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THE U.S. REGULATORY FRAMEWORK FOR LONG-TERM MANAGEMENT OF URANIUM MILL TAILINGS

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INTRODUCTION

The United States established the regulatory structure for the management, disposal, and long-term care of uranium mill tailings in 1978 with the passage of the *Uranium Mill Tailings Radiation Control Act* (UMTRCA) (Pub. L. 95-604). This legislation has governed the cleanup and disposal of uranium tailings at both inactive and active sites.

THE ATOMIC ENERGY ACT

In the United States, nuclear energy first became subject to federal regulations with the passage of the *Atomic Energy Act* (AEA) (Pub. L. 79-585). Its primary purpose was to ensure that nuclear energy was developed in a manner consistent with the security of the United States. The AEA gave the Atomic Energy Commission control of the production and use of fissionable materials.

In 1954, the AEA was amended (Pub. L. 83-703) to encourage private enterprise in the development and use of nuclear energy for peaceful purposes. These amendments ensure that the federal government regulates the processing and use of source, byproduct, and special nuclear materials through a comprehensive licensing process.

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In 1956, the AEA was further amended (Pub. L. 86-373) to do the following:

- Address the respective responsibilities of the states and the Atomic Energy Commission regarding control of source, byproduct, and special nuclear materials.
- Establish an orderly regulatory system for use by the states and the commission to regulate radiation hazards associated with these materials.
- Establish procedures for the transfer of the commission's regulatory responsibilities to the states upon approval of a state program.

However, provisions were maintained that prohibited the commission from turning over to the states the responsibility for regulating the discharge of radioactive effluents from any facilities.

In 1964, the U.S. Congress amended the AEA (Pub. L. 88-488) by adding a new section allowing private ownership of special nuclear materials by Atomic Energy Commission licensees.

DEFINITIONS

The term "source material" means (1) uranium, thorium, or any other material which is determined by the Atomic Energy Commission pursuant to the provisions of section 61 (42 U.S.C. §2091 *et seq.*) to be source material; or (2) ores containing one or more of the foregoing materials, in such concentration as the commission may by regulation determine from time to time. The term "byproduct material" means (1) any inherently radioactive material (except special nuclear material) or material made radioactive by exposure to the radiation incident to the process of producing or utilizing special nuclear material, and (2) the tailings or wastes produced by the extraction or concentration of uranium or thorium from any ore processed primarily for its source material content. The term "special nuclear material" means (1) plutonium, uranium enriched in the isotope 233 or in the isotope 235, and any other material which the commission, pursuant to the provisions of section 51 (42 U.S.C. §2071 *et seq.*), determines to be special nuclear material, but not including source material; or (2) any material artificially enriched by any of the foregoing, but not including source material.

THE URANIUM MILL TAILINGS RADIATION CONTROL ACT

The *Uranium Mill Tailings Radiation Control Act* (UMTRCA) (Pub. L. 95-604) established the regulatory framework for the cleanup and disposal of uranium mill tailings in the United States. Before this law was passed, uranium mill tailings were essentially unregulated. In the UMTRCA, the U.S. Congress acknowledged that misuse of tailings for construction was one of the areas of biggest concern, particularly in the city of Grand Junction, Colorado, where thousands of properties contained tailings used for construction material and fill. Control of tailings was not included in the original licensing procedures for uranium mills by the Atomic Energy Commission, because the tailings were not known to be hazardous; thus, tailings were not controlled under the AEA. With the passage of UMTRCA, the U.S. Congress included uranium mill tailings under the AEA. "Residual radioactive materials (RRM)," as defined under Title I of the UMTRCA, means waste in the form of tailings resulting from the processing of ores for the extraction of uranium and other valuable constituents of the ores; and other wastes at a processing site that relate to such processing, including any residual stock of unprocessed ores or low-grade materials. Title II sites, by definition, contain byproduct materials.

The U.S. Environmental Protection Agency (EPA) was assigned the responsibility of establishing regulations for cleanup and disposal of uranium mill tailings at active and inactive sites. The U.S. Nuclear Regulatory Commission (NRC) was designated as the agency responsible for enforcing the EPA standards. The distinction between inactive and active sites was based on those sites that did *not* have existing production licenses with the NRC at the time the legislation was passed (hence, inactive) and those that did (active). Inactive sites are sometimes referred to as Title I sites, and the active sites are sometimes referred to as Title II sites, based on the title numbers of the legislation.

The UMTRCA designated the DOE as the agency to clean up the 22 inactive mill sites, with 24 tailings piles. The owners of the active sites were required to comply with the standards individually. The legislation also required that the sites be managed in perpetuity by either the DOE or, in limited cases, the state or a federal agency designated by the President.

A mine reclamation requirement was not included in the UMTRCA for several reasons. At the time of the legislation, uranium mines (and mines in general) were not considered to be environmental problems. The *Surface Mining Reclamation Act* of 1977 was the first major federal environmental regulation regarding mines of any kind. Subsequently, many states developed mine reclamation programs and regulations, which is where the primary regulation of mines currently resides within the United States.

THE EPA STANDARDS

In the UMTRCA, the EPA was directed to promulgate standards that were similar to the agency's *Resource Conservation and Recovery Act* (RCRA) standards, where appropriate. The EPA issued draft standards for cleanup and disposal in 1981, and final regulations in 1983. The key points of the standards include the establishment of radium soil cleanup standards, the establishment of a disposal cell longevity standard of 200 to 1000 years, and the creation of a disposal cell radon flux standard.

More specifically, the regulations state the following:

- The concentration of radium-226 in land averaged over any area of 100 square meters shall not exceed the background level by more than
    - 5 picocuries per gram of radium-226 averaged over the first 15 centimeters of soil below the surface
    - 15 picocuries per gram of radium-226 averaged over 15-centimeter-thick layers of soil more than 15 centimeters below the surface.
- The design radon flux standard shall be 20 picocuries per square meter per second for disposal cells, or releases of radon-222 concentrations in air, outside of the disposal site, shall not exceed the average annual background level by more than one-half picocurie per liter.
- The indoor radon-222 standard shall be 0.02 working levels (in any case, not to exceed 0.03 working levels, including background levels).
- The disposal cell longevity shall be 200 to 1000 years.
- Ground water considerations shall be determined site by site.

In 1985, a federal court directed the EPA to redraft specific portions of the inactive standards related to ground water. (At the same time, the court upheld the active-site standards in their entirety.) The EPA issued draft ground water standards for disposal and cleanup in 1987. The final standards become effective in February 1995. The ground water disposal and cleanup standards include requirements to identify hazardous constituents; establish concentration limits at either background levels, maximum concentration limits (MCL) or alternate concentration limits (ACL); and monitor compliance. This is in keeping with the federal court's direction to make the regulations similar to the RCRA and the active-site standards.

An important component in the ground water regulations is the provision for supplemental standards. A ground water can be considered of "limited use" if its concentration of total dissolved solids (TDS) reaches or exceeds 10,000 milligrams per liter; if there is widespread ambient contamination that is not the result of the milling process and that cannot be cleaned up using normal water supply treatment technologies; or if the aquifer is incapable of producing more than 150 gallons (568 liters) per day for a sustainable period. The philosophy behind limited-use ground water is that these aquifers are not considered to be human drinking water resources. The standards require the DOE to consider impacts to existing or future potential beneficial uses and to protect the public health and the environment. The benefit of supplemental standards for ground water compliance is often a lower cost for disposal, from the standpoint of both disposal siting issues and cover permeability issues.

THE NATIONAL EMISSIONS STANDARDS FOR HAZARDOUS AIR POLLUTANTS

Under the *Clean Air Act* (CAA), the EPA promulgated the National Emissions Standards for Hazardous Air Pollutants (NESHAP). These standards were published on 15 December 1989 (54 FR 51654) and included provisions for the regulation of nonoperational and operational uranium mill tailings facilities.

The NESHAPs for nonoperational uranium mill tailings (codified at 40 CFR Part 61, subpart T) applied to both inactive and active sites. The standard had three primary requirements. First, it imposes an air emission limit of 20 picocuries per square meter per second of radon-222 from a disposal pile, consistent with the UMTRCA standard. Second, it requires that, once a uranium mill tailings pile or impoundment ceases to be operational, it must be disposed of and brought into compliance with the emission limit within 2 years of the effective date of the standard or within 2 years of the day it ceases to be operational, whichever is later. Third, it requires monitoring of the disposal pile to demonstrate compliance with the radon emission limit.

With regard to radon emissions at the DOE Uranium Mill Tailings Remedial Action (UMTRA) Project disposal sites, NESHAP compliance is achieved by performing radon flux measurements of each UMTRA Project disposal cell within 60 days following the completion of the radon barrier, to limit radon emissions, but prior to long-term stabilization of the pile. A report detailing the results of the radon flux testing is prepared within 90 days after testing and submitted to the EPA.

It is important to note that while the NESHAP numerical radon emissions limit is the same as the UMTRCA standard under 40 CFR Part 192, the UMTRCA standard is to be met through the proper design of the disposal impoundment and is implemented by the DOE and NRC for the individual sites. Under the CAA regulations, the standard is an emissions limit.

In July 1991, the EPA, the NRC, and the affected states began discussing the dual regulatory programs established under the UMTRCA and the CAA. In October 1992, those discussions resulted in a memorandum of understanding (MOU) among the EPA, the NRC, and the affected states. The MOU outlines the steps each party would take both to eliminate regulatory redundancy and to ensure that uranium mill tailings piles are closed as expeditiously as practicable. This MOU was published by the EPA on 25 October 1991 (56 FR 55434).

The EPA amended 40 CFR Part 192, subpart D, as it pertains to nonoperational Title II sites, on 15 November 1993 (58 FR 60340). The intent was to fill regulatory gaps and to eliminate duplicative requirements between 40 CFR Part 61, subpart T, and 40 CFR Part 192, subpart D. Specifically, the regulatory gaps addressed were "timetables" for closure of tailings piles and radon flux measurements to verify the efficacy of the cell design. These amendments required emplacement of a permanent radon barrier constructed to achieve compliance with the radon emission standard; required interim milestones to ensure progress in placing the final radon barrier; and required that site closure occur as expeditiously as practicable after the impoundments cease operations, with a goal of 31 December 1997 for those nonoperational uranium mill tailings piles listed in the MOU between EPA and NRC (at 56 FR 67568). For all other piles, compliance is required within 7 years after the impoundments cease operations. The amendments also state that the licensee shall conduct appropriate monitoring and analysis of the radon flux through the barrier to verify that the design of the permanent radon barrier is effective and ensure that radon-222 emissions will not exceed the standard.

On 1 June 1994, the NRC amended its regulations governing the disposal of uranium mill tailings (at 59 FR 28220) with the effective date being 1 July 1994. With these changes, existing NRC regulations were made to conform with regulations published by the EPA. This action was related to another by EPA to rescind its NESHAPs for radon emissions from the licensed disposal of uranium mill tailings at nonoperational sites. These amendments were promulgated under appendix A to Part 40. Additionally, the NRC requires the submittal of a reclamation plan, which covers a broader range of activities than required in EPA's tailings closure plan.

On 15 July 1994, EPA rescinded 40 CFR Part 61, subpart T (59 FR 71592), as it applies to owners and operators of uranium mill tailings disposal sites licensed by the NRC or affected agreement states (Title II), with the effective date being 29 June 1994. The EPA determined that the NRC regulatory program is protective of public health with an ample margin of safety to the same level as would implementation of subpart T.

NRC INTERPRETATION OF THE UMTRCA STANDARDS

The EPA standards required that certain features be incorporated in the design of the disposal cells. This prompted the NRC to develop procedures and approaches for complying with the standards. The longevity standard led to a disposal cell design capable of withstanding probable maximum precipitation (PMP) and probable maximum flood (PMF) events. Designs for PMPs and PMFs ultimately led to NRC rock durability scoring criteria. The longevity requirement also resulted in a disposal cell design incorporating natural materials, because man-made materials have not been proven to last 1000 years. The radon flux standard led to emphasis on the cover design to prevent radon emanation. As a result of the ground water standards, cover permeabilities became a major factor in the DOE's efforts to achieve disposal cell compliance.

THE DOE UMTRA PROJECT

The DOE's UMTRA Project Office in Albuquerque, New Mexico, has the overall responsibility for managing the project, including site characterization, decisions on disposal site selection, environmental compliance, construction issues, and closure documentation (including long-term surveillance and monitoring documentation).

The UMTRCA requires the DOE to clean up and stabilize the tailings at the 24 sites. The DOE is required to have a public participation program that involves the local communities and to enter into cooperative agreements with the affected states and, in certain instances, with Native American tribes. The DOE shares the cost of the project, with the states paying 10 percent. The DOE pays the remainder. UMTRA Project activities on tribal lands are funded 100 percent by the DOE.

The 24 inactive uranium mill tailings sites are located in 10 states (Figure 1). Currently, surface remediation is complete at 14 sites. Four sites are under construction, with two scheduled for completion in 1995. The remaining sites are in the advanced stages of planning; construction is scheduled to begin at four of these sites in the spring of 1995 and at the last two sites within the next 2 years.

With the introduction of the draft ground water standards, the DOE began a ground water project aimed at evaluating the need for aquifer cleanup at the 24 sites. This ground water project began in 1991. The key document for this project is a programmatic environmental impact statement that addresses the programmatic impact of the ground water restoration project.

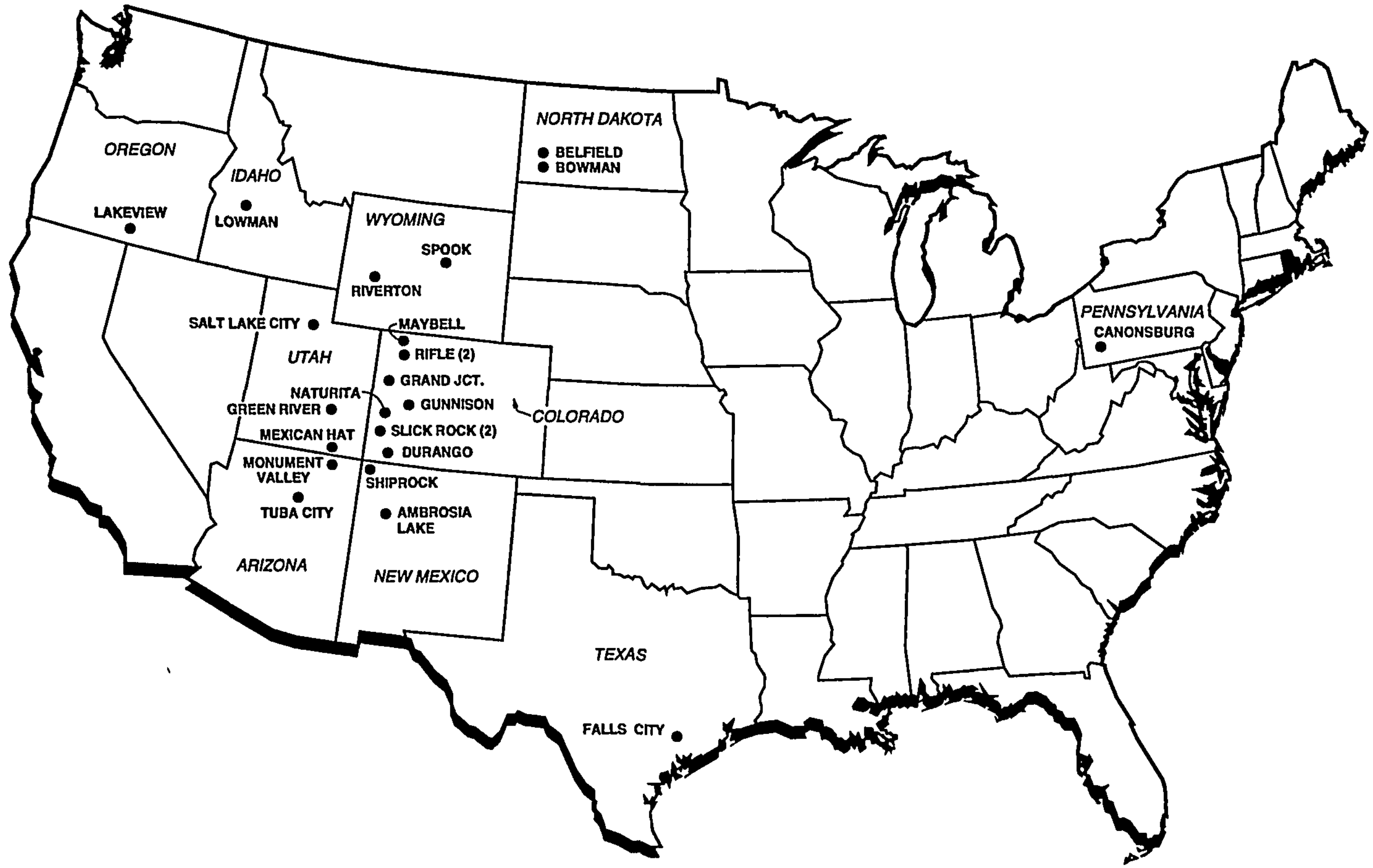

Figure 1. Locations of UMTRA Project Sites

DOE and NRC Cooperation

Since 1982, the DOE and NRC have funded research to examine various technical issues. Research conducted in the early days of the UMTRA Project centered on different types of cover components and cover thicknesses. Later research topics included erosion protection, freeze-thaw effects, and surface water hydrologic studies. More recent studies focus on ground water and risk assessment.

As a result of the research and a desire to streamline the project, a number of programmatic documents were produced that established design requirements as well as document formats. The DOE's *Technical Approach Document* addressed many technical elements related to meeting the EPA standards and NRC requirements. When the EPA issued draft ground water standards, the *Technical Approach Document* was modified to incorporate changes (DOE 1989). The NRC produced an erosion protection technical position (NRC 1989a) that established design standards, such as for rock sizing and durability. The NRC's standard review and content guide (NRC 1989b) formed the basis for the content of the DOE's remedial action plans and the NRC's technical evaluation reports. Other programmatic documents included a quality assurance testing and inspection procedure, a thorium protocol, and procedures for on-site construction reviews by the NRC. Additionally, the DOE and NRC signed an MOU that outlines each agency's roles and responsibilities, including a provision that the NRC must complete its reviews within 45 working days.

Disposal Site Selection

The DOE's mill tailings are either stabilized in place (SIP), stabilized on-site (SOS), or stabilized by relocating to an alternative site. The final location and configuration affects the final disposal cell design. Each type of stabilization can vary from aboveground disposal to different degrees of below-grade disposal. The ultimate goal of disposal alternatives is to assess technically acceptable alternatives in determining the most cost-effective option.

The disposal site selection process considers the geological stability of a site and its impact on disposal cell design, including evaluation of both the seismotectonic and geomorphic setting of the site. The type of stabilization used at UMTRA Project sites is greatly influenced by the expected magnitude of hydrologic impacts. Impacts from watershed runoff, flooding from nearby steams, surface water quality impacts, aquifer parameters, depth to ground water, direction of ground water flow, and potential impacts of tailings seepage on ground water quality (including compliance with EPA ground water standards) can necessitate relocation of the pile within the site boundaries or to an alternative site. For SIP or SOS options, there are greater restrictions with regard to improving surface water drainage conditions. Figure 2 shows a cross section of a typical UMTRA Project disposal cell.

Public sentiment is also considered when selecting the disposal site location. In the case of the Gunnison, Colorado, site, stabilization on-site met all of the technical disposal site selection criteria. However, the public preferred to relocate the tailings away from the city limits of Gunnison. This option was considered and implemented, as a suitable site was selected approximately 13 kilometers east of Gunnison.

Transportation Requirements for Relocation

The DOE UMTRA Project began successful transportation of RRM in 1982. In the past 15 years of operation, some 21.4 million cubic meters of RRM, in the form of truck and train loads, have been moved to safe, permanent disposal sites. The UMTRA Project-specific transportation program for hauling RRM was developed to achieve substantive compliance with Title 49 of the Code of Federal Regulations. The requirements of Title 49 are broad and comprehensive. They are designed to protect the public from the dangers associated with the commercial transport of virtually all materials, hazardous or not.

In 1991, a change in the Project's regulatory interpretation of Title 49 resulted in a reclassification of RRM as a hazardous substance as defined in 49 CFR §171.8. This reclassification imposed additional regulatory provisions, such as hazardous substance reportable quantity (RQ) requirements; shipping manifests; placarding; extensive hazardous material training; increased carrier insurance requirements; equipment inspections; and carrier tariffs. All of these requirements represented changes from the UMTRA Project-specific transportation program which the UMTRA Project had developed before the U.S. Department of Transportation (DOT) adopted hazardous substance provisions. Because a large-scale hauling operation was the only viable means of transporting RRM, and because it was not practical for the UMTRA Project to economically transport loads of RRM that were small (to avoid being classified as a RQ), the UMTRA Project requested a DOT exemption to the hazardous material and hazardous substance provisions of Title 49.

In 1992, the UMTRA Project was granted the exemption (DOT-E-10594). The exemption authorized shipments of low-level radioactive materials in closed vehicles and bulk containers without detailed analysis of their contents and with alternative requirements for hazard communication information. It also provides relief from any transportation regulation other than those specifically stated in the exemption.

The UMTRA Project-specific transportation program has proved to be adequate, safe, and protective of the environment. It contains virtually all of the elements of

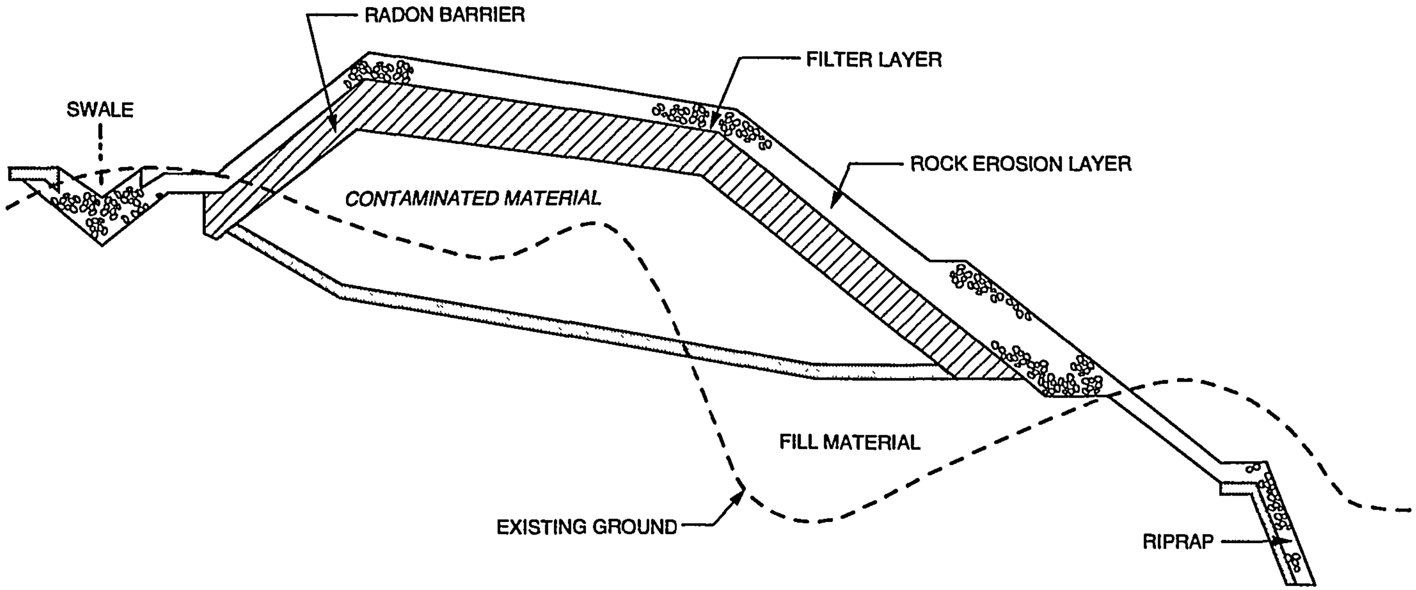

Figure 2. Cross Section of a Typical UMTRA Project Disposal Cell

Title 49, including specific transport procedures; worker/driver training; equipment inspection; carrier insurance; dedicated health, safety, and environmental professionals assigned to transportation activities full-time; and dedicated spill response functions.

Public Participation Program

As mentioned earlier, the DOE was required under the UMTRCA to have cooperative agreements with the respective state or Native American tribe. The DOE was also required by the UMTRCA to have an active public participation program. The DOE has actively pursued public involvement in the planning processes. It has held routine public meetings at the sites and has formed local task forces to examine issues in more detail. The public participation program for the DOE's UMTRA Project has been a model program; in fact, the DOE is using some of the lessons learned in dealing with the public on the UMTRA Project for other DOE Environmental Management programs within the United States.

Compliance with the National Environmental Policy Act

Under the *National Environmental Policy Act* (NEPA) of 1969, the DOE is required to formally evaluate the environmental impacts associated with the cleanup and disposal of the mill tailings. This requires the compilation of either an environmental assessment or an environmental impact statement. The NEPA requires input from applicable federal, state, and local agencies, Native American tribes, and the general public.

TITLE II PROGRAM

As stated previously, private mill owners are responsible for the cleanup and disposal of the tailings at their sites. The NRC reviews and concurs in the reclamation plans for the active sites. The 26 Title II active sites are in various stages of reclamation. With the exception of one site, all the active tailings piles are planned to be stabilized in place. Reclamation at several sites is well under way, with the first site slated for completion sometime in 1996. Some sites have only begun the planning for reclamation. Due to extensive ground water contamination, a few sites will not be completed with reclamation until after the year 2010.

The EPA standards for active sites are similar to the standards for inactive sites. However, there are a few differences between the regulations. The active-site regulations include provisions for the placement of liners, should the surface area of a tailings pile be expanded. Additionally, the Title II regulations do not include a provision for supplemental standards for ground water compliance.

THE TITLE I AND TITLE II DIFFERENCES

One of the major differences between the inactive and active sites is that the U.S. Congress established a deadline for the completion of surface remediation for inactive sites but did not establish a completion deadline for active sites. This is one of the two significant factors when comparing the costs of reclamation between Title I and Title II sites. By establishing a time limit in which to complete reclamation, there was little time for the DOE and NRC to engage in protracted discussions related to disposal issues. This led the DOE to undertake very conservative designs to expedite reclamation. This conservatism can be translated into thicker, less permeable covers and more durable rock covers.

Under the DOE's UMTRA Project, 14 tailings piles either have been or are planned to be relocated to alternate disposal sites. These relocations are very expensive. By contrast, only one active site may be relocated.

The other, more significant factor relates to the ground water compliance standards. This has its foundation in the court remand of the inactive standards in 1985. The court did not require the EPA to reexamine the active-site standards. In the "rewrite" of the ground water standards, the EPA included a provision for assurances that the inactive disposal sites would not cause future ground water contamination. The active-site regulations have no such provision. One might ask how a situation such as this could exist, as this was certainly not the intention of either the U.S. Congress or the EPA. In the authors' opinion, this is a case of one set of regulations (for inactive sites) being more in line with current U.S. regulatory approaches (for example, the RCRA program) than the other set of regulations (for active sites). The EPA finalized the active standards in 1983, long before many of the current interpretations and approaches were conceived. The recently finalized ground water regulations for the inactive sites were 8 years in the making. They constitute many years of policy changes, interpretations, and evolution of the primary regulatory drivers in the United States.

There is also an advantage to the inactive standards: the provision for supplemental standards. This regulatory element allows the current and potential future use of ground water as a drinking water source to be taken into account when setting standards. The EPA standards allow a ground water to be classified as "limited use," based on either poor quality (not affected by contamination from milling operations) or low quantity. This allows for flexibilities in some disposal design issues, such as the permeability of the disposal cell covers and siting of the disposal cells. However, the regulations required assurances that human health and the environment would be protected. The active-site ground water standards have no provision for supplemental standards.

THE FUTURE OF URANIUM PRODUCTION IN THE UNITED STATES

The uranium production industry in the United States has been declining since the infamous Three Mile Island nuclear power plant incident. With an optimistic outlook in 1979 of several hundred new reactors (with associated uranium production requirements) before the turn of the century, estimates of the number of new mines and mills providing feed material to the nuclear power fuel cycle ranged as high as 50 to 100. From 1979 to 1985, U.S. uranium production dropped from about 20,000 metric tons to less than 4000 metric tons per year. The substantial cost of tailings disposal and the high cost of environmental compliance have continued to erode the U.S. uranium production industry since then. In 1992, the United States produced less than 1000 metric tons of uranium, none of which was produced using conventional minerals processing or milling techniques.

At this time in the United States, many mining firms maintain substantial proven reserves of uranium but have no immediate plans to resume operations. With virtually every single conventional mill either disassembled or mothballed, any new uranium production (outside of *in situ* leaching operations) would require a major capital investment. In addition, the national infrastructure for uranium production (skilled work force, assay stations, exploration firms, equipment suppliers, etc.) has been dissolved and would need to be recreated. Until international prices for uranium concentrate rise substantially (about double), or until the cost of environmental compliance equally diminishes, uranium production in the United States will likely continue at current minimal levels from *in situ* leaching operations.

SUMMARY

The passage of the UMTRCA established a federal regulatory program for the cleanup and disposal of uranium mill tailings in the United States. This program involves the DOE, the NRC, the EPA, various states and tribal governments, private licensees, and the general public.

The DOE has completed surface remediation at 14 sites, with the remaining sites either under construction or in planning. The DOE's UMTRA Project has been very successful in dealing with public and agency demands, particularly regarding disposal site selection and transportation issues.

The active sites are also being cleaned up, but at a slower pace than the inactive sites, with the first site tentatively scheduled for completion in 1996.

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