RELATIVE IMPACT OF COMMERCIAL POWER REACTOR AND OTHER LLW STREAMS ON SHALLOW LAND BURIAL SYSTEM PERFORMANCE

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To comply with the provisions of the Low-Level Radioactive Waste Policy Act, States and Compacts are addressing the expected amounts and characteristics of waste for which they will be responsible as well as appropriate waste management procedures for the several sources of LLW generated within their geographical boundaries. One option proposed by certain interest groups is to segregate commercial power reactor LLW from other LLW for alternative "greater confinement" disposal. This option was advanced on the premise that in a typical integrated LLW disposal facility the power reactor LLW is the dominant source of potential offsite exposure.

This study evaluates the relative contribution of power reactor and other LLW streams to the total potential offsite dose due to groundwater migration from a northeastern site as defined in the Environmental Impact Statement on 10 CFR 61. The results of interpretation of a series of computer runs are that whole body dose via the groundwater pathway from the two source streams is of the same order of magnitude and peaks at a fraction of 1 millirem/year.

The conclusion is reached that there is no health and safety benefit that justifies segregation and different disposal requirements for wastes from commercial power reactors.

INTRODUCTION

Current efforts to develop low level radioactive waste (LLW) management systems for interstate compact regions include consideration of alternatives to shallow land disposal. One alternative that has been raised is the segregation of waste by generator category and application of different disposal methods to the separated waste streams. The current analysis was performed to determine the contribution to dose from consumption of groundwater from a shallow land burial facility from waste of power reactor origins and that from other sources.

METHODOLOGY

The analysis consists of computer simulation of the performance of a shallow land burial facility in the *northeastern* United States using the methodology developed for the NRC and described in the Final Environmental Impact Statement (FEIS) on 10 CFR 61. [1] The performance of the facility is characterized in terms of the potential radiological dose via the groundwater pathway. The portion of this dose attributable to waste from commercial nuclear power reactors is specifically identified.

The comparative potential dose from commercial power reactor and other LLW sources has been computed as a function of time and distance from the disposal site. The results are reported in units of millirem (mrem) per year to the whole body. The volumes and waste stream classification on which analysis are based are listed in Table I. Facility design assumptions for the Site are listed in Table II. Table III presents the distances to selected points and groundwater travel times for the case analyzed.

TABLE I

Waste Classification and Distribution

Total Waste Emplaced - 652,000 m^3

	Percent of Total Volume			
	Class A	Class B	Class C	TOTAL
Commercial Power Reactor	26	16	2	44
Other	40	16	<0.1	56

TABLE II

Facility Design Assumptions[1]

1) Regular shallow land burial trench
2) Use of a thick clay cap
3) Compaction using improved methods
4) Segregation of wastes containing organic chemicals
5) Segregation of unstable Class A waste
6) Random disposal of waste
7) Use of a permeable backfill
8) Layering used for disposal of Class C waste
9) Humid site having low permeability soils

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(1)Selected from Table 6.4 of the Final Environmental Impact Statement on 10 CFR 61.

TABLE III

Groundwater Travel Time for Selected Distances[2]

	Distance (Meters)	Groundwater Travel Time (Years)
Water Table	4	50
Site Boundary	30	200
Population Well	500	2,500
Surface Water Body	1,000	5,000

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(2)Selected from Table 6.1 of the Final Environmental Impact Statement on 10 CFR 61.

Thirty seven individual waste streams were evaluated by NRC in the FEIS on the basis of anticipated volumes, concentration of individual isotopes present and anticipated stabilization. This information is necessary because the potential dose is dependent on all of these characteristics and not simply on the volumes of material resulting from a given waste stream. The 37 waste streams defined by NRC have been regrouped in this analysis to identify the 24 streams originating from other than commercial power reactor sources separately from the 13 streams from commercial power reactors. The relative potential dose of the two groups can then be compared directly for a given location and point in time.

RESULTS

A properly designed site conforming to Part 61 and operating under the conditions assumed for a Northeast location will not result in any significant exposure through the groundwater pathway. Maximum site boundary well dose is less than 0.02 mrem/year, a level that occurs some 20,000 years after site closure.

The code computes no exposure from a well located at the site boundary for approximately 400 years. The activity present at that time results in a dose (about 10^{-8} mrem/year) which would not be physically measurable even though analytically calculable. Almost all (99.998%) of this activity, however, is from sources other than commercial power reactors.

It consists of the relatively mobile isotope, tritium, most of which is produced by medical, academic and industrial generators. Because this isotope experiences essentially no retardation relative to groundwater movement, it will be the first to arrive at the site boundary.

Figure 1 illustrates the dose from groundwater consumption at 400 years post-closure as a function of distance from the waste. Also indicated is the contribution to the total dose of waste of power reactor origin. By the time tritium reaches the site boundary at 400 years, radioactive decay will have substantially reduced the amount of the 12 year half-life isotope originally present. Groundwater activity at the site boundary well declines over the next 400 years, resulting in about a 100 fold decrease in dose per 100 years.

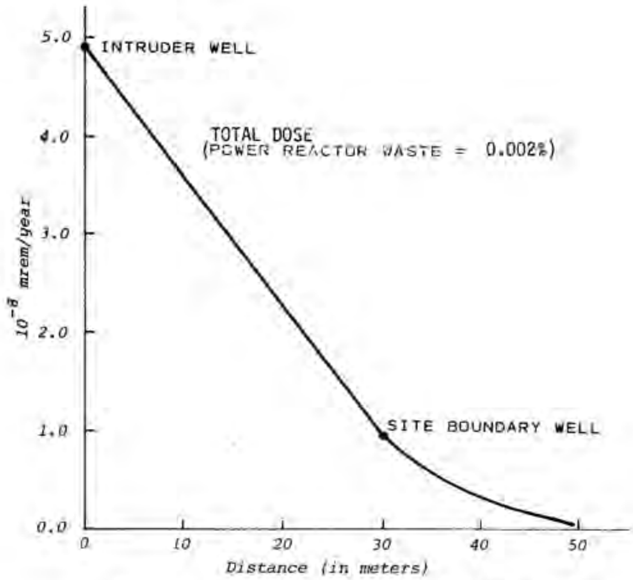

Fig. 1. Dose from groundwater consumption as a function of distance 400 years post-closure.

The next isotopes to be calculable at the site boundary are iodine-129 and technetium-99, both of which were assumed to be transported at 20% the rate of groundwater flow. The presence of these isotopes is observed at 2,000 years post-closure. As shown in Fig. 2, almost the entire 0.0018 mrem/year is due to waste of power reactor origin. Technetium-99 with a 212,000 year half life is found in power reactor waste as well as a small (24%) component from production of radiopharmaceuticals. Iodine-129 is produced in fission and is not a constituent of other than power reactor waste. Because this isotope has a 15 million year half-life, radioactive decay is not a factor in its removal. Groundwater transport and dilution are the only phenomena which will affect the amount of material present and the related doses.

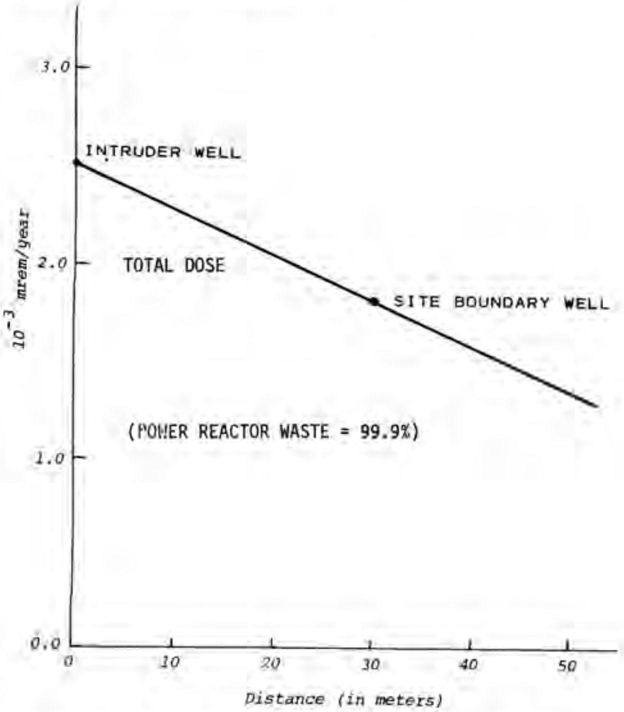

Fig. 2. Dose from groundwater consumption as a function of distance 2,000 years post-closure.

The final long-lived isotope to be measured at the site boundary is the 5730 year half-life carbon-14 which is assumed to be transported at 10% the rate of groundwater flow. A substantial portion of the carbon 14 originally emplaced in the shallow land burial facility is of non-reactor origin. The contribution of reactor wastes to the 0.0052 mrem/year calculated at 4,000 years (Fig. 3) is 73% of the total.

Subsequent decay of the carbon-14 results in a gradual increase in the portion of the total dose which results from the iodine-129 of power reactor origin. The dose from this isotope peaks at less than 0.02 mrem/year about 20,000 years post-closure. In the same time frame, waste of non-reactor origin contributes about 5% of the total dose. As is indicated in Fig. 4, this is less than the dose received from the naturally occurring radium-226 measured in the New York City water system. (2)

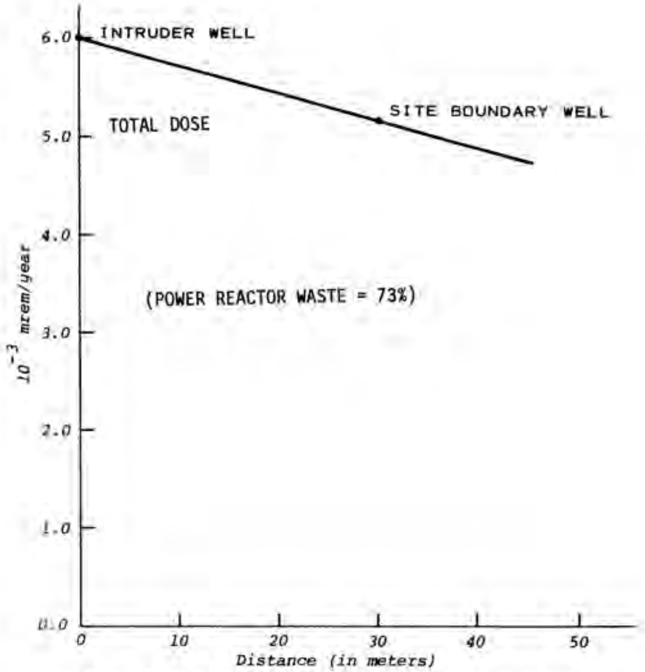

Fig. 3. Dose from groundwater consumption as a function of distance 4,000 years post-closure.

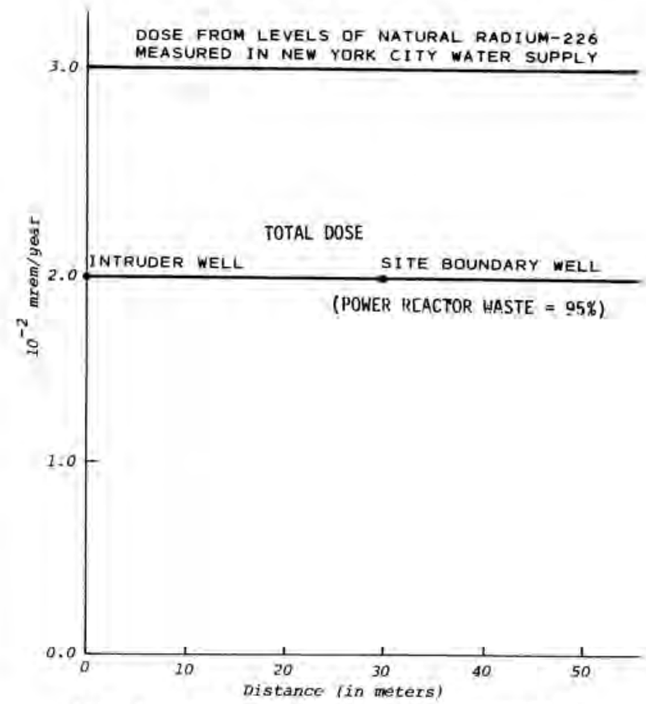

Fig. 4. Dose from groundwater consumption as a function of distance 20,000 years post-closure (maximum boundary well dose).

CONCLUSION

The conclusion is reached that a shallow land burial facility sited, designed and operated in the Northeastern United States in accordance with 10 CFR 61 will result in no significant dose via the groundwater pathway. Further, waste of power reactor origin does not represent any significant difference from other waste. Thus, the performance of the facility would not be appreciably changed by segregating such wastes and requiring different disposal techniques.

The contribution of power reactor waste to dose from consumption of groundwater varies as a function of time as shown in Fig. 1-4. The first calculable dose at the site boundary occurs at 400 years and 99.998% of it is due to waste of non-reactor origin (primarily tritium). Groundwater dose at the site boundary decreases by about nine orders of magnitude over the subsequent 400 years.

Maximum expected dose through the groundwater pathway to a hypothetical individual drinking water from a well at the site boundary of a shallow land burial facility sited in the Northeastern United States is less than 0.02 mrem/year whole body. Waste of commercial power reactor origin contributes about 95% of this very small dose while waste from medical, industrial and academic sources contributes the additional 5%. Such dose increments are indistinguishable from an environmental or health standpoint compared to natural background radiation. They are small fractions of the values currently being studied for designation as below regulatory concern. These levels are reached approximately 20,000 years after site closure. Such a dose is comparable to that received due to the naturally occurring radium-226 present in New York City water [2]. is much smaller than the approximately 20 mrem/year typically received by an individual from internally deposited naturally occurring potassium-40 [3].

There is, in fact, a significant benefit in acceptance of waste of commercial power reactor origin. The economics of disposal are such that the acceptance of such wastes results in a significant reduction in overall unit disposal costs. For example, the New York State Energy Office Low-Level Radioactive Waste Management Study estimates that unit disposal costs for a privately run facility of the scale defined in this Study would be about 59% of the costs for a smaller facility capable of handling the volume of non-power reactor waste [4]. The benefits particularly the small institutional generators, and the non-profit medical and educational institutions.

REFERENCES

(1) Final Environmental Impact Statement on 10 CFR 61 "Licensing Requirements for Land Disposal of Radioactive Waste," NUREG-0945 (November 1982). Volume 3, Appendix D, Computer Codes used for Final Environmental Impact Statement Calculations (1982).

(2) M. Eisenbud, Environmental Radiation Science, (1973).

(3) NCRP45, "Natural Background Radiation in the United States," p. 110, (1975).

(4) "New York State Low-Level Radioactive Waste Management Study," Figure 17, p. 53, New York State Energy Office (April 1984).