COMPARISON OF LAND AND OCEAN DISPOSAL ALTERNATIVES FOR BULK WASTES CONTAINING NATURALLY OCCURRING RADIONUCLIDES

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ABSTRACT

Land and ocean disposal alternatives for a large volume of wastes and residues containing naturally occurring radionuclides are assessed. These wastes and residues are currently stored at the U.S. Department of Energy's Niagara Falls Storage Site near Lewiston, New York. Both land and ocean disposal are considered for the 180,000 m^3 of slightly contaminated wastes (average 36 pCi/g radium-226), whereas only land disposal is considered for the 11,000 m^3 of residues (average 67,000 pCi/g radium-226). The land and ocean disposal alternatives share similar engineering considerations, occupational and transportation risks, and radiological risks. Impacts from placement of the wastes in the ocean would be negligible. However, the land-based activities required to transport the wastes to the ocean would account for most of the potential impacts associated with the ocean disposal alternatives. Thus, the land and ocean disposal alternatives are comparable in terms of potential envionmental impacts.

INTRODUCTION

The Niagara Falls Storage Site (NFSS) of the U.S. Department of Energy (DOE), near Lewiston, New York, contains approximately 190,000 m^3 of wastes and residues containing naturally occurring radionuclides. The 11,000 m^3 of residues resulted from processing of pitchblende and other high-grade ores; they have an average radium-226 activity of 67,000 pCi/g. The 180,000 m^3 of wastes are soils that were contaminated by wind and water erosion of the residues; the wastes have an average radum-226 activity of 36 pCi/g.[1]

Public opinion in the Lewiston area is strongly in favor of removing both the residues and wastes from NFSS. The DOE is in the process of deciding how and where to manage the wastes and residues for the long term. An alternative to long-term management of the large volume of wastes on land is disposal of the wastes in the ocean. A comparative analysis of various alternatives for the long-term management of the wastes and residues has recently been published in an environmental impact statement prepared according to the requirements of the National Environmental Policy Act of 1969.[1] In this paper, some of those alternatives are discussed, including those wherein the slightly contaminated wastes would be disposed in the ocean.

DESCRIPTION OF ALTERNATIVES

Three land alternatives were identified that treat the residues and wastes together: (1) no action (continued interim storage at NFSS), (2) long-term management at NFSS (improved containment), and (3) long-distance transport to other disposal sites for long-term management. The two other land sites considered were the DOE Oak Ridge Reservation (humid site and moderate transport distance) and the DOE Hanford Reservation (arid site and longer transport distance). The fourth alternative specified land disposal of the residues at one of the other DOE sites (Hanford or Oak Ridge), but the large volume of slightly contaminated wastes would either remain on land at NFSS (Alternative 4a) or be removed for disposal in the ocean (Alternative 4b). Disposal of the much more highly radioactive residues in the ocean was not considered because DOE believed that a permit could probably not be obtained for ocean disposal of the residues (see later discussion on regulations).

Three time frames were used to summarize and compare the environmental impacts of these alternatives: an action period of 10 years, a maintenance and monitoring period of 10 to 200 years, and a long-term period of 200 to 1,000 years. The action period includes impacts associated with excavation, transport, and disposal activities. The maintenance and monitoring period includes the time during which the wastes and residues would be managed under plans for perpetual care. Loss of control is postulated for the long term because the radionuclides in the wastes and residues have long half-lives. In the alternative wherein the wastes would be disposed in the ocean, only the residues would have to be maintained and monitored.

OCEAN DISPOSAL ALTERNATIVE

Ocean disposal of large volumes of bulk wastes--such as sewage sludge, cellar dirt, and industrial wastes--has been commonly practiced in the New York City area for many years.[2] The Port of New York and New Jersey contains docks that could be used to load the wastes onto barges, and the types of disposal activities practiced near New York would be appropriate for handling the NFSS wastes. For the purpose of the impact analysis, a representative ocean disposal site was chosen from the many historic disposal locations near major ports in the mid-Atlantic states. A location such as Site 106, an industrial waste site administered by the U.S. Environmental Protection Agency, might be adequate for waste disposal.[3] This site is beyond the edge of the continental shelf in an area where water depths are about 2000 m and the possibility of human intrusion is minimized.[1] To dispose of the wastes within a period of 2 years would require three split-hull, bottom-dump barges towed by an ocean-going tug that made 3 to 5 trips per month during May to October. A more detailed discussion of the ocean disposal scenario is given elsewhere.[1,4]

It is assumed that the wastes would be transported and disposed in the ocean in bulk (noncontainerized) for the following reasons. First, the radioactivity of the wastes is low enough that containerization is not necessary for any of the onland activities. (The wastes would be classified as nonradioactive for the purpose of transport under U.S. Department of Transportation regulations.) Second, the purpose of containerization for ocean disposal is to allow the radionuclides of concern to decay before they are mixed in the environment, but this advantage would not be realized with the NFSS wastes because the radionuclides of concern do not decay significantly for hundreds of thousands of years, much longer than the life of any container. Third, it is not reasonable to move 180,000 m^3 of soil in containers; and such action would prolong the duration, and thus the nonradiological and radiological impacts, of the disposal action by several years. Fourth, analysis of the wastes in direct contact with seawater results in calculation of the greatest exposure to human beings and becomes, in effect, a "worst case".

Regulation of Ocean Disposal

Ocean disposal of the NFSS wastes would be subject to regulations issued by the U.S. Environmental Protection Agency (EPA), and DOE would have to obtain a dumping permit from EPA, which has issued regulations under authority of the the Marine Protection, Research, and Sanctuaries Act of 1972 [33 U.S.C. 1431(b)]. These regulations prohibit ocean dumping of high-level radioactive wastes and would permit dumping of low-level wastes only under special circumstances, including containerization, and only if it can be demonstrated that no other suitable alternative disposal method exists. Since the ocean dumping regulations were issued, EPA has not ruled on any permit application for wastes containing low levels of radionuclides. In 1982, it appeared as if the ocean dumping regulations might be revised to include a definition that would distinguish between nonradioactive materials and low-level radioactive materials. Such a definition would be particularly significant for materials such as the NFSS wastes where the radionuclides of concern are naturally occurring, are present in all soils and other geological material, and are in such low concentrations that the wastes are classified as nonradioactive for other purposes such as transportation. On January 6, 1983, Congress amended the 1972 Act to place a two-year moratorium on permit issuance for any low-level radioactive wastes in order to allow time for additional research into the possible impacts associated with such disposal (Ocean Dumping Amendments Act of 1982; 97th Congress, Rep. 97-567, Part 1, p. 9). The EPA will not determine whether or not the NFSS wastes are radioactive for purposes of ocean disposal until it actually receives an applicaion for a permit.

Impacts Resulting from Ocean Disposal

The physical characteristics of the NFSS wastes will be the overriding factor in the fate of the wastes after being dumped at sea. The NFSS wastes are primarily soils that have been contaminated by wind and water erosion. By the time the soils reached the ocean, they would have been excavated and recompacted several times and thus would be sticky or cloddy. No method is available that can be used to directly calculate the breakup and dispersion of the soils on contact with seawater. The studies of waste dispersion at Site 106 have been for liquid wastes with densities near that of seawater; no empirical data are available regarding the fate of solid wastes. We therefore *defined two bounding* scenarios that could be used for a "worst-case" estimation of the limits of radionuclide exposure to man from disposing the wastes at a controlled disposal site such as Site 106.

In Scenario 1, we assumed that the wastes would descend directly to the bottom as one large mass. We calculated that the mass from a single disposal action would reach the bottom of the dumpsite in 0.8 to 38 hours, depending on the size of the clumps. If all the wastes from all disposal actions covered a contiguous area as large as possible without the activity of the wastes being diluted by the action of bottom-dwelling animals, such an area might be as wide as 2.6 km in diameter and as thick as 7 cm. Water moving over the area would pick up trace elements from the waste pile. Using the highest literature estimate available for radium-226 flux from sediments[5] and assuming that the depth of the bottom mixed layer of ocean water was only 1-m thick, water traveling over the waste pile would pick up 0.002 pCi/L radium-226 in addition to the 0.1 pCi/L already present in average seawater. The only commercially important bottomfish found in the dumpsite area is the juvenile grey sole. This fish belongs to a wide-ranging species that is taken as adults in shallower waters. If such a fish became equilibrated with bottom water moving over the waste pile, the fish would acquire 0.0002 pCi/g radium-226 in addition to the 0.0016 pCi/g in average fish flesh.[1]

In Scenario 2, we assumed that the wastes would disperse immediately on contact with seawater, becoming a heavy soil-water mixture that would descend by convection. Using a simplified calculation,[6] we determined that--depending on the geometry of the waste cloud--convective descent might not carry the wastes below the upper mixed layer of the ocean. Although the soil particles in the waste cloud would continue to sink, silts and clays would remain suspended in the upper mixed layer for days or weeks and might not reach the bottom of the ocean for months or years.

After 4 days, any wastes remaining in the upper mixed layer of the ocean would be diluted to an average of 20 to 200 mg/L when conditions for dispersion were weak, but the wastes would be diluted to an average of 0.1 to 10 mg/L when dispersion conditions were strong. If a fish became equilibrated with water containing the greater waste concentration, it might acquire an additional radium-226 concentration of 0.0007 pCi/g above the average fish flesh concentration of 0.0016 pCi/g.[1] Based on the practice of long-line commercial fishing for large pelagic fish at the edge of the continental shelf, it is possible that a contaminated fish that had briefly lived in the dumpsite during the 2-year action period might be captured and eaten. An adult human who consumed 2 kg of the fish would incur an incremental dose of 0.0072 mrem to the whole body and 0.084 mrem to the bone.[1]

COMPARISON OF IMPACTS OF THE DISPOSAL ALTERNATIVES

Nonradiological Impacts

The area committed for containment on land would be smallest for continued interim storage at NFSS (Alternative 1) (Table I). Improved containment at NFSS (Alternative 2) would require additional space. Disposal of all wastes and residues at another land site (Hanford or Oak Ridge--Alternative 3) or disposal of the wastes at NFSS and the residues at another land site (Alternative 4a) would require the greatest commitments of land. Disposal of the wastes in the ocean (Alternative 4b) would still require 9.3 to 13 ha for land burial of the residues.

TABLE I

Summary of Nonradiological Impacts of Disposal Alternatives for NFSS Residues and Wastes

Alternative	Containment Area (ha)	Offsite Transportation (Round-trip)		Estimated Injuries and Deaths			
				Transportation		Occupational	
		10^6 miles	Years	Injuries	Deaths	Injuries	Deaths
1 No action--continued interim storage	3.4	-	-	-	-	0.13	0.0015
2 Improved containment at NFSS	4.5	-	-	0.19	0.11	12	0.0064
3 Disposal at another land site	12-38	44-130	2-5	22-66	1.4-3.9	100	0.042-0.044
4a Residues disposed at another site, wastes remain at NFSS	7.2-14	5-14	2	2.5-6.9	0.15-0.44	36-42	0.018
4b Residues disposed at another site, wastes disposed in the ocean	2.7-9.3	34-43	2	17-22	1.0-1.3	85-91	0.038-0.040

Source: Reference 1.

TABLE II

Summary of Radiological Impacts of Disposal Alternatives for NFSS Residues and Wastes

Alternative	Estimated Number of Additional Adverse Health Effects in the General Public			Estimated Additional Health Effects to All Workers During the Action Period (10 years)
	Action Period (total/10 yr)	Maintenance and Monitoring Period (total/190 yr)	At Year 1000: Loss of Control (no./10^6 persons/yr)	
1 No action--continued interim storage	<0.0000005	<0.0000005	0.00021	0.0013
2 Improved containment at NFSS	<0.0000005	<0.0000005	<0.0000005	0.0051
3 Disposal at another land site	0.066-0.090	<0.0000005-0.0039	<0.0000005-0.00074	0.15-0.24
4a Residues disposed at another site, wastes remain at NFSS	0.040-0.054	<0.0000005-0.036	<0.0000005-0.0061	0.12-0.18
4b Residues disposed at another site, wastes disposed in the ocean	0.28-0.30	<0.0000005-0.036	<0.0000005-0.0061	0.13-0.20

Source: Reference 1.

The risk of injury and death due to implementation of any alternative would be closely related to the distance required for transportation of the wastes from NFSS to another disposal site, whether land or ocean site (Table I). In Alternatives 1 and 2, the wastes and residues would remain at NFSS, in which case the estimated injuries and deaths would be associated with maintenance activities and would be very low. Risk of injury and death for Alternative 4b (wastes to the ocean and residues to another site) would be more than if only the residues were removed to another site (Alternative 4a) but less than if all wastes and residues were removed to other land disposal sites (Alternative 3). At least one death and a total of about 100 injuries might occur if the residues were moved to another land site and the wastes were moved to the ocean.

Radiological Impacts

Radiological risks, reported in terms of additional adverse health effects, are primarily associated with the action period. Continued interim storage at NFSS (Alternative 1) or improved containment (Alternative 2) would result in very low radiological risk for either workers or the general public (Table II) because the wastes and residues would not be disturbed and the general public would be excluded from the site. The radiological risk for both workers and the general public would be higher during the action period of Alternatives 3, 4a, and 4b. The highest radiological risk to the general public would occur during the action period for the ocean disposal alternative (4b). This is primarily because removal of the wastes to a port for loading on barges would also expose the general public to additional doses during waste transportation. Because the route of travel to the Port of New York would be through a major metropolitan area, the incremental dose from waste transportation would be greater in the ocean disposal alternative than in the land disposal alternative (3) where transport to other land disposal sites would be primarily through less populated areas. The radiological risks for workers would be highest for any of the alternatives wherein the residues would be moved to other sites. Movement of the slightly contaminated wastes, whether to other land sites or to the ocean, would contribute little to the total radiological risks to workers.

For all alternatives, the radiological risks to the general public would increase in the long term if controls were lost and the containment system began to break down. The long-term radiological risk is dominated by the presence of the residues at a land disposal site, irrespective of whether or not the wastes are disposed in the ocean.

CONCLUSIONS

The estimated radiological risks to human beings resulting from disposal of the NFSS wastes in the ocean are very low compared to the radiological risk associated with transporting the wastes to the ocean. The radiological risks are, in turn, much less than the risks of injury and death associated with any large construction project or the transport of any large volume of material. Thus, the greatest risk to the general public and to workers would result not from the wastes residing in the ocean but from the activities associated with transporting the wastes to the ocean. Any proposal for ocean disposal of wastes must therefore carefully consider the onland activities associated with the action.

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