UPDATE OF PART 61 IMPACTS ANALYSIS METHODOLOGY

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ABSTRACT

The U.S. Nuclear Regulatory Commission is expanding the impacts analysis methodology used during the development of the 10 CFR Part 61 regulation to allow improved consideration of costs and impacts of disposal of waste that exceeds Class C concentrations. The project includes updating the computer codes that comprise the methodology, reviewing and updating data assumptions on waste streams and disposal technologies, and calculation of costs for small as well as large disposal facilities. This paper outlines work done to date on this project.

INTRODUCTION

This paper presents a summary of the ongoing project to update the analysis methodology (Ref. 1) used by the Nuclear Regulatory Commission (NRC) to analyze alternatives in the draft and final environmental impact statements (EIS) (Refs. 2, 3) on the regulation 10 CFR Part 61 ("Licensing Requirements for Land Disposal of Radioactive Waste") (Ref. 4). This updated analysis methodology may be potentially used for generic waste classification analysis, and as a methodology that can be used to analyze disposal of individual wastes that exceed Class C concentrations on a case-by-case basis.

Background

The background to this study is dominated by the past definitions of low- and high-level waste, as well as recent initiatives on their regulation.

Resolution of the technical, institutional, social, and political issues surrounding the disposal of low-level radioactive waste has been called by many an important national goal. One of the milestones on the way to meeting this goal was the passage of the Low-Level Waste Policy Act in 1980 (Pub. L. 96-573). This Act establishes the principle that disposal of low-level waste is a state responsibility while reconfirming the principle that disposal of high-level waste is a federal responsibility.

Another significant milestone in achieving the above goal was the promulgation by the NRC of the regulation 10 CFR Part 61 on December 27, 1982 (Ref. 4). The Part 61 regulation was supported by the draft and final EISs (Refs. 2, 3) prepared by the NRC staff. An analytical methodology was created to perform rulemaking analyses in these EISs and the initial version of this analysis methodology (used for the draft Part 61 EIS) is described in reference 1. Considerable modifications to the initial Part 61 analysis methodology were made to perform the calculations for the final EIS.

A waste classification system was instituted in the regulation which establishes three classes of waste suitable for near-surface disposal: Class A, Class B, and Class C. Limiting concentrations for particular radionuclides were established for each waste class, with the highest class being Class C. The regulation states that waste exceeding Class C concentrations is considered to be "not generally acceptable for near-surface disposal," where this is defined in paragraph 61.55(a) as "waste for which waste form and disposal methods must be different, and in general more stringent, than those specified for Class C waste" (Ref. 4). Thus, waste exceeding Part 61 Class C concentrations (less than 1% of the about 3,000,000 ft^3 of commercial low-level waste annually being generated) has been generally excluded from near-surface disposal and is being held in storage by licensees.

Regulation of high-level waste disposal has been proceeding on a parallel course. Based on the authority of the Energy Reorganization Act of 1974 (Pub. L. 93-438), the NRC developed and adopted regulations that govern the licensing of the DOE activities at geologic repositories for disposal of high-level waste. These regulations are codified in 10 CFR Part 60 (Ref. 5). More recently, the Nuclear Waste Policy Act of 1982 (Pub. L. 97-425) provides for the development of repositories for the disposal of high-level radioactive waste and establishes a program of research, development, and demonstration.

Waste Definition

The legal and regulatory definitions of both high-level and low-level wastes are given in an imprecise manner in the above regulations and Acts. All definitions address the source of the waste rather than the specific radioactive contents. This has led to some problems.

One problem is that while the above source oriented definitions were developed with an understanding of the relative difference in hazard potential presented by the two types of waste, there can be some overlap. That is, both high-level and low-level wastes may contain a wide range of radionuclides and radionuclide concentrations. Occasionally these radionuclide concentrations overlap, so that some wastes defined as low-level wastes may have nuclides in concentrations that exceed those in some high-level wastes. A definition of both types of waste which is more precisely based on radioactive hazard is therefore needed.

A second problem is the existence of orphan wastes -- i.e, low-level wastes generated in the commercial sector for which disposal criteria are undefined. Prior to the promulgation of the Part 61 regulation, there was no uniform waste classification system, although all operating low-level waste disposal sites had adopted license conditions that prohibited disposal of waste containing transuranic material in concentrations exceeding 10 nCi/g. Waste exceeding 10 nCi/g was "orphaned" since: (1) there was no commercial (licensed by NRC or an Agreement State) capacity for low-level waste disposal, and (2) the Department of Energy took the position that as long as it was not "high-level waste" the Department had no legal authority to accept the waste for storage and eventual disposal. Licensees therefore had no place to dispose this waste.

Resolution of this Catch-22 situation was not totally accomplished with the promulgation of 10 CFR Part 61, since doing so would have delayed its publication. Many licensees holding wastes exceeding Class C concentrations are therefore in the same essential predicament as before. Wastes exceeding Class C concentrations are still defined as low-level waste and are therefore outside of federal responsibility. The existence of 10 CFR Part 61, however, does provide a regulatory framework to resolve the question.

A third problem is a perception by some that the above uncertainties associated with the definitions of high- and low-level wastes present a hinderence to the compacting process. That is, states are not likely to proceed with the compacting process unless the wastes for which the states are responsible for under the Low-Level Waste Policy Act are precisely defined.

Problem Resolution

NRC is considering a number of possible approaches to accomplishing this. One approach is to examine low-level wastes that exceed Class C concentrations, as well as various alternatives for low-level waste disposal, to determine whether there exists concentrations of wastes that might be safely disposed by these alternative methods. This could result in a new classification of low-level waste -- "Class D waste" -- which would mark the upper limit of low-level waste disposal. Wastes exceeding Class D limits would be defined as high-level waste. To do this, the Part 61 analysis methodology needs to be updated to more precisely define wastes exceeding Class C concentrations and possible disposal methods.

GENERAL APPROACH

The general approach taken in the updated Part 61 analysis methodology is very similar to that taken for the Part 61 analysis methodology originally described in reference 1 and later heavily modified as described in reference 3. The calculational methodology is structured as a number of computer codes, and the selection of a particular code depends upon the type of information desired.

In developing the updated analysis methodology, one of the principal considerations was the great variety of possible methods for treatment and disposal of low-level waste, as well as the great variety of possible site environments in which this treatment and/or disposal can take place. Another consideration was the need to address the significant pathways for human exposure, and to incorporate any significant and appropriate advances in health physics calculational techniques since the development of the original Part 61 analysis methodology. A very important consideration was the need to consider the depth to which site-specific aspects would enter the calculations. A generic type of analysis implies a less detailed set of input and calculational requirements than a site-specific type of analysis, where the greater availability of real site-specific data would justify a more complete analysis. It was furthermore recognized that the main use of the updated methodology would be for regulatory analyses, in which case the comparative differences between two alternatives are more important that the actual calculated numbers. Finally, it was recognized that to maximize the usefulness of the calculational methodology, there was a need to maintain a high degree of flexibility in the methodology.

As a result, a two-pronged approach was taken in the updated methodology. First, the methodology makes heavy use of a reference radioactive waste source term and processing techniques, a reference set of site environments, and a reference set of alternative disposal technologies. Second, the computer codes are constructed so that the user can readily modify or add to the reference waste source term, treatment and disposal site environments, and disposal technologies.

The analysis methodology developed and described in this report includes procedures to calculate:

- o The occupational exposures and the exposures to members of the public (individuals and populations) resulting from the disposal of low-level waste;
- o The occupational and the population exposures resulting from the processing of the waste by the waste generator or at a centralized location within a region (assumed to be located at the disposal site), and the transportation of the waste from the waste generators to the disposal site;
- o The costs associated with processing, transportation, and disposal of low-level waste; and
- o The land area committed to low-level waste disposal.

SPECIFIC APPROACH

The original Part 61 analysis methodology was developed with a specific purpose in mind: comparative analysis of various available options on land disposal of radioactive waste in view of the wastes expected to be generated in the near-future, the commercially available waste processing and disposal technologies, and past disposal experience. The four principal components of the original Part 61 analysis methodology data base include:

(1) Projected waste volumes and characteristics,
(2) Various waste processing options;
(3) Environmental properties of potential waste treatment and/or disposal locations; and
(4) Commercially available disposal technologies.

The radioactive waste source term consisted of 37 individual waste streams which were characterized on a volume, physical, chemical, and individual nuclide basis. Volumes for these waste streams were considered as a function of 4 regions comprising the contiguous United States. Reference waste processing operations were also considered. Within each region a reference site was assumed which had environmental characteristics representative of the region. Finally, a number of alternative near-surface disposal technologies and operating practices were assumed.

All of these components have been modified from the data base used in the original Part 61 analysis methodology. The most important factor influencing these modifications is 10 CFR Part 61 (Ref. 4). This rule creates an overall framework for the assumptions on the above components. For example, Part 61 defines three classes of waste with minimum waste form requirements and radionuclide concentration upper limits for each class. Similarly there are minimum acceptability requirements for siting of disposal facilities, and guidelines for their design, operation, and closure.

Waste Stream Characteristics and Processing Options

The most apparent change is in the waste stream data base. Most of the 37 waste streams in the original Part 61 analysis methodology have been kept, although several improvements have been made in the projected volumes, and physical and radiological characteristics. Many additional waste streams have also been characterized. These additional waste streams can be grouped into three types: (1) routine wastes of small volumes and relatively high concentrations (e.g., waste from sealed source manufacturers), (2) wastes that depend on formulation and implementation of certain decisions (e.g., processing of spent-fuel, and decommissioning through dismantlement of nuclear power plants, and (3) other wastes (e.g., waste from the West Valley Demonstration Project). Table I presents a summary of the waste stream groups considered.

TABLE I

Waste Stream Groups Considered

I. Nuclear Power Plants (13 streams)

II. Other Nuclear Fuel Cycle Facilities (6 streams)

III. Institutional Waste (8 streams)

IV. Industrial Waste
Routine Waste (6 streams)
Large Radioisotope Manufacturers (19 streams)
Small Tritium Manufacturers (6 streams)
Sealed Sources and Devices (12 streams)

V. Other Non-Fuel Cycle Waste
Radium Sources (7 streams)
Military Waste (2 streams)

VI. Non-Routine Waste
Uranium Fuel Processing (20 streams)
Mixed Oxide Fuel Fabrication (3 streams)
Power Plant Decommissioning (19 streams)
West Valley Demonstration Project (25 streams)

VII. Other Waste
Spent Fuel (1 stream)
TMI-2 Waste (7 streams)

The following presents significant changes in the waste stream data base:

- o New and more accurate unit generation rates are used for LWR waste streams based on recent survey data. This new set of unit generation rates permits consideration of LWRs in five categories: PWR Fresh Water Site (FWS), PWR Salt Water Site (SWS), BWR-FWS with Filter Demineralizers, BWR-FWS with Deep Bed Demineralizers, and BWR-SWS.
- o A gross concentration distribution has been obtained and assumed based on shipped waste data for the four trash waste streams from LWRs.
- o High activity and small volume waste streams e.g., waste originally denoted by N-SOURCES, N-ISOPROD, N-TRITIUM) have been split into several other waste streams, and are characterized much more accurately.
- o Waste streams containing radium-226, including sealed sources and ion exchange resins from groundwater treatment processes, have been included.
- o Wastes from some military establishments, small tritium manufacturers, and large industrial sealed source manufacturers have been characterized and added to the data base.
- o A large number of waste streams have been characterized from potential nuclear fuel cycle operations, including reprocessing waste and waste from mixed oxide fuel fabrication facilities.
- o A large number of waste streams from future decommissioning of LWRs have been included, as have wastes from the West Valley Demonstration Project.
- o Activated metal wastes (e.g., end pieces and spacers) from potential fuel consolidation activities have been included.

In addition, the 23 radionuclides considered in the original Part 61 analysis methodology was considered to be relatively limiting. This report considers 53 radionuclides. Moreover, many of these radionuclides have more than one solubility class. Consequently, this project considers a total of 100 distinct radionuclide/solubility combinations. These are presented in Table II.

TABLE II

Radionuclides Considered and Solubilities

H-3	*	Cs-135	D	U-236	D,W,Y
C-14	*	Cs-137	D	U-238	D,W,Y
Na-22	D	Eu-152	W	Np-237	W,Y
Cl-36	D,W	Eu-154	W	Pu-236	W,Y
Fe-55	W,Y	Pb-210	W	Pu-238	W,Y
Co-60	W,Y	Rn-222	*	Pu-239	W,Y
Ni-59	D,W	Ra-226	W	Pu-240	W,Y
Ni-63	D,W	Ra-228	W	Pu-241	W,Y
Sr-90	D,Y	Ac-227	W,Y	Pu-242	W,Y
Nb-94	W,Y	Th-228	W,Y	Pu-244	W,Y
Tc-99	D,W	Th-229	W,Y	Am-241	W,Y
Ru-106	Y	Th-230	W,Y	Am-243	W,Y
Ag-108m	D,W,Y	Th-232	W,Y	Cm-242	W,Y
Cd-109	D,W,Y	Pa-231	W,Y	Cm-243	W,Y
Sn-126	D,W	U-232	D,W,Y	Cm-244	W,Y
Sb-125	D,W	U-233	D,W,Y	Cm-248	W,Y
I-129	D	U-234	D,W,Y	Cf-252	W,Y
Cs-134	D	U-235	D,W,Y		

Reference Environments

The four reference site environments defined in the original Part 61 analysis methodology have been preserved substantially in the same format. However, a few new parameters have been added, e.g., parameters on unsaturated zones of the reference sites. The most significant change has been to incorporate all the site related information, including transportation information, in a separate data file, and permit the user of the codes to easily alter these data and/or add site-specific information. A qualitative description of reference site environments is presented in Table III.

TABLE III

Reference Site Environments

Site Name	General Environment	Population Density	Soil Permeability
Northeast	Humid	High	Low
Southeast	Humid	Moderate	Moderate
Midwest	Humid	Low	Low
Southwest	Semi-Arid	Low	High

Disposal Technologies

This component of the data base underwent a drastic change. The revised analysis methodology permits the use of up to six different disposal technologies at the same location. The number six was selected based on the assumption that each different class of waste could conceivably be disposed using a different disposal technology. Four of these six classes of waste are as follows: Class A, Class A Stable, Class B, and Class C. In addition, a hypothetical "Class D" has been included consisting of wastes that exceed Class C concentration limitations. These are separated into two subclasses for convenience: Class D1 which denotes waste with activities exceeding Class C limits that are routinely generated in relatively small volumes, and Class D2 which denotes waste with activities exceeding Class C limits that are generated intermittently in relatively large volumes.

All waste streams are assumed to comply with the minimum waste form requirements of 10 CFR 61.56(a) (Ref. 4), and all except Class A are assumed to comply with the stability requirements outlined in 10 CFR 61.56(b) and the Low-Level Waste Licensing Branch Technical Position on Waste Form (Ref. 6).

A number of generic disposal technologies have been characterized through the use of the decision indices and associated parameters. A brief list of available reference disposal technologies and operational options considered in quantitative detail in this report is presented in Table IV.

Any one of the disposal technologies given in Table IV can theoretically be used to dispose any of the above six categories of waste. (Clearly, some disposal technologies will be incompatible with certain classes of waste, e.g., Classes C, D1, and D2 must be disposed in accordance with the intruder protection requirements of 10 CFR 61.52(a)(2).) Moreover, the six classes of waste can potentially be mixed among each other (e.g., Class A Stable mixed with Class B), resulting in use of fewer than six different disposal technologies. Some disposal technologies may be appropriate for disposal of all the waste.

Impact Measures and Analysis Methodology

Many changes were made to the calculational algorithms. One significant calculational change, which both expands and updates the methodology, concerns the manner in which waste in very small volumes with very high concentrations (e.g., sealed sources can beclassified, and their impacts calculated. The original Part 61 analysis methodology was oriented towards calculation of impacts based on radioactive concentrations, i.e., activity per unit volume or mass. This treatment was considered adequate and

TABLE IV

Disposal Technology Options Considered

	Disposal Concepts							
Options	Trench	Extension	Unlined Auger	Slit Trench	Concrete Trench	Concrete/ Slit Trench	Lined Caisson	Concrete Repackaged
Location: Humid	X		X	X	X	X	X	X
Arid	X	X	X	X	X	X	X	X
Size: Large	X							
Small	X	X						
Cover: Base	X	X	X	X	X	X	X	X
Improved	X	X	X	X				X
Concrete					X	X	X	X
Compaction: Regular	X	X	X	X	X	X	X	X
Moderate	X	X	X			X	X	X
Extreme	X	X		X				
Backfill: None					X	X	X	X
Soil	X	X	X	X	X	X	X	X
Sand	X	X	X	X	X	X	X	X
Grout	X	X	X	X	X	X	X	X
Emplacement: Random	X							
Stacked	X	X	X	X	X	X	X	X

sufficient to address the major portion of the waste stream volumes being generated. Since then, however, regulators are being faced with the responsibility to make decisions on sealed sources and other small volume waste streams. Consequently, this report allows an option to be considered for these waste streams (generally referred to as sources) that permits their classification on a total activity per source basis. Impacts assessment calculations have also been modified to allow consideration of these and other unique wastes such as activated metals.

Some of the other modifications made to the original Part 61 analysis methodology include:

- o Consideration of the use of several different disposal technologies at a single disposal facility site. An example would be the use of shallow trenches for Class A waste, segregated shallow trenches for Class A Stable and Class B waste with Class C disposed in a layered manner. Class D1 could be disposed in small slit trenches at the bottom of the stable waste trenches and concrete bunkers would be used for Class D2 waste.
- o Consideration of a wide range in annual volumes disposed. The original analysis methodology was principally geared to large disposal facilities (e.g., 50,000 m^3 of waste per year) and could not easily consider disposal costs and some of the impacts for smaller facilities.
- o Modification and expansion of the intruder impact scenarios. For the intruder well scenario, the only impacts which were considered were those from potential consumption and use of contaminated water. Well drilling, however, could potentially intersect the disposed waste, bringing radioactive contamination to the surface which could impact a potential inadvertent intruder through other pathways.
- o A more detailed treatment of groundwater migration by considering unsaturated zone transport separate from saturated zone transport.
- o Calculation of radon emanation and ingrowth within dwellings as part of determining impacts due to potential inadvertent intrusion into disposed waste.
- o An update of the health physics methodology used to determine impacts from radioactive contamination at a given biota access location including regional dependency of certain uptake factors.
- o A more detailed treatment of highly engineered disposal facilities such as concrete bunkers.
- o A more detailed consideration of the factors that contribute to calculation of disposal facility costs. This includes costs during preoperational siting, licensing, and conststruction, as well as operational costs broken down by personnel and equipment hours for each disposal technology.
- o A more accurate analysis of transportation impacts which more fully incorporates the radiological characteristics of specific waste streams. The original Part 61 analysis methodology used a simple approximation based on WASH-1238 (Ref. 7).
- o Consideration of interregional waste shipments. The original Part 61 analysis methodology considered only intraregional transportation and disposal. This was consistent with the then evolving compacting process. However, cross-regional waste shipment still occurs today and may continue to do so in the future for some waste streams.

DISCUSSION

As in all impact analysis methodologies which attempt to describe real world events using idealized models and other simulation tools, the updated Part 61 analysis methodology still contains a number of limitations. Some of these are inherent to its main purpose in being: analysis of alternatives for rulemaking. Certain simplifying assumptions are necessary when performing a comparative analysis of alternatives which would not be as appropriate when performing an analyis of a particular site and a particular disposal design. Similarly, a methodology constructed for analysis of a specific site and facility design would contain features which would be inappropriate for a generic analysis.

Other limitations arise from the fact that the potential variables that could be envisioned are too large to model. There are approximately 20,000 licensees that could potentially generate radioactive waste, and it would be difficult and counterproductive to try and model for each licensee the precise volumes and physical, chemical, and radiological characteristics of specific waste types. Nor would it be an easy task to precisely model all impacts from processing and transport to the disposal facility, given the great diversity in processing options, transport routes and distances, and impacted individuals and populations. Finally, there are an uncountable number of possible disposal methods, facility designs and environmental settings.

As a compromise against the above difficulties, a number of simplifying assumptions are made. These are discussed below.

- o The wide and diverse spectrum of low-level wastes are grouped into a number of individual waste streams, and regional projections are made regarding volumes, physical, chemical, and radiological characteristics. It may also be noted that some waste streams may be more readily predictable than others. For example, waste streams from a nuclear power reactor are predictable since such wastes are routinely generated as part of reactor operations. On the other hand, consider the holder of a large sealed source. This licensee generates no waste; waste in the form of the sealed source is only created when a decision is made that the source can or will no longer be used.
- o The regional projection is still made in terms of four very large regions, which is necessary considering the time and resources necessary to complete the project. The compacts that will eventually be established, however, will probably be more numerous and considerably smaller -- perhaps comprising only one or two states. It would therefore have been preferable, if time and resources were available, to project waste stream generation and characteristics on a state-by-state basis. The waste steams from any number of different states could then be considered. As a compromise, the revised analysis methodology allows the user to consider fractional multiples of waste stream generation in order to arrive at a volume appropriate for any size region.
- o It is impossible to consider for all licensees the costs and other impacts for waste generation and packaging, since this would require detailed knowledge of all licensees' activities. Nor is it possible to consider all possible waste processing technologies. As a compromise, then, the analysis methodology considers costs and other impacts that would arise as an increment to a "base" level of processing. Incremental processing costs include improved compaction and incineration. Postulated techniques are meant to be representative rather than factual and are selected from a range of possible designs.

- o Waste transportation impacts, as well as operational impacts from waste emplacement, are calculated in a simple manner. Thus, the impact measures thus determined should be regarded as being useful on a comparative basis rather than a "realistic" basis.
- o A representative range of near-surface disposal facility designs and operating variations are considered in detail. These represent only a few of the possible techniques, however, and so to expand the flexibility of the analysis methodology, the codes allow the user to alter facility parameters to model specific cases.

These limitations, however, are not deemed to be of major significance within the generic framework of this report. Conclusion of the project is expected in May followed by the publication of the reports a few months later.

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