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RADIONUCLIDE LIMITS FOR VAULT DISPOSAL AT THE SAVANNAH RIVER SITE (U)

by

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ABSTRACT

The Savannah River Site is developing a facility called the E-Area Vaults which will serve as the new radioactive waste disposal facility beginning early in 1992. The facility will employ engineered below-grade concrete vaults for disposal and above-grade storage for certain long-lived mobile radionuclides. This report documents the determination of interim upper limits for radionuclide inventories and concentrations which should be allowed in the disposal structures. The work presented here will aid in the development of both waste acceptance criteria and operating limits for the E-Area Vaults.

Disposal limits for forty isotopes which comprise the SRS waste streams were determined. The limits are based on total facility and vault inventories for those radionuclides which impact groundwater, and on waste package concentrations for those radionuclides which could affect intruders.

BACKGROUND

The new facility for disposal and storage of low-level radioactive waste at the Savannah River Site will consist of four types of disposal units; low activity waste (LAW) vaults, intermediate activity waste (IAW) vaults, tritium waste (TW) vaults, and long-lived waste (LLW) storage buildings.

The disposal vaults will be used to meet the performance objectives of DOE Order 5820.2A.(1) Engineered concrete barriers will provide primary confinement for the waste. To minimize waste contact with water and as a secondary confining feature, a highly permeable layer of gravel will be placed beneath each below-grade unit. In addition, at final closure, a layer of highly impermeable clay will be placed over the vaults to minimize infiltration of water.

DOE Order 5820.2A sets forth the requirements for radioactive waste disposal within the DOE complex. Among other things, each disposal facility is required to have a site-specific performance assessment to demonstrate that the facility will meet the performance requirements stated in the order. Waste acceptance criteria, which guarantee that the waste emplaced in the facility is within the bounds of that analyzed by the performance assessment, are also required. Ideally, the performance assessment would be completed first, and the waste acceptance criteria written based on the results. In the case of the E-Area Vaults, the facility will be constructed and operating before the performance assessment is be completed.

The work presented here provides interim limits on the amounts of individual radionuclides, with the exception of tritium, which can be placed in each of the nontritium disposal units in the new facility. A separate study was undertaken to recommend tritium limits for each of the disposal units. These limits will be superseded when the performance assessment work being done by Oak Ridge National Laboratory at Grand Junction, Colorado is completed in 1993.

Two computer programs were used in this work, the HELP code and PATHRAE code. Each of these codes is described in the following sections, and the methodology used to apply them to this problem is explained.

DESCRIPTION OF THE HELP CODE

The Hydrologic Evaluation of Landfill Performance (HELP) code was developed by the U. S. Army Corps of Engineers for the U. S. Environmental Protection Agency.(2,3,4) The purpose of the code is to evaluate various designs for shallow land burial waste disposal systems in terms of their effect on the overall water balance. Up to fourteen layers may be used, including both closure caps and liners.

Input data required by the code consist of the physical dimensions of the waste site and each of the layers, hydraulic properties of the layers, and climatic information. The dimensions of the site and the cap layers, as well as the layer materials were taken from the conceptual closure design included in the Design Review package. The code itself provides default hydraulic properties for a number of possible cap and liner materials, including most of those proposed for the E-Area Vaults. The only exceptions are properties for highly permeable drainage materials. A saturated hydraulic conductivity of 1 cm/sec was assigned to this material.(5) Climatic data consisted of ten years of daily rainfall data from a nearby onsite meteorologic tower and other data provided with the code for Augusta, Georgia.

Output from the code is the water balance resulting from the particular design and climate. Water balance means that the amount of water exiting the overall system must equal that which enters the system as precipitation. This exiting water is partitioned into evapotranspiration back into the atmosphere, surface runoff, lateral drainage, and infiltration. In general, evapotranspiration and lateral drainage are beneficial to the closure system. Surface runoff can cause erosion of the cap system and should be minimized. Infiltration causes leaching of the buried waste, so it should be reduced to the extent possible.

The HELP code has been the subject of several verification studies by the U. S. Army Corps of Engineers,(6,7) and it has undergone a sensitivity analysis by Oak Ridge National Laboratory. The methodology used in the sensitivity analysis also performs a very rigorous check on the actual computer code to insure that it is self consistent.

DESCRIPTION OF THE PATHRAE CODE

The purpose of the PATHRAE(8) computer code is to calculate doses and health effects which might be caused by disposal of waste material in the near-surface environment. The code was developed by Rogers and Associates Engineering Corporation, of Salt Lake City, Utah, for the U. S. Environmental Protection Agency, and is accepted by that organization. PATHRAE was selected for use in the Environmental Impact Statement on Waste Management Activities and Groundwater Protection at the Savannah River Site(9).

Input to the code consists of a number of parameters which describe the characteristics of the waste, the disposal site, and the surrounding area. The more that is known about the waste and the site, the more confidence there will be in the results produced by the code.

The PATHRAE code can calculate doses due to a number of exposure pathways: groundwater transport to a surface stream, groundwater use in a nearby well, surface erosion and subsequent waste exposure, trench overflow (bathtub effect), food grown on the site, biointrusion into the waste, direct gamma exposure, inhalation of dust onsite, inhalation of radon gas, and atmospheric transport of particulates offsite.

The code assumes that the waste inventory is evenly distributed throughout the waste volume. For the groundwater transport pathways, a specified fraction of the inventory is leached from the waste each year and transported vertically through the unsaturated zone, then horizontally to hypothetical wells at distances of 1 meter and 100 meters, and to a nearby stream. The water velocity through the unsaturated zone is calculated in the code from input values for infiltration and soil porosity. The velocity in the water table is a code input, the value of which was taken from three-dimensional numerical modeling work.

The velocity of each radionuclide considered is calculated based on the partition coefficient (commonly called Kd) and the water velocity. A quantity called the retardation factor is calculated from the partition coefficient and used to modify the velocity of a species relative to the water velocity. For example, uranium with a partition coefficient of 40 has a retardation factor equal to 320, meaning that uranium is transported 320 times more slowly than the groundwater. Reference 10 provides the bases for these values.

In each of the pathways a hypothetical person is exposed to radiation released from the disposal facility. The PATHRAE code calculates the dilution, dispersion, or attenuation provided by the waste site and the environment, and thus the curie concentration of each radionuclide to which the person will be exposed. For the ingestion and inhalation pathways, dose conversion factors from the International Commission on Radiological Protection (ICRP) (11,12) are used to calculate annual doses from curie concentrations. Dose conversion factors for direct gamma exposure are taken from the PRESTO data base(13).

As just stated, the PATHRAE code was used as the basis for dose calculations for the Groundwater Protection and Waste Management Environmental Impact Statement issued by DOE in 1987. One of the supporting documents for the EIS was a quality assurance report on the models used.(14) Several levels of review are documented in this report, (1) review of code documentation, history of use, and previous validation and verification studies, (2) comparison of model results to alternate models using different boundary conditions, (3) comparison of model predictions to measured concentrations, and (4) sensitivity analysis to identify critical input parameters.

DOSE CRITERIA

The dose criteria set forth in DOE Order 5820.2A were used in this study. The order states that the dose to an inadvertent intruder be no more than 500 mrem/yr for a single acute exposure, such as digging into or drilling through the buried waste. For continuous exposure, that is living on the waste site and growing food there, the limit is 100 mrem/yr. No member of the general population should receive more than 25 mrem/yr by all pathways. In addition, the order states that the disposal facility must meet all applicable local, state, and federal regulations for groundwater protection. Though no such regulations exist at this time for radionuclides, SRS has a self-imposed limit of 4 mrem/yr for groundwater at the edge of the disposal facility at all times during operation and after closure.

For this study the 100 mrem/yr limit was used and applied at 100 years after site closure to estimate intruder doses. Studies by Kennedy and Peloquin(15) and Aaberg and Kennedy(16) have shown that the 100 mrem/yr limit for continuous exposure always results in lower allowable waste concentrations that the 500 mrem short-term exposure limit. For times less than 100 years, the general population was considered to be at the SRS boundary. Between 100 and 500 years, the general population was assumed to be at the edge of the disposal site. The SRS exposure limit for workers at the E-Area Vaults is currently 1,500 mrem/yr. In this study the dose criterion for worker exposure was conservatively set at 500 mrem/yr.

The times, locations, and performance objectives for each type of exposure considered in this report are summarized in Table I.

Table I. Locations, Times, and Dose Limits Used

Performance Objective		Point and Time of Compliance: Waste Site	Waste Site Boundary	SRS Boundary
Worker	500 mrem/yr(a)	0-100 years	NA	NA
Groundwater Protection	4 mrem/yr(b)	NA	All time	NA
General Population	25 mrem/yr(c)	NA	>100 years	0-100 years
Intruder	100 mrem/yr(c)	>100 years LAW >300 years IAW	NA	NA

a. DOE limit is 5000 mrem/yr, SRS limit is 3000 mrem/yr, E-Area Vaults limit is 1500 mrem/yr. This limit is one-third the E-Area limit.

b. Proposed EPA limit (Ref 17).

c. From DOE Order 5820.2A (Ref 1).

METHODOLOGY

The initial modeling step in this work was to use the HELP code to estimate the long-term infiltration rate to be expected from the closure cap design currently planned for the E-Area Vaults. The calculated infiltration rate was used both directly as an input to PATHRAE, and to calculate the leach rate for each radionuclide using the method developed by Baes and Sharp.(18)

Dimensions of the E-Area Vaults site and the vaults themselves were taken from design drawings. All other parameters for the PATHRAE code were taken from values used in the Environmental Information Document for new radioactive waste disposal facilities(19) with a few exceptions:

1. For the groundwater pathway the hypothetical person consumed 730 liters of water per year (2 liters per day). In the EID this value was 365 liters per year (1 liter per day).

2. The dose from drinking groundwater was calculated using well characteristics of a monitoring well rather than a domestic well, i.e., a fifteen-foot screen zone rather than the 33 feet used in the EID. This is consistent with the 4 mrem/yr groundwater protection criterion.

3. The dose from groundwater considered only drinking water. Other uses, such as irrigation and watering food and milk producing animals were excluded. This is consistent with the 4 mrem/yr groundwater protection criterion.

4. The atmospheric transport pathway, where contamination is spread by a trench fire to offsite individuals, was not considered credible for vault disposal of waste.

5. The LAW vaults were considered to remain intact and retain all radionuclides for 100 years (the same assumption used in the EID), while the IAW vaults were assumed to retain all radionuclides for 300 years as a result of their more substantial design.

6. In addition to the 100 year active institutional control period mandated by DOE Order 5820.2A, the IAW vaults were assumed to provide an additional 200 years of passive control, by virtue of their more massive construction, to deter intrusion into the waste. The Nuclear Regulatory Commission allows up to 500 years of passive control for stabilized waste forms such as the IAW vaults.(20)

7. The ingrowth of daughters of uranium and the transuranics inside the vaults was considered.

8. The potential dose to postclosure workers from direct gamma exposure from the undisturbed waste was considered.

Each radionuclide was initially assigned an inventory of one billion curies, which is about 100 times the total historic inventory of low-level waste disposed at SRS. The results for each pathway and each radionuclide were examined and compared with the performance objectives in Table I. Radionuclide inventories were adjusted so that the calculated dose for the most limiting pathway for each radionuclide would equal the performance objective for that pathway. Only a few of the ten pathways considered by PATHRAE were found to be significant: groundwater, direct gamma, and food grown onsite.

One of the useful features of the PATHRAE code is that it computes the inventory remaining in the facility at future times considering decay and transport. Since uranium and the transuranics have decay chains which include other radioactive species, this feature was used to determine if any daughter radionuclides would be produced in sufficient quantity to exceed the inventory limit calculated for them as parents. The decay chains which are included in PATHRAE are:

Cm-244 => Pu-240 => U-236

Pu-240 => U-236 => Th-232

Am-243 => Pu-239 => U-235

Pu-241 => Am-241 => Np-237

Pu-238 => U-234 => Th-230 => Ra-226

Pu-242 => U-238 => U-234

Several cases were found where consideration of daughters produced a more restrictive limit than that of the parent isotope. The results of the decay chain calculations are shown in Table II.

Table II. Comparison of Parent and Daughter Limits
(Total Inventory, Curies)
[Most Limiting Vaule is Underlined]

	IAW Vaults		LAW Vaults	
Limit Basis	Parent	Daughter	Parent	Daughter
Cm-244=>U-236	1E+9	7E+6	1E+9	1E+8
Pu-240=>U-236	7E+5	1E+4	2E+5	2E+5
Pu-240=>Th-232	7E+5	>1E+4	2E+5	>2E+5
U-236=>Th-232	1E+0	>1E+0	2E+1	>2E+1
Am-243=>U-235	8E+2	1E+7	2E+3	2E+8
Pu-239=>U-235	7E+5	2E+6	1E+4	4E+7
Pu-241=>Np-237	1E+9	9E+3	2E+5	1E+5
Am-241=>Np-237	2E+6	2E+2	4E+7	3E+3
Pu-238=>U-234	7E+8	5E+3	4E+5	8E+4
Pu-242=>U-238	6E+2	2E+6	6E+3	2E+7
Pu-242=>U-234	6E+3	>2E+6	6E+3	>2E+7
U-238=>U-234	2E+0	>2E+0	3E+1	>3E+1

RESULTS

The results of this study for the IAW vaults and the LAW vaults are shown in Table III. Many of the radionuclides are shown as having no limit, meaning that even with an initial inventory of 1 billion curies the performance objectives are not exceeded. The property that these "No Limit" nuclides have in common is a short half-life. Because the vaults prevent radionuclide release for 100 to 300 years, isotopes with half-lives less than about 5 years decay to insignificant amounts before they can reach the environment. These "No Limit" nuclides will not be considered further in this report.

The remaining isotopes fall into two categories, those which are limited by the groundwater pathway and those which are limited by intruder pathways. This difference in the method of exposure has implications for the manner in which facility limits should be implemented. Radionuclides which impact the groundwater system must first be leached out of the wasteforms by percolating water and then be transported through the vadose (unsaturated) zone. This mechanism therefore integrates over the entire disposal facility, so that the overall facility inventory is the controlling factor. Intrusion scenarios, however, involve a small fraction of the waste disposed of in the facility, only that which is disturbed by excavation and drilling. This means that individual waste package concentrations are the controlling factor.

Table IV summarizes the calculated limits for each radionuclide. Those isotopes which are groundwater limited are given in units of total curies and curies per vault. The intrusion limited isotopes are given in concentration units, curies per cubic meter, curies per cubic foot, and nanocuries per gram (assuming a waste density of 1600 kg/m^3). Several of the transuranic isotopes, which by themselves were intrusion limited, had more restrictive inventories when ingrowth of neptunium and the uranium isotopes was considered. Since the daughters are limited by groundwater, the parent radionuclide is listed in the groundwater side of the table.

DISCUSSION

To assess the impact of the inventory limits calculated in this work, a comparison was made with the historic waste inventory as shown in SRS records. This comparison is given in Table V. Five isotopes, C-14 in reactor moderator deionizers, Np-237, Th-232, U-234, and U-238 have historic inventories higher than the limits calculated here. The deionizers will be sent to the LLW storage building and will not impact the E-Area Vaults. The Th-232 in the existing inventory resulted from programs many years ago to develop a thorium fuel cycle.(21) Such work is not anticipated in the future, so little if any thorium is expected in the E-Area Vaults.

The uranium isotopes are somewhat more problematic. A great deal of the U-234 in the existing inventory came from the Naval Fuel program at SRS, which has since been discontinued. U-234 is the primary isotope of concern in enriched uranium. Future operations are expected to generate only about one-third the amount of enriched uranium waste as in the past.(22) In addition, most enriched uranium wastes are now collected for offsite recovery, so little enriched uranium waste will be disposed in the E-Area Vaults. U-238 is a major component of both enriched and

Table III. PATHRAE Results for E-Area Vaults

	IAW Vaults		LAW Vaults	
Nuclide	Ci	Limiting Pathway	Ci	Limiting Pathway
Am-241	2E+2	Np-237 Ingrowth	3E+3	Np-237 Ingrowth
Am-243	8E+2	Groundwater	2E+3	Direct Gamma
C-14	1E+0	Groundwater	2E+1	Groundwater
Ce-144	1E+9	No Limit	1E+9	No Limit
Cf-252	1E+9	No Limit	1E+9	No Limit
Cm-244	7E+6	U-236 Ingrowth	1E+8	U-236 Ingrowth
Co-60	1E+9	No Limit	1E+9	No Limit
Cs-134	1E+9	No Limit	1E+9	No Limit
Cs-137	8E+7	Direct Gamma	1E+7	Direct Gamma
Eu-154	1E+9	No Limit	1E+9	No Limit
Eu-155	1E+9	No Limit	1E+9	No Limit
I-129	1E-2	Groundwater	2E-1	Groundwater
Nb-94	1E+1	Direct Gamma	3E+1	Direct Gamma
Nb-95	1E+9	No Limit	1E+9	No Limit
Ni-59	2E+3	Direct Gamma	2E+4	Direct Gamma
Ni-63	1E+9	No Limit	1E+9	No Limit
Np-237	2E-2	Groundwater	4E-1	Groundwater
Pm-147	1E+9	No Limit	1E+9	No Limit
Pr-144	1E+9	No Limit	1E+9	No Limit
Pu-238	5E+3	U-234 Ingrowth	8E+4	U-234 Ingrowth
Pu-239	1E+4	Direct Gamma	5E+4	Direct Gamma
Pu-240	1E+4	U-236 Ingrowth	2E+5	Direct Gamma
Pu-241	9E+3	Np-237 Ingrowth	1E+5	Np-237 Ingrowth
Pu-242	6E+2	Direct Gamma	6E+3	Direct Gamma
Rb-87	1E+1	Groundwater	2E+2	Groundwater
Rh-106	1E+9	No Limit	1E+9	No Limit
Ru-106	1E+9	No Limit	1E+9	No Limit
Sb-125	1E+9	No Limit	1E+9	No Limit
Se-75	1E+9	No Limit	1E+9	No Limit
Se-79	3E+0	Groundwater	5E+1	Groundwater
Sm-151	1E+9	No Limit	1E+9	No Limit
Sr-90	1E+9	No Limit	3E+8	Food
Tc-99	9E-1	Groundwater	1E+1	Groundwater
Te-125	1E+9	No Limit	1E+9	No Limit
Th-232	3E-1	Groundwater	5E+0	No Limit
U-234	2E+0	Groundwater	3E+1	Groundwater
U-235	1E+0	Groundwater	2E+1	Groundwater
U-236	1E+0	Groundwater	2E+1	Groundwater
U-238	2E+0	Groundwater	3E+1	Groundwater
Y-90	1E+9	No Limit	1E+9	No Limit

depleted uranium. As previously stated, little enriched uranium waste is expected in the future. Depleted uranium is used as target material in the production of Pu-239. If future efforts at SRS are directed only towards tritium production, then there will be little if any depleted uranium waste sent to the E-Area Vaults.

Pu-238 production is currently being restarted after a period of inactivity. The allowed inventory of Pu-238 is quite large (90,000 curies), and the difference between the calculated and historic inventories is quite large (9 times), so with a little care in waste management practices the limit should not be a problem. Of much more concern is the fact that an intermediate product in Pu-238 manufacture is Np-237, which has a very low calculated limit (0.4 curie) and a historic inventory from past Pu-238 production exceeding the limit (0.7 curie). Disposal of Np-237 must therefore be carefully monitored.

The historic inventories of four other isotopes, Pu-238, Tc-99, U-235 and U-236, are within an order of magnitude of the limits calculated in this report. Pu-238 and associated Np-237 waste has just been discussed. As previously stated, the generation of all types of uranium waste is expected to be much reduced in the future. As Pu-239 production is reduced, reprocessing waste containing fission product material will be reduced as well, which will reduce the amount of technetium sent for disposal.

It should be kept in mind that there will be major programs of Decontamination and Decommissioning arising in the future. Activities in the canyon buildings and the tank farms will produce fission product waste, and efforts in the reactor areas will result in waste containing activation products. Another consideration is the large stockpile of depleted uranium at SRS which may ultimately require disposal.

RECOMMENDATIONS

The inventory and concentration limits presented in this report are intended as interim guidance, pending the conclusion of the much more formal and comprehensive performance assessment that is currently underway. The limits, for the most part, are not restrictive in the context of either past waste generation or that projected for the future. The formal performance assessment may produce limits which are either more or less restrictive than those presented here.

Table IV. Disposal Limits for E-Area Vaults

Intermediate Activity Waste Vaults

Inventory Limited

Nuclide	Curies	Ci/Vault
Am-241	2E+02	2E+01
Am-243	8E+02	8E+01
C-14	1E+00	1E-01
Cm-244	7E+06	7E+05
I-129	1E-02	1E-03
Np-237	2E-02	2E-03
Pu-238	5E+03	5E+02
Pu-240	1E+04	1E+03
Pu-241	9E+03	9E+02
Rb-87	1E+01	1E+00
Se-79	3E+00	3E-01
Tc-99	9E-01	9E-02
Th-232	3E-01	3E-02
U-234	2E+00	2E-01
U-235	1E+00	1E-01
U-236	1E+00	1E-01
U-238	2E+00	2E-01

Concentration Limited

Nuclide	Ci/m^3	Ci/ft^3	nCi/g
Cs-137	1E+03	3E+01	7E+05
Nb-94	1E-04	4E-06	8E-02
Ni-59	3E-02	7E-04	2E+01
Pu-239	2E-01	5E-03	1E+02

Low Activity Waste Vaults

Inventory Limited

Nuclide	Curies	Ci/Vault
Am-241	3E+03	1E+02
C-14	2E+01	9E-01
I-129	2E-01	8E-03
Np-237	4E-01	2E-02
Pu-238	8E+04	4E+03
Pu-241	1E+05	7E+03
Rb-87	2E+02	8E+00
Se-79	5E+01	2E+00
Tc-99	1E+01	7E-01
Th-232	5E+00	3E-01
U-234	3E+01	1E+00
U-235	2E+01	1E+00
U-236	2E+01	1E+00
U-238	3E+01	1E+00

Concentration Limited

Nuclide	Ci/m^3	Ci/ft^3	nCi/g
Am-243	1E-03	4E-05	9E-01
Cs-137	1E+01	3E-01	7E+03
Nb-94	2E-05	6E-07	1E-02
Ni-59	1E-02	3E-04	7E+00
Pu-239	4E-02	1E-03	2E+01
Pu-240	1E-01	4E-03	9E+01
Pu-242	4E-03	1E-04	3E+00
Sr-90	2E+02	7E+00	1E+05

Table V. E-Area Vault Limits vs. SRS Historic Inventory

	E-Area Vault Limits			Historic
	ILNT	LAW	Total	Inventory
Nuclide	Curies	Curies	Curies	Curies
Am-241	2E+02	3E+03	3E+03	1E+01
Am-243	8E+02	2E+03	3E+03	0E+00
C-14	1E+00	2E+01	2E+01	6E-04 (a)
Cm-244	7E+06	1E+08	1E+08	9E+03
Cs-137	8E+07	1E+07	9E+07	7E+04
I-129	2E-02	2E-01	2E-01	3E-03
Nb-94	1E+01	3E+01	4E+01	1E-05
Ni-59	2E+03	2E+04	2E+04	5E-01
Np-237	2E-02	4E-01	4E-01	7E-01 (b)
Pu-238	5E+03	8E+04	9E+04	1E+04
Pu-239	1E+04	5E+04	6E+04	1E+03
Pu-240	1E+04	2E+05	2E+05	2E+01
Pu-241	9E+03	1E+05	1E+05	1E+03
Pu-242	6E+02	6E+03	7E+03	2E-03
Rb-87	1E+01	2E+02	2E+02	3E-06
Se-79	3E+00	5E+01	5E+01	5E-02
Sr-90	1E+09	3E+08	1E+09	7E+04
Tc-99	9E-01	1E+01	1E+01	2E+00
Th-232	3E-01	5E+00	5E+00	3E+03 (b)
U-234	2E+00	3E+01	3E+01	6E+01 (b)
U-235	1E+00	2E+01	2E+01	2E+00
U-236	1E+00	2E+01	2E+01	7E+00
U-238	2E+00	3E+01	3E+01	6E+01 (b)

Notes:

(a) Does not include approximately 7000 curies in reactor deionizers. These will be stored in the future and not disposed in E-Area Vaults.

(b) Indicates cases where historic inventory exceeds calculated E-Area Vaults inventory limit.

Since the concentration limits in Table IV were derived by determining the maximum amount of each radionuclide which would produce the maximum allowable exposure, the Sum of Fractions rule must be used when applying the limits. This means that the ratio of each radionuclide in a waste package or in a vault to its limit is calculated, and all the ratios summed. The sum must be less than one to be acceptable for disposal. For example, if a package contains one-half the limit for one radionuclide and three-fourths the limit for another, then the sum of fractions would be 1.25, and that package would not meet the disposal criteria.

It is also recommended that the inventories of each radionuclide be controlled on a vault basis, perhaps using a moving average technique. This will insure that those isotopes which could impact groundwater are dispersed over the disposal facility, in accordance with the modeling assumptions.

If the limits are viewed as overly restrictive from the point of view of either Waste Management or the waste generators, there is a precedent from the Nuclear Regulatory Commission for increasing concentration limits by a factor of ten using peak to average ratioing.(23)

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