BELOW REGULATORY CONCERN ANALYSIS FOR LIQUID AND SOFT WASTE

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ABSTRACT

Some waste generated at U.S. Department of Energy's (DOE) Rocky Flats Plant (RFP) contains background levels of radioactive materials not necessarily attributable to facility operation. Two such waste streams are characterized. Dose criteria that apply to the disposal of these waste streams are summarized. Off-site facilities that could receive, process, and dispose of such waste are listed. Risk assessments to determine conservative radiation exposures to drivers, facility, workers, members of the general public, and inadvertent intruders are summarized Limiting radionuclide concentrations which cause no radiation exposure to exceed any applicable dose criterion (or other applicable limit) are identified.

INTRODUCTION

The DOE RFP generates waste which is not involved in the processing of radioactive materials. This waste may contain background levels of radioactivity which were present in the material when it was brought on-site, before it was declared a waste, or may result from contact of the material with other materials or equipment contaminated to background levels. This waste may also contain substances which have been designated as hazardous under the provisions of the Resource Conservation and Recovery Act (RCRA).

In response to DOE directives, RFP determined a defensible basis for declaring this waste to be not radioactive (1). Although levels of certain contaminants are essentially at background, the potential impacts of the off-site treatment and disposal of this waste without regard to its radioactive content must be shown to be sufficiently small that the environment and public health will not be adversely affected.

For the purposes of this paper, waste with concentrations of radionuclides so low that it may be exempt from control as radioactive waste is termed candidate below regulatory concern (BRC) waste. This paper characterizes two candidate BRC waste streams generated at RFP: liquid wastes and soft wastes. Off-site treatment and disposal facilities to which these wastes might be dispatched as non-radioactive waste are described. A risk assessment was performed which includes an assessment of projected doses to individuals and populations; doses to workers who handle and process the waste and treatment residues; and doses from postulated accidents. The results of this risk assessment were used to evaluate the validity of the BRC disposal concept for certain waste generated at RFP and to establish limiting radionuclide concentrations for the safe management of this non-radioactive waste. The basic requirements of an implementation plan to ensure RFP compliance with BRC criteria for waste designated as non-radioactive are presented.

RISK ASSESSMENT METHODOLOGY

This risk assessment for candidate BRC waste began with characterizations of the waste streams involved and the off-site handling, treatment, and disposal facilities employed in managing the waste. Following this waste characterization process, the formal assessment of potential exposures resulting from the off-site treatment and disposal of the waste was conducted. These calculations assumed a unit concentration of each of the pertinent radionuclides that are present in the waste. The calculations accounted for all reasonable opportunities for human exposure to radiation originating from the waste, including exposures to workers and other individual members of the general public, and total population exposures as represented in Fig. 1. Computer programs designed specifically for risk assessment applications were used to model the migration of radionuclides to locations where humans could be exposed and to calculate potential doses. Emerging from these calculations were projections of potential doses to maximally exposed individuals for waste containing the assumed radionuclide concentration.

The quotients of the applicable BRC dose criteria and the projected doses provided scaling factors by which the unit concentrations used in the analysis were multiplied to determine the maximum permissible concentrations of the nuclides under consideration. These permissible concentrations provide a basis for deciding if a given waste is a candidate for treatment and disposal as non-radioactive waste, provided responsible Federal and state regulatory agencies agree.

REGULATORY REQUIREMENTS

DOE Order 5820.2A, which prescribes policies and requirements for waste management at DOE and DOE-contractor facilities, specifies that waste containing amounts of radionuclides below regulatory concern may be disposed without regard to its radioactivity content. Waste containing non-radioactive hazardous components must be

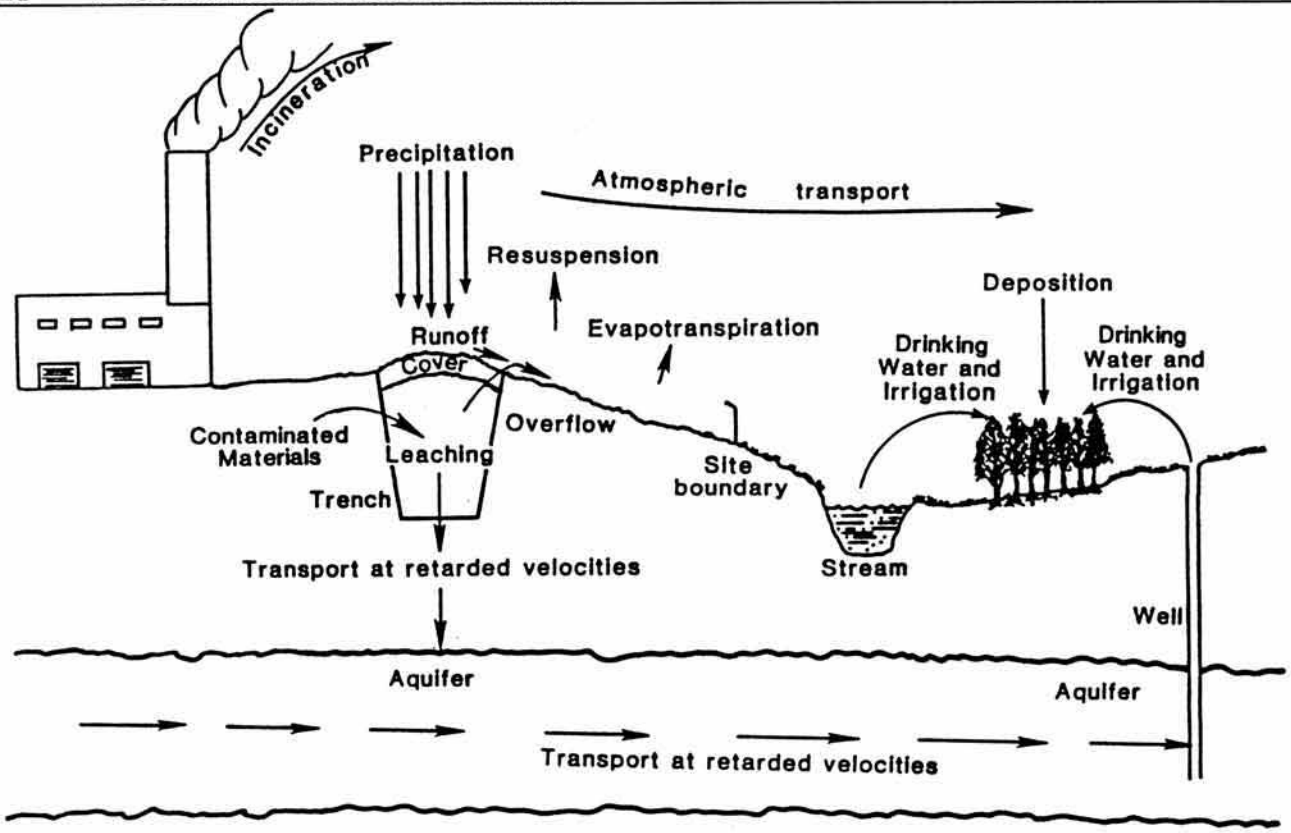

Fig. 1. Pathways modeled in risk assessment.

managed in accordance with the requirements of the Resource Conservation and Recovery Act (RCRA).

The DOE does not have established criteria for determining what constitutes BRC waste. For the purposes of this analysis, BRC dose criteria consistent with criteria currently being proposed by the NRC and the EPA were used. The dose criteria adopted for this analysis include:

- 4 mrem/yr to any individual from drinking contaminated water.
- 10 mrem/yr to any individual from other exposure pathways (except the drinking water pathway).
- 1,000 person-rem/yr annual collective dose to the total population.
- 500 mrem/yr to a member of the general public as a result of an accident condition.

These dose criteria provided the basis for the concentration limits for candidate BRC waste reported in this paper.

The transportation of radioactive material is governed by Department of Transportation (DOT) regulations in 49 CFR, Parts 170 through 189 which define radioactive material as any material having a specific activity greater than 0.002 μCi/g. Waste with specific activity less than 0.002 μCi/g can be transported as non-radioactive waste.

CANDIDATE BRC WASTE STREAMS

The waste streams evaluated as candidate BRC waste streams included liquid wastes and soft wastes. The liquid waste streams include a variety of oils (e.g., automotive, transformer, and machine oils); coolants; paints and paint related materials; and chlorinated solvents. Approximately 15,000 gal (57,000 L) of these wastes are produced annually at RFP. Soft waste includes rags, paper, and plastic from several sources, including machine shops, garages, assembly areas, and paint shops. Approximately 1,100 ft^3 (31 m^3) of this material is produced annually.

For these wastes the radionuclides potentially present are uranium-238, plutonium-239, americium-241, and decay daughters. A total of five daughters: radium-226, thorium-230, thorium-234, protoactinium-234m, and neptunium-237, were included in the risk assessment.

LIQUID WASTE HANDLING AND PROCESS FACILITIES

A flow chart for the off-site processing of candidate BRC liquid wastes from RFP is shown in Fig. 2. All candidate BRC liquid waste generated at RFP is shipped to a fuel

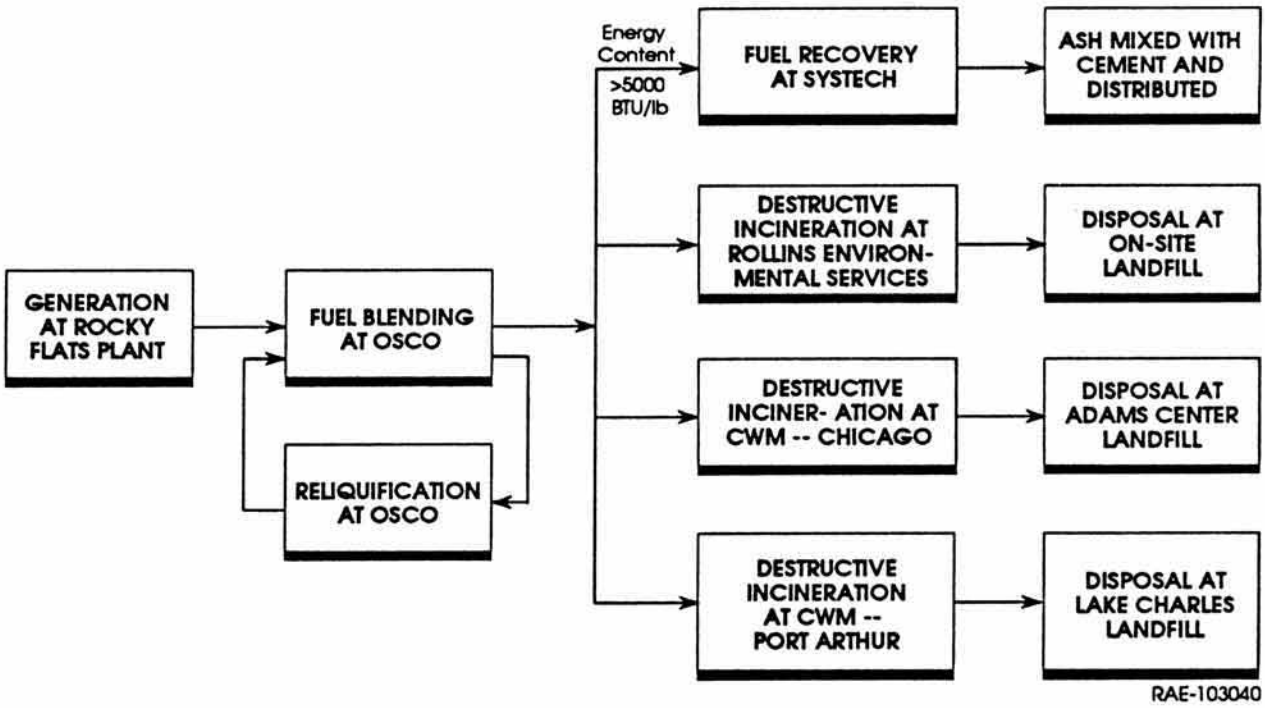

Fig. 2. Probable disposition of candidate BRC liquid waste.

blending facility. If the energy content of the waste is sufficiently large, the waste is sent for fuel recovery which disposes of all ash by mixing it with its product (Portland cement). If the energy content is lower, the waste is destructively incinerated and the ash sent to a disposal site as indicated.

SOFT WASTE HANDLING AND PROCESS FACILITIES

Candidate BRC soft wastes from the RFP are destructively incinerated, whereupon the resulting ash is disposed at either of two landfills.

RISK ASSESSMENT FOR OFF-SITE INDIVIDUALS AND POPULATIONS

Using PATHRAE-RAD (2) potential doses to nearby residents, intruders, and local populations were calculated for various scenarios involving the off-site treatment and disposal of candidate BRC wastes at the facilities shown in Figs. 1 and 2. The input data required to model exposures resulting from each of these facilities were obtained through interviews with representatives of the various incineration and disposal facilities.

Dose assessments were performed for operational and post-closure scenarios involving facilities for the management of both liquid and soft wastes. These scenarios involved both atmospheric and water pathways for the transport of radionuclides to human receptors. Exposures to humans were calculated for inhalation and ingestion of radionuclides and direct exposure to gamma radiation. Dose projections based on unit radionuclide concentrations were used in determining limiting radionuclide concentrations to satisfy the BRC dose criteria.

RISK ASSESSMENT FOR WORKERS

Potential doses to workers who transport, treat, incinerate, and dispose of candidate BRC wastes were calculated using the NRC's de minimis waste impacts analysis methodology (3). This methodology was also used to calculate potential doses to the population along the routes used to transport the waste. Values of parameters used in the worker dose calculations were obtained from descriptions of the waste management facilities and from the NRC's de minimis document.

For destructive incineration, each incineration or disposal facility was assumed to incinerate or dispose of all of the RFP candidate BRC waste designated for destructive incineration. This maximized the worker doses from incineration and ash disposal and resulted in conservatively high worker exposure estimates for these operations. Limiting radionuclide concentrations were determined which satisfied the BRC dose criteria of 10 mrem/yr for workers and 1,000 person-rem/yr to the exposed population.

RISKS FROM ACCIDENTS

Accidents that could occur during any phase of the management of RFP candidate BRC wastes were identified and characterized by reviewing descriptions of waste management operations involving these wastes. An event tree was constructed to assist in characterizing the accidents, as shown in Fig. 3. The analysis of potential accidents through the use of the event tree showed that transportation accidents involving fires have the most serious potential radiological impact.

To assess the consequences of a serious transportation accident involving liquid waste, an accident and fire involving a tanker truck shipment of 5,000 gal (19,000 L) of waste oil was postulated. To assess the consequences of a serious accident involving soft waste, it was postulated that a 20-drum truckload of waste was involved in a collision with a tanker truck, and a fire resulted. Postulated doses to individuals and populations from these accidents were then considered in establishing limiting concentrations for RFP candidate BRC wastes.

LIMITING RADIONUCLIDE CONCENTRATIONS

The risk assessments summarized in the previous paragraphs provide dose estimates to individuals and populations for an assumed concentration of 1 pCi/g of each nuclide in the waste or ash. To determine permissible radionuclide concentrations that conform to dose criteria for BRC disposal it was necessary to define a scaling factor by which the unit concentration could be multiplied. For each scenario for which a dose was calculated, this scaling factor is simply the quotient of the applicable BRC dose criterion and the projected dose for unit concentration.

Limiting concentrations were determined for each radionuclide by identifying the most restrictive (smallest) concentrations. These limiting concentrations are shown by nuclide and facility for liquid waste in Table I and for soft waste in Table II. In Tables I and II, the concentration limits are presented separately for each treatment and disposal facility. Since RFP does not control the disposition of the waste is eventually disposed, the concentration limits for all facilities must be satisfied. Concentration limits which satisfy the criteria for all facilities are also shown in Tables I and II.

Fig. 3. Event tree for transportation accident.

The most restrictive limits summarized in Tables I and II were based only on the risk assessments described in this paper. Before recommended BRC concentrations for waste from RFP could be established, it would be necessary to consider any additional regulatory constraints that may apply. Of particular interest is the DOT limitation that waste with total radioactive content in excess of 2.0E+3 pCi/g must be labeled and shipments of such waste must be placarded as radioactive. Several of the most restrictive limits summarized in Tables I and II exceed this limit.

The highest concentrations of radionuclides in RFP candidate BRC wastes that would meet the BRC dose criteria and also not exceed the DOT regulatory requirement for labeling and placarding are shown in Table III. Four of the six cases are limited by the DOT requirement, while the remaining two are limited by an accident in which the waste catches fire and burns. The BRC concentration for U-238 given in Table III is based on the DOT requirement, assuming that U-238 is in secular equilibrium with its two short-lived daughters. Therefore, the DOT limit of 2.0E+3 pCi/g is reduced by a factor of 3.

Waste containing mixtures of the three nuclides shown in Table III can also be treated and disposed as BRC waste using the "*sum of fractions*" rule and by comparing the total of all radionuclides present to the DOT limit. If the sum of fractions does not exceed 1.0 and if the total radioactivity present does not exceed 2,000 pCi/g, the waste can be disposed without regard to its radioactive content.

IMPLEMENTATION

Management of some RFP wastes as BRC waste would require that RFP personnel develop and implement procedures to ensure compliance with radionuclide concentration and total activity limits on wastes designated for treatment and/or disposal as BRC waste. Compliance would require a waste sampling and analysis program and recordkeeping. Both the waste sampling and analysis program and the records requirements would have to meet criteria acceptable to the DOE, the EPA, state agencies, and the operators of facilities where the waste would be treated and disposed. The sampling procedures and records would be subject to periodic audit and inspection by Federal and state agencies that regulate the treatment and disposal of radioactive and chemically hazardous wastes.

REFERENCES

1. BAIRD, R.D., ET AL., "Evaluation of Candidate BRC Waste Generated at the Rocky Flats Plant," prepared for EG&G Rocky Flats, Inc. by Rogers and Associates Engineering Corporation, RAE-8960-2, February 1990.
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TABLE I

Summary of RFP Candidate BRC Waste Concentration Limits for Liquid Waste
Based Only on Risk Assessments

Facility	Concentration Limit For Facility (pCi/g)	Limiting Receptor
Liquid Waste		
OSCO		
U-238	1.0E+5	Site Worker
Pu-239	--- [a]	---
Am-241	2.6E+4	Site Worker
Systech		
U-238	9.1E+4	Driver
Pu-239	9.1E+5	Max. Individual
Am-241	8.3E+4	Driver
CWM - Chicago		
U-238	5.6E+4	Driver
Pu-239	1.2E+5	Population
Am-241	4.8E+4	Driver
CWM - Port Arthur		
U-238	4.8E+4	Driver
Pu-239	4.5E+5	Max. Individual
Am-241	4.2E+4	Driver
Rollins Environmental Services		
U-238	5.3E+4	Driver
Pu-239	3.0E+5	Max. Individual
Am-241	4.3E+4	Driver
Adams Center		
U-238	4.6E+4	Max. Individual
Pu-239	2.1E+5	Max. Individual
Am-241	4.0E+5	Max. Individual
Lake Charles		
U-238	2.2E+5	Max. Individual
Pu-239	3.6E+6	Max. Individual
Am-241	6.2E+5	Driver
Accidents		
U-238	7.8E+3	Max. Individual
Pu-239	1.8E+3	Max. Individual
Am-241	1.8E+3	Max. Individual
Most Restrictive Limit		
U-238	7.8E+3	Transportation Accident, Max. Individu
Pu-239	1.8E+3	Transportation Accident, Max. Individual
Am-241	1.8E+3	Transportation Accident, Max. Individual

a. Since the dose from Pu-239 was estimated to be zero, no concentration limit was established.

TABLE II

Summary of RFP Candidate BRC Waste Concentration Limits for Soft Waste Based Only on Risk Assessments

Facility	Concentration Limit For Facility (pCi/g)	Limiting Receptor
Soft Waste		
ENSCO		
U-238	1.4E+4	Driver
Pu-239	7.7E+5	Max. Individual
Am-241	1.2E+4	Driver
USPCI - Lone Mountain		
U-238	1.3E+4	Max. Individual
Pu-239	6.2E+4	Max. Individual
Am-241	7.9E+4	Max. Individual
CWM - Emelle		
U-238	1.2E+5	Driver
Pu-239	5.0E+6	Max. Individual
Am-241	1.0E+5	Driver
Accidents		
U-238	4.2E+6	Max. Individual
Pu-239	1.0E+6	Max. Individual
Am-241	9.6E+5	Max. Individual
Most Restrictive Limit		
U-238	1.3E+4	Lone Mtn., Max. Individual
Pu-239	6.2E+4	Lone Mtn., Max. Individual
Am-241	1.2E+4	ENSCO, Driver

TABLE III

Highest Concentrations of Radionuclides in RFP Waste That Could be Treated or Disposed as BRC

Waste	Nuclide	BRC Concentration (pCi/g)	Limiting Condition
Liquid	U-238	6.6E+2*	DOT Regulation (49 CFR 173.403)
	Pu-239	1.8E+3	Transportation Accident, Max. Individual
	Am-241	1.8E+3	Transportation Accident, Max. Individual
Soft	U-238	6.6E+2*	DOT Regulation (49 CFR 173.403)
	Pu-239	2.0E+3	DOT Regulation (49 CFR 173.403)
	Am-241	2.0E+3	DOT Regulation (49 CFR 173.403)

* Assuming U-238 is in secular equilibrium with decay daughters Pa-238 and U-234.

the waste sampling and analysis program and the records requirements would have to meet criteria acceptable to the DOE, the EPA, state agencies, and the operators of facilities where the waste would be treated and disposed. The sampling procedures and records would be subject to periodic audit and inspection by Federal and state agencies that regulate the treatment and disposal of radioactive and chemically hazardous wastes.