003, October 1989.

concentrations.[43] Although EPA and NRC allow the use of "equivalent" models, the specified models almost always are used to avoid the costs of demonstrating equivalence.

Perhaps the most relevant use of pathway modeling is in EPA risk assessment guidance for Superfund sites.[44] This guidance outlines procedures for calculating "preliminary remediation goals" for radionuclides in all environmental media and for most conceivable exposure pathways.

The primary advantages of a combined lookup table and pathway model include:

- Radionuclide concentrations could be derived by using standardized equations with inputs that reflect actual site conditions. Unlike the use of a lookup table alone, this approach would avoid the possibility that concentrations would be unnecessarily low or high given site-specific conditions.

- The pathway model would provide specific procedures for translating radionuclide concentrations into doses and risks. This would make implementation easier and would lead to less variability, uncertainty, and inaccuracy than would specifying a dose or risk limit alone.

- The use of a pathway model would be consistent with the approaches taken in several other radioactive waste and hazardous materials programs.

- A lookup table and pathway model could address all categories of radioactive materials and wastes at sites, including radionuclides controlled under the AEA and naturally occurring radionuclides.

The disadvantages of this approach include:

- It may be more difficult to develop than would a dose or risk limit or a table of radionuclide concentrations alone. Besides determining an acceptable dose or risk limit and developing a table of corresponding radionuclide concentrations, EPA would have to provide detailed guidance on how to develop site-specific concentrations to be used in place of the table concentrations. (This additional effort may be reduced, however, if EPA can use an existing model or guidance with little or no modification.)

- It may be more difficult to implement than would a table of radionuclide concentrations alone, depending on how much site-specific modeling is conducted. This approach may impose higher burdens and costs than would a concentration table approach alone, which would require only environmental sampling. This approach also might be more difficult to enforce than would a concentration table alone because more effort and expertise would be required to review the pathways analysis.

[43]For example, Regulatory Guide 1.109 establishes procedures for NRC licensees to use in calculating annual doses to members of the public resulting from routine releases of reactor effluents for the purpose of evaluating compliance with 10 CFR Part 50.

[44]"Risk Assessment Guidance for Superfund: Volume I — Human Health Evaluation Manual (Part B, Development of Risk-based Preliminary Reduction Goals)," Interim Final, EPA Office of Emergency and Remedial Response, Publication 9285.7-01B, October 1991.

- A comparable model for estimating the combined cancer risks of exposure to radiation and nonradioactive chemicals would have to be found or developed should the Agency decide to consider additive risks under this approach.

3.4 Technology-Based Approach

EPA could promulgate cleanup regulations that require the use of best available control technology. This approach would link the technology requirement to a risk-based standard to ensure that technologies are used in ways that ensure protection of human health and the environment. As indicated in Chapter 2, EPA has two basic ways to pursue a technology-based approach. The Agency could require:

- Use of specific technologies that have been shown to be effective in cleaning up certain types of radioactive contamination.

- Sites to meet cleanup standards (which could be concentration limits) that are known to be achievable based on the performance of certain technologies. (This would provide greater flexibility in selecting technologies based on site-specific conditions.)

The EPA approach under the RCRA land disposal restrictions (LDR) program is a combination of the two. The Agency prefers to set treatment levels (i.e., concentration limits) whenever possible, because the effectiveness of a technology standard depends on how well the technologies are operated. When EPA lacks sufficient data to set treatment levels for certain wastes, however, the Agency specifies a technology as the treatment standard.[45]

Many other EPA programs also use technology-based approaches. Under Section 111 of the Clean Air Act (CAA), for example, EPA establishes New Source Performance Standards (NSPS) that reflect the emissions reductions possible through the use of the best achievable control technology. The technology must have been adequately "demonstrated," or proven in use, and its costs and other impacts also must be considered. The drinking water program also uses technology-based standards such as "best available technology" or BAT. National Pollutant Discharge Elimination System (NPDES) permits require facilities to install end-of-pipe controls to reduce pollutant discharges to specific levels, which are based on the performance of control technology rather than on health risk. DOE includes the BAT concept in addition to health-based dose limits and ALARA process requirements in DOE 5400.5 and proposed in 10 CFR 834.

Selection of a technology-based approach would require the Agency to:

- Develop criteria for assessing current technologies.

- Evaluate the effectiveness of current technologies.

- Determine the best way to express the technology-based cleanup standard (either as a requirement to use a specific technology or as a requirement to meet a concentration level based on the known performance of certain technologies).

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[45] "Implementing the LDR: Q&A Document," EPA Office of Solid Waste and Emergency Response, October 1989, p. 1.2.

- Select the standard.

Perhaps most important, EPA would need to determine whether current technologies sufficiently protect human health and the environment. In determining how best to express the requirement, EPA would have to decide whether the Agency or site owners/operators should determine which technologies are to be used. The Agency also would have to decide how the regulations would accommodate future advances in technology.

The primary advantages of a technology-based approach include:

- It would be easy to implement, demonstrate compliance with, and enforce because the required cleanup methods would be spelled out clearly.

- It could be developed to apply to all types of radionuclides, including NARM/NORM, and to nonradioactive chemicals.

The primary disadvantages of such an approach include:

- It might be the most difficult to promulgate of all the approaches discussed in this paper because EPA initially would need to undertake an enormous amount of analysis and study to determine an appropriate range of technologies, given the wide variation in types of radioactive contamination problems.

- It would require EPA to spend considerable effort keeping abreast of technological advances and keeping the regulations up to date.

- It would not allow cleanup actions to be tailored to site-specific conditions, which are likely to vary greatly.

Chapter 4
Summary and Next Steps

4.1 Summary

This issues paper, including Appendixes A and B, discussed the issues, alternative regulatory approaches, and preliminary analyses relevant for Agency development of radiation site cleanup regulations. Among the significant issues are:

- Which statute, or combination of statutes, should be used as the basis for EPA radiation site cleanup regulations?
- What is an acceptable cleanup level and how should it be determined?
- What consideration should be given to future land use when specifying cleanup levels?
- How should additive risks be handled?
- Who should the regulations protect—individual, whole populations or both? Populations especially sensitive to radiation? The general public, remediation workers, or both?
- How should the regulations ensure protection of people *and* the environment?
- What time frame should be considered when calculating individual doses?
- Are available measuring and modeling techniques adequate to support the regulations?
- Are technologies available to achieve specified cleanup levels?

The paper also discussed four regulatory approaches currently under consideration by EPA. From the site owner's point of view, these four approaches range from flexible to prescriptive. They are:

- Establishing a dose or risk limit.
- Requiring the use of a lookup table of radionuclide- and medium-specific concentrations and pathway modeling to calculate cleanup levels based on individual site conditions.
- Requiring the use of a "lookup table" that would specify cleanup levels that apply to all regulated sites.
- Recommending specific technologies to be employed in radiation site cleanups.

Whichever approach EPA finally chooses will be used to achieve risk- or health-based cleanup levels designed to protect the public and the environment. As the Agency develops its radiation site cleanup regulations, it will provide opportunity for the public to participate in the approach selection process, since public acceptance and support will be critical to its successful implementation. The public also will be given opportunity to participate in the site-by-site decisionmaking process. Public participation also will help focus the process on environmental justice concerns.

4.2 Next Steps

EPA is committed to moving forward with the rulemaking as expeditiously as possible, coordinating with all interested parties, as follows:

- The public will have opportunity to review and comment on supporting EPA documents.

- EPA also will coordinate with other federal agencies, state and local governments, Native American tribes, environmental groups, and industry and trade associations.

- The Agency is establishing a subcommittee under the auspices of the National Advisory Council for Environmental Policy and Technology (NACEPT). Chartered under the Federal Advisory Committee Act, NACEPT provides environmental policy information and advice to the EPA Administrator and other Agency officials. To ensure balanced representation and a wide range of viewpoints, the NACEPT subcommittee will comprise representatives of various governmental agencies, industry, and public interest groups.

- EPA also is coordinating its regulatory development activities with the NRC, DOE, and DoD. These agencies face several of the same steps during cleanup, and each step represents many technical challenges. All four agencies understand the advantages of a unified approach to meeting these challenges that combines the best scientific and technical resources and experiences of each agency. EPA intends to coordinate this federal effort and to ensure that all facets of the technical implementation guidance are based on scientifically sound and technologically feasible principles and methods.

- EPA is cooperating with NRC efforts to codify radiological criteria for decommissioning NRC-licensed facilities. Under the terms of an MOU with the NRC, EPA will "endeavor to resolve issues of concern to both agencies that relate to the regulation of radionuclides in the environment." If EPA determines that the NRC regulatory program achieves a sufficient level of protection of the public health and the environment, EPA will propose in the *Federal Register* that NRC licenseholders be exempted from EPA radiation site cleanup regulations. EPA believes this dual-track approach provides the best means of ensuring consistency between EPA cleanup regulations and NRC decommissioning standards.

In addition, EPA is preparing a Background Information Document (BID) to support the development of its radiation site cleanup regulations. Among the topics to be covered by the BID are:

- Radiation site characteristics.

- Current regulatory cleanup programs and strategies, and a summary baseline analysis of current cleanup practices.

- Risk assessment and multimedia pathway modeling analyses.

- Evaluation of current remediation technologies and methodologies.

Much of the information generated for the BID also will be used in the preparation of a Regulatory Impact Analysis (RIA), which will quantify the costs and benefits of the regulations developed by EPA.

EPA invites comments on this issues paper from the general public and from other federal agencies, state and local governments, American Indian Tribes, environmental groups, and industry and trade associations. The Agency requests that comments be submitted by November 15, 1993. Comments should be submitted, in duplicate, to the docket clerk at this address:

U.S. Environmental Protection Agency
Mail Stop LE-131
Air Docket No. A-93-27
Room M-1500
First Floor Waterside Mall
401 M Street, S.W.
Washington, DC 20460

The docket is open from 8:30 a.m. to noon and from 1:30 p.m. to 3:30 p.m., Monday through Friday, excluding federal holidays. A reasonable fee may be charged for copies of docket materials.

Further information on other rulemaking activities and documents is available from EPA's Superfund/RCRA Hotline, 800 424-9346 from outside the Washington, DC area and 703 412-9810 within the Washington area. The Cleanup Regulation Electronic Bulletin Board is another source of information. To access the bulletin board, call 800 700-STDS (800 700-7837) outside the Washington area and 703 790-0825 locally.

Appendix A
Background

Understanding current radiation protection programs is a complex task. Although primarily the responsibility of the federal government, regulations currently are written at many different levels of government, each using its own terms and implementing its own requirements. Several federal agencies administer radiation protection programs, and many of these programs overlap, further complicating matters. Further, the technical issues involved make understanding radiation protection programs even more intricate.

To help simplify things, this appendix briefly describes the:

- Different categories of radioactive materials and wastes that may be subject to EPA cleanup regulations.

- Type and number of sites contaminated with radioactive materials may be subject to the cleanup regulations.

- Current authorities and roles of government agencies for responding to these sites.

- Regulations and programs being implemented by the different agencies.

Appendix B briefly compares and evaluates the four statutes available to EPA as authority for its radiation site cleanup regulations.

A.1 Radioactive Materials and Wastes

For the purposes of this paper, "radioactive" refers to any material that contains, in whole or in part, elements that spontaneously undergo nuclear transformations. Such elements are called radionuclides. Radioactive materials, and the waste and contamination often associated with their production and use, generally are categorized by their origin or composition. (They may, however, also be classified by their level of radioactivity.) The principal categories of radioactive materials subject to regulation are defined by statute, although a number of different, interchangeable terms are often used in practice.

Radioactivity is a process in which the nucleus of an atom spontaneously undergoes a nuclear transformation, releasing one or more types of ionizing radiation. Radiation emitted by radioactive substances can transfer sufficient localized energy to atoms to remove electrons from the electric field of their nucleus (ionization). In living tissue this energy transfer can destroy cellular constituents and produce electrically charged molecules (i.e., free radicals). Extensive biological damage can lead to adverse health effects. The type of ionizing radiation emitted by a particular radionuclide depends on the exact nature of the nuclear transformation, and may include emission of alpha particles, electrons (beta particles or positrons), and neutrons; each of these transformations may be accompanied by emission of photons (gamma radiation or x-rays). Each type of radiation differs in its physical characteristics and in its ability to inflict damage to biological tissue. These characteristics and effects are summarized below.

- *Alpha particles* are doubly charged cations, composed of two protons and two neutrons, which are ejected monoenergetically from the nucleus of an atom when the neutron-to-proton ratio is too low. Because of their relatively large mass and charge, alpha particles tend to ionize nearby atoms quite readily, expending their energy in short distances. Alpha particles will usually not penetrate an ordinary sheet of paper or the outer layer of skin. Consequently, alpha particles represent a significant hazard only when taken into the body, where their energy is completely absorbed by small volumes of tissues.

- *Beta particles* are electrons ejected at high speeds from the nucleus of an unstable atom when a neutron spontaneously converts to a proton and an electron. Unlike alpha particles, beta particles are not emitted with discrete energies but are ejected from the nucleus over a continuous energy spectrum. Beta particles are smaller than alpha particles, carry a single negative charge, and possess a lower specific ionization potential. Unshielded beta sources can constitute external hazards if the beta radiation is within a few centimeters of exposed skin surfaces and if the beta energy is greater than 70 keV. Beta sources shielded with certain metallic materials may produce low energy x-ray radiation which may also contribute to the external radiation exposure. Internally, beta particles have a much greater range than alpha particles in tissue. However, because they cause fewer ionizations per unit path length, beta particles deposit much less energy to small volumes of tissue and, consequently, inflict much less damage than alpha particles.

- *Gamma radiations* are photons emitted from the nucleus of a radioactive atom. X-rays, which are extra-nuclear in origin, are identical in form to gamma rays, but have slightly lower energy ranges. There are three main ways in which x- and gamma rays interact with matter: the photoelectric effect, the Compton effect, and pair production. All three processes yield electrons which then ionize or excite other atoms of the substance. Because of their high penetration ability, x- and gamma radiations are of most concern as external hazards.

A.1.1 Radioactive Materials

The major categories of radioactive materials used in different regulatory programs are:

- Source Material
- Special Nuclear Material
- Byproduct Material
- Naturally Occurring or Accelerator-Produced Radioactive Material (NARM)
- Naturally Occurring Radioactive Material (NORM)

Source, special nuclear, and byproduct material are given special status under the Atomic Energy Act (AEA) because they are uniquely associated with atomic energy production; consequently, they are often referred to as "AEA materials." NARM is a catch-all term for radioactive materials not defined by the AEA, and NORM is a subset of NARM. Although these classifications are commonly used, they are not mutually exclusive, and that can be a source of confusion. Some source materials, for example, also are naturally occurring. Table A-1 defines the categories as they are used in regulatory programs.

Table A-1
Categories of Radioactive Material

Category of Radioactive Material	Definition	Examples of Materials and Uses
Source Material	Uranium or thorium, or any combination thereof in any physical or chemical form, or ores that contain (by weight) 0.05 percent or more of uranium, thorium, or any combination of the two.	Unrefined and refined ores from which thorium, uranium, and other elements are extracted, and purified materials or by-products (e.g., depleted uranium) used or produced in the uranium enrichment and fuel fabrication process.
Special Nuclear Material	Plutonium, uranium-233, uranium enriched in the U-233 or U-235 isotope, and any other material that the Nuclear Regulatory Commission, pursuant to the provisions of section 51 of the Atomic Energy Act, determines to be special nuclear material.	Enriched uranium at nuclear fuel fabrication plants, nuclear fuel at reactor sites, nuclear weapons components, and purified radiation sources used in research.
Byproduct Material	Any radioactive material (except special nuclear material) yielded in, or made radioactive by, exposure incident to the process of producing or utilizing special nuclear material, and the tailings or wastes produced by the extraction or concentration of uranium and thorium from ore processed primarily for its source material content, including discrete surface wastes resulting from uranium solution extraction processes. (Underground ore bodies depleted in uranium by solution extraction operations do not constitute "byproduct" material within this definition.)	A wide range of radionuclides used for medical diagnosis and therapy, research, and commercial/industrial applications (e.g., density gauges and well logging devices); also includes uranium and thorium mill tailings, which contain radionuclides very similar to many NORM wastes, but excludes uranium and thorium mine tailings. Specific examples include strontium-90, cesium-137, cobalt-60, nickel-63, and uranium and thorium series radionuclides.
Naturally Occurring or Accelerator-Produced Radioactive Material (NARM)	Any radioactive material produced as a result of nuclear transformations in an accelerator, and any nuclide that is radioactive in its natural physical state (i.e., not anthropogenic), excluding source and special nuclear material.	Numerous radionuclides produced in accelerators and used for medical and other purposes; and NORM sources. Specific examples include cobalt-60, cobalt-57, manganese-54, sodium-22, and radium-226.
Naturally Occurring Radioactive Material (NORM)	A subset of NARM (i.e., naturally occurring radionuclides excluding source and special nuclear material).	Radium sources, such as radium needles, gauges and dials, ores and large-volume wastes at mining and mineral processing sites, coal and coal ash, and radioactive wastes generated during oil and gas exploration and production.

Radionuclides also can be categorized according to their principal type of radioactive emission: i.e., alpha, beta, or gamma emitters. This categorization is significant with regard to radiation protection and public health because the types of emissions represent different types of hazards (e.g., threats via external exposure and threats via internal exposure, such as through inhalation and ingestion). Finally, radionuclides are often categorized according to the principal physical and chemical properties that influence their mobility and behavior in the environment.

A.1.2 Radioactive Wastes

Many different terms are used to refer to categories of radioactive waste. Table A-2 presents and defines the terms used in various statutes and regulations. This method of grouping radioactive waste is sometimes confusing because many of the categories are based on waste origin, not its properties pertinent to safe management and disposal. In addition, many of the definitions are ambiguous and overlapping

Table A-2
Statutory and Regulatory Categories of Radioactive Waste

Category of Radioactive Waste	Definition	Citation
High-Level Waste (HLW)	Irradiated reactor fuel, liquid waste resulting from the operation of the first cycle solvent extraction system, or equivalent, and the concentrated wastes from subsequent extraction cycles, or equivalent, in a facility reprocessing irradiated reactor fuel; and solids into which such liquid wastes have been converted.	Nuclear Waste Policy Act [10 CFR 60]
Low-Level Waste (LLW)	Radioactive waste not classified as high-level waste, transuranic waste, spent fuel, or byproduct materials such as uranium and thorium mill tailings.	Low Level Radioactive Waste Policy Act [10 CFR 61]
Class A, B, C, and Greater-Than-Class-C (GTCC) Wastes	LLW categorized according to its radionuclide concentration and half-life. In general, Class A wastes have the lowest concentrations of particular radionuclides. Class B and C wastes contain radionuclides in higher concentrations. GTCC wastes exceed the concentration limits established for Class C waste.	10 CFR 61
Transuranic Waste (TRU Waste)	Waste containing elements with atomic numbers greater than 92 and half-lives greater than 20 years, in concentrations greater than 100 nCi/g of alpha-emitting isotopes.	40 CFR 191
AEA Wastes	Wastes containing or contaminated with source, byproduct, or special nuclear material.	Atomic Energy Act
NARM/NORM Wastes	Wastes containing or contaminated with any radioactive material produced as a result of nuclear transformations in an accelerator, and any nuclide that is radioactive in its natural physical state (i.e., not anthropogenic), excluding source and special nuclear material.	State authority
Mixed Wastes	Hazardous waste as defined by RCRA containing or contaminated with source, byproduct, or special nuclear material.	Federal Facilities Compliance Act of 1992

In general, radioactive wastes are grouped in categories defined by the Nuclear Regulatory Commission (NRC) regulations governing their management and disposal. High-level and transuranic waste (HLW and TRU, respectively) are considered more hazardous than low-level wastes (LLW) and require more stringent disposal practices. TRU wastes contain certain alpha-emitting radionuclides that are radiotoxic if inhaled or ingested. They also tend to have long half-lives; for example, the half-lives of the isotopes uranium-238 and uranium-235 are 4.47 billion years and 704 million years, respectively. Consequently, TRU wastes are defined as a unique category of radioactive waste requiring special consideration.

Commercial LLW is subdivided into Class A, Class B, Class C, and Greater-Than-Class-C (GTCC) wastes based on the NRC regulations that govern their disposal. As the concentrations of radionuclides increase from Class A to GTCC, the wastes are considered more hazardous and warrant increasingly stringent disposal methods.

The U.S. Department of Energy (DOE) manages its waste differently from the NRC. Through DOE Order 5820.2A, DOE waste management facilities conduct performance assessments to determine waste acceptance criteria, instead of managing wastes according to NRC generally applicable classes. DOE waste acceptance criteria are based on the abi... . a facility to manage and dispose of the waste safely; this ability, in turn, depends on site-specific design factors, geological and hydrological conditions, and other considerations. Waste not meeting the acceptance criteria for a particular disposal site is considered special case waste. Special case waste must be transferred to a waste management site that has acceptance criteria matching the waste. DOE 5320.2A recognizes GTCC waste and indicates that LLW that has radionuclides in concentrations exceeding Class C limits must be handled as special case waste. Disposal of GTCC waste requires special authorization and must be justified by a National Environmental Policy Act (NEPA) analysis.

"NARM/NORM waste" is waste contaminated with naturally occurring or accelerator-produced radionuclides not defined under AEA. EPA is evaluating the need to divide NORM waste into two groups: discrete NORM waste and diffuse NORM waste. *Discrete* NORM wastes contain radionuclides in relatively high concentrations (greater than 2,000 pCi/g), but in small volumes (e.g., radium needles). *Diffuse* NORM wastes contain relatively low radionuclide concentrations (less than 2,000 Pci/g), but in large volume (e.g., radioactive waste generated from oil and gas exploration and production).[46] EPA also is considering the question of 11(e)(2) byproduct material, a class of waste comprising uranium and thorium processing residues that is similar to diffuse NORM waste in radionuclide concentrations and hazards.

"Mixed waste" is any hazardous waste mixed with AEA waste. The Resource Conservation and Recovery Act (RCRA) regulations define hazardous waste as any solid waste listed in Subpart D of 40 CFR Part 261, or that exhibits any of the characteristics of ignitability, reactivity, corrosivity, or toxicity as described in 40 CFR Part 261 Subpart C. RCRA explicitly excludes source, byproduct, and special nuclear material (i.e., AEA waste) from the definition of "solid," and therefore "hazardous," waste; but it does not explicitly exclude NARM/NORM. Mixed waste presents unique waste management challenges because the radioactive and the chemically hazardous components must be handled and disposed of safely. Under current regulations, the disposal of mixed waste must satisfy both RCRA and AEA regulatory requirements.

A.1.3 Radioactive Sites

Although no one knows for certain how many sites are contaminated with radioactive materials, EPA estimates the number requiring cleanup may be in the thousands. Part of the difficulty in identifying such sites is that the responsible government agencies lack a uniform, consistent definition of "site." Even a single agency may have more than one definition. Some programs use "site" to mean specific areas of contamination at a facility, while other programs use "site" to mean the entire facility. Table A-3 presents some examples of definitions of "site," "facility," and "installation" that have been adopted by different government agencies to meet the various needs of specific programs or regulations. Reconciling and consolidating these definitions to derive a clear picture of the number and types of sites that may be

[46] "Low-Level and NARM Radioactive Wastes, Draft Environmental Impact Statement for Proposed Rules, Volume 1, Background Information Document," EPA Office of Radiation Programs, EPA 520/1-87-012-1, June 1988.

Table A-3
Example Definitions of Site, Facility, and Installation

Agency/Citation	Definition
	"SITE"
EPA [40 CFR Part 300, Appendix A, Hazard Ranking System under CERCLA]	"Area(s) where a hazardous substance has been deposited, stored, disposed, or placed, or has otherwise come to be located. Such areas may include multiple sources and may include the area between sources." This definition is restricted to the actual geographic area covered by a source and the extent of associated contamination as delineated during the Preliminary Assessment/Site Inspection (PA/SI) and Remedial Investigation (RI).
EPA [40 CFR Part 260 under RCRA]	On-site "... means the same or geographically contiguous property which may be divided by public or private right-of-way, provided the entrance and exit between the properties is at a crossroads intersection, and access is by crossing as opposed to going along, the right-of-way. Noncontiguous properties owned by the same person but connected by a right-of-way which controls and to which the public does not have access, is also considered on-site property."
EPA [40 CFR Part 270 under RCRA]	Site "... means the land or water area where any facility or activity is physically located or conducted, including adjacent land used in connection with the facility or activity." Off-site "... means any site which is not on-site" as defined above.
DOE [Environ. Restoration and Waste Management Program, Draft Five-Year Plan, FY 1993-1997]	"Lands, installations, and/or facilities for which DOE has or shares responsibility for Environmental Restoration and Waste Management activities." Release site means: "A location at which a hazardous, radioactive, or mixed waste release has occurred or is suspected to have occurred. It is usually associated with an area where hazardous, radioactive waste, mixed waste, or waste-contaminated substances have been used, treated, stored, migrated, and/or disposed of."
DoD [U.S. Army's Draft Installation Restoration Program Management Guidance]	"... [a] location on an installation where hazardous wastes have been stored, disposed, spilled or otherwise released to the environment. A site includes land and water resources where they are contaminated by the release, and it includes structures, earth works or equipment that are clearly associated with the release. Where multiple sites may contribute to contamination of an aquifer or a common land area, the contaminated resources may be identified as a site that is distinguished from the sites where the releases occurred."
	"FACILITY"
EPA [CERCLA sections 101 and 120]	"... means (A) any building, structure, installation, equipment, pipe or pipeline (including any pipe into a sewer or publicly owned treatment works), well, pit, pond, lagoon, or (B) any site or area where a hazardous substance has come to be deposited, stored, disposed of, or placed, or otherwise come to be located; but does not include any consumer product in consumer use or any vessel." Facility also "... means all buildings, equipment, structure, and other stationary items which are located on a single site or on contiguous or adjacent sites and which is owned or operated by the same person (or by any person which controls, is controlled by, or under common control with such person)."
EPA [40 CFR Parts 260 and 270 under RCRA]	"... means all contiguous land, and structures, other appurtenances, and improvements on the land, used for treating, storing, or disposing of hazardous waste. A facility may consist of several treatment, storage, or disposal operational units (e.g., one or more landfills, surface impoundments, or combinations of them)."
	"INSTALLATION"
DoD [U.S. Army's Draft Installation Restoration Program Management Guidance]	"... [t]he real property owned or leased by the Army including a main base and any associated real properties under control of an Installation Commander. An installation is the basic unit of reporting for Federal Agencies Hazardous Waste Compliance Docket and the Annual Report to Congress."

covered by the radiation site cleanup regulations will likely be a major effort associated with regulation development. This paper uses "site" broadly to refer to the land and facilities that might be subject to the regulations.

Radioactive sites can be grouped into three main categories according to the agency or agencies with jurisdiction over them. The categories are:

- Licensees of the Nuclear Regulatory Commission and its Agreement States
- Department of Energy and Department of Defense sites
- Other sites (generally under state or Superfund authority) where naturally occurring or accelerator-produced radioactive materials have been used

The NRC and its Agreement States (states to which NRC has delegated licensing authority) currently license about 22,000 facilities for the production and handling of radioactive materials.[47] (To become an Agreement State, a state must have adopted regulations compatible with those of NRC.) About one-third of the facilities are NRC licensees, and the remainder are licensed by Agreement States under Section 274 of the AEA. Licensees include power plants, universities, medical facilities, radioactive source manufacturers, and companies that use radioisotopes for industrial purposes. About 75 percent of the 22,000 licensed facilities use either sealed radioactive sources or only small amounts of short-lived radioactive materials. These facilities are unlikely to require cleanup because the radionuclides generally remain encased and cause little, if any, contamination or they rapidly decay to nonradioactive elements. A few licensees (e.g., radioactive source manufacturers, radiopharmaceutical makers, and radioactive ore processors) conduct operations that could result in substantial radioactive contamination in portions of their facilities. In addition, about 250 facilities associated with the nuclear fuel cycle[48] maintain large inventories of radioactive materials, and many of these facilities may require cleanup before their licenses can be terminated.

DOE currently is responsible for cleaning up more than 100 contaminated facilities[49] in 36 states and territories. They include about 45 national laboratories and nuclear weapons production and testing facilities where environmental restoration and waste management activities are now taking place. Many are large sites with facilities that have been used for multiple activities related to weapons research, production, and testing and that have many contaminated areas. Many DOE facilities also have extensive mixed-waste contamination. Several DOE facilities have literally hundreds of areas that are being investigated and cleaned up separately. For example, the DOE facility in Hanford, Washington, encompasses 570 square miles and is divided into about 1,100 individual waste sites containing radioactive and/or hazardous materials. These sites range from 1 square foot to 1,800 acres and have been grouped into 78 "operable units" based on their waste characteristics or other factors.

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[47]"Nuclear Regulatory Commission Information Digest, 1993 Addition," Office of the Comptroller, NUREG 1350, Vol. 5, March 1993.

[48]These include nuclear power plants, nonpower (research and test) reactors, fuel fabrication plants, uranium hexafluoride production plants, uranium mill facilities, and independent spent fuel storage installations.

[49]From the "Mission, Vision, and Objectives" statement (p.8) in the *Environmental Restoration and Waste Management Plan*, Fiscal Years 1994-1998. Volume I, U.S. Department of Energy, January 1993.

In addition, the DOE Formerly Utilized Sites Remedial Action Program (FUSRAP) is responsible for cleaning up about 30 privately owned sites that were used during the 1940's and 1950's by the former Atomic Energy Commission and the Manhattan Engineering District for research, processing, and production of uranium and thorium and for storage of residues. Most of the FUSRAP sites are contaminated with uranium or depleted uranium (source material), or 11(e)(2) byproduct material (uranium or thorium) processing tailings. The Surplus Facilities Management Program (SFMP) oversees the environmental restoration of about 30 miscellaneous DOE sites that have been declared surplus to government needs. Also, approximately 25 inactive uranium mill tailings sites are being addressed under the Uranium Mill Tailings Remedial Action Project (UMTRAP) established under the Uranium Mill Tailings Radiation Control Act of 1978 (UMTRCA). EPA would expect its new radiation site cleanup regulations to apply to all of these DOE sites—except for those being addressed under UMTRAP—since the UMTRAP sites are being remediated under specific cleanup standards already promulgated by EPA at 40 CFR Part 192.

The DoD Installation Restoration Program (IRP) comprises more than 17,500 potential hazardous waste sites at 1,877 installations.[50] Only a few of these are known to have radioactive contamination. Since these sites have not been fully characterized, however, the number of radioactive sites cannot be estimated reliably. DoD sites vary widely in function and size; they include hospitals and laboratories, bombing and gunnery practice ranges, weapons manufacturing and storage facilities, and reactors. DoD sites may contain small enclosed radiation sources, such as radium and tritium instruments; larger sources, such as research reactors contaminated with fission products; and dispersed sources, such as laboratory waste storage areas and test ranges.

The third jurisdictional category includes sites that are not licensed by the NRC or Agreement States but are under state or Superfund authority. This category includes about 1,000 particle accelerator sites, which generally contain small amounts of residual radioactivity after shutdown. Other sites in this category are contaminated with long-lived naturally occurring radionuclides that range from small packaged sources to large areas of mostly dispersed wastes from mining and ore processing, university or commercial research, or oil and gas exploration and production.

Almost any of the sites just discussed could be placed on the National Priorities List (NPL), the EPA roster of high-priority hazardous waste sites eligible for federally funded clean up under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The two exceptions are:

- Current NRC license holders (but not facilities licensed by Agreement States), which are not listed on the NPL as a matter of policy.[51]
- Sites being cleaned up by DOE under UMTRAP. (Releases of radioactivity from such sites are exempted from the definition of "release" under CERCLA.)

As of June 1993, the NPL contained 75 sites contaminated with radioactive material. They included DOE facilities, Air Force bases, mill tailings sites, processing and disposal sites, commercial landfills, research facilities, commercial manufacturing facilities, and a former LLW disposal facility. Varying greatly in size, complexity, and environmental setting, each site poses unique cleanup challenges.

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[50]Baca, Thomas E., "DoD Environmental Requirements and Priorities," Federal Facilities Environmental Journal, Autumn 1992.

[51]48 FR 40661

A.3 Authorities and Roles for Cleanup of Radioactive Sites

A variety of laws authorizes the regulation of radionuclides to protect human health and the environment. Table A-4 lists the major relevant federal statutes.

EPA, NRC, DOE, and DoD are the federal agencies with primary regulatory authority for the cleanup of radioactively contaminated sites. Several other federal agencies, such as the Department of Transportation (DOT), also have radioactive waste programs, but they generally are more narrow in scope than those of EPA, NRC, DOE, and DoD. States also may have major roles in site cleanups. The main functions and jurisdictions of the federal agencies are discussed briefly below:

- EPA authority to protect public health and the environment from the adverse affects of exposure to ionizing radiation derives from several statutes, including the AEA; the Clean Air Act (CAA); UMTRCA; the Nuclear Waste Policy Act (NWPA); the Energy Policy Act of 1992; the Low-Level Radioactive Waste Policy Act of 1980, as amended in 1985; CERCLA; and the Toxic Substances Control Act (TSCA). Major EPA responsibilities in this area include the development of federal guidance and standards, surveillance of radiation in the environment, and cleanup of CERCLA sites. Agency authority extends to all types of radioactive material. Under the AEA, NRC and DOE prepare and enforce regulations that are consistent with EPA regulations and generally applicable guidance.

- NRC licenses and regulates the possession and use of source, byproduct, and special nuclear material, primarily by the private sector. The NRC does not license NARM, although NARM may be subject to NRC regulation when it is associated with material licensed by the NRC. NRC licensing and regulatory requirements do not apply to most DOE operations or to certain DoD activities involving nuclear weapons and the use of nuclear reactors for military purposes.

- DOE is responsible for conducting or overseeing radioactive material operations at its contractor-operated facilities, which compose the largest component of government facilities. Under its AEA authority and responsibility to protect the public from radioactive materials used at its production and research-and-development facilities, DOE regulates source, byproduct, special nuclear material, and NARM through its directive system. DOE also is responsible for managing several inactive sites that contain radioactive waste, such as sites associated with the FUSRAP, SFMP, and UMTRAP, as discussed in Section A.2 above.

- DoD, through its Departments of the Army, Navy, and Air Force, controls a large number of sites in and outside of the continental United States. (DOT controls U.S. Coast Guard installations.) Most DoD radioactive waste management activities are regulated by NRC, EPA, or both. Since 1983, the DoD Defense Environmental Restoration Program (DERP) has been working to restore active and former defense sites.

- DOT has issued regulations that set packaging, labeling, record keeping, and reporting requirements for the transport of radioactive material (49 CFR Parts 171 - 179). Other federal agencies, such as the Department of the Interior, also may play a role in certain radiation site cleanups.

Besides these federal agencies, a number of national and international bodies provide recommendations on protecting humans from exposure to ionizing radiation. They include the National Council on Radiation Protection and Measurements (NCRP), the International Commission on Radiological

Table A-4
Statutory Authorities for Radiation Protection

Legislation or Executive Order
EXECUTIVE ORDER 10831, "Federal Compliance With Pollution Control Standards": Executive Order 10831 charges the Administrator of the Environmental Protection Agency to "...advise the President with respect to radiation matters, directly or indirectly affecting health, including guidance for all Federal agencies in the formulation of radiation standards and in the establishment and execution of programs of cooperation with States." EPA issues its Federal radiation guidance under this Order. (Reorganization Plan No. 3 of 1970 transferred to EPA responsibility for promulgating generally applicable radiation protection standards and the advisory functions of the former Federal Radiation Council.)
ATOMIC ENERGY ACT, AS AMENDED (AEA): The AEA requires the management, processing, and utilization of radioactive materials in a manner that protects public health and the environment. It is the principal basis for EPA, NRC and DOE authorities.
COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION, AND LIABILITY ACT (CERCLA): CERCLA, as amended, authorizes EPA to act, consistent with the national contingency plan, to provide for remedial action in response to releases or substantial threats of releases of hazardous substances into the environment. Hazardous substances are defined as any substance designated or listed under the Clean Air Act, the Federal Water Pollution Control Act, the Toxic Substances Control Act, and the Resource Conservation and Recovery Act. Because the CAA designated radionuclides as a hazardous air pollutant, the provisions of CERCLA apply to radionuclides.
TOXIC SUBSTANCES CONTROL ACT (TSCA): TSCA regulates the manufacture, distribution in commerce, processing, use and disposal of chemical substances and mixtures. Materials defined in the AEA are expressly excluded from TSCA. However, naturally-occurring and accelerator produced radionuclides are not.
RESOURCE CONSERVATION AND RECOVERY ACT (RCRA): RCRA provides for detailed regulation of hazardous waste from generation to final disposal. Hazardous waste generators and transporters must comply with EPA standards. Owners and operators of treatment, storage, or disposal facilities must obtain RCRA permits. Materials defined in the AEA are expressly excluded from the definition of solid waste, and, thus from regulation under RCRA. Naturally-occurring and accelerator produced radioactive materials, however, are not.
URANIUM MILL TAILINGS RADIATION CONTROL ACT (UMTRCA): UMTRCA requires stabilization and control of byproduct materials (primarily mill tailings) at licensed commercial uranium and thorium processing sites. NRC and DOE implement standards under this Act.
FEDERAL WATER POLLUTION CONTROL ACT (FWPCA): FWPCA protects the nations's water quality, chiefly through the use of technology-based effluent limits; the national pollutant discharge elimination system (NPDES) permitting system, pretreatment requirements for industrial discharges; and toxicity based water quality standards. A 1976 U.S. Supreme Court opinion held that sour special nuclear, and byproduct material are not pollutants within the meaning of the Act.
CLEAN AIR ACT (CAA): CAA protects and enhances the nation's air quality through national ambient air quality standards, new source performance standards, and other provisions. Radionuclides are a hazardous air pollutant regulated under Section 112 of the Act.
SAFE DRINKING WATER ACT (SDWA): As amended in 1986, SDWA seeks to protect public water supply systems through protection of groundwater. Any radioactive substances that may be found in water are regulated under the Act (although the current regulations specify some individual substances).
NUCLEAR WASTE POLICY ACT (NWPA): The NWPA is intended to provide an orderly scheme for the selection and development of repositories for high-level radioactive waste and spent nuclear fuel.
LOW LEVEL RADIOACTIVE WASTE POLICY ACT, AS AMENDED (LLRWPA): LLRWPA assigns States responsibility for ensuring adequate disposal capacity for low-level radioactive waste generated within their borders.

Protection (ICRP), and the National Academy of Sciences National Research Council (NAS/NRC). The NCRP was chartered by Congress to collect, analyze, develop, and disseminate information and recommendations about radiation protection and measurements. The ICRP's function is basically the same, but on an international level. The NAS/NRC summarizes available scientific knowledge and recommendations on radiation protection through its Committee on the Biological Effects of Ionizing Radiations (BEIR) reports. Although the NCRP, ICRP, and NAS/NRC have no regulatory authority, their recommendations often serve as the basis for many of the general (i.e., not source-specific) regulations on radiation protection developed at the federal and state levels. Several professional organizations, such as the Health Physics Society, also provide nonregulatory guidance and recommendations on radiation protection and measurement.

Although they often overlap in scope and purpose, the standards, advisories, and guidance of these various agencies and advisory groups are designed primarily to be consistent with each other. Nevertheless, there are some important differences between agencies and programs, such as in the radiation doses that are permitted for members of the general public.

A.4 Current Regulatory Controls

A.4.1 Federal Programs

Very few current standards expressly govern the cleanup of radioactively contaminated sites and structures. The principal exceptions are health and environmental protection standards for mill tailings under UMTRCA. Table A-5 summarizes the relevant federal regulatory programs.

A.4.2 State Programs

Each state has its own authority and regulations for managing certain types of radioactive material and waste. Twenty-nine states (known as Agreement States) have signed agreements with NRC in which the Commission relinquishes to the state its authority over source, byproduct, and small quantities of special nuclear material (defined in Section 274 of the AEA). Agreement and Nonagreement States can regulate NARM, although not all do so.

The Conference of Radiation Control Program Directors (CRCPD) has prepared Part N (fifth draft) radiation regulations relating to NORM for states to consider. The regulations specify criteria for the handling and disposition of NORM-contaminated oil and gas production equipment in terms of concentration and surface contamination limits. Several state agencies also are developing NORM policies, regulations and requirements. A few examples include:

- The New Jersey Department of Environmental Protection and Energy (NJDEPE) published a draft document (Jan. 20, 1993) on "Proposed Amendments to NJAC 7:28-11: Generation, Storage and Disposal Requirements for Radioactive Waste Licensing of Naturally-Occurring and Accelerator-Produced Radioactive Material." NJDEPE's proposed regulations specify limits and waste management requirements for concentration and volumes of diffuse and discrete NORM for four categories of waste generators. The regulations also set a residential indoor air concentration limit for radon (1 pCi/l above natural background) associated with the unrestricted release of properties contaminated with NORM soil concentrations of less than 5 pCi/g and waste volumes of less than 100 cubic feet.

Table A-5
Examples of Federal Regulatory Controls

Regulation	Authorizing Statute	Applicability	Standard	Other Applications
EPA REGULATIONS				
40 CFR 192 — Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings	UMTRCA	Cleanup criteria for uranium and thorium mill tailings and Title I properties contaminated with uranium and thorium mill tailings	The concentration of radium 226 in land averaged over any area of 100 square meters shall not exceed the background level by more than (1) 5 pCi/g, averaged over the first 15 cm of soil below the surface and (2) 15 pCi/g, averaged over any 15 cm thick layers of soil more than 15 cm below the surface. Only the 5 pCi/g standard is health based; the 15 pCi/g standard is intended to identify discrete concentrations of radionuclides for cleanup. 20 pCi per square meter per second of Rn 222 flux, 500 yrs longevity for tailings piles 20 μR/hr indoors above ambient background radiation exposure rate Thorium limits same as for Ra 226; thoron limits as for radon	• Used by the Department of Energy as the basis for part of its standards for residual radioactive material in DOE 5400.5 and has been applied under the Formerly Utilized Sites Remedial Action Program (FUSRAP) • Used as an applicable or relevant and appropriate requirement (ARAR) at some NPL sites
40 CFR 141 — National Interim Primary Drinking Water Regulations	SDWA	Maximum contaminant levels (MCLs) for radionuclides in drinking water	4 mrem/yr for beta and photon emitters. Other values for alpha-emitting radionuclides in pCi/l. Revised standards also contain guidelines for disposal of radioactive waste, including radium, generated during the cleanup of drinking water systems.	• Used as an ARAR at NPL sites
40 CFR 61 — National Emission Standards for Hazardous Air Pollutants: Standards for Radionuclides	CAA	Emission standards for eight categories of facilities	10 mrem/yr, plus other criteria, such as for radon emanation	• Used as an ARAR at NPL sites
Proposed 40 CFR 191 (58 FR 7924; February 10, 1993) — Spent Nuclear Fuel, and High Level and Transuranic Waste	AEA	Standards applicable to the disposal of spent nuclear fuel, high level radioactive waste, and transuranic wastes	15 mrem/yr; 10,000 yrs longevity Groundwater protection standards require disposal systems to meet limits of 40 CFR 141 in underground sources of drinking water	• Used as an ARAR at NPL sites for Greater Than Class C wastes
40 CFR 300 — National Contingency Plan (NCP) and Supporting Guidance	CERCLA	Organizational structure and procedures for preparing for and responding to discharges of oil and releases of hazardous substances, pollutants, and contaminants	Acceptable risk range of 10[illegible] to 10[illegible]	• Establishes criteria for selecting remediation goals at NPL sites

Table A-5 (Continued)
Examples of Federal Regulatory Controls

Regulation	Authorizing Statute	Applicability	Standard	Other Applications
NRC REGULATIONS				
10 CFR 20 — Standards for Protecson Against Radiation	AEA	Radiation protection criteria for NRC licensed activities	100 mrem/yr, plus ALARA ("As Low As Is Reasonably Achievable")	• State regulations • Used as an ARAR at NPL sites
10 CFR 61 — Licensing Requirements for Land Disposal of Radioactive Waste	AEA	Procedures, criteria, and terms and conditions that apply to the issuing of licenses for the land disposal of radioactive waste produced by NRC licensees	25 mrem/yr, plus ALARA	• Used as an ARAR at NPL sites
PRINCIPAL DOE ORDERS AND REGULATIONS				
DOE Order 5400.4 — Comprehensive Environmental Response, Compensation, and Liability Act Requirements	AEA	DOE CERCLA policies and procedures as prescribed by the NCP	Acceptable risk range of 10^{-4} to 10^{-6}	• Could be used to establish criteria for selecting remediation goals at other sites
DOE Order 5400.5 — Radiation Protection of the Public and the Environment	AEA	Standards and requirements for operations of DOE and DOE contractors with respect to protection of the public and the environment against undue risk from radiation	100 mrem/yr, plus ALARA. Also includes additional pathway and activity specific dose limits, such as 10 mrem/yr air, 10 mrem all pathway reporting requirements, 25 mrem/yr for waste management, and others	• Could be [illegible]ed to set site specific c[illegible]nup goals at other site[illegible]
DOE Order 5820.2A - Radioactive Waste Management	AEA	DOE's equivalent to NRC's 10 CFR 61 for low level waste management includes requirements for managing 11(e)(2) byproduct material and NARM waste (Supplemented by DOE 5400.5)	25 mrem/yr, 10 mrem/yr for air emissions	• Could be used to set site specific cleanup goals at other sites
Proposed 10 CFR 834 (Notice of Proposed Rulemaking, 58 FR 16268, March 25, 1993) — Radiation Protection of the Public and the Environment	AEA	Proposed standards and requirements for operations of DOE and DOE contractors with respect to protection of the public and the environment against undue risk from radiation	100 mrem/yr, plus ALARA. Also includes additional pathway and activity specific dose limits, such as 10 mrem/yr air, 10 mrem all pathway reporting requirements, 25 mrem/yr for waste management, and others Best Available Technology + ALARA for liquid waste discharges	• Could be used to set site specific cleanup goals at other sites

- The Mississippi Department of Health has drafted radiation protection standards for the possession, use, transfer, transport, storage, and disposal of NORM. These draft regulations address the introduction of NORM into materials or products; sludge and scale in pipes and equipment; soil and water contaminated by the cleaning of scale deposits; and waste generation, management, transfer, and disposal at inactive and active sites involved in storing and/or treating contaminated pipes and equipment.

- Louisiana has promulgated final regulations, similar to the CRCPD draft regulations. The Louisiana regulations identify criteria for unrestricted release, which are similar to the American National Standards Institute recommendations of ANSI N13.12.

- Texas has issued an interim policy establishing guidelines for the handling and disposal of NORM in pipe scale. The guidelines also address radiation protection measures for workers. Specific numeric criteria are provided reflecting, in part, the proposed CRCPD NORM criteria and draft proposed EPA regulations for NORM.

- Illinois and EPA have signed an MOU regarding the management of materials contaminated with radium. The MOU addresses disposal of such waste in landfill facilities, land spreading, and for unrestricted use. Eventually, the state plans to address the disposal of NORM waste in a broader set of regulations covering the disposal of all forms of radioactive waste.

- New Hampshire is modifying existing regulations to address the disposal of water treatment wastes containing NORM.

- Wisconsin is revising its regulations that govern the application of radium-contaminated sludge on agricultural fields. The regulations specify limits on radium concentrations, frequency, and application rates, and also require that the sludge be analyzed to determine the presence and levels of NORM.

States and organizations such as the CRCPD also are closely following the ongoing NRC and EPA activities related to the development of radiation cleanup regulations. EPA is monitoring state activities in this area as well.

States can become authorized to implement the RCRA program, including the regulation of mixed waste, by developing a program that is equivalent to or more stringent than the EPA RCRA program. So far, 32 states and 1 territory have received authorization to regulate mixed waste under RCRA. California and New Jersey are two of the states that have adopted mixed waste regulatory programs that are more stringent than the Federal program.

A.4.3 International Programs

The International Atomic Energy Agency (IAEA) has issued *Principles for the Exemption of Radiation Sources and Practices from Regulatory Control* (Safety Series No. 89). This guidance states that an individual effective dose of 1 to 10 mrem per year would result in trivial risks. However, based on the possibility of multiple exposures from several exempted practices, the guidance recommends an annual *de minimis* dose of 1 mrem.

The IAEA also has drafted a technical report titled *Criteria for Unrestricted Release of Facilities, Sites or Materials from Decommissioning*, but has delayed its issuance until the technical basis for NRC decommissioning guidance is complete. In addition, IAEA consultants and an advisory group have held meetings and are preparing a document titled *National Policies and Regulations for Decommissioning Nuclear Facilities*, which is still in the early stages of preparation and is not yet available. Furthermore, an IAEA advisory group is preparing a document concerning the recycling of contaminated materials titled *Exemption from Regulatory Control: Recommended Unconditional Exempt Levels for Solid Radioactive Materials*.

A.5 EPA Coordination Activities

The current rulemaking effort is not taking place in a vacuum. As noted earlier, several federal agencies are involved in the regulation of radionuclides. Coordination of the EPA rulemaking effort with these other agencies is an important part of the current effort.

EPA is working with the Interagency Steering Committee on Radiation Site Cleanup Standards to ensure that appropriate resources and priority are given to the development of the regulations. The Director of the EPA Office of Radiation and Indoor Air chairs the committee, which comprises senior managers from DOE, DoD, NRC, and other EPA program Offices. An Interagency Workgroup is examining technical issues related to developing and implementing radiation site cleanup regulations.

The Agency will be working with the Conference of Radiation Control Program Directors (CRCPD) Committee on Decontamination and Decommissioning. EPA is establishing a subcommittee under the National Advisory Council for Environmental Policy and Technology (NACEPT) to ensure scientific and technical objectivity and public openness. (NACEPT provides environmental policy information and advice to the EPA Administrator and other Agency officials.) To ensure a balanced perspective, the subcommittee will include representatives from government and the private sector. EPA also has organized an internal workgroup drawn from various program offices to oversee development of the radiation site cleanup regulations.

EPA also is coordinating its rulemaking with the NRC, which is developing separate regulations governing the decommissioning of NRC-licensed facilities. A Memorandum of Understanding (MOU) signed by EPA and NRC on March 16, 1992 discusses NRC authority to develop such regulations and defines how EPA and NRC will avoid overlapping regulations affecting NRC license holders. If EPA determines that the NRC regulatory program achieves a sufficient level of protection of the public health and environment, EPA will propose in the *Federal Register* that NRC licensees be exempted from the EPA radiation site cleanup regulations.

EPA and NRC are sharing information received and developed in support of their respective rulemaking efforts. For example, EPA recently participated in NRC Enhanced Participatory Rulemaking Workshops. The Agency believes this parallel approach will ensure that its cleanup regulations and NRC decommissioning standards will be consistent, fully protective of public health and the environment, and issued as soon as possible.

Appendix B
Statutory Authorities

As noted in Appendix A, several federal statutes, alone or in combination, could serve as the basis for EPA's development of radiation site cleanup regulations. This Appendix briefly evaluates and compares the four statutory authorities that EPA could use to develop these regulations. They are:

- The Atomic Energy Act (AEA) and Reorganization Plan No. 3 of 1970
- The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA)
- The Resource Conservation and Recovery Act (RCRA), as amended by the Hazardous and Solid Waste Amendments (HSWA)
- The Toxic Substances Control Act (TSCA)

Medium-specific statutes, such as the Clean Air Act (CAA) and the Safe Drinking Water Act (SDWA), and contaminant-specific statutes, such as the Uranium Mill Tailings Radiation Control Act (UMTRCA), are not being considered in detail because they either exclude most radionuclides or cannot address all media or exposure pathways. Approaches that would combine these statutes to cover all radionuclides, all media, and all exposure pathways might result in conflicting requirements (e.g., regarding acceptable levels of risk) and a patchwork of regulatory controls and oversight. For example, the CAA airborne emission standards for radionuclides apply to individual source categories (e.g., NRC licensees) and are based on a dose limit of 10 mrem per year[52] (a lifetime cancer risk of roughly 4×10^{-4}). The maximum contaminant levels for radionuclides in drinking water established under the SDWA, however, are based on a dose limit of 4 mrem per year (a lifetime cancer risk of roughly 2×10^{-4}). Regulatory approaches using the combined authority of the CAA and SDWA would have to reconcile these risk differences and, even then, would apply only to certain types of sites.

EPA has developed several criteria to guide its evaluation of the statutory approaches:

- **Provides authority to develop radiation site cleanup regulations.** This criterion evaluates the extent to which the statute authorizes EPA to develop radiation site cleanup regulations.
- **Applies to the universe of sites contaminated with radionuclides.** The universe includes all federal and nonfederal sites, including Superfund sites, DOE and DoD federal facilities, NRC and Agreement State licensees, and sites controlled under state authority.

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[52] All dose limits are effective dose equivalents (e.d.e.) to the whole body.

- **Considers all radionuclides.** "All radionuclides" means source, byproduct, and special nuclear materials as defined by the AEA, as well as NARM/NORM regardless of their origin or legal definition.

- **Covers multiple media and multiple exposure pathways.** This criterion addresses whether a statute permits the development of regulations covering all contaminated media and all human and ecological exposure pathways.

- **Provides EPA with implementation and enforcement authority.** This criterion addresses whether a statute gives EPA, instead of other agencies, implementation and direct enforcement authority.

Table B-1 provides a broad comparison of the four statutory authorities using the criteria outlined above. Each statute is described in greater detail below. The discussion of each statute highlights the major issues that are critical in weighing and comparing the different authorities.

Table B-1
Evaluation of Statutory Authorities

Evaluation Criterion	AEA	CERCLA	TSCA	RCRA
(1) Provides EPA with authority to develop radiation site cleanup regulations	Yes. Clear authority to set regulations for certain types of radioactive material.	Yes.	No. TSCA does not cover AEA materials.	No. RCRA does not cover AEA materials.
(2) Applies to the universe of sites contaminated with radioactivity	No. Sites containing NARM/NORM only may be excluded.	Yes. However, EPA excludes active NRC licensees and UMTRAP sites as a matter of policy.	No. Covers only NARM/NORM sites.	No. Applies only to RCRA TSD facilities.
(3) Considers all radionuclides	No. May exclude NARM/NORM.	Yes.	No. Excludes AEA materials.	No. Excludes AEA materials.
(4) Covers multi-media and multiple exposure pathways.	Yes.	Yes.	Yes.	Yes.
(5) Provides EPA with implementation and enforcement authority	No. Responsibility likely to be vested with NRC and DOE.	Yes.	Yes.	Yes.

B.1 Atomic Energy Act (AEA)

The AEA requires that radioactive materials be managed, processed, and used in a manner that protects public health and the environment. Traditionally, the AEA has been interpreted as applying only to the regulation of source, special nuclear, and byproduct materials and not to NARM/NORM.

Under the AEA and Reorganization Plan No. 3 of 1970, EPA is authorized to issue federal guidance on radiation protection matters as deemed necessary by the Agency or as mandated by Congress.

This guidance could be issued as regulations, given EPA authority to promulgate generally applicable radiation protection standards under Reorganization Plan No. 3. (EPA promulgated its environmental radiation protection standards for nuclear power operations at 40 CFR Part 190, for example, under AEA authority). Specific advantages and disadvantages of using AEA authority include the following:

Advantages

- The AEA clearly gives EPA authority to develop site cleanup guidance and regulations for most types of radioactive material.
- EPA's generally applicable standards would be implemented and enforced by federal agencies.
- The regulations could apply to all environmental media and exposure pathways.
- Regulations developed under AEA might be considered applicable or relevant and appropriate requirements (ARARs) at Superfund sites.[53]

Disadvantages

- Implementation and enforcement responsibilities would be vested in agencies other than EPA, such as NRC and DOE. The possibility exists that NRC and DOE might promulgate inconsistent regulations implementing these requirements.
- Cleanup regulations promulgated under the AEA might not apply to NARM/NORM-contaminated waste and materials. The Act has been used mainly to regulate source, special nuclear, and byproduct materials.

B.2 Comprehensive Environmental Response, Compensation and Liability Act (CERCLA)

CERCLA provides broad federal authority to respond to releases of hazardous substances, which are defined under the law to include all radionuclides. CERCLA provides that "whenever . . . any hazardous substance is released or there is a substantial threat of such release into the environment . . . the President is authorized to act, consistent with the National Contingency Plan (NCP), to . . . provide for remedial action relating to such hazardous substance." Although EPA has never promulgated a cleanup regulation under CERCLA, the Agency could develop regulations to extend the NCP definition of "protective of human health and the environment"—which is currently defined in terms of the remedial risk range (10^{-4} to 10^{-6} lifetime excess risk of cancer incidence)—by establishing clear and measurable levels applicable to remedial actions at radioactively contaminated sites.

The major advantages and disadvantages of using CERCLA authority for the radiation site cleanup regulations are as follows:

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[53]Specific cleanup regulations have not been developed under CERCLA. Instead, CERCLA remedial actions are required to meet ARARs established under other statutory authorities.

Advantages

- Cleanup levels could be set for all radionuclides because all radionuclides, including NARM/NORM, are considered hazardous substances under CERCLA.

- CERCLA applies to all environmental media and exposure pathways, so cleanup levels would cover multiple media and multiple exposure pathways.

- CERCLA gives EPA comprehensive enforcement mechanisms for implementing cleanup regulations.

- The cleanup requirements would be binding on all CERCLA cleanups, including those conducted by other federal agencies.

Disadvantages

- As stated above, with the exception of rulemaking on adjustments to reportable quantities, EPA has never used CERCLA to develop regulations, preferring instead to use standards established under other statutory authorities as ARARs for CERCLA remedial actions.

- In accordance with the NRC deferral policy[54], active NRC licensees generally are not cleaned up under CERCLA. In addition, based on the statute's definition of "release," CERCLA cannot be used to respond to releases of source, byproduct, or special nuclear material at DOE UMTRAP sites.

B.3 Toxic Substances Control Act (TSCA)

Toxic substances controlled under this Act are defined to exclude source, special nuclear, and byproduct material as defined in the AEA (Section 3(2)(B) of TSCA). However, EPA might be able to use TSCA Section 6(a) to set cleanup regulations for diffuse NORM. The Agency has considered using that section to propose disposal requirements for discrete NORM waste, which currently is not covered under any other law and which can pose a significant risk of injury to health and the environment if handled or disposed of improperly. The advantages and disadvantages of basing radiation site cleanup regulations on TSCA include the following:

Advantages

- TSCA requirements could be applied to federal facilities and to NRC licensees.

- The cleanup levels would cover multiple environmental media and multiple exposure pathways.

- Cleanup regulations developed under TSCA likely would be considered ARARs under CERCLA.

- TSCA gives EPA numerous enforcement mechanisms.

[54] 48 FR 40661

Disadvantages

- TSCA does not cover source, byproduct, and special nuclear material.

B.4 Resource Conservation and Recovery Act (RCRA)

RCRA explicitly excludes the regulation of source, special nuclear, or byproduct material as defined by the AEA, but not NARM/NORM (RCRA Section 1004(27)). It also does not designate "radioactivity" as a characteristic of hazardous waste. Therefore, RCRA would need to be amended before it could be used to develop cleanup regulations for all radionuclides.

Currently, when wastes have hazardous and radioactive components (i.e., the wastes are known as "mixed waste"), RCRA applies to the nonradioactive components and AEA applies to the radioactive components. The two laws are not fundamentally inconsistent or incompatible, but when the application of both regulatory regimes is inconsistent or incompatible, RCRA (Section 1006) defers to AEA. Problems associated with the regulation of mixed waste, however, are more institutional than legal in nature. The advantages and disadvantages of using RCRA as the basis for radiation site cleanup regulations include:

Advantages

- Developing radiation site cleanup regulations under RCRA might help ensure an effective, coordinated approach to addressing mixed-waste cleanups.
- Cleanup regulations developed under RCRA would cover multiple environmental media and multiple exposure pathways.
- Cleanup regulations developed under RCRA likely would be considered ARARs under CERCLA.
- RCRA provides numerous enforcement mechanisms that EPA can use to ensure compliance with applicable requirements.

Disadvantages

- Source, byproduct, and special nuclear materials under the AEA are not subject to RCRA regulations. In addition, radioactivity is not considered a defining "characteristic" of hazardous waste. Therefore, RCRA regulations would need to be amended before they could be applied to radionuclides.
- RCRA corrective action jurisdiction is limited to facilities defined as "treatment, storage or disposal" (TSD) facilities under the Act.

Appendix C
Text of Memorandum of Understanding—Guiding Principles of EPA/NRC Cooperation and Decisionmaking[55]

Introduction

The Environmental Protection Agency (EPA) and the Nuclear Regulatory Commission (NRC), in recognition of a mutual commitment to the effective and efficient protection of public health and safety and the environment, have developed this Memorandum of Understanding in order to establish a basic framework within which EPA and NRC will endeavor to resolve issues of concern to both agencies that relate to the regulation of radionuclides in the environment.

Goal

The goal of this Memorandum of Understanding is to foster cooperation in fulfilling the responsibilities of each agency to ensure protection of the public health and safety and the environment in accordance with existing agency responsibilities and authorities.

Principles

EPA and NRC, in carrying out the respective responsibilities of the two agencies in the regulation of radionuclides, will strive to:

1. Base regulatory decisions on a determination that such actions will result in a substantial reduction of significant risk to the public health and safety and the environment, and in making such decisions consider, to the extent permitted by law, the importance of the risk reductions to be achieved when compared to other radiological risks already subject to existing regulations, the overall economic impact on NRC licensees of additional regulatory requirements to achieve such reductions, and pursue the most efficient, cost-effective course in the regulation of those licensees.

2. Focus agency priorities on those significant safety and environmental problems subject to the authority of both agencies that offer the greatest potential for substantial risk reduction;

3. Avoid unnecessary duplicative or piecemeal regulatory requirements for NRC licensees, consistent with the legal responsibilities of the two agencies, and ensure that standards and regulations, when issued, can be effectively implemented; and

4. Effectively and responsibly carry out the provisions of Reorganization Plan No. 3 of 1970. Under the Plan, EPA issues generally applicable environmental limits on radiation exposure or levels, or concentrations or quantities of radioactive materials, in the environment outside the boundaries of locations

[55]57 FR 54127, November 16, 1992.

under the control of persons possessing or using radioactive materials, and NRC implements these standards by the use of its licensing and regulatory authority.

Implementation Guidance

A. Scope

For certain facilities or materials licensed or regulated by the NRC, EPA is required by statute to develop environmental standards for radionuclides which are applicable directly to NRC- regulated facilities or materials. For example, EPA is required to develop generally applicable environmental standards for offsite releases from radioactive material in high-level waste repositories under the Nuclear Waste Policy Act. For other program activities, such standards are authorized but, depending sometimes on the circumstances, are not legally required. With exception of Section C, below, this Memorandum of Understanding is intended to address issues associated with both types of standards. Section C applies according to its terms where EPA standards are not legally mandated. This MOU does not apply to matters arising under RCRA or CERCLA.

B. General

Each agency will keep the other generally informed of its relevant plans and schedules regarding such activities, will respond to the other agency's requests for information to the extent reasonable and practicable, and will strive to recognize and ameliorate to the extent practicable anticipated problems with regard to implementation and consistency with other program activities.

Each agency will deal with the other in a spirit of cooperation to achieve the goals of this Memorandum of Understanding. Agency management will endeavor, to the maximum possible extent, to resolve informally and in a timely manner those differences identified as a result of the procedures contained in this Memorandum of Understanding. If differences cannot be resolved, the respective General Counsels of each agency will arrange for the matter to be presented by the necessary parties to the heads of both agencies for resolution.

Each agency will keep the other fully informed of its priorities for the development of regulations and will endeavor to develop a common understanding of the priorities and schedules for resolution, with the highest priorities accorded to initiatives which offer the greatest potential for significant risk reduction.

If both agencies agree, in accordance with these principles and guidance, that duplicative regulation in a particular area is undesirable, but nevertheless is required by law, then the agencies will cooperate in considering and, if appropriate, supporting legislative changes.

C. Governing Criteria and Procedures

This Section applies to the issuance of regulations for releases applicable to NRC regulated facilities or activities for releases into the environment of source, byproduct or special nuclear materials under the Clean Air Act. It also applies to the issuance of such regulations under the Atomic Energy Act and other provisions of law which may give rise to duplication of effort and overlapping regulation of NRC regulated facilities or activities, but only to the extent issuance of such standards is authorized but not legally mandated. Subjected to the above, EPA and NRC agree as follows:

1. Criteria. EPA's decisions not to impose emission standards for hazardous air pollutants under the Clean Air Act for NRC licensed materials or facilities will, in accordance with 112(d)(9) of the Clean

Air Act, be based upon a determination that NRC's regulatory program provides an ample margin of safety to protect the public health. Similarly, EPA's decisions to impose or not impose other regulations regarding NRC licensed materials or facilities will be based upon a determination as to whether NRC's regulatory program achieves a sufficient level of protection of the public health and environment. This determination may be influenced by particular risk reduction or risk prevention goals being pursued and this Memorandum of Understanding does not reflect agreement on such goals at this time. Ideally, agreement on risk reduction or prevention goals for radionuclides will be reached pursuant to paragraph D. below but in a particular case where EPA and NRC cannot agree on such goals, this Memorandum of Understanding is without prejudice to EPA deciding to proceed with
regulation, without NRC concurrence, based upon an EPA inability to find that NRC's program provides a sufficient level of protection.

EPA and NRC will jointly seek to minimize unnecessary duplication of effort and overlapping regulation of NRC-licensed materials and facilities.

2. Procedures. In developing regulations in accordance with its authorities, if EPA, after finding that NRC's regulatory program fails to provide a sufficient level of protection of the public health and safety or the environment, identifies an area where it believes that EPA regulation applicable to NRC licensees regarding radionuclides may be necessary, EPA will, before developing and proposing rules in the Federal Register, informally and promptly inform the NRC of the basis for its position. If NRC believes that such direct regulation of its licensees by EPA is unnecessary, the two agencies will endeavor to resolve any issues, including consideration of information from NRC regarding the level of protection achieved by NRC regulatory programs and any necessary modification to NRC's regulatory program, so that duplicative regulation and implementation are avoided. Decisions rendered pursuant to this paragraph will fully consider the implementation of existing regulatory programs in assessing the level of protection being achieved by regulated facilities. Final EPA conclusions on whether EPA will impose regulations applicable to NRC-licensed materials or facilities, and final NRC conclusions on whether NRC will develop modifications to its program, will be accomplished in a public process based upon a full and public record. Any decision made pursuant to this memorandum is subject to review and modification based upon actual experience with its implementation.

Similarly, if NRC undertakes the development of new regulations that would affect the level of protection of public health and safety and the environment related to an area where EPA has authority to issue regulations applicable to NRC licensees, or if NRC undertakes any rulemaking or other regulatory activity to fulfill its agreements made pursuant to this Memorandum of Understanding, NRC will promptly and informally notify and consult with EPA before developing and proposing rules in the Federal Register, and before any final decision by the commission on the proposal.

Where either agency is developing new regulations for radionuclides in an area not covered by an exiting regulatory program, the agencies will, before proposing new regulations, consult concerning what the proper division of responsibility should be.

D. Risk Assessment

In carrying out this Memorandum of Understanding, the agencies will actively explore ways to harmonize risk goals and will cooperate in developing a mutually agreeable approach to risk assessment methodologies for radionuclides.

E. Other Provisions

1. Nothing in this Memorandum of Understanding limits the authority of either agency to exercise independently its authorities with regard to matters that are the subject of this Memorandum of Understanding.

2. Nothing in this Memorandum of Understanding shall be deemed to establish any right nor provide a basis for any action, either legal or equitable, by any person or class of persons challenging a government action or a failure to act.

3. This Memorandum of Understanding will remain in effect until terminated by the written notice of either party submitted six months in advance of termination.

Ivan Selin
Chairman, U.S. Nuclear Regulatory Commission

William K. Reilly
Administrator, U.S. Environmental Protection Agency

This Memorandum of Understanding was signed by the Chairman of the Nuclear Regulatory Commission and the Administrator of the Environmental Protection Agency on March 16, 1992.

Appendix D
NRC's Enhanced Participatory Rulemaking on Radiological Criteria for Decommissioning

August 1993

In November 1992, the Nuclear Regulatory Commission initiated a rulemaking to establish radiological criteria for decommissioning through a process that provides enhanced opportunities for public participation. The rulemaking began with a series of public workshops involving individuals from diverse perspectives in roundtable discussions on key aspects associated with the rulemaking. NRC held the workshops from January through May 1993 in Chicago, San Francisco, Boston, Philadelphia, Dallas, Atlanta, and Washington, DC. The workshops provided a forum for participants to communicate and explore their positions on the issues prior to the formulation of a proposed NRC staff position on the rule. In addition to the Environmental Protection Agency, active participants in the workshops included representatives from State and local governments, Indian tribes and tribal organizations, industry groups (utilities, non-power reactors, fuel cycle facilities, and materials facilities), citizen groups, environmental and environmental justice organizations, professional societies, and decommissioning contractors.

NRC focused the workshop discussions using a Rulemaking Issues Paper that identified key issues associated with the development of radiological criteria for decommissioning. NRC developed the Issues Paper with input from EPA, States, Industry, and public interest groups in an attempt to ensure that the paper presented the issues in an unbiased manner. The two primary issues identified in the Issues Paper were: (1) what health and safety objectives should the criteria be based on, and (2) how should practicality considerations be considered in developing the criteria. NRC described four alternative approaches for defining the health and safety objectives: risk limits, risk goals, best effort (technology based standards), and return to background. Secondary issues described in the paper included: individuals or populations to be considered, potential for reuse/recycle of materials released, time frame for calculations, need for pathway specific criteria, consideration of radon, and consideration of previously buried radioactive wastes.

The workshops began with a general introduction to the subject of decommissioning and the issues associated with the development of radiological criteria for decommissioning to provide a context for the workshops. The discussions quickly launched into a general exploration of whether NRC should develop generally applicable requirements. Following that discussion, most of the workshop focused on four cross-cutting issues that were used to elaborate on the strengths and weaknesses of the four alternative regulatory approaches. The cross-cutting issues included protection of human health and the environment, waste management implications, relationship to existing regulatory framework, and technical capabilities and implementation considerations. The purpose of the workshops was not to seek consensus on the issues, but rather to ensure complete ventilation of the viewpoints of the various participants in each workshop.

The remainder of this article briefly summarizes some of the diverse viewpoints expressed in the workshops. NRC is actively considering these views in developing the draft radiological criteria. All of the views are captured in transcripts prepared for the workshops and in written comments submitted to NRC. In addition, the views have been catalogued in a comment data base and summary document. The views described below were expressed by some, but by no means all participants. No significance should be drawn by the inclusion or exclusion of views herein. However, these views are representative of the range of perspectives discussed in each of the workshops.

One of the most unexpected views that surfaced in each of the workshops was the questioning of the unrestricted use objective that is currently incorporated in NRC's requirements. A diverse group of interests challenged the credibility and practicality associated with requiring each nuclear facility to be sufficiently remediated to release it for unrestricted use at the time its license is terminated. Other general views expressed in the workshops included: (1) meaningful public involvement is needed in each phase of rulemaking and implementation of the decommissioning criteria, (2) the ultimate goal of decommissioning should be the return to radiological background (i.e., the radiological level that existed prior to construction and operation of a nuclear facility) at each site, and (3) it may be appropriate to establish different requirements for different types of licensed activities (e.g., distinguish between medical facilities and nuclear utilities).

In terms of the four alternative regulatory approaches described in NRC's Issues Paper, participants generally recognized that risk or dose limits are important to ensure compliance. However, some participants believed that the risk level that NRC would use to establish these limits would be too high, thus allowing too much risk to humans and the environment. In contrast, participants believed that goals may be more appropriate in some situations, but would be difficult to enforce. Participants generally discounted the utility of technology-based or best effort standards because they could allow too much risk and create future liabilities for additional decommissioning in the future if technology improves. The fourth alternative, return to background, was favored by many participants as the ultimate objective of decommissioning. However, some participants stressed that it may be difficult to demonstrate compliance with a background standard through measurements and may not be justifiable from a risk or cost standpoint. Additional views included the need to provide flexibility in the standards to adjust for site-specific variations that could increase or decrease risk and cost. In addition, while industry and professional society representatives generally supported applying the concept of ALARA (that doses or risk be kept as low as is reasonably achievable), citizen groups and environmental organizations tended to distrust its application because of cost implications and insufficient opportunities for public oversight of the process.

Regarding human and environmental protection, participants generally agreed that the requirements should protect existing and future generations from risks associated with residual radioactivity. A number of participants pointed out that removing radiological contamination from a nuclear facility to a waste disposal facility may merely transfer the risks. Participants believed that the requirements should provide equal protection for individuals, especially rural populations, people of color, and the environment. Diverse opinions were offered on whether requirements established to protect human health are sufficiently protective of the environment. Strong views were also expressed on the scientific basis for health risk estimates associated with ionizing radiation. Some participants stressed reliance on national and international organizations, such as the National Council on Radiation Protection and Measurements or the International Commission on Radiological Protection. Others openly distrusted the recommendations of these organizations and urged NRC to consider alternative risk estimates developed by scientists that are not considered part of the mainline scientific movement.

Diverse participants suggested that all types of risk be considered in developing and applying the requirements, such as occupational risk, public risk, and transportation risk. The assessments should also consider both radiological and non-radiological risks. Participants urged NRC to ensure that non-radiological and radiological risks are sufficiently mitigated or eliminated prior to terminating a license. In terms of appropriate magnitudes for the radiological criteria, the views varied widely, ranging from using the new public dose limit in 10 CFR Part 20 (100 mrem/yr) to dose values as low as 0.03 mr/yr or

"0" (background level). Other options presented and discussed included use of the exemption levels recommended by the International Atomic Energy Agency (a few mrem/yr) and values consistent with the risk range EPA finds acceptable in selecting remedial goals for Superfund sites (10^{-4} to 10^{-6} lifetime risk of cancer).

Most participants recognized the close linkage between decommissioning and waste disposal. Some participants argued for containing and storing wastes from decommissioning onsite, where they were generated, until demonstrably safe disposal facilities can be developed or until the waste decays away. Participants also opined that wastes formerly disposed at nuclear facilities should not be "grandfathered" in applying the new requirements, unless they pose no significant health or safety hazards. Individual participants urged NRC against allowing any decommissioning activities without an approved decommissioning plan. Some participants encouraged NRC to reconsider the merits of the ENTOMB option, which was severely restricted in NRC's 1988 rulemaking to establish procedural and financial requirements for decommissioning. In contrast, other participants noted that some existing nuclear sites would be unsatisfactory for long-term storage of waste because the environmental characteristics of the sites do not contribute to long-term isolation, such as locations in floodplains or areas of shallow groundwater.

Other broad issues discussed included the need to ensure that future designs of nuclear facilities enable return to background levels and minimize the generation of waste and contaminated materials. Diverse groups questioned how NRC will determine and require compatibility of Agreement State programs, including the prerogative of the States to set more stringent standards. Some participants stressed the need for NRC and EPA to consider potential implications of the decommissioning criteria on sites that have been contaminated with naturally occurring radioactive material (NORM).

NRC is currently considering the workshop comments, as well as written comments received on the Rulemaking Issues Paper, in developing the draft radiological criteria for decommissioning. NRC is also developing a Generic Environmental Impact Statement (GEIS) as a decision-aiding document in the development of the radiological criteria. Scoping meetings for the GEIS were held in Washington, DC, San Francisco, Oklahoma City, and Cleveland at the end of July 1993. EPA is participating in the development of the GEIS as a cooperating agency. A draft of the GEIS should be complete by December 1993.

NRC plans to circulate the draft radiological criteria for decommissioning to the Agreement States, workshop participants, and other interested parties in January 1994, in advance of formal Commission review of the draft proposed rule. The NRC staff will forward the draft proposed rule for Commission consideration in May 1994, allowing publication of the proposed rule for formal public comment in June 1994. On this schedule, the final rule should be complete by May 1995.

NRC staff contacts regarding the rulemaking are Mr. Francis X. Cameron, Office of General Counsel, telephone 301-504-1642, and Dr. Robert A. Meck, Office of Nuclear Regulatory Research, telephone 301-492-3737. Information related to the rulemaking is also available on an electronic bulletin board which can be accessed by calling 800 880-6091. The NRC staff contact for the bulletin board is Ms. Christine Daily, telephone 301 492-3999.

Appendix F
Glossary

ACTIVITY - The mean number of nuclear transformations occurring in a given quantity of radioactive material per unit time. The International System (SI) unit of activity is the becquerel (Bq) and the conventional unit is the curie (Ci). 1 Bq = 1 nuclear transformation per second; 1 Ci = 3.7×10^{10} Bq.

ALARA (Acronym for "<u>A</u>s <u>L</u>ow <u>A</u>s Is <u>R</u>easonably <u>A</u>chievable") - A basic concept of radiation protection that specifies that exposure to ionizing radiation and releases of radioactive materials should be reduced as far below regulatory limits as is reasonably achievable considering economic, technological, and societal factors, among others. ALARA is not a dose limit, but rather a process with the objective of limiting dose levels as far below applicable limits as reasonably achievable.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI) - An organization that develops standards for a wide variety of practices, using a consensus process so that the standards are broadly agreed upon. ANSI has developed a large number of standards that apply to the nuclear industry and to radionuclide measurement.

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARs) - Standards, requirements, criteria or limitations under any federal environmental law, or more stringent standards under State environmental law or facility siting laws, that apply in selecting a remediation approach and determining the level of cleanup required. The National Contingency Plan provides guidance on how to determine ARARs.

ATOMIC ENERGY ACT (AEA) as amended — 42 USC 2011-2296. Provides authority for EPA to establish generally applicable environmental radiation standards and guidance, applicable to all radioactive materials (including source, byproduct, and special nuclear material). EPA establishes standards and other agencies are responsible for actual implementation. It is also a basis of NRC's and DOE's authorities.

BACKGROUND RADIATION - Ionizing radiation in the natural environment from cosmic sources and naturally occurring radioactive elements in their unaltered forms. Background radiation does not include radiation from technologically enhanced levels of naturally occurring radionuclides or radiation from source, byproduct, or special nuclear materials regulated by the Nuclear Regulatory Commission.

BYPRODUCT MATERIAL - Two types of materials are defined: 1) any radioactive material (except special nuclear material) yielded in, or made radioactive by, exposure to the radiation generated by producing or using special nuclear material; and 2) the tailings or wastes produced by extracting or concentrating uranium or thorium from ore processed primarily for those purposes, including surface wastes resulting from uranium solution extraction processes. (Underground ore bodies depleted by solution extraction operations are not "byproduct material" under this definition.)

CLEAN AIR ACT (CAA) as amended — 42 USC 7401 - 7671 q. The CAA began to take its current form in 1970 and 1971, with major amendments in 1977. It was substantially revised, particularly with respect to hazardous materials (including radionuclides), in 1990.

COLLECTIVE DOSE - The sum of the individual doses received in a given period of time by a specified population from exposure to a specified source of radiation.

COMPREHENSIVE ENVIRONMENTAL, RESPONSE, COMPENSATION, AND LIABILITY ACT OF 1980 (CERCLA) as amended — 42 USC 9601-9657. Commonly known as "Superfund," this act provides for cleanup and emergency response when hazardous substances are or may be released into the environment, and for cleaning up inactive hazardous waste disposal sites. The major amendment was the Superfund Amendments and Reauthorization Act of 1986 (P.L. 99-499, known as SARA.)

CONFERENCE OF RADIATION CONTROL PROGRAM DIRECTORS (CRCPA) - An organization of state officials responsible for radiation protection that works to establish programs to protect public health and safety from exposure to radiation. CRCPD cooperates with federal agencies in these efforts.

DECOMMISSIONING - The process for safely removing a nuclear facility from service and reducing residual radioactivity to a level that permits release of the facility for unrestricted use and termination of the license.

DOSE — Specifically, the energy imparted by ionizing radiation to a unit mass of matter, measured in rads. In general usage, dose also may refer to dose-equivalent which is measured in rems. Dose-equivalent is the product of the dose times a quality factor that accounts for increased biological damage that can be inflicted (per unit dose) by neutrons and alpha particles. [Note: In measuring the intensity of photons, the term exposure also has a specific meaning and is measured in roentgens. In this document, the common usage of the word is meant unless otherwise specified.]

EXPOSURE - Direct contact with or assimilation of radioactive materials or proximity to unshielded sources of ionizing radiation.

EXPOSURE PATHWAY - The physical course a chemical or pollutant takes from the source to the organism exposed.

EXPOSURE ROUTE - The way a chemical or pollutant enters an organism after contact, e.g., by ingestion, inhalation, or dermal absorption.

EXTERNAL EXPOSURE - Radiation exposure from radioactive sources located outside of the body.

FORMERLY UTILIZED SITES REMEDIAL ACTION PROGRAM (FUSRAP) - A DOE program to clean up certain sites that are no longer in use. These sites are not covered by UMTRCA, but have similar contamination problems, so similar cleanup criteria may apply.

HALF-LIFE, RADIOACTIVE - The time required to decrease the original number of atoms of a given radioactive substance by 50% due to radioactive decay. Each radionuclide has a unique half-life.

HAZARD RANKING SYSTEM (HRS) - A scoring system developed and used by EPA to assess the relative risk to human health and the environment posed by actual or potential releases of hazardous substances from sites and facilities. The HRS is the principal mechanism for placing sites on the National Priorities List (NPL). It was adopted by EPA as appendix A to the National Oil and Hazardous Substances Contingency Plan, 40 CFR Part 300, on July 16, 1982 (47 FR 31180) and was revised substantially (55 FR 51532, on December 14, 1990) to comply with statutory requirements in the Superfund Amendments and Reauthorization Act of 1986.

Appendix E
List of Acronyms

AEA	Atomic Energy Act
ALARA	As Low As is Reasonably Achievable
ANSI	American National Standards Institute
ARARS	Applicable or Relevant and Appropriate Requirements
BAT	Best Available Technology
CAA	Clean Air Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CRCPD	Conference of Radiation Control Program Directors
DERP	DoD's Defense Environmental Restoration Program
DoD	Department of Defense
DOE	Department of Energy
DOT	Department of Transportation
FEMA	Federal Emergency Management Agency
FFCA	Federal Facilities Compliance Act of 1992
FUSRAP	Formerly Utilized Sites Remedial Action Program
GTCC	Greater Than Class C Waste
HLW	High-Level Waste
HSWA	Hazardous and Solid Waste Amendments to the Resource Conservation and Recovery Act
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
IRP	DoD's Installation Restoration Program
LLW	Low-Level Waste
MCL	Maximum Contaminant Level
MOU	Memorandum Of Understanding
NARM	Naturally occurring and Accelerator-produced Radioactive Materials
NCP	National Contingency Plan
NCRP	National Council on Radiation Protection and Measurements
NESHAPS	National Emission Standards for Hazardous Air Pollutants
NORM	Naturally Occurring Radioactive Materials
NPL	National Priorities List
NRC	Nuclear Regulatory Commission
NWPA	Nuclear Waste Policy Act of 1982
OERR	Office of Emergency and Remedial Response (EPA)
OSWER	Office of Solid Waste and Emergency Response (EPA)
RAGS	Risk Assessment Guidance for Superfund
RCRA	Resource Conservation and Recovery Act
SARA	Superfund Amendments and Reauthorization Act of 1986
SDWA	Safe Drinking Water Act
SFMP	Surplus Facilities Management Program
TSCA	Toxic Substances Control Act
TRU	Transuranic(s)
UMTRAP	Uranium Mill Tailings Remedial Action Program
UMTRCA	Uranium Mill Tailings Radiation Control Act

HAZARDOUS SUBSTANCE - Substances (usually thought of as chemicals or mixtures) that are declared hazardous by various environmental statutes. Radioactive materials are not always considered hazardous substances. For example, radionuclides are hazardous substances under the CAA, but other acts exclude "source, special nuclear, or byproduct material" from their definitions. RCRA exempts radionuclides from its definition of solid waste and, hence, does not consider radionuclides to be hazardous waste.

HIGH-LEVEL WASTE (HLW) - The highly radioactive material resulting from the processing of spent nuclear fuel, including liquid waste produced directly in processing and any solid material derived from such liquid waste that contains fission products in sufficient concentrations and other highly radioactive material that the [Nuclear Regulatory] Commission, consistent with existing law, determines by rule requires permanent isolation.

INTERNAL EXPOSURE (INTERNAL EMITTER) - Radiation exposure from radionuclides distributed within the body.

INTERNATIONAL ATOMIC ENERGY AGENCY (IAEA) - Based in Vienna, Austria, IAEA helps to assure that atomic energy programs in all countries meet certain standards through a program of voluntary compliance and inspection. IAEA also offers guidance on a wide variety of radiological topics, including waste mitigation, minimization, and prevention of radiation risks to the environment.

INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION (ICRP) - An international organization that develops guidance and standards for radiological measurement and protection of public and occupational health. The ICRP is composed of a Chairman and never more than 12 other members. The selection of the members is made by the ICRP from nominations submitted to it by the National Delegations to the International Congress of Radiology and the ICRP staff itself. Members of the ICRP are chosen on the basis of their recognized activity in the fields of medical radiology, radiation protection, physics, biology, genetics, biochemistry, and biophysics. The Commission's rules require that its members be elected every four years.

IONIZING RADIATION - Alpha, beta, or neutron particles, and gamma photons and x-rays (or both), released during the radioactive decay of an unstable atom, that have sufficient energy to produce ionization directly in their passage through a substance.

ISOTOPES - Atoms of the same chemical element that have the same number of protons but different numbers of neutrons in the nucleus. Isotopes of an element have the same atomic number but different atomic weights.

LOW-LEVEL WASTE (LLW) - Radioactive waste that is not classified as high-level waste, transuranic waste, spent nuclear fuel, or byproduct material as defined in the Atomic Energy Act of 1954. Commercial LLW is subdivided into Class A, Class B, Class C, and Greater-Than-Class-C (GTCC) wastes based on the NRC regulations that govern their disposal. As the concentrations of radionuclides increase from Class A to GTCC, the wastes are considered more hazardous and warrant increasingly stringent disposal methods. DOE Order 5820.2A further specifies that test specimens of fissionable material irradiated for research and development only, and not for the production of power or plutonium, may be classified as low-level waste, provided the concentration of transuranic elements is less than 100 nCi/g.

MAXIMUM CONTAMINANT LEVEL (MCL) - An enforceable standard under the Safe Drinking Water Act, set as close to the maximum contaminant level goal as feasible considering cost, availability of treatment technologies, and other practical issues.

MILLIREM (mREM) - A unit of dose equal to 1 x 10^{-3} rem. This is the dose unit most commonly used in the radionuclide NESHAPs under the Clean Air Act.

MIXED WASTE - Waste that contains both hazardous waste, as defined by RCRA, and source, special nuclear, or by-product material as defined in the Atomic Energy Act of 1954 (Federal Facilities Compliance Act of 1992).

NATIONAL OIL AND HAZARDOUS SUBSTANCES CONTINGENCY PLAN (NCP) - The plan published under Section 311(c) of the Federal Water Pollution Control Act, or revised under Section 105(a) of the Comprehensive Environmental, Response, Compensation, and Liability Act. The NCP deals with removal of oil and hazardous substances from water bodies and land-based facilities.

NATIONAL COUNCIL ON RADIATION PROTECTION AND MEASUREMENTS (NCRP) - A U.S. nonprofit organization chartered by Congress in 1964 to, among other functions, collect, analyze, develop, and disseminate information about radiation protection and radiation measurements, quantities, and units. The NCRP is made up of the members and the participants who serve on the 54 Scientific Committees of the Council. The Scientific Committees, composed of experts having detailed knowledge and competence in the particular area of the Committee's interest, draft proposed recommendations. These recommendations are then submitted to the full membership of the Council for careful review and approval before being published. To facilitate and stimulate cooperation among organizations concerned with the scientific and related aspects of radiation protection and measurement, the Council has created a category of NCRP Collaborating Organizations. National or international organizations that are concerned with scientific problems involving radiation may be admitted to collaborating status by the Council.

NATIONAL EMISSION STANDARDS FOR HAZARDOUS AIR POLLUTANTS (NESHAPS) - Emission standards promulgated under Section 112 of the Clean Air Act. NESHAPs have been promulgated for both chemical substances, such as benzene, and for radionuclides emitted from eight categories of sources: underground uranium mines (radon); DOE facilities (non-radon); NRC and non-DOE federal facilities (all radionuclides); elemental phosphorus plants (polonium-210); DOE facilities (radon); phosphogypsum stacks (radon); disposal of uranium mill tailings (radon); and operating mill tailings (radon).

NATIONAL PRIORITIES LIST (NPL) - A nationwide list of sites with threatened or known releases of hazardous substances, ranked in order of priority according to relative risk or danger to the public after considering several criteria. The NPL is published under Section 105(8)(B) of the Comprehensive Environmental, Response, Compensation, and Liability Act.

NATURALLY OCCURRING AND ACCELERATOR-PRODUCED RADIOACTIVE MATERIALS (NARM) - Any radioactive material produced as a result of nuclear transformations in an accelerator, and any nuclide that is radioactive in its natural physical state (i.e., not anthropogenic), excluding source, byproduct, and special nuclear material. A common use for accelerator-produced radionuclides is in the manufacture of radiopharmaceuticals. Currently, NARM is not generally covered by any federal regulatory program (other than FDA, DOT), but states may issue their own regulations. CRCPD acts as a coordinating group to see that states regulate these materials similarly. See "NORM" for a description of naturally occurring radioactive materials.

NATURALLY OCCURRING RADIOACTIVE MATERIALS (NORM) - A subset of NARM (i.e., naturally occurring radionuclides excluding source, byproduct, and special nuclear material). NORM is typically associated with mineral processing and extraction industries. Radionuclide concentrations in NORM range from a few times background levels commonly found in coal ash to more than 100,000 times background levels that can be found in the scale deposits that build up in oil and gas production and adhere to the pipes and processing equipment.

NRC LICENSEE - The holder of an NRC or Agreement State license.

NUCLEAR WASTE POLICY ACT OF 1982 (NWPA) as amended — 42 USC 10101-10270. The NWPA established formal procedures for evaluating and selecting sites for geologic repositories for the disposal of spent nuclear fuel, wastes from reprocessing that fuel, and TRU wastes with activities and/or long half-lives. As part of the federal responsibilities under the NWPA, EPA is to promulgate generally applicable standards for protecting the environment from offsite releases of radioactive materials. NRC is directed to issue a license to DOE to operate a repository that meets all relevant requirements.

RADIOACTIVE DECAY - The spontaneous transformation of a nuclide into one or more different nuclides accompanied by either the emission of energy and/or particles from the nucleus, nuclear capture or ejection of orbital elements, or fission. Unstable atoms decay into a more stable state, eventually reaching a form that does not decay further or is very long-lived.

RADIONUCLIDE (NUCLIDE) - Any naturally-occurring or artificially produced radioactive element or isotope.

REM (historical origin = Roentgen Equivalent in Man) — A common unit of radiation measurement that accounts for the differences in biological effectiveness of different types of ionizing radiation. The rem is the product of the absorbed dose (the energy imparted to a unit mass of tissue) and a quality factor (a coefficient that is specific to the type of radiation being measured and that approximates its relative biological harm) and thus provides a standard unit of measurement for radiation protection purposes. For example, if 1 unit of beta or gamma radiation equals one rem, the same amount of energy of alpha radiation (quality factor = 20) will equal 20 rems, reflecting the greater biological harm delivered by the heavier alpha particles.

REMEDIAL INVESTIGATION/FEASIBILITY STUDY (RI/FS) - Evaluations conducted at waste sites under CERCLA to determine the extent of contamination and possible ways to reduce that contamination.

REPORTABLE QUANTITY - The amount of a hazardous substance that, when released to the environment, must be reported to the appropriate federal agency (usually the EPA for releases from facilities, and the National Response Center for releases from offshore facilities and ships) under Section 102 of CERCLA.

RESOURCE CONSERVATION AND RECOVERY ACT (RCRA) as amended — 42 USC 6901-6991i. Also known as the Solid Waste Disposal Act (SWDA). The major purposes of RCRA are to control disposal of solid and hazardous wastes, and to encourage resource recovery.

RISK ASSESSMENT GUIDANCE FOR SUPERFUND (RAGS) - A set of manuals being developed by the EPA Office of Solid Waste and Emergency Response (OSWER) for use during RI/FS studies at CERCLA sites. Volume I provides guidance for developing health risk information, and Volume II provides guidance for environmental assessments.

ROENTGEN - A unit of measurement of x- or gamma radiation exposure. One roentgen will produce one electrostatic unit of electricity in 1 cubic meter of dry air at 0 degrees Celsius and standard atmospheric pressures. [Note that the roentgen is only defined for photons, i.e. it is not a measure of alpha or beta radiation.]

SAFE DRINKING WATER ACT (SDWA) as amended — 42 USC 300f-300j-g. Originally concerned with surface waters and public water supply systems, later amendments have reflected concerns with aquifers and groundwater. Standards for all radionuclides in water have been promulgated.

SOURCE MATERIAL - This definition includes two types of material: 1) uranium or thorium or any combination of those elements in any physical or chemical form; or 2) ores that contain, by weight, 0.05 percent or more of uranium, thorium, or any combination of those elements. Special nuclear material is not included.

SPECIAL NUCLEAR MATERIAL - This definition includes two types of material: 1) plutonium, uranium-233, uranium enriched in the isotopes 233 or 235, and any other material that the NRC determines to be special nuclear material; or 2) any material artificially enriched by any of the above. Source material is not included.

SUPERFUND - (See CERCLA)

SURPLUS FACILITIES MANAGEMENT PROGRAM (SFMP) - A DOE program to clean up certain sites that are still owned by DOE and are still operational, but are no longer needed for DOE programs. These sites are not covered by UMTRCA, but have similar contamination problems, so similar cleanup criteria may apply.

TOXIC SUBSTANCES CONTROL ACT (TSCA) as amended — 15 USC 2601-2671. TSCA is aimed primarily at preventing health and environmental hazards from chemicals distributed in commerce. It covers any "element or uncombined radical," but excludes "source material, special nuclear material, [and] byproduct material" as defined in the AEA.

TRANSURANIC WASTE - Material contaminated with elements that have an atomic number greater than 92, including neptunium, plutonium, americium, and curium, and that are in concentrations greater than 10 nanocuries per gram, or in such other concentrations as the Nuclear Regulatory Commission may prescribe to protect the public health and safety (Atomic Energy Act, 1954 Supplement, § 2014(ee).

UNRESTRICTED USE - Return of a site formerly contaminated with radioactivity to a use for any purpose by the public. This requires that contamination in buildings, equipment, surface water, groundwater, and soil be reduced to a level that is acceptable to protect public health and safety.

URANIUM MILL TAILINGS RADIATION CONTROL ACT (UMTRCA) of 1978 as amended — 42 USC 2014-2201, 7901-7942. This law requires EPA to set standards for controlling residual radioactive material at uranium mills and tailings disposal sites to protect public health and the environment.

URANIUM MILL TAILINGS REMEDIAL ACTION PROGRAM (UMTRAP) - A DOE program to clean up tailings sites under its jurisdiction. The program reflects EPA standards (40 CFR 192), DOE Orders, and ALARA.