



1 of 1

LOW-LEVEL RADIOACTIVE WASTE DISPOSAL IN
THE UNITED STATES: AN OVERVIEW OF CURRENT
COMMERCIAL REGULATIONS AND CONCEPTS

W. E. Kennedy, Jr.

August 1993

Presented at the
IAEA Training Course on Management of
Radioactive Wastes from Nuclear Power Plants
August 23-27, 1993
Chicago, IL

Work supported by
the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830

Pacific Northwest Laboratory
Richland, Washington 99352

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

MASTER

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

LOW-LEVEL RADIOACTIVE WASTE DISPOSAL
IN THE UNITED STATES: AN OVERVIEW OF CURRENT COMMERCIAL
REGULATIONS AND CONCEPTS

W. E. Kennedy, Jr.
Pacific Northwest Laboratory^a
P.O. Box 999
Richland, Washington 99352

ABSTRACT

Commercial low-level radioactive waste disposal in the United States is regulated by the U.S. Nuclear Regulatory Commission (NRC) under 10 CFR 61 (1991). This regulation was issued in 1981 after a lengthy and thorough development process that considered the radionuclide concentrations and characteristics associated with commercial low-level radioactive waste streams; alternatives for waste classification; alternative technologies for low-level radioactive waste disposal; and data, modeling, and scenario analyses. The development process also included the publication of both draft and final environmental impact statements. The final regulation describes the general provisions; licenses; performance objectives; technical requirements for land disposal; financial assurances; participation by state governments and Indian tribes; and records, reports, tests, and inspections. This paper provides an overview of, and tutorial on, current commercial low-level radioactive waste disposal regulations in the United States.

INTRODUCTION

In the mid 1970's, the NRC began the lengthy process of establishing new regulations for the land disposal of radioactive waste. For low-level radioactive wastes, the objective was to provide rules in Title 10, Code of Federal Regulations (10 CFR), that would provide licensing procedures, performance objectives, and technical requirements for licensing land disposal. The regulations were to consider standards of performance;

^a The Pacific Northwest Laboratory is operated by Battelle Memorial Institute for the U.S. Department of Energy under Contract DE-AC06-76RLO 1830.

technical requirements for siting, design, operation, and closure; technical requirements regarding waste forms; waste classification; administrative and licensing requirements; and financial-assurance requirements.

The regulation that resulted from the NRC efforts is now known as 10 CFR 61, Licensing Requirements for Land Disposal of Radioactive Waste (1991). This regulation describes and defines the procedures, criteria, and licensing conditions "for the disposal of radioactive wastes containing byproduct, source and special nuclear material received from other persons" (10 CFR 61 1991). The regulation specifically does not apply to disposal of high-level waste, disposal of uranium or thorium tailings in quantities greater than 10,000 kg containing more than five millicuries of ²²⁶Ra, or disposal of licensed material.

BACKGROUND/HISTORY

The development process for 10 CFR 61 resulted in a series of documents that specifically addressed the major technical issues. The NRC produced early programmatic and issues documents, including The Nuclear Regulatory Commission Low-Level Radioactive Waste Management Program (NRC 1977); NRC Task Force Report on Review of the Federal/State Program for Regulation of Commercial Low-Level Radioactive Waste Burial Grounds (NRC 1977); and Essays on Issues Relevant to the Regulation of Radioactive Waste Management (Bishop et al. 1978). In the area of waste classification, notable documents produced for the NRC and others include A Classification System for Radioactive Waste Disposal--What Waste Goes Where? (Adam and Rogers 1978), Development of a Radioactive Waste Disposal Classification System (43 FR 36722-36725), Determination of a Radioactive Waste Classification System (Cohen and King 1978), and A Radioactive Waste Disposal Classification System (Rogers 1979).

As part of the rulemaking process, the NRC then produced a Draft Environmental Impact Statement on 10 CFR Part 61: "Licensing Requirements for Land Disposal of Radioactive Waste" (NRC 1981). This draft Environmental Impact Statement (EIS) contained an exhaustive and detailed analysis of a wide range of low-level waste disposal alternatives. As a rulemaking EIS, the document had two

distinct purposes. The first was to fulfill NRC's responsibility under the National Environmental Policy Act of 1969 (NEPA) requiring federal agencies to produce an EIS for major actions significantly affecting the human environment. The second objective was to demonstrate the decision process employed in developing Part 61, which considered alternative courses of action relative to costs, environmental impacts, and health and safety concerns. The NRC limited the draft EIS analysis to near-surface technologies (i.e., within the top 15-20 m of the earth's surface), leaving disposal in deep-mined cavities, oceans, or outer space to subsequent rulemakings. The draft EIS was not a generic EIS because it did not analyze all of the issues associated with low-level waste disposal; rather, it focused on the basic decision analysis needed for 10 CFR 61.

Supporting the draft EIS, the NRC published the technical information, data, and models used in the determination of public radiation doses. The primary data appeared in Data Base for Radioactive Waste Management (Oztunali et al. 1981), which consisted of a three-volume set. Volume 1 of this set provided a summary and analysis history of the low-level waste disposal at both commercial and governmental facilities. Volume 2 provided a summary of low-level waste characteristics and volumes, with projections to the year 2000. Volume 3 documented the methods and data used for analyzing the radiation doses resulting from waste handling and disposal, including alternative waste forms, facility designs, operating practices, environmental settings, and institutional controls.

After about a year of technical and public review, the NRC determined that no new alternatives or principles were identified that required analysis. Thus, no major changes were required for the overall performance objectives, administrative and procedural requirements for licensing, and financial assurance. There were several areas, however, in which the draft EIS required clarification and explanatory changes. As a result, the NRC issued a three-volume final EIS entitled Final Environmental Impact Statement on 10 CFR 61: "Licensing Requirements for Land Disposal of Radioactive Waste" (NRC 1982). The final EIS was not a revision of the draft, but rather a stand-alone statement using the draft EIS as a resource and reference document. Included

in the final EIS were refinements to the draft EIS assumptions, data, and analysis methodology. The NRC strategy was to produce a final EIS of a more manageable size reaching conclusions in a more concise manner. After the final EIS was issued, an application of the analysis methodology with a focus on *de minimis* waste impacts was developed and issued (Oztunali and Roles 1984). The NRC also published a User's Guide for the 10 CFR 61 Impact Analysis Codes (Widmayer 1983). In 1986 an update of Part 61's methods for impact analysis was issued to describe the computerized models used to conduct the radiation dose assessments (Oztunali and Roles 1986).

In parallel with the draft and final EIS development, the NRC issued the Federal Register version of the draft 10 CFR 61 for public comment. Following the release of the final EIS, the NRC issued the final version of 10 CFR 61.

OVERVIEW OF 10 CFR 61

The final version of 10 CFR 61 consists of seven subparts that describe the general provisions; licenses; performance objectives; technical requirements for land disposal; financial assurances; participation by state governments and Indian tribes; and records, reports, tests and inspections. The following sections outline the contents of each subpart.

SUBPART A - GENERAL PROVISIONS

Subpart A of 10 CFR 61 contains nine chapters that define the document's purpose and scope and provide and describe definitions, license requirements, communications, interpretations, exemptions, concepts, reporting and recordkeeping, employee protection, and completeness and accuracy of information.

The purpose of 10 CFR 61 is to establish the procedures, criteria, and terms and conditions upon which the NRC issues licenses for the disposal of low-level radioactive waste. Key definitions in 10 CFR 61 (1991) include the following:

- *Buffer Zone* is a portion of the disposal site that is controlled by the licensee and that lies under the disposal units and between the disposal units and the boundary of the site.
- *Disposal* means the isolation, by emplacement in a land disposal facility, of radioactive wastes from the biosphere inhabited by man and containing his food chains.
- *Disposal site* means that portion of a land disposal facility that is used for disposal of waste. It consists of disposal units and a buffer zone.
- *Engineered barrier* means a man-made structure or device that is intended to improve the land disposal facility's ability to meet the performance objectives in subpart C.
- *Inadvertent intruder* means a person who might occupy the disposal site after closure and engage in normal activities, such as agriculture, dwelling construction, or other pursuits in which the person might be unknowingly exposed to radiation from the waste.
- *Intruder barrier* means a sufficient depth of cover over the waste that inhibits contact with waste and helps to ensure that radiation exposures to an inadvertent intruder will meet the performance objectives set forth in this part, or engineered structures that provide equivalent protection to the inadvertent intruder.

As a requirement, 10 CFR 61 limits receipt, possession, and disposal of source, special nuclear, or by-product material only at NRC-licensed disposal facilities. Exemptions to the general requirements in 10 CFR 61 may be granted by the Commission, if it is determined that such exemptions will not endanger life or property or the common defense and security, and if the exemption is in the public interest.

Several important concepts are defined in 10 CFR 61, subpart A (1991). Near-surface disposal of radioactive waste must be done in a manner that will protect the general population from releases of radioactivity, protect individuals from inadvertent intrusion, protect individuals during operations, and provide stability of the waste and site. Stability of the waste and site will help minimize water access to the waste, thus minimizing radionuclide

migration and long-term maintenance. Wastes containing relatively low concentrations of radionuclides, with little need for stability requirements, is termed Class A waste. Wastes containing higher concentrations of radionuclides, with increased stability requirements, are termed Class B and Class C wastes. These classes of wastes should have waste forms or containers that are designed to maintain gross physical properties and identity over 300 years. Class A waste that meets the stability requirements may be mixed with Class B and C wastes.

The principal controls defined in the regulation to prevent inadvertent intrusion into disposed wastes are 1) institutional control over the site after disposal operations are terminated and 2) disposing of wastes that may present an unacceptable risk to intruders in a manner that provides some form of intruder prevention. Institutional controls are defined to last for 100 years. Wastes that will not pose an undue hazard beyond 100 years (i.e., their concentrations will be greatly reduced during the 100-year period by radioactive decay) are Class A and Class B wastes. Because Class C wastes will contain higher concentrations that will not decay to acceptable levels within 100 years, they must be disposed of at greater depths or with other engineered intruder barriers to prevent intruders from contacting wastes for up to 500 years. Wastes exceeding the defined concentrations for Class C wastes are generally unacceptable for near-surface disposal. Case-by-case evaluations of alternative waste-disposal methods, perhaps including special processing or disposal system design, could permit disposal of greater than Class C wastes, with NRC approval.

SUBPART B - LICENSES

Subpart B to 10 CFR 61 contains 21 sections describing the details of the licensing process for low-level waste disposal. The information ranges from general to specific, including sections of technical analyses, institutional information, financial information, standards for issuance of a license, conditions of licenses, changes, amendments, license transfer, and license termination.

The first several sections of subpart B describe the contents of a license application. The specific technical information that must be included in a license application includes a description of the site and its natural characteristics, a description of the design features of the disposal system, a description of the effect of design-basis natural events compared with the design criteria, and a description of the site closure plan. Detailed descriptions of the disposal operation are also required, including estimates of the quantities of radionuclides to be disposed of, the radiation safety programs to protect site workers, the radiation monitoring program to ensure compliance with occupational and environmental criteria, and a description of the administrative procedures used to control all activities at the disposal site.

The technical analyses must include analyses to demonstrate reasonable assurance that the performance objectives defined in subpart C will be met. The pathways to be analyzed to demonstrate protection of the surrounding population include releases to the air, soil, groundwater, surface water, plants, and exhumation by burrowing animals. The analyses must show the aspects attributed to both the natural and engineered systems in isolating wastes and clearly demonstrate reasonable assurance that the public radiation protection standards can be met. Intruder analyses are generally covered by the definition of the waste classification system; however, intruder analyses must demonstrate reasonable assurance that waste classification and segregation requirements will be met to prevent inadvertent intrusion.

For site closure, the licensee must submit an application to amend the license that includes the specific details of the closure plan and notes any additional geologic, hydrologic, or other site data important to determining the long-term containment of emplaced wastes. The application must also contain the results of any experiments or analyses that may improve the ability to assess long-term performance of the disposal system. Following completion of the site closure, responsibility for the site must be maintained by the licensee for five years to permit post-closure observation and maintenance. Upon assurance that the institutional requirements are met, the licensee may apply for license termination.

SUBPART C - PERFORMANCE OBJECTIVES

Subpart C of 10 CFR 61 (1991) contains five parts that define general requirements, as well as specific requirements for protection of workers and the public. For protection of the general population, annual radiation dose limits are established at 25 mrem to the whole body, 75 mrem to the thyroid, and 25 mrem to any other organ. Efforts should be made to maintain releases to the environment as low as reasonably achievable. For inadvertent intrusion, the site design, operation, and closure must ensure protection of any individual occupying the site or contacting waste after active institutional controls are removed. The radiation protection standards that apply to workers during site operations are generally defined in 10 CFR 20 (56 FR 23360-23474, 1991). Finally, subpart C requires that the disposal site and its operation ensure long-term stability to eliminate the need for long-term active post-closure maintenance, beyond environmental surveillance and monitoring.

SUBPART D - TECHNICAL REQUIREMENTS FOR LAND DISPOSAL FACILITIES

Subpart D to 10 CFR 61 (1991) contains 13 sections that describe disposal site suitability and design requirements, facility operation and closure conditions, environmental monitoring, alternatives for design and operation, waste classification, waste characteristics, labeling, alternatives for classification and characteristics, and institutional requirements.

A number of site-suitability requirements are identified in subpart D, including the following: sites shall be capable of being characterized, modeled, analyzed, and monitored; projected population growth and future development should not affect the ability of the site to meet performance objectives; sites with natural resources that could be exploited should be avoided; sites should be well drained and free from flooding or ponding (above the 100-year flood plain and high-hazard coastal areas); sites should have sufficient depth to the water table to minimize ground-water intrusion (transport should be diffusion-limited); sites should not have ground water discharges to surface water within the site boundary; and sites with tectonic

or geologic processes like faulting, folding, seismic activity, vulcanism, mass-wasting, erosion, slumping, landslides, or weathering should be avoided.

Additional requirements in subpart D describe: the conditions for segregating Class A from Class C wastes, disposing Class C wastes at least 5 m below grade or with intruder barriers to protect against inadvertent intrusion for at least 500 years, filling void spaces between waste containers to ensure site stability, covering wastes to reduce radiation dose rates, clearly marking disposal trenches, and maintaining a buffer zone between buried waste and the site boundary. Requirements are also provided to ensure that an environmental monitoring program will be established to provide early warning of releases of radionuclides before they migrate offsite.

One of the most important sections in subpart D of 10 CFR 61 (1991) describes waste classification. Wastes may be classified in three separate classes, depending on radionuclide content and stability, as Class A, Class B, and Class C. Class A waste must meet minimum stability requirements and 1) can not exceed 0.1 times the concentration in Table 1 (1991) and 2) can not exceed the concentration in Column 1 of Table 2 (1991). Class B wastes are those wastes that meet more rigorous requirements on stability and waste form than Class A wastes and exceed the concentrations listed in Table 2, Column 1, but are less than those in Table 2, Column 2. Class C wastes are those wastes that not only meet more rigorous requirements on stability and waste form, but also meet additional requirements to protect against inadvertent intrusion, and do not exceed the concentrations in Table 1 and the concentrations in Column 3 of Table 2. If wastes do not contain the radionuclides shown in Table 1, classification will be made based on the radionuclides in Table 2 alone. If wastes do not exceed 0.1 times the concentration in Table 1, the classification will be based on comparison with Table 2 concentrations. If wastes contain radionuclides in both Tables 1 and 2, the classification shall be determined using the sum of fractions rule. If the concentrations exceed the values in Table 1 or Column 3 of Table 2, then the waste is not generally acceptable for near-surface disposal. The concentrations of radionuclides in wastes may be determined by indirect methods, including the use of scaling

factors relating the relative concentrations of hard-to-detect radionuclides to ones that can be detected; however, there must be reasonable assurance that the indirect methods can be correlated with actual measurements.

Several requirements are included in subpart D on the characteristics of low-level radioactive wastes. The major requirements include avoiding cardboard or fiberboard boxes; solidifying liquid wastes or including enough adsorbent material to absorb twice the liquid volume; avoiding free-standing liquids in containers greater than 1 percent by volume; avoiding explosive or reactive waste forms; avoiding waste forms capable of producing toxic gases, vapors, or fumes; avoiding pyrophoric wastes; packaging gaseous wastes with pressures not to exceed 1.5 atmospheres at 20° C; treating wastes with hazardous, biological, pathogenic, or infectious materials to reduce the potential hazards from non-radioactive materials; ensuring stability of wastes to avoid slumping, collapse, or other failures that could lead to enhanced water infiltration or other conditions that may jeopardize site performance; and reducing void spaces within the waste packages.

SUBPART E - FINANCIAL ASSURANCES

As part of the licensing conditions in subpart E of 10 CFR 61 (1991), licensees must provide assurance that they have the ability to carry out disposal site closure and decontamination and decommissioning activities that may be needed. The assurances shall be provided using NRC-approved cost estimates based on the NRC-approved site disposal plan. To avoid unnecessary duplication, the NRC will accept other financial sureties developed at the request of other federal or state agencies or local governing bodies. Acceptable financial surety arrangements include surety bonds, cash deposits, certificates of deposit, escrow accounts, irrevocable letters or lines of credit, trust funds, or combinations of the above arrangements.

Table 1. Radionuclide Concentrations from 10 CFR 61 (1991), Table 1

Radionuclide	Concentration, Ci/m ³	
¹⁴ C	8	
¹⁴ C in activated metal		80
⁵⁹ Ni in activated metal	220	
⁹⁴ Nb in activated metal		0.2
⁹⁹ Tc	3	
¹²⁹ I	0.08	
Alpha-emitting transuranic nuclides with half-life greater than five years		100 ¹
²⁴¹ Pu	3,500 ¹	
²⁴² Cm	20,000 ¹	

¹ Units are nanocuries per gram

Table 2. Radionuclide Concentrations from 10 CFR 61 (1991), Table 2

Radionuclide	Concentration, Ci/m ³		
	Col. 1	Col. 2	Col. 3
Total of all nuclides with less than 5 year half-life	700	(¹)	(¹)
³ H	40	(¹)	(¹)
⁶⁰ Co	700	(¹)	(¹)
⁶³ Ni	3.5	70	700
⁶³ Ni in activated metal	35	700	7000
⁹⁰ Sr	0.04	150	7000
¹³⁷ Cs	1	44	4600

¹ There are no limits established for these radionuclides in Class B or C wastes. Practical considerations such as the effects of external radiation and internal heat generation on transportation, handling, and disposal will limit the concentrations for these wastes. These wastes shall be Class B unless the concentrations of other nuclides in Table 2 determine the waste to be Class C independent of these radionuclides.

SUBPART F - PARTICIPATION BY STATE GOVERNMENTS AND INDIAN TRIBES

Subpart F of 10 CFR 61 (1991) describes the formal process that the NRC will use to request state or tribal governments to participate in the review of a license application. This information is not intended to bar other actions by states or tribes as provided under other federal regulations. The process outlined describes filing proposals for state and tribal participation and NRC approval of such proposals.

SUBPART G - RECORDS, REPORTS, TESTS, AND INSPECTIONS

The final subpart of 10 CFR 61 (1991) describes records and other documentation that must be maintained as part of the licensing conditions. Records maintained during site operations and closure must be maintained and transferred to the chief executive of the nearest municipality, the chief executive of the county, the county zoning board or land development and planning agency, the state governor and other state, local, and federal agencies, as required by the NRC. Waste shipment records shall record the date of disposal of waste, the location within the site, the condition of the packages received, evidence of leaking or damaged packages, and radiation or contamination levels in excess of transportation limits. In addition, each licensee shall submit annual reports to the NRC summarizing activities for the previous year of operation. These reports shall include the specific quantity of each of the principal radionuclides released to unrestricted areas in liquid and airborne effluents, the results of the environmental monitoring program, a summary of disposal unit survey and maintenance activities, a summary of the quantities of radionuclides disposed of by waste class, and other information required by the NRC. Each licensee shall allow the NRC to inspect the wastes to be disposed of and the site and operations at all reasonable times. Finally, the NRC has the right to issue an injunction or other court order for the payment of a civil penalty if violations of the Atomic Energy Act of 1954 occur.

SUMMARY

Low-level radioactive waste disposal operations in the U.S. are licensed by the NRC using 10 CFR 61 (1991). This regulation is based on a substantial body of information and research regarding alternatives for the safe disposal of low-level radioactive wastes in the near-surface environment. The regulation covers all aspects of site operation and closure, establishes basic performance objectives, and provides a waste classification system for determining specific waste-disposal conditions. Reasonable assurance must be provided by licensees that the site will meet both the operational and post-closure performance objectives.

REFERENCES

10 CFR 61. 1991. U.S. Nuclear Regulatory Commission: "Licensing Requirements for Land Disposal of Radioactive Waste." U.S. Code of Federal Regulations.

43 FR 36722-5. August 18, 1978. Development of a Radioactive Waste Disposal Classification System. *Federal Register*.

56 FR 23360-23474. May 21, 1991. "Standards for Protection Against Radiation." (10 CFR 20) *Federal Register*.

Adam, J. A., and V. L. Rogers. 1978. A Classification System for Radioactive Waste Disposal--What Waste Goes Where? NUREG-0456, FBDU-224-10. U.S. Nuclear Regulatory Commission, Washington, D.C.

Bishop, W. P., I. R. Hoos, N. Hilberry, D. S. Metlay, and R. A. Watson. 1978. Essays on Issues Relevant to the Regulation of Radioactive Waste Management. NUREG-0412. U.S. Nuclear Regulatory Commission, Washington, D.C.

Cohen, J. J., and W. C. King. 1978. Determination of a Radioactive Waste Classification System. UCRL-52535, Lawrence Livermore Laboratory, University of California, Livermore, California.

Oztunali, O. I., G. C. Re, P. M. Moskowitz, E. D. Picazo, and C. J. Pitt. 1991. Data Base for Radioactive Waste Management. NUREG/CR-1759, Volumes 1-3. U.S. Nuclear Regulatory Commission, Washington, D.C.

Oztunali, O. I., and G. W. Roles. 1984. De Minimis Waste Impacts Analysis Methodology. NUREG/CR-3585, Vols. 1 and 2. U.S. Nuclear Regulatory Commission, Washington, D.C.

Oztunali, O. I., and G. W. Roles. 1986. Update of Part 61 Impacts Analysis Methodology. NUREG/CR-4370, Vols. 1 and 2. U.S. Nuclear Regulatory Commission, Washington, D.C.

Rogers, V. C. 1979. A Radioactive Waste Disposal Classification System. NUREG/CR-1005, Vol. 1. U.S. Nuclear Regulatory Commission, Washington, D.C.

U.S. Nuclear Regulatory Commission. 1977. NRC Task Force Report on Review of the Federal/State Program for Regulation of Commercial Low-Level Radioactive Waste Burial Grounds. NUREG-0217. Washington, D.C.

U.S. Nuclear Regulatory Commission. 1977. The Nuclear Regulatory Commission Low-Level Waste Management Program. NUREG-0240. Washington, D.C.

U.S. Nuclear Regulatory Commission. 1981. Draft Environmental Impact Statement on 10 CFR 61: "Licensing Requirements for Land Disposal of Radioactive Waste." NUREG-0945, Vols. 1-3, U.S. Nuclear Regulatory Commission, Washington, D.C.

U.S. Nuclear Regulatory Commission. 1982. Final Environmental Impact Statement on 10 CFR 61: "Licensing Requirements for Land Disposal of Radioactive Waste." NUREG-0945, Vols. 1-3, U.S. Nuclear Regulatory Commission, Washington, D.C.

Widmayer, D. A. 1983. User's Guide for 10 CFR 61 Impact Analysis Codes. NUREG-0959. U.S. Nuclear Regulatory Commission, Washington, D.C.

DATE

FILMED

12 / 29 / 93

END