UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

CHAIRMAN

Commissioner Asselstine's
comments on page 2.

MEMORANDUM FOR: Commissioner Roberts
Commissioner Asselstine
Commissioner Bernthal
Commissioner Zech

FROM: Nunzio J. Palladino

SUBJECT: PROPOSED AMENDMENTS TO
URANIUM MILL TAILINGS REGULATIONS AND
ADVANCE NOTICE OF PROPOSED RULEMAKING

The purpose of this memorandum is to document my individual meetings with each of you yesterday on the above subject.

I met with each of you to discuss the proposed amendments and the Advance Notice of Proposed Rulemaking sent to the Federal Register on July 30, 1984. [

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M-1

cc: SECY
EDO
OGC
OPE
OCA
OPA

August 6, 1984

Joe-- This accurately reflects my position on the issue. However, I continue to be very distressed that the Commission would change a final position based upon the type of pressure from the staff of one of our oversight committees that you discribe in this draft memorandum.

Sd JKA for JKA

cc: Comm. Roberts
Comm. Bernthal
Comm. Zech

federal register

Friday
October 7, 1983

Part IV

Environmental Protection Agency

Environmental Standards for Uranium and Thorium Mill Tailings at Licensed Commercial Processing Sites; Final Rule

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L-28

ENVIRONMENTAL PROTECTION AGENCY

40 CFR Part 192

[AD-FRL-2431-6]

Environmental Standards for Uranium and Thorium Mill Tailings at Licensed Commercial Processing Sites

AGENCY: Environmental Protection Agency.

ACTION: Final rule.

SUMMARY: These are final health and environmental standards to govern stabilization and control of byproduct materials (primarily mill tailings) at licensed commercial uranium and thorium processing sites. These standards were developed pursuant to Section 275 of the Atomic Energy Act (42 U.S.C. 2022), as added by Section 206 of Pub. L. 95–604, the Uranium Mill Tailings Radiation Control Act of 1978 (UMTRCA).

The standards apply to tailings at locations that are licensed by the Nuclear Regulatory Commission (NRC) or the States under Title II of the UMTRCA. The standards for disposal of tailings require stabilization so that the health hazards associated with tailings will be controlled and limited for at least one thousand years. They require that disposal be designed to limit releases of radon to 20 picocuries per square meter per second, averaged over the surface of the disposed tailings, and require measures to avoid releases of radionuclides and other hazardous substances from tailings to water. The standards for tailings at operating mills, prior to final disposal, add two elements and a measure of radioactivity to the ground water protection requirements now specified under the Solid Waste Disposal Act, as amended. Existing EPA regulations and Federal Radiation Protection Guidance currently applicable to tailings remain unchanged. The Agency will monitor continuing development of technical and economic information as the Department of Energy proceeds with disposal of the inactive tailings piles, and revise these standards if this information suggests that modifications are warranted.

This notice summarizes the comments received on proposed standards published on April 29, 1983, and provides a summary of the Agency's consideration of major comments. Detailed responses to comments are contained in the Final Environmental Impact Statement.

DATE: These final standards take effect on December 6, 1983.

ADDRESSES: *Background Documents*—Background information is given in the Final Environmental Impact Statement for Standards for the Control of Byproduct Materials from Uranium Ore Processing (40 CFR Part 192), EPA 520/1–83–008 (FEIS) and the Regulatory Impact Analysis of Environmental Standards for Uranium Mill Tailings at Active Sites, EPA 520/1–83–010 (RIA). Single copies of the FEIS and the RIA, as available, may be obtained from the Program Management Office (ANR–458), Office of Radiation Programs, U.S. Environmental Protection Agency, Washington, D.C. 20460; telephone number (703) 557–9351.

Docket: Docket Number A–82–26 contains the rulemaking record. The docket is available for public inspection between 8:00 a.m. and 4:00 p.m., Monday through Friday, at EPA's Central Docket Section (LE–130), West Tower Lobby, Gallery I, 401 M Street, SW., Washington, D.C. 20460. A reasonable fee may be charged for copying.

FOR FURTHER INFORMATION CONTACT: Mr. Jack Russell, Guides and Criteria Branch (ANR–460), Office of Radiation Programs, U.S. Environmental Protection Agency, Washington, D.C. 20460; telephone number (703) 557–8224.

SUPPLEMENTARY INFORMATION:

I. Introduction

On November 8, 1978, Congress enacted Pub. L. 95–604, the Uranium Mill Tailings Radiation Control Act of 1978 (henceforth designated "UMTRCA"). In the Act, Congress stated its finding that uranium mill tailings "* * * may pose a potential and significant radiation health hazard to the public, * * * and * * * that every reasonable effort should be made to provide for stabilization, disposal, and control in a safe and environmentally sound manner of such tailings in order to prevent or minimize radon diffusion into the environment and to prevent or minimize other environmental hazards from such tailings." The Administrator of the Environmental Protection Agency (EPA) was directed to set "* * * standards of general application for the protection of the public health, safety, and the environment * * *" to govern this process of stabilization, disposal, and control.

UMTRCA established two programs to protect public health, safety, and the environment from uranium mill tailings, one for certain designated sites which are now inactive (i.e., at which all milling has stopped and which are not under license) and another for active sites (those sites licensed by the Nuclear Regulatory Commission (NRC) or the State in which the site is located, wi[illegible] this State is an Agreement State of [illegible] NRC under Section 274 of the Atomic Energy Act).

Tailings at the inactive uranium milling sites are defined in UMTRCA as residual radioactive materials. The program for inactive sites covers the disposal of tailings and the cleanup of onsite and offsite locations contaminated with tailings. Final cleanup and disposal standards for the inactive sites were published by EPA on January 5, 1983 (48 FR 590). The U.S. Department of Energy (DOE) is responsible for carrying out these activities in conformance with these standards, with the concurrence of the NRC, and in cooperation with the States.

Tailings at active uranium milling sites are defined in UMTRCA as uranium byproduct materials. The program for active sites covers the final disposal of tailings and the control of effluents and emissions during and after milling operations. UMTRCA requires EPA to establish standards for this program, and that standards for nonradioactive hazards protect human health and the environment in a manner consistent with standards established under Subtitle C of the Solid Waste Disposal Act, as amended (SWDA). NRC or the licensing Agreement State is responsible for assuring compliance with the standards at active mill sites.

On January 4, 1983, Congress amended UMTRCA to provide additional guidance on the matters to be considered in establishing these standards and to establish new deadlines for their promulgation: "In establishing such standards, the Administrator shall consider the risk to the public health, safety, and the environment, the environmental and economic costs of applying such standards, and such other factors as the Administrator determines to be appropriate." The Act (Pub. L. 96–415) established a deadline of October 1, 1983 for promulgation of the standards. These final standards conform to the above requirements.

II. Summary of the Final Rule

This final rule modifies and clarifies some of the provisions of the proposed standards because of information obtained during the comment period and at public hearings (May 31, 1983, in Washington, and June 15–16, 1983, in Denver).

EPA received a wide range of comments on the proposed standards and the supporting documents. Several hundred letters were received and 34 individuals testified and/or submitted comments at the public hearings. Comments were received from a broad spectrum of participants, including private citizens, public interest groups, members of the scientific community, representatives of industry, and State and Federal agencies. EPA has carefully reviewed and considered these comments in preparing the FEIS, the RIA, and in developing these final standards. EPA's responses to major comments are discussed in this "preamble" and comments are discussed in detail in the FEIS. Section III of this preamble summarizes the major considerations upon which these standards are based, and in Section IV we discuss the major issues raised in public comments, our responses to them, and the specific changes in the standards that resulted from our consideration of public comments.

These standards are divided into two parts. The first part applies to management of tailings during the active life of the pile, and during the subsequent "closure period," i.e., after cessation of operations but prior to completion of final disposal, including the period when the tailings are drying out. These are standards that govern milling operations.

The second part specifies the conditions to be achieved by final disposal. Those standards guide the activities carried out during the closure period to assure adequate final disposal. They are standards that govern the design of disposal systems.

The major provisions of the final rule are summarized in the following list, with changes from the proposed rule noted. The final rule:

(1) Applies to management and disposal of byproduct materials at sites where ore is processed primarily to recover its uranium or thorium content.

(2) Applies to the regulatory activities of NRC and the States that license uranium or thorium mills.

(3) Requires that ground water be protected from uranium tailings to background or drinking water levels to preserve its future uses by incorporating the Solid Waste Disposal Act (SWDA) rules.

(4) Requires that disposal of uranium tailings piles be designed so that, after disposal, radon emissions will be limited to 20 picocuries per square meter per second.

(5) Requires that the disposal of uranium tailings be designed to maintain its integrity, in most cases, for at least 1000 years.

(6) Requires liners be used for ground water protection.

(7) Permits the regulatory agency to issue alternate ground water standards when the normally required levels will be satisfied no further from the edge of tailings than the site boundary, or within 500 meters of the tailings, whichever is less (instead of requiring EPA concurrence, as proposed).

(8) Requires corrective action to restore groundwater to its background quality to be in place within 18 months of a determination of noncompliance (instead of the proposed 12 months).

(9) Requires equivalent levels of protection for wet sites (where precipitation exceeds evapotranspiration) as for dry sites (by deleting the exception permitting a nonpermeable cap at wet sites).

(10) Requires the same level of protection at all sites regardless of current local populations.

(11) Establishes equivalent requirements for thorium byproduct materials.

III. Summary of Background Information

A. The Uranium Industry

The major deposits of high-grade uranium ores in the United States are located in the Colorado Plateau, the Wyoming Basins, and the Gulf Coast Plain of Texas. Most ore is mined by either underground or open-pit methods. At the mill the ore is first crushed, blended, and ground to the proper size for the leaching process which extracts uranium. Several leaching processes are used, including acid, alkaline and a combination of the two. After uranium is leached from the ore it is concentrated from the leach liquor through ion exchange or solvent extraction. The concentrated uranium is then stripped or extracted from the concentrating medium, precipitated, dried, and packaged. The depleted ore, in the form of tailings, is pumped to a tailings pile as a slurry mixed with water.

Since the uranium content of ore averages only about 0.15 percent, essentially all the bulk of ore mined and processed is contained in the tailings. These wastes contain significant quantities of radioactive uranium decay products, including thorium-230, radium-226, and decay products of radon-222. Tailings can also contain significant quantities of other hazardous substances, depending upon the source of the ore and the reagents used in the milling process. Most of the tailings are a sand-like material and, because such materials are attractive for use in construction and soil conditioning, have been improperly used in the past, thereby contributing to spreading the radioactive materials offsite. Tailings materials are also subject to wind and water erosion, which may spread radioactive materials offsite.

As of January 1983, there were 27 licensed uranium mills, of which only 14 were operating. By early 1983, the amount of stored tailings had reached about 175 million metric tons (MT). The size of individual tailings piles ranges from about 2 million MT to about 30 million MT.

The future demand for uranium is projected to be almost exclusively for electrical power generation. Based on recent DOE projections, it is estimated that at least an additional 175 million MT of tailings will be generated by the year 2000 in the United States. This projection is for the conventional milling of uranium described above. A small quantity of uranium is also recovered as a secondary product in the extraction of other minerals, such as phosphate and copper, and also by solution (*in situ*) mining methods. Foreign sources of uranium may also influence demand projections for the domestic uranium industry, especially since some foreign deposits are richer in uranium, which permits lower pricing.

The United States Government purchased large quantities of uranium, primarily for use in defense programs, from 1943 to 1970. Many of the producers of this uranium continued operating after 1970 to supply the commercial demand for uranium. In most cases the tailings from Government and commercial purchases were mixed and stored in the same pile. These mixed tailings are now referred to as "commingled" tailings. There are about 51 million MT of defense-related tailings commingled with approximately 74 million MT of other tailings at 13 of the sites which are now licensed for milling uranium ore.

B. Hazards Associated with Uranium Byproduct Materials

The most important of the hazardous constituents of uranium mill tailings is radium, which is radioactive. We estimate that currently existing tailings at the licensed sites contain a total of about 90,000 curies [1] of radium. Radium in addition to being hazardous itself, produces radon, a radioactive gas whose decay products can cause lung cancer. Because of the long life of thorium-230 (about 75,000 years half-life), the amount of radium in tailings, and therefore, the rate at which radon is produced, will decay to about 10 percent of the current amount in several

[1] A curie is the amount of radioactive material that produces 37 billion nuclear transformations (e.g., disintegrations of radium into radon) per second.

hundred thousand years. Other potentially hazardous constituents of tailings include arsenic, molybdenum, selenium, uranium, and, usually in lesser amounts, a variety of other toxic substances. The concentrations of all of these materials vary from pile to pile.

The radioactivity and toxic materials in tailings may cause cancer and other diseases, as well as genetic damage and teratogenic effects. More specifically, tailings are hazardous to man primarily because: (1) Radioactive decay products of radon may be inhaled and increase the risk of lung cancer; (2) individuals may be exposed to gamma radiation from the radioactivity in tailings; and (3) radioactive and toxic materials from tailings may be ingested with food or water. Our analysis shows the first of these hazards to be by far the most important.

As noted above, the radiation hazard from tailings lasts for many hundreds of thousands of years, and some nonradioactive toxic chemicals persist indefinitely. The hazard from uranium tailings therefore must be viewed in two ways. Tailings pose a present hazard to human health. Beyond this immediate but generally limited health threat, the tailings are vulnerable to human misuse and to dispersal by natural forces for an essentially indefinite period. In the long run the future risks to health of indefinitely-extended contamination from misused and dispersed tailings due to inadequate control overshadows the short-term danger to public health. The congressional report accompanying UMTRCA recognized the existence of long-term risks, and expressed the view that the methods used for disposal should not be effective for only a short period of time. It stated: "The committee believes that uranium mill tailings should be treated * * * in accordance with the substantial hazard they will present until long after existing institutions can be expected to last in their present forms * * *" and, in commenting on the Federally-funded program to clean up and dispose of tailings at the inactive sites, it stated "The committee does not want to visit this problem again with additional aid. The remedial action must be done right the first time." (H.R. Rep. No. 1480, 95th Cong., 2nd Sess., Pt. I, p. 17, and Pt. II, p. 40 (1978).)

For the purpose of establishing standards for the protection of the general public from radiation, we assume a linear, nonthreshold dose-effect relationship as a reasonable basis for estimating risks to health. This means we assume that any radiation dose poses some risk and that the risk of low doses is directly proportional to the risk that has been demonstrated at higher doses. We recognize that the data available preclude neither a threshold for some types of damage below which there are no harmful effects, nor the possibility that low doses of gamma radiation may be less harmful to people than the linear model implies. However, the major radiation hazard from tailings arises not from gamma radiation, but rather is due to alpha radiation from inhaled radon decay products. As pointed out by the National Academy of Sciences' (NAS) Advisory Committee on the Biological Effects of Ionizing Radiation (the BEIR Committee) in its 1980 report, for "* * * radiation, such as from internally deposited alpha-emitting radionuclides, the application of the linear hypothesis is less likely to lead to overestimates of risk, and may, in fact, lead to underestimates."

Our quantitative estimates of the risk due to inhalation of radon decay products are based on our review of epidemiological studies, conducted in the United States and in other countries, of underground miners of uranium and other metals who have been exposed to radon decay products. We have also considered reports by scientific groups, such as *Health Effects of Alpha Emitting Particles in the Respiratory Tract (1976)* and *The Effects on Populations of Exposure to Low Levels of Ionizing Radiation* (1980) by the NAS; the report of the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) entitled *Sources and Effects of Ionizing Radiation* (1977); Report No. 32, *Limits for Inhalation of Radon Daughters by Workers* (1981) of the International Commission on Radiological Protection (ICRP); and *Risk Estimates for the Health Effects of Alpha Radiation*, by D.C. Thomas and K.G. McNeill (1982), a detailed review prepared for the Atomic Energy Control Board of Canada (AECB). Details of our risk estimates are provided in a previous EPA report, *Indoor Radiation Exposure Due to Radium-226 in Florida Phosphate Lands* (EPA 520/4-78-013), and in the FEIS.

Although the studies of underground miners show that there is a significant risk of lung cancer from exposure to radon decay products, there is uncertainty in its magnitude. Our estimates of the risk due to inhalation of radon decay products exceed those of the ICRP and UNSCEAR by a factor of at least two. However, neither group considered continuous exposure for the duration of a person's lifetime nor documented that they properly projected the risk observed to date in groups of underground miners over the balance of their expected lifetimes. These factors were explicitly considered by the 1980 NAS BEIR Committee. Although the NAS Methodology differs from that employed by EPA, their numerical estimates of risk due to lifetime exposure are essentially identical to those of EPA. The most recent and complete assessment of the miner data, that performed for the AECB, yields a result within 20 percent of the EPA value. Numerical estimates of risk by various other observers differ by up to a factor of eight. We also considered the views of these other observers and discuss their results in the FEIS.

The uncertainties in risk estimates for exposure of miners to radon decay products arise from several sources. Exposures of miners were estimated from the time spent in each location in a mine and the measured radon decay product levels at those locations. However, radon decay product measurements were infrequent and often nonexistent for exposures of miners prior to the 1960's. The uncertainty increases when data for miners are used to estimate risk to members of the general public, because there are differences in age, physiology, exposure conditions, and other factors between the two populations.

We must also make numerous assumptions to estimate the radiation dose to individuals and population groups due to uranium mill tailings, and these introduce additional uncertainties. For example, we make risk estimates for individuals who are assumed to reside at the same location for their life spans, and we further assume that people will continue to have the same life expectancy as the U.S. population did in 1970. Nevertheless, we believe the information available supports estimates of risk which are sufficiently reliable to provide an adequate basis for these proposed standards.

It is not possible to reduce the risk to zero for people exposed to radiation or, for that matter, to many other carcinogens. To decide on a reasonable level of incremental residual risk, we evaluated the practicality and benefits of different levels of control. We also considered technical difficulties associated with implementing different levels of control.

Uranium mill tailings can affect man through four principal environmental pathways:

• *Diffusion of radon-222, the decay product of radium-226 tailings into indoor air.* Breathing radon-222, an inert gas, and its short half-life decay products, which attach to tiny dust particles, exposes the lungs to alpha radiation (principally from polonium–218 and polonium–214). The exposures involved may be large for persons who have tailings in or around their houses, or who live very close to tailings. Additional, but smaller, exposures to alpha radiation may result from long-lived radon–222 decay products (principally lead–210 and polonium–210). Exposure due to radon from tailings in or around buildings is best estimated from direct measurements of its decay products in indoor air.

• *Dispersal of radon and of small particles of tailings material in air.* Radon emitted from tailings is widely dispersed in air, and exposes both nearby residents and those at greater distances. These doses are predominantly to the lungs. Wind erosion of unstabilized tailings creates local airborne tailings material. The predominant dose from airborne tailings is to the bones from eating foods contaminated by thorium–230, radium–226, and lead–210, and is small. Exposure due to airborne transport of radon and particulates from tailings usually can be directly measured only near the pile or impoundment, but may be reliably estimated for larger distances using meteorological transport models.

• *Direct exposure to gamma radiation.* Many of the radioactive decay products in tailings produce gamma radiation. The most important are lead–214, bismuth–214, and thallium–210. Hazards from gamma radiation are limited to persons in the immediate vicinity of tailings piles or removed tailings. Exposure due to gamma radiation from tailings is readily estimated from direct measurements.

• *Waterborne transport of radioactive and toxic material.* Dispersal of unstabilized tailings by wind or water, or leaching, can carry radioactive and other toxic materials to surface or ground water. Current levels of contamination appear to be low at most sites. However, contamination of surface and ground water and consequent intake by animals has been identified at three locations. Potential exposure due to this possibility of ground and surface water contamination is highly site-specific and can generally only be determined by a careful survey program.

Our assessments of risks from tailings deal primarily with risks to man. This is because risks to other elements of the biosphere are judged to be mush less significant, and would therefore be controlled to acceptable levels by measures adequate to protect man. In addition, the following discussion focuses largely on *current* levels of risk to man from tailings through air and water pathways. However, these current risks could be expanded by future misuse of tailings by man and by uncontrolled future effects of natural forces. Our disposal standards reflect consideration of both current and potential future risks from tailings.

1. Air Pathways

We estimated the hazards posed by emissions to air from tailings piles or impoundments and from tailings used in and around houses. For the first case we used standard meteorological transport models and considered exposure of people in the immediate neighborhood of the existing tailings sites, the population in local regions, and the remainder of the national population. For the second, we drew largely upon experience from houses contaminated by tailings in Grand Junction, Colorado. Four sources of exposure were considered: inhaled short-lived radon decay products, gamma radiation, long-lived radon decay products, and airborne tailings particulates.

From this analysis we conclude:

(a) Lung cancer caused by the short-lived decay products of radon is the dominant radiation hazard from tailings. Estimated effects of gamma radiation, of long-lived radon decay products, and of airborne tailings particulates are relatively less significant, although high gamma radiation doses may sometimes occur.

(b) Individuals who have tailings in or around their houses often have large exposures to indoor radon and hence high risks of lung cancer. For example, in 50 percent of a sample of 190 houses with tailings in Grand Junction, Colorado, we estimate that the excess lifetime risk to occupants due to exposure to short-lived radon decay products prior to remediation may have been greater than 4 chances in 100.

(c) Individuals living near an uncontrolled tailings pile or impoundment are also subject to high risks fom short-lived radon decay products of radon emitted directly from tailings. For example, we estimate that people living continuously next to some tailings sites can have incremental lifetime lung cancer risks as high as 2 chances in 100.

(d) Based on models for the cumulative risk to all exposed populations, we estimate that, without control, the radon released directly from all tailings currently in existence at presently (1983) licensed sites would cause about 500 lung cancer deaths per century. This figure does not account for any deaths from misuse or windblown tailings because their number is more difficult to predict, even though risk to individuals from such tailings may be somewhat greater than from direct radon emissions. By the year 2000, we estimate that, without control, the amount of tailings existing then would cause approximately 600 lung cancer deaths per century. Approximately one-half of these deaths are projected to occur less than 50 miles from the piles. This increase is small, due primarily to the large amount of unused capacity at present sites, so that most new tailings could be placed on top of existing tailings. This analysis assumes that this will be the actual case, although it is possible that ground water contamination problems would be severe enough to require some piles to be closed. If this is the case, this estimate would be increased.

There is substantial uncertainty in these estimates because of uncertainties in the rate of release of radon from tailings sites, the exposure people will receive from its decay products, and from incomplete knowledge of the effects on people of these exposures. The values presented here represent best estimates based on current knowledge. In addition, these estimates are based upon current sizes and geographical distributions of populations and estimated production of tailings to the year 2000. As populations continue to increase in the future, and as production continues beyond the year 2000, the estimated impact will be larger.

Many commenters addressed the need to prevent misuse. Most concluded that misuse was the most hazardous aspect of tailings and should receive foremost attention. Although most concluded that misuse should be discouraged through means of passive controls, some concluded that misuse could be adequately controlled by institutional means. We conclude that a primary objective of standards for control of hazards from tailings through air pathways should be isolation and stabilization to prevent their misuse by man and dispersal by natural forces, such as wind, rain, and flood waters. A second objective is to minimize radon emissions from tailings sites. A third objective is the elimination of significant exposure to gamma radiation from tailings.

2. Water Pathways

Water contamination does not now appear to be a significant source of radiation exposure at most sites. However, in addition to radionuclides, nonradioactive toxic substances, such as arsenic, molybdenum, and selenium, can be leached from tailings and contaminate water. Such contamination could affect crops, animals, and people. Process water is used to carry tailings to the piles or impoundments as a slurry. Rainwater also may collect on the tailings. The greatest threat of contamination appears to be from process water discharged with the tailings from the mill, although, in principle, it could be from the gradual effects of rainwater over the indefinite future. Most of this water eventually evaporates or seeps away. Elevated concentrations of toxic or radioactive substances in ground water have been observed at many active sites (seven are identified in the FEIS), and in some standing surface water ponds (but only rarely in surface running water). Any future contamination of water after disposal would arise from the effects of rain or through flooding, from penetration of tailings from below by ground water, or from leaching of tailings transported offsite.

A theoretical analysis performed for the NRC of a large model tailings impoundment with no seepage control showed that contamination of ground water by selenium, sulfate, manganese, and iron might exceed current drinking water standards over an area 2 kilometers wide and 8 to 30 kilometers long. More than 95 percent of this projected contamination was attributed to initial seepage of process water discharged with the tailings during mill operations.

We recognize that the NRC generic model is only one of several that could be applied to transport of contaminants in groundwater. Other models could predict greater or less risks of ground water contamination. An example of greater risk is a plume of contamination that, under certain circumstances, could still move cohesively towards a water supply after the flow of liquid through the tailings has stopped following closure of a pile.

In general, the movement of contaminants through a pile and subsoil to ground water depends on a combination of complex chemical and physical properties, as well as on local precipitation and evapotranspiration rates. Chemical and physical processes can effectively remove or retard the flow of many toxic substances passing through subsoil. However, some contaminants, such as arsenic, molybdenum, and selenium, can occur in forms that are not removed. Typically, ground water can move as slowly as a few feet per year, and only in coarse or cracked materials does the speed exceed one mile per year. For these reasons, contaminants from tailings may not affect the quality of nearby water supply wells for decades or longer after they are released. However, once contaminated, the quality of water supplies cannot usually be easily restored simply by eliminating the source (although, in some cases, removing or isolating the tailings may contribute to improving water quality).

Based on results from the NRC generic model for mill tailings, it is likely that the observed cases of ground water contamination result from seepage of the liquid waste discharges from the mill, and can be controlled by preventing this seepage until the tailings dry out by natural evaporation. Additional future contamination of ground water after these liquid wastes are dried up should be much smaller, and in most cases would be expected to be eliminated by measures required to control misuse of disposed tailings by man and dispersal by wind, rain, and flood waters. These measures should also effectively eliminate the threat of contamination of surface water by runoff or from leaching of tailings transported offsite, and provide a degree of protection of surface and ground water from contamination by flooding. However, at some sites, especially in areas of high rainfall or where ground water tables intersect the tailings, special consideration of potential future contamination of ground water may be needed in designing disposal systems. For example, some commenters suggested incorporation of the SWDA rules for impoundment caps for wet sites. Others pointed out that for new piles careful site selection would provide protection of ground water.

We conclude that the primary objective of standards for control of hazards from tailings through water pathways is to prevent loss of process water through seepage, prior to closure. A secondary objective is to avoid surface runoff and infiltration both before and after disposal.

C. Control of Hazards from Tailings

We consider methods for control so as to assess the achievability, economic impact, and reliability of controls to meet alternative standards. As noted above, the objectives of tailings disposal (and of tailings management prior to disposal) are to prevent misuse by man, to reduce radon emissions and gamma radiation exposure, and to avoid the contamination of land and water by preventing erosion of tailings by natural processes and seepage of waste process water. The longevity of control is particularly important. This can be affected by the degree to which control measures discourage disruption by and by the resistance of control measures to such natural phenomena as earthquakes, floods, and windstorms, and to chemical and mechanical processes in the piles or impoundments. ("Piles" commonly means tailings simply piled up on the ground, and "impoundments" means piles constrained by dikes made of other materials. We will use the term "piles" to mean both henceforth.) Prediction of the long-term integrity of control methods becomes less certain as the period of concern increases. Beyond several thousand years, longer-term geomorphological processes and climatic change become the dominant factors. Methods are available for projecting performance for periods up to about 1000 years. A recent report prepared for the NRC ("Design Considerations for Long-Term Stabilization of Uranium Mill Tailings Impoundments," Colorado State University, 1983) provides an up-to-date detailed review of these matters.

Methods to prevent misuse by man and disruption by natural phenomena may be divided into those whose continued integrity depends upon man and his institutions ("active" control and those that do not ("passive" controls). Examples of active controls are fences, warning signs, restrictions on land use, inspection and repair of semi-permanent tailings covers, temporary dikes, and drainage courses. Examples of passive controls are thick earthen covers, rock covers, massive earth and rock dikes, burial below grade, and moving tailings piles out of locations highly subject to erosion, such as unstable river banks.

Erosion of tailings by wind, rain, and flooding can be inhibited by contouring the pile and its cover, by stabilizing the surface (with rock, for example) to make it resistant to erosion, and by constructing dikes to divert rapidly moving flood waters. Erosion can be inhibited even more reliably by burying tailings in a shallow pit and/or by locating them away from particularly flood-prone or otherwise geologically unstable sites. Thus, especially in the case of new tailings piles, shallow burial and sites with favorable long-term characteristics should be given preferred consideration.

Methods to inhibit the release of radon range from applying a simple barrier (such as an earthen cover) to such ambitious treatments as embedding tailings in cement or processing them to remove radium, the precursor of radon. Covering tailings with a permeable (porous) barrier, such as compacted earth, delays radon diffusion so that most of it decays in and is therefore effectively retained by the cover. In addition to simple earthen covers, other less permeable materials such as asphalt, clay, or soil cement (usually in combination with earthen covers) could be used. The more permeable the covering material, the thicker it must be to achieve a given reduction in radon release. However, maintaining the integrity of control of radon by thin, very impermeable covers, such as plastic sheets, is unlikely, even over a period as short as several decades, given the chemical and physical stresses present at piles.

The most likely constituents of cover for disposal of tailings are locally available earthen materials. The effectiveness of an earthen cover as a barrier to radon depends most strongly on its moisture content. Typical clay soils in the uranium milling regions of the West exhibit ambient moisture contents of 9 percent to 12 percent. For nonclay soils ambient moisture contents range from 6 percent to 10 percent. The exact value depends upon the material involved, and on local climatic conditions. The following table provides an example of the changes in cover thicknesses that might be required to reduce radon emission to 20 pCi/m²s for the above ranges of soil moisture. Four examples of tailings are shown that cover the probable extreme values of radon emission from bare tailings (100 to 1000 pCi/m²s); the most common value for old tailings is approximately 500 pCi/m²s, and for new tailings is approximately 300 pCi/m²s.

ESTIMATED COVER THICKNESS* (IN METERS) TO ACHIEVE 20 PCI/M²S**

Radon emission from tailings (pCi/m²s)	Percent moisture content of cover			
	6	8	10	12
100	1.7	1.3	1.0	0.7
300	2.8	2.2	1.5	1.1
500	3.4	2.6	2.0	1.5
1000	4.1	3.2	2.4	1.8

* These values were calculated from equation (9) in Appendix P of the Final Generic Environmental Impact Statement on Uranium Milling, U.S. Nuclear Regulatory Commission, NUREG-0706, September 1980. They do not include allowance for uncertainties in tailings moisture content or diffusion properties of the cover.

** A picocurie (pCi) is a trillionth of a curie. One picocurie of material produces just over two transformations per minute. A pCi/m²s is a unit for the release rate of radioactivity from a surface (m = meter, s = second).

These values are for homogeneous covers, and assume the tailings have the same moisture content as the cover. In practice, somewhat thicker covers would be required to provide long-term assurance of satisfying any particular level of control. Some of the factors that must be considered for predicting long-term performance are moisture content of the tailings and cover at equilibrium, and the measured diffusion characteristics of cover materials. The DOE and NRC have conducted studies which provide a basis, at least within a limited range of control and predictability, for addressing these factors in the design of tailings covers based on locally available materials and climate.

Methods that control radon emissions will also prevent transport of particulates from the tailings pile to air or to surface water. Similarly, permeable covers sufficiently thick for effective radon control will also absorb gamma radiation effectively (although thin impermeable covers will not).

Two methods may be considered for protecting ground water at new tailings piles. The first is the placement of a physical barrier, called a liner, between the tailings and the aquifer zone, to prevent water containing hazardous constituents from entering the aquifer. Either clay or plastic liners can be installed at about the same cost. Both have shortcomings. Plastic liners are impermeable, but may be subject to rupture through poor installation or uneven loading. Clay liners are permeable to some constituents, and may require use of additional measures, such as partial neutralization of the tailings, especially at acid leach mills, to satisfactorily protect ground water, but are expected to retain their effectiveness for long periods of time. The second method is treatment of process water to modify its acidity or alkalinity, if such treatment were shown to prevent contamination. At a neutral level many hazardous constituents of tailings liquids become insoluble and thus not available to contaminate ground water. However, not all hazardous constituents are so affected, and the action of rainwater, certain weathering processes, and mineralization of the soil or rock matrix can upset this neutralization over time, thereby releasing contaminants. There is little difference in costs for these two methods. Liners (either clay or synthetic) are currently required by NRC as a matter of good engineering practice for most new tailings impoundments.

EPA does not believe it is environmentally desirable to require all new wastes at existing sites to be placed on new piles, because new piles would increase radon emissions, at least until the pre-existing pile is covered, and would permanently contaminate more land. Satisfying ground water standards at existing tailings sites that do not have liners, however, will require widely varying actions from site to site. Neutralization of existing tailings is not a generally feasible option since it would require excavation of most, if not all of the tailings to assure mixing, and may not immobilize all hazardous constituents. Ground water contamination is known to have occurred at seven sites, and may be occurring at many others. It may not be possible to cleanup the ground water at some sites. In the worst cases a new, lined tailings pile may be required to prevent contamination from new tailings. In other cases, existing tailings piles may release essentially no contaminants to ground water because the type of soil they rest on acts as an effective liner. We have discussed the range of possible costs for cleanup of ground water in the FEIS and RIA. In practice, we expect most tailings piles will fall somewhere between these two extremes. Less expensive corrective action than a new liner may be sufficient to satisfy ground water standards for hazardous constituents at many sites. For example, an active water management program may be employed to reduce the quantity of water in the tailings and thus reduce the driving force for ground water contamination, or back pumping of water around the piles may prevent losses to the surrounding ground environment. Actions such as these are already being taken at certain sites (Cotter Mill, Canon City, CO, and Homestake Mill, Grants, NM, for example).

Control of possible long-term low-level contamination of ground water may sometimes be difficult. In cases where intrusion of contamination into ground or surface water is a potentially significant problem, liners and caps may provide a good degree of protection for at least many decades. However, more permanent protection may, in such cases, require choice of (for new tailings) or removal to (for existing tailings) a site with more favorable hydrological, geochemical, or meteorological characteristics.

Very effective long-term inhibition of misuse by man, as well as of releases to air and surface water, could be achieved by burying tailings in deep mined cavities. In this case, however, direct contact with ground water would be difficult to avoid. The potential hazards of tailings could also be reduced by chemically processing them to remove contaminants. Such processes have limited efficiencies, however, so the residual tailings would still require some control. Furthermore, the extracted substances (e.g., radium and thorium) would be concentrated, and would themselves require careful control.

We analyzed the practicality of a number of possible control methods. These are described in the FEIS and the RIA. The total cost of disposal by surface or shallow burial is affected most strongly by the type of material used to stabilizer the surface of the trailings against erosion and to inhibit misuse by man, and by the water protection features required. Total costs are less sensitive to the amount of cover required to inhibit radon release. In general, costs of covers using man-made materials (e.g., asphalt) are somewhat higher than costs for earthen covers, and the reliability is lower. Active control measures are usually less costly in the short term than are passive measures, but are considered much less reliable in the long term. Deep burial of tailings piles or use of chemical processing to extract radium are much more costly than for surface or shallow burial (below grade) disposal using covers, and the practicality is not demonstrated.

D. Environmental Standards and Guidance Now Applicable to Uranium Tailings

EPA recognizes that it is establishing standards in an area that is already the subject of governmental regulation and has taken into account, where relevant, the existing schemes and levels of protection in developing these standards.

EPA promulgated 40 CFR Part 190, "Environmental Radiation Protection Standards for Uranium Fuel Cycle Operations," on January 13, 1977 (42 FR 2858). These standards specify the upper limits of radiation doses to members of the general public to which normal operations of the uranium fuel cycle must conform. They cover radiation doses due to all environmental releases of uranium by-product materials during the period a milling site is licensed, with the exception of emissions of radon gas and its decay products.

The Nuclear Regulatory Commission promulgated rules in 10 CFR Part 40 on October 3, 1980, which specify licensing requirements for uranium and thorium milling activities, including trailings and wastes generated from these activities (45 FR 65521). These rules specify technical, surety, ownership, and long-term care criteria for the management and final disposition of by-product materials. Some of these rules are affected by these standards. For example, they specified a design objective of 2 pCi/M²s and a longevity of greater than 1000 years for disposal of tailings. Due to congressional actions, these regulations have never been enforced by NRC, although some Agreement States have enforced comparable regulations. We note that the NRC regulations specified design objectives; that is, the values specified were to be achieved based on average performance; whereas these EPA rules specify standards, which designers must plan not to exceed, with a reasonable degree of assurance. The NRC has noted that any changes necessary will be made when these EPA standards are promulgated, and has already suspended those portions of its regulations which are affected by these standards (48 FR 35350; August 4, 1983).

Under the Agreement State program, States can issue licenses for uranium processing activities, including control and disposal of by-product materials. The NRC has enumerated in 10 CFR Part 150 the authorities reserved to it in its relations with Agreement States under the provisions of UMTRCA, and has specified conditions under which Agreement States may issue licenses under UMTRCA (45 FR 65521). NRC's conditions include the specification that State licenses must ensure compliance with EPA's standards. Some Agreement States can adopt more stringent rules than those adopted and enforced by the NRC, including requirements that are more stringent than EPA's standards.

EPA promulgated 40 CFR Part 260 et seq., "Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," under Subtitle C of the Solid Waste Disposal Act, as amended on July 26, 1982 (47 FR 32274). Although radioactive materials controlled under the Atomic Energy Act of 1954, as amended, are not covered by the SWDA, UMTRCA requires that the standards proposed herein provide for protection of human health and the environment from nonradioactive hazards in a manner consistent with applicable standards promulgated under Subtitle C of the SWDA. The Act also requires the NRC to ensure conformance to "* * * general requirements established by the Commission, with the concurrence of the Administrator, which are, to the maximum extent practicable, at least comparable to requirements applicable to the possession, transfer, and disposal of similar hazardous material under [Subtitle C of SWDA]."

EPA promulgated 40 CFR Part 440, "Ore Mining and Dressing Point Source Category: Effluent Limitations Guidelines and New Source Performance Standards, Subpart C—Uranium, Radium and Vanadium Ores Subcategory," on December 3, 1983 (47 FR 54598). The purpose of 40 CFR Part 440 is to establish effluent limitations and standards under the Clean Water Act for existing and new sources in a number of ore mining and dressing subcategories. Out of 27 mills in the uranium, radium and vanadium ores subcategory existing at that time, only one was discharging directly to surface water. In view of this, the regulations did not establish best available technology (BAT) limitations for existing sources in this subcategory. The one uranium mill directly discharging effluents is currently regulated by a discharge permit in accordance with previously existing best practicable control technology (BPT) effluent limitations contained in 40 CFR Part 440. The new source performance standards (40 CFR 440.34(b)) were based upon the demonstration of no discharge to surface waters at the 26 other mills. These standards apply to locations where the annual evapotranspiration rate exceeds the annual precipitation rate (as is the case in most uranium milling areas), and require no discharge of process waste water to surface waters from mills using the acid leach, alkaline leach, or combined acid and alkaline leach process for the extraction of uranium. For locations where there is more precipitation than evapotranspiration process waste water can be discharged up to the difference between annual precipitation and evapotranspiration.

Solution extraction, or "*in situ*" mining, is a processing method in which uranium is recovered from ore without moving or disturbing the ore body. In this method holes are drilled at selected points around an ore body and a solvent is pumped into some holes and the resulting solution out other holes. The solvent passes through the ore, dissolves the uranium, and carries it back to the surface. The uranium is then stripped from the solution and concentrated. The solvent, which is stored in holding ponds, can be treated and reused or discarded. Although this method produces no sandy tailings, it does produce sludges that contain many of the same radioactive and nonradioactive substances found in tailings piles. Consequently, the above-ground wastes from *in situ* mining are covered in these proposed standards. We note that because *in situ* mining and conventional milling currently are done in the same regions of the country, disposal of sludges on tailings piles may often be arranged.

Rules for protection of ground water from the underground operations of *in situ* mining are provided by the Underground Injection Control program promulgated under Sections 1421 and 1422 of the Safe Drinking Water Act.

The associated regulations, 40 CFR Parts 144, 145, and 146, impose administrative and technical requirements on such operations, through either approved State programs or EPA-implemented programs. These regulations are not intended to apply to the underground ore bodies depleted by *in situ* uranium mining operations.

In addition to these rules established under UMTRCA, EPA is required to establish emission standards under the Clean Air Act (CAA) for hazardous air pollutants. Although there are no final standards for air emissions applicable to mill tailings piles, a proposed rule for radionuclides has been published in the **Federal Register** (48 FR 15076) on April 6, 1983. The relationship of the Clean Air Act of this rule is discussed in more detail later in this preamble.

Finally, radiation protection guidance to Federal agencies for the conduct of their radiation protection activities was issued by the President on May 13, 1960 and published on May 18, 1960 (25 FR 4402). Federal Radiation Protection Guidance governs the regulation of radioactive materials by the NRC and Agreement States, and includes the following guidance: "* * * every effort should be made to encourage the maintenance of radiation doses as far below [the Federal Radiation Protection Guides] as practicable * * *" and "There can be no single permissible or acceptable level of exposure without regard to the reason for permitting the exposure. It should be general practice to reduce exposure to radiation, and positive effort should be carried out to fulfill the sense of [this Guidance]. It is basic that exposure to radiation should result from a real determination of its necessity." This guidance is currently known as the "as low as reasonably achievable" (ALARA) principle. It is particularly suited to minimizing radiation exposure under conditions that vary greatly from site to site, or from time to time, and is an integral part of NRC and Agreement State licensing determinations.

The standards published here will supplement the above standards, guidance, and regulations in order to satisfy the purposes of UMTRCA to "* * * stabilize and control * * * tailings in a safe and environmentally sound manner and to minimize or eliminate radiation health hazards to the public." UMTRACA does not provide specific criteria to be used in determining that these purposes have been satisfied. EPA's objective, when not preempted by other statutory requirements, has been to propose standards that: (1) Take account of health, safety, and environmental and economic costs and benefits in a way that assures adequate protection of the public health, safety, and the environment; (2) can be implemented using presently available techniques and measuring instruments; and (3) are reasonable in terms of overall costs and benefits.

The legislative record shows that Congress intended that EPA set general standards and not specify any particular method of control. "The EPA standards and criteria should not interject any detailed or site-specific requirements for management, technology or engineering methods * * *" (H.R. Rep. No. 1480, 95th Cong., 2nd Sess., Pt. I, P.17.) UMTRCA gives the NRC and the Agreement States the responsibility to decide what methods will assure these standards are satisfied at specific sites. (However, EPA must concur with NRC regulations established to implement Section 82a(3) of UMTRCA.) Therefore, our analyses of risk, control methods, costs, and other pertinent factors emphasize the general characteristics of uranium mill tailings and the affected sites.

IV. Resolution of Major Issues Raised in Public Comments

A. The Basis for the Standards

1. Health Risk Models

Several commenters expressed the view that the models used by EPA overestimate health risks from breathing radon decay products. Others believe EPA underestimated the risk. For example, the American Mining Congress (AMC) stated that "EPA has systematically overestimated the factors which determine potential health effects from mill tailings. In the aggregate, these overestimates combine to yield an overestimate factor of about 60." These alleged factors are:

Area of model tailings piles	1.4
Radon flux per unit activity	1.8
Transport and dispersion models	5.0
Equilibrium for radon decay products	1.7
Risk of lung cancer	3.0
Population near tailings piles	Unknown

The total radon emitted from tailings is approximately proportional to the surface area covered by tailings. EPA used the same area that NRC used in its FGEIS, 80 hectares, to estimate radon emissions. The AMC prefers 50 hectares, and points out that NRC (in NUREG-0757, Feb. 1981) later revised its estimate to 50 hectares. However, current projections of uranium production indicate that very few new mills or piles, if any, will start up between now and the late 1990's. Thus, unless a significant number of existing piles are unable to comply with the requirements of this rule regarding ground water protection, essentially all radon emissions will be from existing piles, which have an average area of about 70 hectares, as shown in the FEIS. In addition, radon may be emitted from on-site areas contaminated by windblown tailings. We conclude the area of piles has been overestimated at most by a factor of 1.16.

The emission rate of radon per unit area of tailings is directly related to the activity of radium-226 in tailings. Several factors which are not well understood influence this emission rate. In the report cited above, the NRC concluded: "Considering the variation observed under differing conditions at a number of sites, the staff has elected to apply conservative specific flux values of 0.3 (pCi of radon-222 per square meter-second/pCi of radium-226 per gram of tailings) for wet tailings and 1.0 for dry tailings and to count moist tailings as dry in making the calculations." EPA agrees with this conclusion and believes no correction which assumes that some tailings are permanently wet is appropriate for this factor.

Regarding transport models, measurements are consistent with the transport and dispersion models we used. This is discussed in detail in the FEIS. The method used by EPA has been the basic work-horse of local dispersion estimation for years. In 1977, the participants of an expert group assessing atmospheric transport of radionuclides concluded that, for distances out to 10 km in reasonably flat terrain, and given good local wind observations: "Accuracy for the usual annual average concentration is about a factor of $\pm$ 2." Furthermore, these dispersion estimates are based on an empirical approach that is inherently unbiased and that should therefore be as likely to overpredict as to underpredict.

It should be noted that we are not modeling background concentrations of radon. While it may be experimentally difficult to demonstrate the increment above background due to a tailings pile at distances greater than 1 km, there is no reason to believe that the basic physical principle of conservation of mass does not continue to be valid. Once released to the atmosphere, radon, which is a chemically inert gas, disperses freely until it is removed by radioactive decay. We conclude that our dispersion estimates provide a reasonable basis for calculating atmospheric concentrations of radon.

There appears to be a misconception about the conditions to which EPA's assumption of a 0.7 equilibrium fraction for radon decay products applies. (The "equilibrium fraction" expresses the amount of radon decay products actually present relative to the maximum theoretically possible. This fraction is important, since the health risk is primarily due to radon decay products, not to radon itself.) Most of the data cited by commenters to support a lower equilibrium fraction are for situations in which the source of radon is diffusion into houses from underlying soil. In this situation the initial decay product equilibrium fraction is zero. For the airborne radon from tailings piles considered in EPA's estimates, the decay product equilibrium fraction in outdoor air approaches 1.0, beyond the vicinity of a pile. After taking into account periods of time an individual spends indoors and outdoors, periods of time a house is well-ventilated by outdoor air, and the fate of radon and decay products in outdoor air when it infiltrates a house, we conclude use of an average value of 0.7 for the effective equilibrium fraction for exposure of people to airborne radon from piles is appropriate for distances far from tailings piles. This value is therefore retained for calculations of total impact of radon releases from piles. Very close to tailings piles, however, the decay product equilibrium factor in outdoor air is low. We conclude, therefore, after taking the same indoor/outdoor factors into account, that an average effective decay product equilibrium fraction about one-half as large is probably more appropriate next to piles. This lower value should be applied to estimates of the maximum individual risk next to piles.

The EPA estimate of lung cancer risk from radon decay products is based on studies of uranium and other heavy metal miners, is consistent with the most recent recommendations of the NAS BEIR Committee (1980), and is within 20 percent of the value recommended for use in a recent, exhaustive study conducted in Canada for their Atomic Energy Control Board (1982). We have noted our difficulties with the assumptions which underlie other estimates cited by commenters in our detailed responses to comments in the FEIS. We conclude the EPA value should be used in the absence of any convincing evidence that another value is more appropriate.

EPA used two regional populations for its risk estimates: the first population, identified as for a "remote" site, was hypothetical, and was taken from NRC's "Final Generic Environmental Impact Statement on Uranium Milling" (FGEIS). The second population, identified as for a "rural" site, is that for the Edgemont, S.D. site, and is based on 1970 census data. We assumed that a mix of six "rural" and 17 "remote" sites would properly represent the 23 sites modeled in the DEIS. We have just received the results of a 1983 population survey for all 52 mill tailings sites performed for us by Battelle Pacific Northwest Laboratories. This survey, which was limited to individuals within 5 km of the piles, shows that the total population at the 26 active sites was 2054 within 2 kilometers of all active tailings piles, and 14,737 within 5 kilometers.

We have re-evaluated the local and regional health risk based upon this re-survey of current populations within 5 km and 1970 census results for populations from 5 to 80 km of the 26 active sites. The re-evaluation show a small decrease in calculated local effects, and an increase of equal size in calculated regional effects. (Our estimates of risk to more distant populations, i.e., to the remainder of the United States, are unaffected.) These data indicate that our initial estimate of total health effects to populations is correct. (We note that we have assumed that there will be no increases of populations at these sites over the next 1000 years, a clearly nonconservative assumption.)

In summary, we do not believe the total health effects in the DEIS have been overestimated. The factor of about 1.16 due to a slightly different average pile area is likely to be negated by normal population increases (not accounted for in our estimates) within the first few decades of the lifetime of the hazard posed by these tailings. The estimate of maximum individual risk for a model pile is affected principally by our assumption for the equilibrium fraction for radon daughters, and should be reduced by about a factor of two. We believe this change is insufficient to warrant changing our basic conclusions regarding the risk from tailings.

2. Significance of Risk from Radon Emitted by Tailings Piles

Several commenters argued that EPA has not demonstrated that the risks associated with radon emissions from tailings are significant, and observed that much of the health impact attributed to tailings accrues to very large numbers of people at very low levels of individual risk. They suggested that the proper test of significance is to compare such risks with common hazards, such as the risk from the natural background radiation. For example, they would compare the 6 lung cancers per year that EPA estimates (see FEIS) could result from uncontrolled tailings piles after the year 2000 with: the 21,000 such cancers a commenter estimated as caused annually by background radiation; deaths from motor vehicle accidents (50,000 per year) and home accidents (25,000); tornadoes (130); etc. Based on such comparisons, these commenters concluded that the risks from radon emitted from tailings are not significant, and that EPA's standard should not limit such emissions.

EPA believes these comparisons are misdirected and do not address a central purpose of the legislation that requires this rulemaking, which is to "* * * make every reasonable effort to * * * prevent or minimize radon diffusion into the environment * * * from * * * tailings." EPA recognizes that radiation background and other common hazards cause far greater total annual harm than anyone would reasonably estimate might occur from uncontrolled radon emissions from tailings. However, these other risks are not the subject of this rulemaking. Comparisons of the type suggested may be useful for setting priorities for efforts to reduce the variety of hazards to public health (to the extent that they are avoidable), but they are not useful for deciding the appropriate level of control for a specific source of hazard. That decision must be based upon the specifics peculiar to the hazard under consideration. The existence of other hazards does not, absent Congressional direction, justify EPA's delaying these standards until all other controllable hazards are addressed, or justify EPA's ignoring Congress' will that standards be set.

The fact that the health impact of tailings is in large part attributable to small radiation doses delivered to large numbers of people over long periods of time was recognized when UMTRCA was enacted. The then Chairman of the NRC testified as follows: "The health effects of this radon production are tiny as applied to any one generation, but the sum of these exposures can be made large by counting far into the future, large enough in fact to be the dominant radiation exposure from the nuclear fuel cycle. Whether it is meaningful to attach significance to radiation exposures thousands of years in the future, or conversely, whether it is justifiable to ignore them, are questions without easy answers. The most satisfactory approach is to require every reasonable effort to dispose of tailings in a way that minimizes radon diffusion into the atmosphere." (H.R. Rep. No. 1480, 95th Cong., 2nd Sess., Pt. II, p. 25.) We have concluded that maximum individual lifetime risk (estimated as 2 in 100) and the long-term cumulative impact on populations (potentially many tens of thousands of deaths over the long term) due to radon emissions from tailings are clearly significant enough to justify controls. As discussed in the FEIS, RIA, and a later section of this Preamble, our analysis shows that tailings can, at a reasonable cost, be disposed of in a manner that provides, among other benefits, greatly reduced radon emissions.

3. Standards Based on Current Populations

During the review of the standards for the inactive sites by certain Federal agencies, questions were raised regarding the appropriateness of the control standards for general application to all 24 inactive sites. Some reviewers suggested that less restrictive standards might be appropriate for sites that are in currently sparsely-populated areas. Other reviewers suggested that we consider a radon standard that applies at and beyond the fenced boundary of such a site, i.e., a standard that relies in part on dispersion and institutional maintenance of control over access. EPA requested public comments on these issues for the inactive sites (48 FR 605, January 5, 1983). These issues are most simply stated as: (1) Should the degree of radon control after disposal depend in part on the size of the current local population, and (2) Should implementation of the disposal standards be permitted to depend primarily or in part on maintenance of institutional control of access (e.g., by fences)? We also specifically requested comments on these issues in the April 29, 1983 notice of proposed rulemaking for active mills.

Most commenters who addressed the first of these issues opposed different standards at remote sites (although most industry comments favored less restrictive standards for *all* sites). Many raised the "equity" consideration, i.e., the fairness of protecting a few people less just because of where they live. Others commented that many of these sites are locations where people are unlikely to live, or, conversely, that the sizes of populations in the future are not predictable and cited examples of recent changes. Finally, commenters who addressed the issue of whether EPA is authorized to set different standards based on "remoteness" denied that the Agency has such authority.

In 1983 EPA counted the number of people living close to all the active and inactive mill sites. Of the 52 sites surveyed, only 7 had no people living within 5 kilometers (3 miles). Another 6 sites had 10 or fewer people living within 5 kilometers. Collectively, however, the mill sites have a normally distributed continuous range of local populations, and it is not possible to distinguish a special set of sites. The definition of a remote site is therefore difficult to achieve, unless it is done arbitrarily. In addition, demographers have concluded that it is not possible to determine that a population at a specific location will remain low in the future, if it is low now. Therefore, a choice of two different standards implies a need for institutional oversight of future population shifts and for having to upgrade the disposal at those sites that exceed some criterion of "remoteness." Presumably, the State or Federal custodian would be responsible, not the original owner.

The motivation for considering relaxed standards at "remote" sites is to reduce the cost of disposal. Our analysis shows that any potential cost saving from less restrictive standards at such sites is not commensurate with the loss of benefits. In a later section we report the costs for several relaxed radon standards. These results show, for the case of *no* radon emission limit (case C1) and with no provision for the added costs of institutional control through fencing, land-use control, and land acquisition (to avoid unacceptably high individual doses to nearby residents), and with no provision for increased costs to meet closure requirements under SWDA (discussed below), that 46 percent of the cost of disposal at the level required by these standards (case C3) would be potentially recoverable. We have examined the added costs required for institutional control and conclude that they may vary from about 10 to 50 percent of these potentially recoverable costs, depending mostly on the cost of land acquisition at specific sites. Costs for conformance to RCRA closure requirements for a cap under § 264.228(a)(2)(iii)(E) range from about 50 to 140 percent of these potentially recoverable costs, depending upon whether or not the pile has an impermeable liner under it or not. (This SWDA requirement was excepted under the proposed standards, on the basis that it would interfere with the moisture required for radon control. This basis would no longer exist in the absence of a radon limit.) Any savings through deletion of radon control would be achieved by forgoing approximately one-half of the annual benefit (the entire impact on nonregional national populations), a considerable degree of protection against misuse, and a significant part of the anticipated total term of effective protection from all hazards, due to the greatly reduced thickness of the cover. We have concluded, therefore, independent of other considerations, that when costs for institutional control and compliance with SWDA closure are added and the net saving is applied to only those sites that might be defined as "remote", the potential total cost saved is not significant enough in comparison to the benefits foregone to justify separate standards.

Finally, with regard to the Agency's legal authorization to establish a separate level of protection at remote sites by issuing two sets of standards, UMTRCA clearly contemplates that these standards be adequate for the long term and that they achieve the benefits of radon control. Regarding those objectives, we are aware of no site that is uninhabited and can also reasonably be assumed will remain uninhabited, nor are we aware of any scientific basis for concluding that there is no impact on national populations due to radon emissions from remote sites. We conclude, therefore, that relaxed standards for "remote" sites are not feasible on demographic grounds, are not defensible on legal grounds, and are not attractive, in any case, on the basis of cost-effectively achieving the various public health and environmental goals of this rulemaking.

4. Passive vs. Institutional Controls

As noted above, EPA also requested comments on whether a radon limit applied at the boundary ("fenceline") of the Government-owned property around a tailings pile, i.e., a "dispersion" standard, would be an appropriate form of standard for the sites with low nearby populations. (Such consideration could also apply to some more populated sites.) Such a dispersion standard could be satisfied largely by institutional methods, i.e., by acquiring and maintaining control over land. The proposed disposal standard, by comparison, would require generally more costly physical methods (such as applying thick earthen covers) that directly control the tailings and their emissions with minimal reliance on institutional methods (i.e., it is a "control" standard). EPA also requested comments on the adequacy of such a radon "fenceline" standard to meet the objectives of the UMTRCA.

Comments on this issue ranged from strong support of primary reliance on passive stabilization for periods greater than 1,000 years to protection for only a few decades wih primary reliance on institutional controls. A majority of commenters recommended retaining primary reliance on passive control rather than on institutional control. Those that favored use of institutional control (principally of misuse and maximum individual exposure) argued for limiting public access through use of fences and administrative control of land use. Those opposed cited the lack of reliability of such control, especially through use of fences in remote areas of the western United States.

EPA considers that protection from the long-term hazards associated with radioactive waste should primarily rely on passive control methods. We note, in this regard, the intent of Congress as stated in the congressional report accompanying UMTRCA: "The committee believes that uranium mill tailings should be treated in accordance with the substantial hazard they will present until long after existing institutions can be expected to last in their present forms." In addition, as noted in the proceeding section, the costs of land acquisition to limit maximum individual exposures can easily negate a significant fraction of potential savings through use of thinner covers. However, institutional controls can play a useful secondary role in supplementing passive controls and in assuring during the early period of disposal, that passive controls are adequate to achieve their design objectives.

Section 202 of the UMTRCA requires the Federal Government or the States to acquire and retain control of these tailings disposal sites under licenses. The licensor is authorized to require performance of any maintenance, monitoring, and emergency measures that are needed to protect public health and safety. We believe that these institutional provisions are essential to support any project whose objective is as long-term as are these disposal operations, and for which we have as little experience. This does not mean we believe that primary reliance should be placed on institutional controls; rather, that institutional oversight is an essential backup to passive control. For example, as long as the Federal Government or the States exercise their ownership rights and other authorities regarding these sites, they should not be inappropriately used by people. In this regard, even with the disposal actions required by these standards it would not be safe to build habitable structures on the disposal sites. Federal or State ownership of the sites is assumed to preclude such inappropriate uses.

5. Control of Radon Releases During Milling Operations

The proposed rule anticipated that the regulatory agency apply the "as low as reasonably achievable" (ALARA) principle of Federal Radiation Protection Guidance in establishing management procedures and regulations to control radon from operating mills. This approach was proposed because EPA concluded that a numerical standard to control radon was inappropriate for application during operations. This is because practical methods for reducing radon emissions during operations of existing mills and piles vary in effectiveness with time; it is very difficult to measure, quantitat‹ ely, their efficacy; and different methods are appropriate for different sites. The primary means for controlling radon emissions from existing tailing piles during operations are to keep the tailings as wet as possibile or to use phased disposal.

Some commenters indicated that the provisions of the proposed rule were inadequate to assure that the public would be protected. They argued that EPA has the responsibility under both UMTRCA and the Clean Air Act to provide suitable health protection to all members of the public. They suggested that requiring certain work practices or tailings management practices would provide greater public health protection than the provisions of the proposed rule. For example, they note that "staged" or "phased" disposal of tailings and good water management practices could be effective and reasonable.

EPA will consider further the feasibility and practicality of providing greater assurance that radon releases will be minimized during milling operations than would the proposed rule. The Agency has not sufficiently analyzed work practice and tailings management techniques to determine whether they are suitable for this purpose and which alternatives are best. Therefore, the Agency will publish an Advance Notice of Proposed Rulemaking under the Clean Air Act for condideration of the control of radon emission from uranium tailings piles during the operational period of a uranium mill. The ANPR will enable the Agency to gather information on the feasibility, effectiveness, and cost of various alte‹ natives that would control radon releases from operating mills. This will enable EPA to be better informed when judging whether standards are needed, and, if so, the most suitable requirements.

B. Disposal Standards

1. Design Requirements for Long-Term Protection

Comments on this issue were greatly divergent. Some commenters believed controls should be required to last for thousands of years while others thought a few decades would be adequate. Comments from experts in the fields of civil engineering and geomorphology were useful in resolving this issue.

Standard design practice for structures that, should they fail, could lead to loss of life or significant destruction of property is based on the likelihood that a sufficiently disruptive event (e.g., a flood or hurricane) might occur within a specified time. For example, a bridge may be designed to withstand all disruptive events that have more than 1 chance in 100 of occurring within, say, 50 years.

Commenters noted that rushing water caused by very high rainfall events might damage or destrey a tailings containment system that lies in its path (floods that merely cover or wet a pile are not as significant). Therefore, they suggested, the disposal method should be designed to withstand any such rainfall events that have more than a small likelihood of occurring during t! period for which control is to be "reasonably assured." Expert commenters noted that floods of greater magnitude than a "1000-year flood," for example, as they are generally defined, have a high likelihood of occurring within 1000 years. Thus, in order to provide reasonable assurance that a pile will withstand all floods that have more than some small chance of occurring within 1000 years, the control system must be designed to withstand much rarer events, such as a "probable maximum flood." In practice, they suggested, adequately protecting piles for even a few hundred years requires designing control systems to withstand all events that are likely to occur within thousands of years. Furthermore, the maximum rainfall that might be expected to occur within thousands of years is very nearly the maximum possible rainfall. Therefore, in practice, the system would have to be designed for approximately the same (i.e., maximum) rainfall whether the control period is 200 years or 1000 years.

As discussed above, we believe protection for only a short period (a f decades) is inconsistent with the inte of Congress. Some commenters argued for periods longer than 1000 years. We believe that the specification of a design period of 1000 years will achieve the objectives of these commenters, while at the same time giving engineers who must carry out these standards a design criterion reasonable to assess. We note that commenters did not identify any specific design features that would flow from a greater than 1000-year criterion that would not already be required to satisfy a 1000-year requirement.

Based on these considerations we conclude that the time over which protection should be provided should be specified as proposed.

A closely related matter is the degree of assurance with which controls can be designed to meet the longevity requirement. Some failure modes can be well quantified (e.g., performance of dikes, etc.) and others may not be as well characterized (e.g., aging characteristics of rock used to stabilize slopes). We recognize that, in some cases, it may therefore be difficult to certify conformance in all respects to a 1000-year requirement for longevity of control. For this reason we have retained the flexibility of the proposed rule to certify for shorter periods (but in no case less than 200 years). We leave the matter of fully defining what constitutes "reasonable assurance" to the implementing governmental agencies, but expect that standard engineering (design) criteria will be used to limit the probability of failure over the required longevity period to a value consistent with other design situations where public health and safety are important concerns.

2. Radon Emission Limit

Quantitative estimates of health effects from tailings can reasonably be made for radon emissions and windblown particulates. Health effects from misuse of tailings and water contamination cannot be quantified because of the extremely high degree of uncertainty associated with the likelihood and extent to which misuse and contamination might occur and the consequent degree to which people will consequently be exposed to radiation and toxic substances. (For example, tailings used as fill in unoccupied areas would not result in direct human exposure. Using tailings as fill for residential buildings carries a high probability of very significantly elevating radiation exposure and risk. The degree to which people might be exposed to contaminants from tailings through waterborne pathways is subject to similarly high uncertainties.)

The likelihood of health effects from exposure to radon and its decay products is, considerably greater than from particulates, even when external radiation and food chain contributions are included in the estimates for particulates. Therefore, the only quantitative estimates of effects discussed are those for radon emissions. We believe, however, that effects from misuse or water contamination could be comparable to those from radon emissions if long-term protection is not afforded.

The primary concern of commenters who thought the proposed radon emission standard was too lax was the risk to nearby individuals. The estimated added lifetime risk of fatal lung cancer for someone living 600 meters from the center of a model pile is 1 in 1000 due to radon from a tailings pile emitting radon at the level of 20 pCi/m²s, if the cover is designed to just achieve that emission level without employing additional control to provide reasonable assurance of achieving it for 1000 years.

Commenters who thought the proposed radon emission standard is too strict contended that the cost of compliance would be too high, in view of the small contribution radon from tailings makes to a population's total exposure to atmospheric radon. They also generally believed EPA had overestimated the health effects from radon. We have addressed this last concern in an earlier section of this notice.

Selecting a limit for radon emission from tailings involves four public health objectives, in addition to reducing health effects from radon released directly from the pile. These may all be achieved by using a thick earthen cover, which serves to inhibit misuse of tailings, to stabilize tailings against erosion and contamination of land and water, to minimize gamma exposure, and to avoid contamination of ground water from tailings. A radon emission limit of 20 pCi/m²s or less would require use of a sufficiently thick earthen cover to achieve all of these objectives. A limit of 60 pCi/m²s or greater could be satisfied in many cases by a cover too thin to effectively inhibit misuse. Such a cover would also permit higher individual risks (up to 3 in 10^3) and would leave 20 percent of the potential health impact on populations uncontrolled. Our analysis shows that a limit of 20 pCi/m²s is also cost-effective for eliminating most (95%) health effects in regional and national populations from radon released directly from the pile. Such a limit would also reduce maximum individual risks to residents near tailings piles to less than one in 1000. We concluded that levels higher than 20 pCi/m²s are not justified, based on the cost-effectiveness of reduction of cancer deaths in populations, the high maximum individual risks involved at higher levels, and the likelihood that control to a level of 20 pCi/m²s is reasonably achievable.

The risk to people who live permanently very close to tailings piles can still be relatively high, up to 1 in 1000 for lifetime residency, for a limit of 20 pCi/m²s. However, the practicability of providing more radon control by requiring design for lower levels of emission falls rapidly below 20 pCi/m²s. We note that no pile has ever been protected by such a cover; that is, covers with defined levels of control and longevity are undemonstrated technology. The design of covers to meet a specific radon emission limit at these low levels must be based on measurements of properties of local covering materials and prediction of local parameters, such as soil and tailings moisture, over the long term. Because of uncertainties in measuring and predicting these parameters, the uncertainty of performance of soil covers increases rapidly as the stringency of the control required increases. Thus, in the case of lower levels, the primary issue becomes whether conformance to a design standard for such levels is practicably achievable. There is some field information available regarding the practicality of reduction of radon emissions to levels approaching background. Tests conducted at a pile in Grand Junction, Colorado, showed that test plots of 3-meter thick covers made from four different earthen combinations reduced radon emissions to values ranging from 1.0 + 1.1 to 18.3 + 25.2 pCi/m²s. The efficiencies of these covers ranged from 88.8 percent to 99.7 percent. These results apply to the first two years after emplacement, and do not reflect performance after long-term moisture equilibrium is achieved (some moisture contents were still considerably elevated over prevailing levels). We believe results like these can generally be expected, because the radon control characteristics of earthen materials used for covers will vary from site to site. Three of the four covers studied satisfied 20 pCi/m²s with a reasonable degree of certainty over the term of the test. The other cover (18.3 + 25.2 pCi/m²s) was uncompacted and its poor performance can therefore be discounted. Exactly how much thicker these covers would need to be to reliably achieve a lower limit (e.g., 6 or 2 pCi/m²s) is not known. Experts commented during hearings on the standards that, although covers can be designed to meet such levels as 20 pCi/m²s, estimation models are not reliable at significantly lower emission levels.

We concluded that achieving conformance with a radon emission standard that is significantly below 20 pCi/m²s (6 or 2 pCi/m²s, for example) clearly would require designers to deal with unreasonably great uncertainty for this undemonstrated technology. That is particularly so because EPA is already requiring a margin of safety in calling for any control system to meet the designated emission level with reasonable assurance over 1000 years. Given the predictive uncertainties in designing to meet this standard, EPA judged that to force an accounting for a second set of predictive uncertainties by forcing the standard to very low nominal levels would be to exceed the limits of reasonably available technology.

The risk from radon emissions diminishes rapidly with distance from the tailings pile (declining by a factor of three for each doubling of the distance beyond a few hundred meters). There currently are only about 30 individuals living so near to active piles that they might be subject to nearly maximum annual post-disposal risks. We expect that the actual number of people who might experience near maximal lifetime risk will be smaller, since they would have to maintain lifetime residence in the land area immediately adjacent to a tailings piles. In sum, we believe that the probability of a substantial number of individuals actually incurring these maximum calculated risks is small.

We conclude that it is not reasonable to reduce the emission standard below 20 pCi/m²s because of: (1) The uncertainty associated with the feasibility of implementing a requirement for a significantly lower standard, (2) the small increase in total health benefits associated with such thicker covers, and (3) the limited circumstances in which the maximum risk to individuals might be sustained.

As noted above, the 20 pCi/m²s mission limit was selected to meet the stated objectives of reducing the likelihood of misuse, spreading due to erosion, and control of radon emissions after a thorough evaluation of the current existing information on the technical and economic aspects of alternative levels of control. EPA recognizes the limitations inherent in this information, since no pile has yet been disposed of. Better information may well become available within the next several years as DOE proceeds with the disposal program for inactive piles. Therefore, consistent with Section 275(b)(2) of UMTRCA, EPA intends to continue to monitor these efforts over the next several years and will propose revising these standards if subsequent technical and economic information shows modifications are warranted.

The standard requires that disposal be designed to provide "reasonable assurance" that radon emissions will not exceed 20 pCi/m²s (averaged over the disposal area) for 1000 years. Some commenters expressed the opinion that the meaning of this term was not clear. A key word in this requirement is "designed," since we do not intend compliance with a 1000-year requirement to be determined by monitoring. "Reasonable assurance" in the design of covers means the radon emission limit should be expected to be achieved, over the required term, with a degree of assurance commensurate with the "reasonable assurance" of longevity discussed in the preceding section. Thus, in designing the cover the uncertainties in attenuation characteristics of material used should be taken into account in a conservative manner. This will tend to increase the cover thickness required over that calculated from "best estimated" values, which would yield an approximately equal probability of achieving above or below the design level. An example of uncertainty to be considered is that in the long-term equilibrium value of moisture to be expected in the cover material (i.e., over 1000 years), even though the cover material may be sprayed with water when it is laid down and compacted, and layers of coarse materials introduced to inhibit capillary action. Such spraying and layers increase the moisture (and therefore attenuation) of the cover in the near term, but it is the long-term equilibrium moisture content which governs the performance of the cover over most of its useful life. Other factors include uncertainties in measured diffusion characteristics of the particular earthen materials [illegible] moisture content), [illegible]-term equilibrium moisture content of the tailings themselves. In summary, we intend that the design requirement for "reasonable assurance" should lead to thick durable covers that have a substantial likelihood of maintaining radon emissions below the 20 pCi/m²s limit for 1000 years.

A related matter is implementation of the specification that the standard for radon emission applies to the "average" value of the release rate. This averaging is to be carried out in two ways. First, it applies over the spatial extent of any disposal area. Thus, anticipated variations due to different concentrations of radium in different parts of the pile, or minor cracks or the effects of burrowing animals and plant roots are to be averaged over, since it is the net radon from the entire tailings pile that is of significance to health. Second, the averaging is specified to apply over a time period of at least one year. Thus, daily and seasonal variations in radon emission are to be averaged over, since these are also not of significance to public health. Finally, this averaging may extend over longer periods to accommodate normal fluctuations in soil moisture content due to short-term climatic variations. Thus, the lowest recorded values of soil moisture content should not be used; rather, the average values are appropriate. Such averages should not, however, extend to times as long as the normal human lifespan, since that could result in a significant alteration in the level of protection of public health. Similarly, averaging performance over the entire period of longevity of the cover is not within the meaning of the standard.

3. Relationship to the Clean Air Act Emission Standard Requirements

The Clean Air Act also requires that EPA provide public health protection from air emissions from tailings piles. Further, EPA is publishing an ANPR to consider additional control of radon emissions during the operational phase of mills. This discussion relates to the disposal phase.

The Clean Air Act requires that the Administrator establish a standard at the level which in his judgment provides an ample margin of safety to protect the public health from hazardous air pollutants. The Agency published proposed rules for radionuclides as National Emission Standards for Hazardous Air Pollutants (NESHAPS) on April 6, 1983 (48 FR 15076). The proposed rule addressed all of the sources of emissions of radionuclides that EPA had identified. The proposed rule either provided standards for various source categories or proposed not to regulate them and provided reasons for that decision.

In the proposed NESHAPS for radionuclides EPA did not propose additional standards for uranium mill tailings, because the Agency believed the EPA standards to be established under UMTRCA would provide the same degree of protection as required by Section 112 of the Clean Air Act. The Agency explained that Congress did not describe the degree of protection that provides an ample margin of safety, nor did it describe what factors the Administrator should consider in making judgments on the appropriate standard. The Agency indicated that it did not believe that it was reasonable to establish standards for nonthreshold pollutants like radionuclides at levels that preclude any possible risk. EPA concluded that it should follow an approach that would allow it to consider various factors that influence society's health and well being. Therefore, EPA chose to consider the following factors in deciding whether standards are needed and the appropriate level of such standards:

1. The radiation dose and risk for nearby individuals;
2. The cumulative radiation dose and health impacts in populations;
3. The potential for radiation emissions and risk to increase in the future;
4. The availability, practicality, and cost of control technology to reduce emissions, and
5. The effect of current standards under the Clean Air Act or other applicable authorities.

The first three factors are used to assess the likely impact of emissions on the health of individuals and large populations and to estimate the potential for significant emissions in the future. The fourth factor enables EPA to assess whether state-of-the-art control technologies are currently in use and whether there are any practical means of reducing emissions through control technology or other control strategies. The last factor allows EPA to assess whether regulations or standards that have been established to control other pollutants are also minimizing releases of radionuclides.

The dose and risk for the individuals nearest a site are often the primary considerations when evaluating the need to control emissions of radionuclides. Controlling maximum individual dose assures that people living nearest a source are not subjected to unreasonably high risk. Further, protecting individuals often provides an adequate level of protection to populations living further away from the source.

EPA believes that cumulative dose and health impacts in populations are also an important factor. The cumulative radiation dose and health impact are determined by adding together all of the individual doses and risks that everyone receives from an emission source. This factor can sometimes be more important than the maximum individual risk in deciding whether controls are needed, particularly if an extremely large population may be exposed at low levels. The aggregate dose and population impact can be of such magnitude that it would be reasonable to require a reduction in the total impact even though, if the maximum individual dose were considered alone, one might conclude that no further controls are needed. For mill tailings, although population doses and health impacts were an important part of our consideration, doses to the most exposed individual were equally important.

In addition, EPA considers the potential for emissions and risk to increase in the future, even though the current projected maximum individual and population risks may be very low. In this case, we do not anticipate significant future increases in the size of this industry, although populations around these sites may increase, as the national population increases.

The availability and practicality of control technology are important in judging how much control of emissions to require. EPA believes that the standard should be established at a level that will, at least, require use of best available technology. Additional actions, such as forcing the use of undemonstrated technology, closure of a facility, or other extreme measures may be considered if significant emissions remain after best available technology is in place or if there are significant emissions and there is no applicable demonstrated control technology. EPA defines best available demonstrated technology as that which, in the judgment of the Administrator, is the most advanced level of controls adequately demonstrated, considering economic, energy, and environmental impacts. We concluded that requiring the use of undemonstrated technology was appropriate for mill tailings, since their emissions are significant and there is no applicable demonstrated control technology.

Finally, EPA believes it is reasonable to consider whether other EPA standards are achieving approximately the same goal as the Clean Air Act, i.e., protecting public health with an ample margin of safety. In cases where other standards are providing comparable control, EPA believes it is appropriate not to propose redundant standards under the Clean Air Act. There would be no benefits because the public health would already be protected with an ample margin of safety, but there could be unnecessary costs associated with implementing an additional standard.

The Clean Air Act specifies that the Administrator promulgate emissions standards to protect the public health. The Administrator is also authorized to promulgate design, equipment, work practice, or operational standards, or a combination, if it is not feasible to prescribe or enforce emission standards. The Administrator can conclude that "it is not feasible" if a hazardous pollutant cannot be emitted through a conveyance or the use of the conveyance would be contrary to laws, or if measurement methodologies are not practicable due to technological or economic limitations. As noted above, we will consider the need for such standards for the operational phase of mills.

With respect to these disposal standards, EPA has concluded that design to provide reasonable assurance that the release of radon will not exceed 20 pCi/m²s for a period of 1000 years is appropriate. The level of the standard was selected after considering potential impacts both on individuals and large population groups. We consider that the uncertainties involved in design to various levels and durations of control are important factors. Potential increases in the number of mill tailings piles due to future needs for uranium were also considered. In addition, the cost and socio-economic impact of the standard and other alternatives were considered. In light of all of these considerations, EPA judges it appropriate that the standard require a level of control not heretofore applied, but for which the design uncertainties that must be accommodated are within the range of practical feasibility.

It would be desirable to reduce potential maximum individual risk further. However, the uncertainties associated with attempting designs to achieve assurance of conformance to a significantly lower standard through use of thicker covers are, we believe, unreasonably great, and would impose large and unpredictable costs. Somewhat thicker covers than bare (or average) compliance with a 20 pCi/m²s standard would require will, moreover, be called for by the requirement to provide reasonable assurance of compliance. (Other types of control are even more costly and do not provide the comprehensive protection thick covers provide.) Consequently, we have concluded it would be unreasonable to impose a standard below the 20 pCi/m²s required by this rule.

The Agency believes that the standards for the disposal of uranium mill tailings established in this rule provide protection of public health comparable to that which might be established under the Clean Air Act, because the considerations on which these standards are based are comparable to those the Agency uses in establishing standards under Section 112 of the Clean Air Act. However, the final determination will be made in the

Section 112 rulemaking on radionuclides.

4. Radon Concentration vs. Emission Rate Limits

A radon emission rate limit was proposed as a design standard for the disposal of tailings. Some commenters suggested that we should instead establish a concentration limit for radon in air at locations where people would be exposed. They expressed the view that EPA should establish standards based on health risk alone and that a concentration limit applied where people can live is therefore more suitable.

A design limit for emissions addresses a primary goal of these standards, the placement of a thick, durable earthen cover over the tailings, because the limit relates directly to the thickness of the cover and requires direct control of radon emissions. It also is in a form which conforms to the requirements of the Clean Air Act, which specifies direct control of emissions from a source. Under the suggested air concentration limit, transport calculations would be needed to estimate emission rates for use in determining cover thicknesses. We believe no purpose is served by introducing the uncertainty of this extra (transport) variable into the calculations for cover thickness. In addition, the thickness of the cover required to satisfy such a standard could be arbitrarily reduced (to zero in many cases) by use of fences to restrict access. Such a situation would be unsatisfactory because it would: (1) Require permanent (for 1000 years) control of access by institutional means, and (2) would not require a cover sufficient to deter misuse. In summary, if such a standard is comparable to an emission limit, it is needlessly complex, due to the introduction of transport calculations. If not, it affords less protection by permitting dispersion instead of control.

5. Cleanup Standards

Commenters expressed confusion regarding the purpose and applicability of the proposed § 192.32(b)(2). We intended this section to distinguish disposal areas for tailings piles from other land areas on disposal and/or licensed sites that are sufficiently uncontaminated by tailings as to not require application of the disposal standards of § 192.32(a). The definition of "disposal area" and the language of § 192.32(b) have been revised to clarify these objectives.

Some commenters objected to the proposed definition. On the assumption that it was a cleanup standard they argued it is not necessary to clean up land which will be converted to government ownership upon closure, since a government agency could control use of the land. Also, they argued that even if the government allowed use of the land, including residential use, "no reliable evidence exists to indicate that levels exceeding the proposed cleanup standard would necessarily convert to indoor radon daughter exposures of sufficient magnitude to constitute significant health risks."

EPA believes there are good reasons not to leave contaminated land (other than areas meeting the disposal standards) at former milling sites. First, the contamination may spread further, and thereby necessitate cleanup of adjacent land or properties. High indoor radon levels clearly can result if houses are built on contaminated land. Second, there are significant radiation risks (identified in the FEIS and DEIS) from pathways other than inhalation of indoor radon decay products, including external (gamma) radiation and inhalation of windblown particulates. Finally, the government agency accepting ownership of contaminated land would have to impose additional control and, possibly, incur the costs to maintain such control. EPA has decided not to change the proposed levels which define on-site land that need not satisfy the standards applicable to disposal areas.

Finally, some commenters suggested that we issue standards for the cleanup of any off-site land and buildings that may contain tailings from licensed mills. There was an implication in some comments that establishing the responsibility of any party to perform remedial actions for such sites could be affected by whether or not EPA had issued cleanup standards. EPA has issued cleanup standards (40 CFR Part 192, Subpart B) for the Federal cleanup program for off-site tailings from 24 inactive processing sites that was established under Title I of UMTRCA. Sites for which a license for uranium or thorium production was in effect on or after January 1, 1978, are excluded from coverage under Title I. We note, however, that the standards (40 CFR Part 192, Subpart B) we have already issued for the Title I program would be suitable for application to off-site contamination from active mills.

6. Wet Sites vs. Dry (Arid) Sites

Several commenters from Virginia and Illinois expressed concern regarding the applicability of the standards to wet sites, i.e., locations where annual average precipitation exceeds annual average evapotranspiration. EPA stated in the **Federal Register** notice accompanying the proposed standards that if uranium mining and milling is conducted in wet regions, the adequacy and appropriateness of the standards may have to be reviewed, particularly the water protection requirements. Based on this statement the commenters were concerned that EPA intended to apply less stringent standards for tailings control at wet sites.

Our remarks concerning wet sites in the preamble for the proposed standards were intended only to acknowledge that all current U.S. uranium mills are located in arid and semi-arid areas, and that we have less experience with many of the control measures needed to comply with the standards under wet than under dry conditions.

We have modified the final standards to require environmental and health protection in all regions of the United States. EPA developed the basic ground water protection provisions in these standards for national application to hazardous waste sites. The New Source Performance Standards, 40 CFR 440.34, protect surface water by prohibiting discharges from new mills except for the amount by which precipitation may exceed evapotranspiration. Any discharged water must satisfy concentration standards corresponding to use of the best available demonstrated treatment technology. We have modified our proposal to not apply the requirements of 40 CFR 264.228 that are referenced by 40 CFR 264.221 ("Design and Operating Requirements") in order to avoid the post-closure "bathtub" effect that could otherwise occur in wet locations. For mills locationed in regions of net precipitation the final standard applies 40 CFR 264.228(a)(2)(iii)(E), which requires the closure cover to be less permeable than any liner beneath the tailings so the pile will not fill with water.

We believe these and the other provisions of the final standards provide adequate protection for wet and dry areas, considering differences in both net precipitation and population density.

C. Ground Water Standards

1. Summary of the Proposed Standards

Consistent with the standards EPA issued under the SWDA for hazardous wastes (47 FR 32274–388, July 26, 1982) the standard for tailings piles has two parts: (1) A "primary" standard that requires use of a liner designed to prevent migration of hazardous substances out of the impoundment, and (2) a "secondary" ground water protection standard requiring, in effect, that any hazardous constituents that leak from the waste not be allowed to degrade ground water. The primary standard applies to new portions of new or existing waste depositories. The secondary standard applies to new and existing portions, the point of compliance being at the edge of the waste impoundment. The specific hazardous substances and concentrations (i.e., background levels) that define noncompliance with the secondary standard at each site will be established for uranium mill tailings by NRC and Agreement States. The SWDA rules, however, permit alternate concentration limits to be established when they will not pose " * * * a substantial present or potential hazard to human health or the environment" as long as the alternate concentration limit is not exceeded. The rule also allow "hazardous constituents" to be exempted from coverage by the permit based on the same criterion. EPA determines the alternate concentration standard or exemption under the SWDA; EPA's concurrence would be required under the proposed standards for tailings.

EPA recognized in proposing these standards that UMTRCA continues the dual regulatory system for uranium fuel cycle facilities under which EPA sets health and environmental standards and NRC establishes implementing technical, engineering, and management regulations. Under the SWDA, EPA performs all such regulatory functions for chemical hazardous wastes. UMTRCA promotes uniform Federal regulation of wastes, however, by requireing NRC's regulations for these wastes (i.e., uranium and thorium mill tailings) to be "comparable" to requirements EPA establishes for similar hazards under the SWDA.

2. The Primary Standard

The primary standard, 40 CFR 264.221, can usually be satisfied only be using liner materials (such as plastics) that can retain all wastes. Exemptions permitting use of other liner materials (such as clay) that may release water or small quantities of other substances or, in some cases, permitting no liner may be granted only if migration of hazardous constituents into the ground water or surface water would be prevented indefinitely.

Some commenters stated that no liner technology is available which would achieve the goal of the primary standard, i.e., preventing waste from entering the ground or water. They stated that synthetic liners would tear under the strains of tailings and heavy equipment, or that they could not reliably be properly installed in such large impoundments. Other commenters noted that thicker plastic liners than that have been conventional or double liners would be more successful. A number of commenters argued that clay liners may have important advantages over plastics, but questioned whether clay liners could satisfy the conditions for an exemption.

The rulemaking record does not establish that either clay or plastic liners have unequivocal advantages or disadvantages. EPA considered these technologies when it developed the SWDA liner requirement and decided to require a liner that is capable, as a matter of engineering, of preventing migration of waste into the ground and water. The fact that failures may occur did not justify establishing a less protective standard. Recognizing that such liners may sometimes fail, EPA also issued the secondary standard to limit the consequences of such failures. UMTRCA requires standards for tailings to be consistent with the standards EPA established under SWDA. We have concluded that commenters did not establish that conditions at tailings impoundments are sufficiently different from conditions EPA considered in developing the SWDA standard to justify departures from that standard.

Under these standards, all new waste storage areas (whether new waste facilities or expansions of existing piles) are subject to the primary standard—the liner requirement. If new wastes are added to an existing pile, however, the pile must comply with the secondary standard—the hazardous constituent concentration standards for health and environmental protection. Whether for a new or existing pile, if the secondary standards are found not to be satisfied and subsequent corrective actions fail to achieve compliance in a reasonable time, the operator must cease depositing waste on that pile.

3. The Secondary Standard and the Complementary Roles of EPA and NRC

Commenters correctly noted that virtually all existing tailings piles have contaminated ground water beyond the edge of their impoundments. The reason is that many of these piles were constructed without liners and before NRC increased regulatory requirements in the late 1970's. NRC's recent regulatory practice has been to require remedial actions on a cost/benefit basis when underground contaminant plumes threaten to degrade or have already degraded the potential usefulness of offsite water.

Many commenters, including NRC, argued that the existing practices for tailings piles sufficiently protect health and the environment. They noted that under the proposed standard virtually all existing mill operations would have to either request exemptions and alternate standards and/or begin remedial actions. Commenters stated that regulating by exceptions is inappropriate. NRC and others further argued that an EPA concurrence role for exemptions and alternative standards that would be invoked at virtually all existing mills was inconsistent with UMTRCA's foreclosure of any EPA permitting for tailings under UMTRCA or SWDA.

We have made modifications of the rule to both improve its administration and clarify its objectives.

EPA considered a wide range of alternatives before adopting the secondary standard, including a policy similar to NRC's. When EPA issued the SWDA rules, it recognized that many existing hazardous waste sites had operated for many years without liners and would not immediately satisfy the secondary standard. EPA created the opportunity for exemptions and alternative concentration standards to avoid remedial actions where such exceptions would "not pose a substantial present or potential hazard." In establishing such exemptions or alternative standards, the SWDA rules require EPA to consider specified fate-related and health and environment-related factors (see 40 CFR 264.93(b) and 264.94(b)). "Fate" refers to the destiny of contaminants released from the waste under site-specific hydrogeochemical conditions.

EPA agrees that administrative burdens related to the dual regulatory system under UMTRCA should be minimized. We have concluded that it is appropriate under UMTRCA that the regulatory agencies (NRC and Agreement States) perform or approve analyses of fate, because this involves primarily technical and site-specific judgments. EPA does not believe, however, that it can or should delegate its responsibility for setting health and environmental protection standards. This was the reason for proposing to require EPA's concurrence with exemptions and alternative concentration standards recommended by regulatory agencies for site-specific licenses. Therefore, in determining situations requiring concurrence, EPA will consider the health and environment-related factors in §§ 264.93(b) and 264.94(b).

Administrative burdens can be further reduced by permitting the regulatory agency to exercise discretion, pursuant to the requirements of 40 CFR 264.94(b).

for establishing alternate concentration limits, as long as any contamination permitted will remain close to the pile and is within the boundaries of the licensed site. Such situations can be identified solely through analysis of fate, and we have decided not to require concurrence in such cases. This avoids the dual administrative process for alternative concentration standards under conditions where they certainly would be requested and granted. We believe this is appropriate. The contamination would be very limited in extent and concentration, can be expected to eventually dissipate after the site is closed in accordance with our closure standard, and these sites will be under effective government jurisdiction during this period. We have chosen 500 meters as the maximum distance for the purpose of this section of the rule, because it limits contamination to a small area, and, considering the size of disposal areas, will provide an adequate margin of distance to implement corrective action programs if they are required to prevent offsite contamination.

The revised standard for existing piles should be implemented in a manner consistent with the following scenario. Monitoring wells should be established at the edge of the tailings at the compliance point. This monitoring location is unique in providing the earliest practical notice of contaminants migrating from the impoundment. The regulatory agency should determine through further monitoring and fate analysis whether hazardous constituent levels now and in the future will satisfy the secondary standard within 500 meters or any closer site boundary, what corrective actions are appropriate to correct any on-site contamination, and, if some contamination is found to be not practicable to eliminate, the alternate concentration limit at the edge of the tailings to indicate the minimum practicable on-site contamination. If environmental contamination is a realistic possibility (or fact) beyond 500 meters (or the site boundary), remedial actions must be taken, or alternative concentration standards (with EPA concurrence) are required.

Unlike EPA's role in SWDA, EPA's role for controlling hazardous materials from uranium tailings under UMTRCA is limited to setting standards and does not include an implementing responsibility. That responsibility is vested in the NRC and the States as the licensing agencies under Title II of UMTRCA (Section 84a(3)) and will be carried out through regulations set by the NRC, with the concurrence of the Administrator, upon promulgation of these standards by EPA.

Many of the factors that must be considered by NRC in carrying out its responsibilities for enforcing EPA's standards are discussed in the pertinent section of the notice proposing these standards (48 FR 19522–5). For convenience, we repeat here the listing of sections of the SWDA's regulations which relate to the separate EPA and NRC responsibilities. EPA's responsibilities to establish standards under Section 206 of UMTRCA are carried out through adoption of all or part of the following sections of the SWDA regulations:

i. Subpart F:

40 CFR 264.92 Ground water protection standard

40 CFR 264.93 Hazardous constituents

40 CFR 264.94 Concentration limits

(These three sections are modified and adopted as § 192.32(a)(2))

40 CFR 264.100 Corrective action program

(This section is modified and adopted as § 192.33)

ii. Subpart G:

40 CFR 264.111 Closure performance standard

(This section is adopted as part of § 192.32(b)(1))

iii. Subpart K:

40 CFR 264.221 Design and operating requirements for surface impoundments

(This section is modified and adopted as § 192.32(a)(1))

NRC's responsibilities under UMTRCA are to implement EPA's standards and to "* * * insure that the management of any byproduct material * * * is carried out in such a manner as * * * conforms to general requirements established by the Commission, with the concurrence of the Administrator, which are, to the maximum extent practicable, at least comparable to requirements applicable to the possession, transfer, and disposal of similar hazardous material regulated by the Administrator under the SWDA, as amended." EPA will insure that NRC's regulations satisfy these admonitions through its concurrence role. Relevant SWDA regulations are those embedded in Subparts A (except Section 264.3), B, C, D, E, F, G, H, and K. Examples of areas which NRC must address in discharging these responsibilities involve functions under the six sections listed immediately above which are incorporated into these EPA standards, and the following sections of the SWDA regulations:

i. Subpart F:

40 CFR 264.91 Reequired programs

40 CFR 264.95 Point of compliance

40 CFR 264.96 Compliance period

40 CFR 264.97 General ground water monitoring requirements

40 CFR 264.98 Detection monitoring program

40 CFR 264.99 Compliance monitoring program

ii. Subpart G:

40 CFR 264.117 Post-closure care and use of property

iii. Subpart K:

40 CFR 264.226 Monitoring and inspection (of impoundment liners), as applicable

40 CFR 264.228 Closure and postclosure care, as applicable.

There are several of these SWDA regulations that specify monitoring after closure of an impoundment. Monitoring is a compliance activity conducted to assure that health and environmental standards are being met. The regulatory agency is responsible for establishing such requirements, including post-closure monitoring consistent with the SWDA regulations. The period over which post-closure monitoring is normally required under SWDA is 30 years. The regulatory agency should recognize, however, that monitoring of ground water for shorter or longer periods may be needed for the specific sites where tailings are located and, when appropriate, change this requirement.

A difficult consideration regarding the closure of a tailings impoundment is deciding when disposal must take place. Several factors must be evaluated in this regard, including: (1) The likelihood that a mill will resume operations; (2) the specific condition of the tailings impoundment, such as the fraction of design life remaining, and environmental contamination problems, such as windblown tailings and the likelihood that significant quantities of tailings might be spread by flooding; and (3) the cost of maintaining releases from the inactive pile in conformance with the regulations which apply to operating mills prior to disposal (including maintaining radon emissions at ALARA levels). Evaluating these factors may be difficult and complex. However, although an adequate drying-out period makes possible long-term isolation of the tailings and stabilization of the piles, radon emissions will be greater during this period than before or after disposal. For this reason the regulatory agency should require, once a pile is allowed to begin to dry out, that disposal proceeds in an expeditious fashion, and that new liquids are not introduced to the pile so that a new drying-out period will be incurred.

The period required for the tailings to dry out is highly dependent on local meteorology. This precludes establishing a single fixed time for disposal of the tailings. We have concluded that the regulatory agency should exercise the responsibility of determining when disposal should occur, by site-specifically judging the advantages and detriments associated with all pertinent factors. This responsibility is governed by the need to conform to regulations established to satisfy the SWDA, by 40 CFR Part 190, and by the ALARA requirement on radon emissions.

NRC's closure regulations must be comparable, to the maximum extent practicable, to requirements under the SWDA, wherein short closure periods (90 and 180 days) are specified. Drying out of piles will take much longer. However, disposal should occur promptly when piles are allowed to dry out. In addition, some of the older mill sites already contain essentially completed (filled) tailings piles. The regulatory agency should promptly identify and require disposal of such tailings.

EPA and NRC are coordinating their efforts to insure health and environmental protection from uranium byproduct materials. In particular, we are working closely with the NRC to assure that NRC's general requirements for ground water protection will be comparable, to the maximum extent practicable, to EPA's requirements under the SWDA for similar hazardous materials.

4. Timing of Corrective Actions

The proposed standard requires corrective actions for ground water to be initiated within one year after a noncompliance determination is made. Commenters expressed concern that it may take longer than one year to devise and implement an effective corrective action, for both technical and administrative reasons. Based on these considerations, EPA has revised the time limit for implementation of corrective actions to eighteen (18) months. We also note that § 264.99 of SWDA regulations require submission of corrective action plan within 180 days. This provision remains unaffected by the above revision.

Once corrective actions have begun, the regulatory agency should evaluate their effectiveness and determine whether to continue, alter, or discontinue the actions. Because corrective actions are very site-specific, such determinations cannot be made under the same uniform, pre-established schedule for all sites. It is the regulatory agency's responsibility, however, to assure that necessary decisions are rendered in a timely fashion. Acceptable plans for corrective actions should offer a high likelihood of achieving compliance with the standards. Furthermore, corrective actions which, once begun, show inadequate promise of achieving compliance should result in the regulatory agency's promptly disallowing the addition of new tailings to a noncomplying tailings pile.

5. Nonhazardous Materials

Comments were received on two matters regarding the contamination of ground water by nonhazardous materials. (They include chlorides, sulfates, manganese, and total dissolved solids, amoung others.) At high concentrations, these materials can make water unfit for use for other than health related reasons.

One view of these materials held that several of them are more mobile than hazardous materials. Thus, they precede the hazardous material in contaminating ground water. Ground water monitoring for these materials allows the prediction of future ground water contamination by hazardous materials. This detection scheme might therefore provide an early warning of ground water contamination and allow early corrective actions to be taken, thereby effectively preventing ground contamination by hazardous materials.

EPA agrees with this comment. Analyzing water samples for the substances from tailings that are expected to be most mobile in a given ground water environment is a very useful feature of site-specific monitoring requirements. We note that § 264.98 already contains such a requirement and that the implementing regulatory agencies may be expected to establish such (or comparable) requirements.

A second view held that much of the ground water in the Western States is already contaminated with nonhazardous materials to an extent that it is unsuitable for use. These are primarily shallow aquifers (or uppermost aquifers) which would be the first to be contaminated by tailings materials. Since these ground waters are already contaminated, the argument goes, there is no need to prevent additional contamination.

This comment would require changing the ground water protection policy EPA has established for hazardous wastes under the SWDA rules. UMTRCA requires standards for tailings to be consistent with the SWDA standards. EPA has already considered the views expressed in these comments when it established its policy under the SWDA (47 FR at 32236, July 26, 1982). We do not think this rulemaking for byproduct materials is an appropriate forum in which to reconsider EPA's policies for hazardous wastes.

6. Neutralization of Tailings

Some commenters recommended that EPA require neutralization of tailings as a method to protect ground water. Neutralization is chemical treatment that would make the tailings neither acid nor alkaline. When tailings are neutralized many hazardous constituents are taken out of solution and thereby are less prone to move through the earth and into ground water.

An EPA study of tailings neutralization in 1980, discussed in the FEIS, identified several issues regarding neutralization. First, some of the hazardous constituents in tailings form complex compounds that remain in solution over wide ranges of acidity and alkalinity. Selenium, arsenic, and molybdenum—all constituents of tailings—are particularly troublesome in this regard. Adequate control would require careful operation of the neutralization process. Second, the costs of neutralizing the tailings are significant, about the same as installation of a liner. Most of the cost is due to the need for a sludge storage lagoon. Finally, neutralization would not preclude the need for a liner.

The structure of regulation established by UMTRCA consists of generally applicable environmental standards established by EPA and regulations to implement these by NRC. Requirements for specific control methods, such as neutralization, are left to the implementing agency, to be used, as required, to ensure that EPA's general standards are satisfied. In view of the above, EPA has concluded that a standard requiring neutralization of tailings is inappropriate.

D. Procedural Issues

1. Molybdenum and Uranium Improperly Listed Under SWDA Requirements

Comments were received stating EPA improperly proposed listing molybdenum and uranium as hazardous constituents, because SWDA listing procedures were not followed.

EPA listed molybdenum and uranium as hazardous constituents only for purposes of controlling uranium and thorium byproduct materials. EPA does not intend in this rulemaking to add molybdenum and uranium to the SWDA list of hazardous constituents, 40 CFR part 261, Appendix VIII. Therefore, the procedure we followed is proper. Clarification of this matter has been added to § 192.32(a)(2) of the final standard.

2. Inclusion of Thorium in the Standards

Several commenters pointed out that the DEIS contained no background supporting information for the thorium standards (Subpart E) and recommended deleting the thorium standards from this rule. Commenters also stated that there are significant differences in the physical and chemical characteristics and the radiological risk between uranium and thorium. They concluded, therfore, the EPA should not substitute the same requirements for thorium as for uranium, as was proposed.

The FEIS contains appropriate discussions of thorium and a review of the implications of the radiological differences between thorium and uranium for the level of protection provided, the cost of control, and the feasibility of implementation of these standards. These effects are sufficiently small for EPA to conclude that the thorium standards should be promulgated as proposed.

IV. Regulatory Impact Analysis

Under Executive Order 12291, EPA must judge whether a regulation is "Major" and therefore subject to the requirement of a Regulatory Impact Analysis. We have not classified this rule as major, since it will not cause significantly large incremental costs above those which must be incurred in the absence of these regulations. We have prepared a Regulatory Impact Analysis (RIA), however, since there are wide variations in views on the extent of needed environmental controls in the uranium industry.

A. Benefit-Cost Analysis

The RIA examines the benefits and costs of selected alternative disposal standards, for both existing and new tailings piles. As discussed earlier, most of the benefits of tailings disposal cannot be quantified. The benefit we are best able to estimate is the number of lung cancer deaths avoided by controlling the radon emanation from tailings piles. Since the other benefits of disposal—prevention of misuse, ground water protection and prevention of the surface spread of tailings—cannot be quantified (let alone monetized), we could not make a completely numerical determination, within the traditional benefit-cost analysis framework.

We first performed a partial benefit-cost analysis of alternative disposal standards by relating the disposal costs for each alternative to the health effect estimates for direct radon emissions alone. Although this analysis relates only one category of benefit to the entire cost of disposal, it provides useful results to the extent that these benefits are found to be greater than the total cost of control. Second, we performed a cost-effectiveness analysis of alternative standards which assigns different sets of arbitrary weights to the entire range of benefits of tailings disposal. To perform this analysis, we also developed an index which quantifies the relative effectiveness of the disposal methods in providing designated types of control which correspond to the benefit categories. The cost-effectiveness analysis does not address whether the cost increases of tighter controls are worth incurring. Rather, by examining the sensitivity of the results to different choices of weighting schemes for the various benefits, in addition to identifying at what level additional gains in effectiveness start becoming increasingly more expensive, it points out to what degree the choice of standards is sensitive to the relative importance assigned to different types of benefits. Based in part on these analyses, we have made a qualitative judgment that the societal benefits of the standards outweigh the societal costs, considering the long-term continuing train of benefits to society from isolating these hazardous materials from man and the environment.

A range of alternatives was evaluated for protection of public health and the environment. These alternatives included a range of control methods from no control to high levels of control and are summarized below. They do not include different levels of ground water protection, since those requirements must be consistent with standards already established under the SWDA. However, the length of time ground water is expected to be protected is indicated in the assessment of benefits.

Brief descriptions of each alternative follow:

Alternative A. This is the "no standards" case and represents the reference case representing conditions if nothing is done. The piles would remain hazardous for a long time, taking about 265,000 years for the radioactivity to decay to 10 percent of current levels. The radon emission rate is estimated to be 400 pCi/m²s from a typical pile. The background rate for typical soils is about 1 pCi/m²s. The concentration of some toxic chemicals in the tailings is hundreds of times background levels in ordinary soils, so that the potential for contaminating water and land is prese[nt] and continues indefinitely.

Alternative B. These are "institutional care" cases and represent situations in which maintenance is required to assure the standard is satisfied. B1 specifies no radon emission limit, but requires control of wind-blown tailings and gamma radiation. B2 specifies radon control limits of 60 pCi/m²s and B3 specifies 20 pCi/m²s; both require control of wind-blown tailings and gamma radiation.

Alternative C. These are "long-term passive control" cases and represent situations in which design is for long-term protection using engineered, passive methods requiring no continued maintenance. The radon emission limits examined are:

C1 none
C2 60 pCi/m²s
C3 20 pCi/m²s
C4 6 pCi/m²s
C5 2 pCi/m²s

Disposal methods would be designed to be effective for 1000 years in this case, in addition to providing control of wind-blown tailings and gamma radiation.

Alternative D. These cases assume staged disposal. They do not require continued maintenance and achieve control similar to Alternative C, plus improved control of radon during operations at new tailings piles. The radon emission limits examined are:

D2 60 pCi/m²s
D3 20 pCi/m²s
D4 6 pCi/m²s
D5 2 pCi/m²s

Disposal methods would be designed to be effective for 1000 years in this case, in addition to controlling wind-blown tailings and gamma radiation. Further, additional control of radon is achieved during the operational period at new tailings piles through use of staged disposal.

The costs and the benefits for these alternatives are listed in the accompanying tables. We examined the cost per death avoided from radon emissions for alternative control levels from several viewpoints. This range of viewpoints included the length of time over which health effects should be related to costs and whether nationwide population effects should be included with regional population effects in making benefit-cost comparisons. We conclude that the incremental cost per radon death avoided at a 20 pCi/m²s emission limit is a reasonable expenditure under all scenarios. The range of incremental costs per death avoided at this control level is from

$130,000 (nationwide health effects estimated for 1000 years) to $2.5 million (regional health effects estimated for only 100 years). For the next, more stringent, level of control, 6 pCi/m²s, the incremental costs are also higher: $630,000 to $12 million per radon death avoided. These costs are more uncertain and more likely to have been underestimated. For the next, less stringent, level of control, 60 pCi/m²s, the incremental costs are lower: $70,000 to $1.4 million. Whether or not the expenditure for a control level is acceptable depends on one's view of the relevant factors to be considered in valuing the benefit stream. On a relative basis, the incremental cost increases by at least a factor of 5 for going from the 20 pCi/m²s limit to 6 pCi/m²s, and increase by only a factor of 2 for going from 60 pCi/m²s to 20 pCi/m²s.

The results of our cost-effectiveness analyses, which incorporate different weighting schemes for all the benefits of disposal, indicate that the incremental costs per unit of overall effectiveness are relatively insensitive to the choice of weighting of benefits. The cost-effectiveness of obtaining increased benefits beyond 60 pCi/m²s decreases monotonically by up to factors of two for each incremental level of control for all weighting schemes examined.

B. Economic Impact Analysis

In the RIA, we developed cases for analyzing the industry-wide costs and economic impacts associated with tailings disposal methods assumed to be required for compliance with the alternative standards. Each case represented a different combination of disposal methods applied to both existing and new tailings. The estimated economic impacts include potential mill closures (on a model mill basis) and uranium price increases. We estimated the impacts for each case according to different financial scenarios and different assumptions on the ability of companies to pass-through tailings disposal costs to their customers. The results from this analysis are used to represent the costs and impacts of the proposed standards.

We estimate that compliance with the standards, if other regulatory requirements did not exist, would cost the uranium milling industry about 280 million dollars for all tailings which exist today at licensed sites. If we include all those tailings which we estimate will be generated by the year 2000, based on recent DOE projections, the total cost to the uranium milling industry would be from 310 to 540 million dollars. These costs are present worth estimates (discounted at a 10 percent rate) expressed on a 1983 constant dollar basis. The range in cost is due to different assumptions on what actions are needed to meet requirements for ground water protection for new tailings at existing mills.

We estimate that increases in the price of uranium could range from 2 to 7 percent. In light of the currently poor economic condition of the industry and the threat of foreign competition, it is unlikely that mills will be able to pass through substantial portions of the disposal costs. Using our models and under the assumption of an average cash flow, we estimate that if mills are forced to absorb the entire cost of disposal, no mills would cease operation due to these standards. Under the conditions of no pass-through and lower cash-flow, one small model mill may close. However, we estimate that this closure can be avoided with the limited price pass-through stated above.

These costs and economic impacts are not all attributable to these standards, since some of these costs would probably occur in the absence of these standards due to other regulatory requirements at most sites. These include existing NRC licensing regulations and requirements established by agreement States, and regulations required under Section 84(a) (1) and (3) of UMTRCA. We did not estimate the costs imposed by these other requirements because that would require a site-specific investigation and these requirements have been continuously changing in the past few years (mostly toward more stringent requirements). Therefore, we could only estimate the upper bounds of cost and economic impacts imposed by these standards, and could not estimate the net impact of the standards.

This regulation was submitted to the Office of Management and Budget for review as required by Executive Order 12291. We believe the analysis discussed above complies with the intent of the Order. Any comments from OMB to EPA and any EPA response to those comments are available for public inspection at the docket cited above under "ADDRESSES."

C. Regulatory Flexibility Analysis

This regulation would not have a significant impact on a substantial number of small entities, as specified under Section 605 of the Regulatory Flexibility Act (RFA). Therefore, we have not performed a Regulatory Flexibility Analysis. The basis for this finding is that of the 27 licensed uranium mills, only one qualifies as a small entity and this mill will not be impacted by the standards. Almost all the mills are owned by large corporations. Three of the mills are partly-owned by companies that could qualify as small businesses, according to the Small Business Administration generic small entity definition of 500 employees. However, under the RFA, a small business is one that is independently owned and operated. Since these three mills are not independently owned by small businesses, they are not small entities.

D. OMB Regulations on the Paperwork Reduction Act

This rule does not contain any information collection requirements subject to OMB review under the Paperwork Reduction Act of 1980 U.S.C. 3501, et seq.

TABLE I—COSTS OF ALTERNATIVE STANDARDS FOR TAILINGS CONTROL TO THE YEAR 2000 (MILLIONS OF 1983 DOLLARS)

Alternative standard	Present Worth Costs (10 percent discount rate) (a)		Total cost
	Existing tailings	Future tailings	
A	0	1	1
B1	117	83	200
B2	192	95	287
B3	256	111	367
C1	115	95	210
C2	192	112	304
C3	260	128	388
C4	336	146	482
C5	403	165	568
D2	192	156	348
D3	260	160	430
D4	336	186	522
D5	403	204	607

[a] These cost estimates assume that two-thirds of the future tailings generated at existing mills will be placed in existing impoundments and the other one-third will be placed in new, lined, impoundments. We assume that the average radium contents of existing and future tailings is 400 pCi/g. These costs are our best estimates, but their uncertainty increases as the level of required radon control increases.

TABLE II—BENEFITS OF ALTERNATIVE STANDARDS FOR TAILINGS CONTROL TO THE YEAR 2000 (1)

Alternative standard	Stabilization		Radon Control			Water protection
	Chance of misuse	Erosion avoided (y)	Maximum risk (2) of lung cancer (percent reduction)	Deaths avoided		Longevity (y)
				First 100 years	Total	
A	Very likely	0	2 in 10^2(0)	0	0	0
B1	Likely	Hundreds	1 in 10^2(50)	300	1,000	100
B2	Less likely	do	4 in 10^3(80)	480	1,500	100
B3	do	do	1 in 10^3(95)	570	2,000	100
C1	Likely	Thousands	1 in 10^2(50)	300	Thousands	100
C2	Less likely	do	4 in 10^3(80)	480	Many thousands	Hundreds
C3	Unlikely	do	1 in 10^3(95)	570	Tens of thousands	1,000
C4	Very unlikely	Many thousands	3 in 10^4(98.5)	590	do	>1,000
C5	do	do	1 in 10^4(99.5)	597	do	>1,000
D2	Unlikely	Thousands	4 in 10^3(80)	480	Several thousands	1,000
D3	do	Many thousands	1 in 10^3(95)	570	Tens of thousands	>1,000
D4	Very unlikely	do	3 in 10^4(98.5)	590	do	>1,000
D5	do	do	1 in 10^4(99.5)	597	do	>1,000

(1) These estimates include the benefits resulting from control of 26 existing piles and 9 projected new piles. No credit is taken for any engineering safety factors incorporated to provide the required "reasonable assurance" of conformance.
(2) Lifetime risk of fatal cancer to an individual assumed to be living 600 meters from center of a model tailings pile.

This standard is promulgated on the date signed.

List of Subjects in 40 CFR Part 192

Air pollution control, Radiation protection, Hazardous materials, Uranium, Environmental protection, Hazardous constituents, Groundwater protection, Radon, Radium, and Thorium.

Dated: September 30, 1983.

William D. Ruckelshaus,

Administrator.

In 40 CFR Chapter I, Part 192 is amended by adding Subparts D and E as follows:

PART 192—HEALTH AND ENVIRONMENTAL PROTECTION STANDARDS FOR URANIUM AND THORIUM MILL TAILINGS

* * * * *

Subpart D—Standards for Management of Uranium Byproduct Materials Pursuant to Section 84 of the Atomic Energy Act of 1954, as Amended

Sec.

192.30 Applicability.
192.31 Definitions and Cross-references.
192.32 Standards.
192.33 Corrective Action Programs.
192.34 Effective Date.

Subpart E—Standards for Management of Thorium Byproduct Materials Pursuant to Section 84 of the Atomic Energy Act of 1954, as Amended

192.40 Applicability.
192.41 Provisions.
192.42 Substitute Provisions.
192.43 Effective Date.

Authority: Sec. 275 of the Atomic Energy Act of 1954, 42 U.S.C. 2022, as added by the Uranium Mill Tailings Radiation Control Act of 1978, Pub. L. 95-604, as amended.

* * * * *

Subpart D—Standards for Management of Uranium Byproduct Materials Pursuant to Section 84 of the Atomic Energy Act of 1954, as Amended

§ 192.30 Applicability.

This subpart applies to the management of uranium byproduct materials under Section 84 of the Atomic Energy Act of 1954 (henceforth designated "the Act"), as amended, during and following processing of uranium ores, and to restoration of disposal sites following any use of such sites under Section 83(b)(1)(B) of the Act.

§ 192.31 Definitions and Cross-references.

References in this subpart to other parts of the Code of Federal Regulations are to those parts as codified on January 1, 1983.

(a) Unless otherwise indicated in this subpart, all terms shall have the same meaning as in Title II of the Uranium Mill Tailings Rediation Control Act of 1978, Subparts A and B of this part, or Parts 190, 260, 261, and 264 of this chapter. For the purposes of this subpart, the terms "waste," "hazardous waste," and related terms, as used in Parts 260, 261, and 264 of this chapter shall apply to byproduct material.

(b) *Uranium byproduct material* means the tailings or wastes produced by the extraction or concentration of uranium from any ore processed primarily for its source material content. Ore bodies depleted by uranium solution extraction operations and which remain underground do not constitute "byproduct material" for the purpose of this Subpart.

(c) *Control* means any action to stabilize, inhibit future misuse of, or reduce emissions or effluents from uranium byproduct materials.

(d) *Licensed site* means the area contained within the boundary of a location under the control of persons generating or storing uranium byproduct materials under a license issued pursuant to Section 84 of the Act. For purposes of this subpart, "licensed site" is equivalent to "regulated unit" in Subpart F of Part 264 of this chapter.

(e) *Disposal site* means a site selected pursuant to Section 83 of the Act.

(f) *Disposal area* means the region within the perimeter of an impoundment or pile containing uranium by product materials to which the post-closure requirements of § 192.32(b)(1) of this subpart apply.

(g) *Regulatory agency* means the U.S. Nuclear Regulatory Commission.

(h) *Closure period* means the period of time beginning with the cessation, with respect to a waste impoundment, of uranium ore processing operations and ending with completion of requirements specified under a closure plan.

(i) *Closure plan* means the plan required under § 264.112 of this chapter.

(j) *Existing portion* means that land surface area of an existing surface impoundment on which significant quantities of uranium byproduct materials have been placed prior to promulgation of this standard.

§ 192.32 Standards.

(a) *Standards for application during processing operations and prior to the end of the closure period.* (1) Surface impoundments (except for an existing portion) subject to this subpart must be designed, constructed, and installed in such manner as to conform to the requirements of § 264.221 of this chapter.

except that at sites where the annual precipitation falling on the impoundment and any drainage area contributing surface runoff to the impoundment is less than the annual evaporation from the impoundment, the requirements of § 264.228(a)(2)(iii)(E) referenced in § 264.221 do not apply.

(2) Uranium byproduct materials shall be managed so as to conform to the ground water protection standard in § 264.92 of this chapter, except that for the purposes of this subpart:

(i) To the list of hazardous constituents referenced in § 264.93 of this chapter are added the chemical elements molybdenum and uranium,

(ii) To the concentration limits provided in Table 1 of § 264.94 of this chapter are added the radioactivity limits in Table A of this subpart,

(iii) Detection monitoring programs required under § 264.98 to establish the standards required under § 264.92 shall be completed within one (1) year of promulgation,

(iv) The regulatory agency may establish alternate concentration limits (to be satisfied at the point of compliance specified under § 264.95) under the criteria of § 264.94(b), provided that, after considering practicable corrective actions, these limits are as low as reasonably achievable, and that, in any case, the standards of § 264.94(a) are satisfied at all points at a greater distance than 500 meters from the edge of the disposal area and/or outside the site boundary, and

(v) The functions and responsibilities designated in Part 264 of this chapter as those of the "Regional Administrator" with respect to "facility permits" shall be carried out by the regulatory agency, except that exemptions of hazardous constituents under § 264.93 (b) and (c) of this chapter and alternate concentration limits established under § 264.94 (b) and (c) of this chapter (except as otherwise provided in § 192.32(a)(2)(iv)) shall not be effective until EPA has concurred therein.

(3) Uranium byproduct materials shall be managed so as to conform to the provisions of:

(a) Part 190 of this chapter, "Environmental Radiation Protection Standards for Nuclear Power Operations" and

(b) Part 440 of this chapter, "Ore Mining and Dressing Point Source Category: Effluent Limitations Guidelines and New Source Performance Standards, Subpart C, Uranium, Radium, and Vanadium Ores Subcategory."

(4) The regulatory agency, in conformity with Federal Radiation Protection Guidance (FR, May 18, 1960, pgs. 4402–3), shall make every effort to maintain radiation doses from radon emissions from surface impoundments of uranium byproduct materials as far below the Federal Radiation Protection Guides as is practicable at each licensed site.

(b) *Standards for application after the closure period.* At the end of the closure period:

(1) Disposal areas shall each comply with the closure performance standard in § 264.111 of this chapter with respect to nonradiological hazards and shall be designed [1] to provide reasonable assurance of control of radiological hazards to

(i) Be effective for one thousand years, to the extent reasonably achievable, and, in any case, for at least 200 years, and,

(ii) Limit releases of radon-222 from uranium byproduct materials to the atmosphere so as to not exceed an average [2] release rate of 20 picocuries per square meter per second (pCi/m²s).

(2) The requirements of Section 192.32(b)(1) shall not apply to any portion of a licensed and/or disposal site which contains a concentration of radium-226 in land, averaged over areas of 100 square meters, which, as a result of uranium byproduct material, does not exceed the background level by more than:

(i) 5 picocuries per gram (pCi/g), averaged over the first 15 centimeters (cm) below the surface, and

(ii) 15 pCi/g, averaged over 15 cm thick layers more than 15 cm below the surface.

§ 192.33 Corrective Action Programs.

If the ground water standards established under provisions of Section 192.32(a)(2) are exceeded at any licensed site, a corrective action program as specified in 264.100 of this chapter shall be put into operation as soon as is practicable, and in no event later than eighteen (18) months after a finding of exceedance.

[1] The standard applies to design. Monitoring for radon-222 after installation of an appropriately designed cover is not required.

[2] This average shall apply to the entire surface of each disposal area over periods of at least one year, but short compared to 100 years. Radon will come from both uranium byproduct materials and from covering materials. Radon emissions from covering materials should be estimated as part of developing a closure plan for each site. The standard, however, applies only to emissions from uranium byproduct materials to the atmosphere.

§ 192.34 Effective date.

Subpart D shall be effective December 6, 1983.

TABLE A

	pCi/liter
Combined radium 226 and radium-228	5
Gross alpha-particle activity (excluding radon and uranium)	15

Subpart E—Standards for Management of Thorium Byproduct Materials Pursuant to Section 84 of the Atomic Energy Act of 1954, as Amended

§ 192.40 Applicability.

This subpart applies to the management of thorium byproduct materials under Section 84 of the Atomic Energy Act of 1954, as amended, during and following processing of thorium ores, and to restoration of disposal sites following any use of such sites under Section 83(b)(1)(B) of the Act.

§ 192.41 Provisions.

The provisions of Subpart D of this part, including §§ 192.31, 192.32, and 192.33, shall apply to thorium byproduct material and:

(a) Provisions applicable to the element uranium shall also apply to the element thorium;

(b) Provisions applicable to radon-222 shall also apply to radon-220; and

(c) Provisions applicable to radium-226 shall also apply to radium-228.

(d) Operations covered under § 192.32(a) shall be conducted in such a manner as to provide reasonable assurance that the annual dose equivalent does not exceed 25 millirems to the whole body, 75 millirems to the thyroid, and 25 millirems to any other organ of any member of the public as a result of exposures to the planned discharge of radioactive materials, radon-220 and its daughters excepted, to the general environment.

§ 192.42 Substitute provisions.

The regulatory agency may, with the concurrence of EPA, substitute for any provisions of § 192.41 of this subpart alternative provisions it deems more practical that will provide at least an equivalent level of protection for human health and the environment.

§ 192.43 Effective date.

Subpart E shall be effective December 6, 1983.

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