

SYSTEMS FOR CLASSIFICATION OF LOW-LEVEL RADIOACTIVE WASTE: SURVEY AND ANALYSIS

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This paper presents systems for classification of non-commercial low-level radioactive waste in the context of remediation and disposal of the waste. It traces development of classification systems from regulation of low-level radioactive waste under the Atomic Energy Act, the Low-Level Radioactive Waste Policy Act as amended, the Uranium Mill Tailings Radiation Control Act, and the Comprehensive Environmental Response, Compensation and Liability Act, through classification systems from the Department of Energy and the Nuclear Regulatory Commission to Naturally Occurring Radioactive Material. The authors then discuss disposal options for these wastes, and analyze decision factors for classifying a waste for management and disposal.

INTRODUCTION

Classification of a low-level radioactive waste determines to a large degree the range of transportation and disposal options for that waste and the cost for disposal. When deciding how to classify a waste, a full range of waste classification options should be considered early in the remedy selection process with an awareness that the costs of transporting and disposing of waste are a significant fraction of the total cost of the alternatives that use off-site disposal.

Misclassification of low-level radioactive waste may result in a faulty basis for comparison of remedial alternatives, thus jeopardizing the validity of the final remedy selection process.

When classifying low-level radioactive material, the first demarcation occurs between commercially-generated waste and defense waste. On the one hand, commercially-generated waste is regulated by the Nuclear Regulatory Commission (NRC) under an NRC license, and is usually classified in accordance with the scheme set out in NRC regulations. On the other hand, classification of defense waste is not so well-defined. No statutes or rules specify any procedures or methods for classifying defense low-level radioactive waste, nor do any provisions exist specifying who is to classify the waste.^A Instead, it is a well-established practice that defense-generated radioactive waste is classified by the federal agency managing the waste, within the parameters of source, regulatory program, and radionuclide characteristics.

Regardless of the regulatory program governing its management and disposal, radioactive waste is the same physical substance on the isotopic level, posing the same threats to human health or the environment. That is to say, uranium and thorium produce the same daughters in the same series of decompositions regardless of whether the uranium and thorium derive from source ore production, byproduct materials, phosphate mining, or oil and gas production. Likewise, radioactive waste is the same physical substance whether it is classified as 11(e)(2) byproduct material, low-level radioactive waste under the Low Level Radioactive Waste Policy Act, a hazardous substance under CERCLA, or a naturally occurring radioactive material (NORM).

In this paper, first we discuss various systems of classification for low-level radioactive waste

along with the legal authorities associated with each classification system. Next we briefly touch upon waste disposal options. Then we evaluate what avenues are feasible to pursue in classifying low-level radioactive waste for remediation and disposal. Finally we set forth guidelines to follow when classifying waste for disposal.

The various systems for classification of low-level radioactive waste discussed in this paper are the following already established systems: low-level radioactive waste as defined in the Low-Level Radioactive Waste Policy Act as Amended (LLRWPA); residual radioactive material under the Uranium Mill Tailings Radiation Control Act of 1978 (UMTRCA); 11(e)(2) byproduct material from active uranium mill tailings facilities; low-level radioactive waste as defined by DOE in DOE Order 5280.2A; residual radioactive material under DOE Order 5400.5; and naturally-occurring radioactive material (NORM). One new classification system is discussed, comprising radioactive waste under CERCLA as a hazardous substance. The NRC scheme for classifying commercially-generated low-level radioactive waste based on physical characteristics such as radionuclide half-lives and radiation type is briefly discussed.

All of the above-mentioned waste classifications consist of materials exhibiting the same radiological characteristics at the isotopic level. It is recognized in the literature, though, that uranium mill tailings and their residues have lower levels of radioactivity and larger volumes than other low-level radioactive wastes.

ORIGIN OF WASTE CLASSIFICATION SYSTEMS - THE ATOMIC ENERGY ACT

Prior to enactment of the Atomic Energy Act, radioactive materials were not regulated. The Atomic Energy Act vested authority in the Atomic Energy Commission to regulate radionuclides. In 1974, the Atomic Energy Commission was abolished and its functions passed on to the Energy Research and Development Administration (ERDA) and the NRC. Two agencies were established in place of one preexisting agency in order to separate out the nuclear development programs from the nuclear regulatory programs. NRC was assigned the regulatory functions. In 1977, ERDA was abolished and its functions passed along to the newly created Department of Energy (DOE). Under the Atomic Energy Act, both the NRC and the DOE have been directed to consult with the Department of Defense (DoD) when issuing certain licenses (NRC) or when allowing the distribution of certain nuclear material (NRC and DOE).

Authority to regulate nuclear materials under the Atomic Energy Act flows to either the Nuclear Regulatory Commission or the Department of Energy. Because the Atomic Energy Act authorizes the DOE to act separately from the NRC, the DOE is said to be self-regulating in the area of low-level radioactive waste management. No other Federal agencies are self-regulating in this sense.

This allocation of authority has ramifications for how radioactive waste was initially classified. In the Atomic Energy Act, Congress established three categories of radioactive materials: source material, special nuclear material, and byproduct material. As originally defined in the Atomic Energy Act, byproduct material did not cover what is now known as 11(e)(2) waste. Rather,

byproduct material was originally defined as:

...any radioactive material (except special nuclear material) yielded in or made radioactive by exposure to the radiation incident to the process of producing or utilizing special nuclear material,... (Definition found at 42 USC 2014(e)(1)).

Under the regulatory scheme set up by the Atomic Energy Act, any radioactive material regulated by NRC or the DOE had to fall within one of those categories.

LOW-LEVEL RADIOACTIVE WASTE POLICY ACT

In 1980, the Atomic Energy Act was amended by enactment of the Low-Level Radioactive Waste Policy Act (LLRWPA). Low-level radioactive waste is defined in the Low Level Radioactive Waste Policy Act as Amended (LLRWPA) at 42 U.S.C. 2011b(10), as:

radioactive material that -

- (A) is not high-level radioactive waste, spent nuclear fuel, or byproduct material (as defined in section 2041(e)(2) of this title); and
- (B) the Nuclear Regulatory Commission, consistent with existing law and in accordance with paragraph (A), classifies as low-level radioactive waste.

In the LLRWPA, Congress specified that the federal government is to have custody and control of low-level radioactive waste generated by the federal government, while states are to take custody and control of commercially-generated low-level radioactive waste. In dividing responsibilities between the federal and state governments, Congress did not designate a responsible federal agency. Under the language of the LLRWPA, any federal agency can be responsible for disposal of low-level radioactive waste covered by the provisions of the Act.

It is notable that waste disposed of in accordance with the LLRWPA must be disposed of in accordance with NRC rules.

Previous to 1980, the NRC had recognized a class of radioactive waste that had so little activity as to pose no threat to human health or to the environment. In the 1980 LLRWPA, Congress recognized and acknowledged that such a class of low-level radioactive waste could exist by providing legislative authority for the NRC to establish a special class of low-level radioactive waste known as “below regulatory concern” wastes.

URANIUM MILL TAILINGS RADIATION CONTROL ACT (UMTRCA)

As part of the Atomic Energy Act, the Uranium Mill Tailings Radiation Control Act of 1978 (UMTRCA) regulates uranium mill tailings waste material from active and inactive uranium processing and millings operations.

In the UMTRCA, Congress set forth two categories of wastes for uranium milling operations: “residual radioactive material” and “byproduct material.” Under the UMTRCA, Congress directs that DOE remediate “residual radioactive material” at sites designated in UMTRCA as [inactive] uranium processing sites, and that NRC license “byproduct material” management at

active mill operations processing uranium or thorium ore, with NRC authority to continue after termination of processing operations in order to regulate the management of mill tailings.

Thus, as initially set forth in the UMTRCA, 11(e)(2) byproduct material is waste material produced during active mill operations and after termination of such operations and is managed under a license from NRC, while residual radioactive material is waste material present at inactive uranium processing sites designated in the Act.

Residual Radioactive Material (UMTRCA Site-Specific, Inactive Uranium or Thorium Mills)

“Residual radioactive material” is defined in UMTRCA at 42 U.S.C. 7911(7) as:

- (A) waste ... in the form of tailings resulting from the processing of ores for the extraction of uranium and other valuable constituents of the ores; and
- (B) other waste ... at a processing site which relate to such processing, including any residual stock of unprocessed ores or low-grade materials.

11(e)(2) Byproduct Material (Active Uranium or Thorium Mills)

UMTRCA directed that the definition of “byproduct material” in the Atomic Energy Act be amended to include uranium mill tailings, at Section 11(e)(2) (42 U.S.C. 2014(e)(2)). Section 11(e)(2) waste is defined as:

The term “byproduct material” means ... the tailings or wastes produced by the extraction or concentration of uranium or thorium from any ore processed primarily for its source material content.

This definition was added to 42 USC Section 2014 in order to enable NRC to extend its licensing authority over management of mill tailings waste material. This definition of byproduct material corresponds with authority accorded to the NRC to license the mill tailings management process as well as the uranium production or milling process during active mill operations and after termination of such operations.

UNIMPORTANT QUANTITIES OF SOURCE MATERIAL

Per the Atomic Energy Act, the NRC is authorized to define quantities of source material that are exempt from license requirements as being too insignificant to be of environmental or human health consequence. Source material is defined as:

- (1) Uranium or thorium, or any combination thereof, in any physical or chemical form or (2) ores which contain by weight one-twentieth of one percent (0.05%) or more of: (i) Uranium, (ii) thorium or (iii) any combination thereof. Source material does not include special nuclear material. (See the NRC regulations at 10 CFR § 40.4).

In 10 CFR § 40.13, the NRC has defined unimportant quantities of source materials in accordance with the definition of source material. From the definition of source material, it can

be calculated that 0.05% is approximately equal to 350 pCi/g of natural uranium and 50 pCi/g of thorium. One can argue that either: (1) the original ore fits the definition of source material as well as the definition of byproduct material, has a uranium/thorium content lower than specified in the rule, and is therefore exempt from regulation as a source material or (2) that the waste materials fit the definition of source material as well as the definition of byproduct material, have a uranium/thorium content lower than is specified in the rule, and are therefore exempt from regulation as a source material.

DOE CLASSIFICATION SYSTEMS

DOE Low-Level Radioactive Waste

DOE has set forth a slightly different definition of low-level waste in DOE Order 5820.2A. DOE classifies low-level waste as:

...waste that contains radioactivity and is not classified as high-level waste, transuranic waste, or spent nuclear fuel or 11e(2) byproduct material as defined by this Order.

In contrast to the LLRWPA requirement that NRC classify the waste as low-level radioactive waste, the DOE has no requirement that NRC classify its waste.

DOE Integrated Data Base (IDB)

In its Integrated Data Base (IDB), DOE has established a category of waste called Environmental Restoration waste, which includes contaminated media waste. Environmental Restoration wastes usually have much lower concentrations of radionuclides than wastes associated with processing operations. In the IDB, DOE subdivides environmental restoration wastes into three categories: low-level wastes; transuranic wastes; and 11e(2) byproduct material. In the IDB, it was noted that even though materials being managed under Title I of the UMTRCA are defined as residual radioactive material distinct from 11e(2) byproduct material, the residual radioactive material consists of uranium mill tailings as well as soil and debris contaminated with uranium mill tailings. Since this material has the same physical and radioactive properties as 11e(2) byproduct material, it is included in the 11e(2) byproduct material category for report purposes.^B

Residual Radioactive Material Under DOE Order 5400.5

DOE Order 5400.5 sets forth in Chapter IV requirements for managing residual radioactive material, which it defines as “any radioactive material which is in or on soil, air, equipment, or structures as a consequence of past operations or activities.” DOE sets forth generic guidelines or a method to calculate site-specific guidelines to attain a level of residual radioactive material that will allow the property to be used without restrictions, without adverse health or environmental effects. DOE then establishes an Authorized Limit for the property, which limit is equal to or below the guideline value. When the property is cleaned up or treated to the level of radioactivity which reflects the Authorized Limit, the property is safe for release to the public for unrestricted use. Similarly, radionuclide-contaminated material which does not exceed the Authorized Limit and which complies with radiological limits of a Resource Conservation and Recovery Act (RCRA) Subtitle C hazardous waste disposal facility or Subtitle D solid waste

disposal facility's waste acceptance criteria can be released for disposal at that facility.

NATURALLY OCCURRING RADIOACTIVE MATERIALS (NORM) WASTE

Most radionuclides are regulated under the authority of the Atomic Energy Act (AEA). The AEA, however, does not cover naturally-occurring radioactive material (NORM) unless that material is specifically designated as source material, such as high grade uranium and thorium ore.

NORM materials are those whose radioactivity has been enhanced, that is, their radionuclide concentrations have been increased or redistributed either naturally or as the result of human intervention or processes. Levels of specific activity for these wastes typically vary from 2 to 200 pCi/g. Examples of NORM wastes are exploration and production wastes from the oil and natural gas industries and phosphate slag piles from the phosphate mining industry.^c

CERCLA HAZARDOUS SUBSTANCE WASTE

Under CERCLA, some federal agencies have another option for radioactive waste classification. This option can be a possibility through the nature of a grant of authority to administer and execute a program and by the existence of RCRA Subtitle C hazardous waste landfills or Subtitle D solid waste landfills that can accept radioactive materials up to a certain level of activity. This option applies only to radioactive waste materials that are not covered by the provisions of a license from the NRC.

The CERCLA hazardous substance list includes radionuclides as a hazardous substance, but the CERCLA regulatory scheme does not classify radionuclides as a certain kind of radioactive waste. A federal agency could manage the wastes it generates under CERCLA as a category of low-level radioactive waste known as a CERCLA hazardous substance. This category of waste material under CERCLA would be comparable to residual radioactive material under Title I of UMTRCA, or to the category of residual radioactive material established under DOE Order 5400.5.

Both RCRA Subtitle C hazardous waste landfills and Subtitle D solid waste landfills are permitted to accept CERCLA hazardous substances that meet the waste acceptance criteria of the particular landfill. Some Subtitle C and Subtitle D landfills are permitted to accept certain levels of radioactive waste materials. Those landfills that are permitted to accept certain levels of radioactive waste materials would be able to accept low-level radioactive waste generated as a CERCLA hazardous substance.

CLASSIFICATION ACCORDING TO RADIOLOGICAL PROPERTIES

NRC Waste Classifications for Disposal at NRC Licensed Facilities

At 10 CFR 61.55, NRC sets forth four categories for waste classification according to radiological properties: Class A, B, C, and greater than Class C (GTCC).

Class A wastes are those which have a very low concentration of long-lived radionuclides. Class A wastes require the least rigorous disposal conditions.

Class B wastes are those that meet minimum requirements and stability requirements set forth in 10 CFR 61.55, as well as certain concentration limits for short-lived radionuclides.

Class C wastes are those that meet more rigorous stability requirements. Class C wastes must meet greater inadvertent intruder provisions, certain long-lived radionuclide requirements and short-lived radionuclide requirements.

GTCC wastes are generally not acceptable for near-surface disposal.

A comparison of the engineering standards requirements for Class A waste disposal facilities with standards for a Subtitle C landfill or state-of-the-art Subtitle D landfill yields the information that Subtitle C or state-of-the-art Subtitle D landfills are more protective of the environment than Class A waste disposal facilities. Disposing of the equivalent of Class A wastes in a Subtitle C or state-of-the-art Subtitle D facility would be more protective of human health and the environment than disposal of the equivalent of Class A wastes in an NRC-licensed facility.

DISPOSAL OPTIONS

NRC Disposal Facility

All NRC-licensed waste or low-level radioactive waste managed by NRC licensees must be disposed in an NRC-licensed disposal facility. These disposal facilities may also accept from the federal government waste that is not managed under an NRC license, depending on the individual license provisions for each disposal facility.

RCRA Subtitle C Hazardous Waste Landfill

At the Federal level, no regulations exist to prohibit disposal of non-NRC licensed radionuclide waste in a Subtitle C hazardous waste disposal facility, in spite of the fact that radionuclide waste is not a RCRA hazardous waste.

Two potential impediments exist to disposal of radioactive waste in a Subtitle C landfill. The first would be any state rules which prohibit the disposal of radioactive waste in non-NRC licensed facilities or ban the disposal of any level of radioactive wastes in the State.

If no such state laws or rules exist, the second potential impediment to disposal is permit conditions for the facility itself. An individual hazardous waste disposal facility must have in its permit terms and conditions allowing it to accept the level of radioactive material contained in the radioactive waste.

Subtitle D Solid Waste Landfill, Including "Special Waste" Landfills

State-of-the-art Subtitle D landfills should meet technological requirements that render them safer for disposal of the equivalent of Class A wastes than facilities licensed to accept Class A NRC wastes.

As with Subtitle C landfills, the two potential impediments to disposal are state laws and rules and individual landfill permit requirements.

Under CERCLA, a state can assert its laws and rules as applicable or relevant and appropriate requirements (ARARs) if the following conditions are satisfied:

- (1) the state standard, requirement, criteria or limitation is of general applicability and was adopted by formal means (i.e., the requirement must be a promulgated rule of general applicability);
- (2) the state standard, requirement, criteria, or limitation was adopted on the basis of hydrologic, geologic, or other relevant considerations and was not adopted for the purpose of precluding onsite remedial actions or other land disposal for reasons unrelated to protection of human health and the environment;
- (3) the state arranges for, and assures payment of the incremental costs of utilizing, a facility for disposition of the hazardous substances.

If the above three conditions are satisfied, a state standard, requirement, criteria or limitation, including any state siting requirement, will apply. If the above three conditions are not satisfied, then a state standard, requirement, criteria or limitation, including any state siting standard, which could effectively result in the statewide prohibition of land disposal of hazardous substances, shall not apply.

In other words, if the effect of a state law or rule is to prohibit land disposal of a hazardous substance statewide, it must be demonstrated that the ARAR meets the three conditions contained in CERCLA Section 121(d)(2)©.

Some states allow disposal of “below regulatory concern” wastes, while other states do not. Texas allows disposal of soil containing residual amounts of short-lived radioactive material in a sanitary landfill; Ohio does not. Missouri may allow disposal of NORM waste in a sanitary landfill. Disposal in a sanitary waste landfill is generally cheaper than disposal in a hazardous waste landfill.

Technical Requirements for NRC-Licensed Landfills as Compared With Technical Requirements for Subtitle C or Subtitle D Landfills

RCRA, a 1976 amendment to the Solid Waste Disposal Act, addresses safe disposal of huge volumes of municipal and industrial solid waste. Subpart N of 40 CFR Part 264 prescribes design and operating standards for landfills. Each Subtitle C facility is required to have a double-lined (synthetic and compacted clay) double-leachate collection system. The lower leachate collection system acts as a leak detection system for the primary liner. This requirement is significantly more stringent than current design requirements for radioactive waste disposal facilities which usually consist of a single 3 foot thick compacted clay liner. Even Subtitle D facilities built to the current technical requirements, double-lined with leachate collection, surpass those requirements.

Therefore, a waste classification that will allow disposal in a Subtitle C or state-of-the-art Subtitle D landfill actually provides greater environmental protection than a waste classification that allows disposal only in an NRC-licensed facility.

SUMMARY OF WASTE CLASSIFICATIONS AND CLASSIFICATION CONSIDERATIONS

Low-Level Radioactive Waste Under the LLRWPA, Then Exempt as a Waste Stream (Residual Contamination)

To proceed under this regulatory program, an entity would have to request that the NRC classify its waste as a low-level radioactive waste. Once that classification is obtained, the entity would have to submit a petition to the NRC requesting to exempt that waste stream from regulation as “below regulatory concern.” Either of these procedures is potentially burdensome, rendering this avenue potentially undesirable to pursue.

UMTRCA - Residual Radioactive Material

Waste classification must be compatible with the regulatory program under which the classifying agency is authorized to proceed. In order to classify its waste as residual radioactive material under the UMTRCA, the classifying agency must be authorized by the AEA to manage the waste in accordance with the UMTRCA.

UMTRCA - 11(e)(2) Byproduct Material

As with the residual radioactive material designation under UMTRCA, the classifying agency must be authorized to proceed under the AEA. Classification of the material as 11(e)(2) waste may run into regulatory program compatibility issues

Unimportant Quantities of Source Material

In order to classify residual radioactive material or waste as an unimportant quantity of source material, one needs to expand the accepted meaning of the term “source material” to make the argument work. However, strictly legally speaking, characterization of certain waste material as “source material” fits within the regulatory definition.

DOE Analysis (Residual Radioactive Contamination)

Under the DOE approach for releasing property containing residual radioactive contamination, DOE establishes an Authorized Limit for the property using one of three methods, based on a dose-based as low as reasonably achievable (ALARA) assessment, or on the surface activity guidelines in DOE 5400.5 Chapter IV, or Table 1 in DOE’s November 1994 guidance. DOE then ascertains that conditions of the Authorized Limits have been achieved, by confirming or certifying that:

1. The specified radiological conditions have been met;
2. Any required use restrictions have been implemented; and
3. Documentation and notification requirements have been appropriately addressed.

When all three conditions have been met, the property can be released in accordance with the conditions of use.

Once contamination is removed from the property and the property is released, it is described as "property certified to comply with applicable DOE-approved Authorized Limits for the designated use or disposition of the property." Other property descriptors are: "Hazardous waste containing residual radioactive material certified to be at or less than Authorized Limits for disposition at a RCRA-permitted TSD facility;" or "Waste certified not to contain residual radioactive material in excess of DOE Authorized Limits for unrestricted use;" or "Personal property certified to meet DOE Authorized Limits for unrestricted release and reuse."

Under this approach DOE was able to dispose of contaminated soil from one contaminated site in a Subtitle C landfill. DOE took the soil containing residual amounts of radionuclides and reclassified it as "hazardous waste containing residual radioactive material certified to be at or less than Authorized Limits for disposition at a RCRA-permitted TSD facility." DOE then disposed of the soil in a Subtitle C landfill in New York which had a permit allowing it to accept low levels of radioactive materials.

Classifying the waste as a residual radioactive material under DOE Order 5400.5 may run into problems with compatibility with regulatory program.

Naturally Occurring Radioactive Material (NORM)

The largest amounts of NORM waste are associated with metal mining mineral processing, phosphorous production, uranium mining, and ash from coal combustion in utility and industrial boilers. No regulatory program exists for NORM waste at the federal level, although some states have requirements for management or disposal of NORM wastes.

For example, the State of Missouri has promulgated rules which provide that NORM waste is prohibited from disposal in a sanitary landfill in the State except with prior written approval from the Missouri Department of Natural Resources (DNR). (See 10 CSR 80-3.010(3)(E)).

Radionuclide waste material in soil could often meet the criteria for being a NORM waste, and could be classified as such.

Classifying the waste as a NORM waste may give rise to public perception problems, as NORM wastes are not regulated under any specific program. Also, disposal of NORM wastes may cost as much as disposal of other low-level radioactive waste. For example, DOE currently disposes of NORM wastes at Envirocare or U.S. Ecology, Inc. This practice would not result in any cost savings to most programs. In addition, if a federal agency is proceeding under a specific regulatory program, the radioactive waste should be classified as appropriate for that program.

CERCLA Hazardous Substance

In order to classify a soil contaminant as a CERCLA hazardous substance, a substance contained on the list of hazardous substances found at 40 CFR Part 302 must be present in the soil. No minimum amount needs to be present in order to classify the media-contaminant a CERCLA

hazardous substance and to consider the need for remediation. While substances released into the environment after 1980 may qualify as CERCLA hazardous substances, substances released into the environment before 1980 and not regulated under the RCRA Corrective Action program definitely qualify as CERCLA hazardous substances.

Classification of radionuclide waste in soil as a CERCLA hazardous substance would be consistent with a federal agency's authority under Executive Order 12580 to conduct environmental restoration. Two federal agencies have standards that can be followed during CERCLA cleanups, as described in the following paragraphs.

NRC Process for Decontamination and Decommissioning (Standards for CERCLA Hazardous Substances)

On July 21, 1997, NRC published a final rule setting forth its *Radiological Criteria for License Termination*. In this rule, NRC set a cleanup level of 25 mrem/yr as the primary standard with exemptions allowing dose limits of up to 100 mrem/yr, equal to about 2×10^{-3} increased lifetime risk. USEPA claims that the cleanup level of 25 mrem/yr is equal to about 5×10^{-4} increased lifetime cancer risk. USEPA claims that this level of radioactivity is not sufficiently protective to meet USEPA's standards, which are set at the equivalent of 3×10^{-4} increased lifetime cancer risk. However, soil containing an equivalent amount of radionuclide contamination may meet radionuclide limits established in a landfill permit. In that case, the soil could be disposed in a Subtitle C or Subtitle D landfill.

USEPA Standards for Decontamination and Decommissioning (Standards for CERCLA Hazardous Substances)

On August 22, 1997, USEPA issued OSWER Directive No. 9200.4-18, *Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination*. This guidance is helpful in that it indicates what level of residual contamination USEPA considers to be protective of human health. For radioactive contamination at CERCLA sites, USEPA sets site-specific remediation levels that represent an excess upper bound lifetime cancer risk to an individual of between 10^{-4} and 10^{-6} . In order to meet the requirement of being a protective cleanup, USEPA recommends a cleanup level not exceeding 15 mrem/yr, which USEPA claims equals an increased lifetime risk of about 3×10^{-4} . Cleanup should achieve a level of risk within the 10^{-4} to 10^{-6} carcinogenic risk range based on the reasonable maximum exposure for an individual. Correspondingly, soil contaminated with radioactive materials below the levels established in this guidance could be released to a Subtitle C or Subtitle D Landfill.

ANALYSIS - Classification Options for Low-Level Radioactive Waste Disposal

Many sites across the United States contain large volumes of low-level radioactive soil and other materials that must be addressed by remedial action. In some cases federal law provides clear direction as to how the waste should be classified, limiting disposal options to classification-specific facilities. For instance, active uranium and thorium mill sites regulated under UMTRCA must dispose of their byproduct waste in a facility authorized to accept 11(e)(2) waste.

In cases where the classification is clear, the options for off-site disposal are clear - ship the waste to a facility that is authorized to receive the waste as classified and which provides the lowest combination of transportation and disposal costs.

However, there are numerous sites to be addressed, particularly under CERCLA, where the specific classification of waste material is not mandated. In these cases, the site manager must perform a more complex analysis to determine the most cost effective means for final disposition of the waste.

Each site will likely contain a range of radioactive metal concentrations in the soil, varying from background to relatively high activity levels. It is not unusual for the volume to activity relationship to be distributed logarithmically with large volumes of soil having relatively low activity levels and small volumes of soil possessing high activity levels.

As previously noted, the disposition of the soil depends on the radioactivity levels in the following manner.

- Soil with radioactivity levels above background, but below the site cleanup criteria, may remain on the site. For NRC regulated sites, "unimportant quantities of source materials" should also remain on site.
- Soil with radioactivity levels above the cleanup criteria, but below the risk-based or specified Subtitle C or D landfill criteria, may be disposed of in those landfills in accordance with state laws.
- The options for disposal of low-level radioactive soil that exceeds Subtitle C or D activity levels are limited and expensive. In essence, disposal of this material, regardless of classification, is limited to 11(e)(2) cells, cells on federal reservations, or storage facilities developed as specific components of site remedies. The additional expense can be attributed to two primary factors; 1) the limited availability of facilities allows higher prices to be charged and 2) the available facilities tend to be located in remote areas requiring high transportation costs.

Far too many combinations of lead agencies/potentially responsible parties (PRPs), regulatory regimes, and radionuclide distributions in waste materials are possible to develop a step-by-step matrix for disposition of wastes at every radioactive site. Instead, a brief conceptual model must suffice.

When developing the remedial strategy for a low-level radioactive site, the site manager should distinguish whether clear legislative constraints apply to the disposition of the waste. In lieu of clear legislative direction, the waste should be divided into categories using the following guidelines.

1. Define the full range of available remaining classification authority. (Remember that these waste have already been recognized as not being clearly covered by a legislatively mandated classification category).
2. Thoroughly assess the availability of existing facilities and facilities expected to be available over the life of the project. Distinguish them by disposal price, transportation distance and delivery mode, acceptance criteria, and how long into the future they may reasonably be expected to be able to continue receiving waste. Also, note whether any regulatory actions pending or expected exist which may limit their future availability or change their waste acceptance criteria.
3. Using 1 and 2 above, combine this information to create site-specific categories of waste (classified by radioactivity levels and volumes that correspond to the different waste acceptance criteria by facilities).
4. Optimize the disposal of waste by using the combination of classification categories and disposal facilities that allows for the lowest total cost to transport and dispose of the waste.

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FOOTNOTES

^ASee list of "References" for sources consulted. Some brief quotes from these sources about classifying defense low-level radioactive waste are:

...No one knows how to define it...Ref. # 9, p183

the Currently defined by exclusion, low level waste is that which does not fall into high-level category...Ref. 912, p183

Radioactive waste ...is generated in diverse forms that have traditionally been distinguished by their source, not by their physical characteristic...Ref. # 6, p1

There is no standard accepted scheme for listing types of wastes. Ref. # 10, p59

^BThe Integrated Data Base (IDB) Report is prepared mainly to report spent fuel and radioactive waste inventories, projections and characteristics. It is an annual inventory report which contains summaries of data which can be useful for programmatic planning purposes within DOE. The intent of the IDB is to provide a common basis for both DOE management-level planning and for more detailed analyses of the waste management system conducted by DOE contractors and field offices. (IDB p.1-2). Data categories in the IDB were set up by DOE Headquarters as a consensus effort with field offices, before data were collected. The actual data categories as established reflect data needs for, for example, *The Current and Planned Low-Level Waste Disposal Capacity Report*.

^CThis description of NORM waste was taken from the IDB.

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