Disposal of Greater-than-Class C (GTCC) and Transuranic Waste

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Draft Regulatory Basis – For Public Comment

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Abbreviations and Acronyms

ADAMS	the NRC's Agencywide Documents Access and Management System
AEA	Atomic Energy Act of 1954, as amended
ANPR	Advance Notice of Proposed Rulemaking
BDOSE	Biosphere Dose Model
CER	Cumulative Effects of Regulation
CFR	*Code of Federal Regulations*
DOE	U.S. Department of Energy
EIS	Environmental Impact Statement
EPAct	Energy Policy Act of 2005
FR	*Federal Register*
FY	Fiscal Year
GTCC	Greater-than-Class C
IAEA	International Atomic Energy Agency
ILW	Intermediate Level Waste
LLRW	Low-Level Radioactive Waste
MIPS	Medical Isotope Production System
MPPB	Main Plant Process Building (West Valley Demonstration Project)
MURR	Missouri University Research Reactor
NEI	Nuclear Energy Institute
nCi/g	nanoCuries/gram
NDA	NRC-licensed disposal area associated with the West Valley Demonstration Project
NMSS	Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission
NRC	U.S. Nuclear Regulatory Commission
NSIR	Office of Nuclear Security and Incident Response, U.S. Nuclear Regulatory Commission
PRM	Petition for Rulemaking
RG	Regulatory Guide
SDA	State-licensed disposal area at the West Valley Site
SECY	Office of the Secretary of the Commission, U.S. Nuclear Regulatory Commission
SNAP	Systems for Nuclear Auxiliary Power
SNM	Special Nuclear Material
SRM	Staff Requirements Memorandum
TRU	Transuranic – chemical elements with atomic numbers greater than 92, which is the atomic number of uranium, are referred to as transuranics
TCEQ	Texas Commission on Environmental Quality
WVDP	West Valley Demonstration Project
WCS	Waste Control Specialists LLC
WVTF	West Valley Tank Farm (West Valley Demonstration Project)

Definition of Terms (as used in this document)

Applicant
Any person, including a current licensee, who submits an application for license to the NRC or an Agreement State for operation of a near-surface disposal facility with the intent to dispose of greater-than-class C waste.

Disposal unit
A discrete portion of the disposal site where waste is emplaced for disposal. A disposal facility is typically comprised of multiple disposal units (e.g., vaults, trenches). "Disposal unit" and "disposal cell" are terms that can be used interchangeably.

GTCC-like waste
The term "GTCC-like waste" is a term used by DOE to describe radioactive waste that is owned or generated by the DOE (including LLRW and non-defense transuranic [TRU] waste) and has characteristics similar to those of GTCC LLRW.

Inadvertent Intruder
A person who might occupy the disposal site after closure and engage in normal activities such as agriculture and dwelling construction, or other pursuits in which the person might be unknowingly exposed to radiation from the waste.

Intruder Barrier
A sufficient depth of cover over the waste that inhibits contact with the waste and helps to ensure that radiation exposures to an inadvertent intruder will meet the performance objectives in 10 CFR Part 61 or engineered structures that provide equivalent protection to the inadvertent intruder.

Land disposal facility
The land, building and structures, and equipment that are intended to be used for the disposal of radioactive wastes. A "geologic repository," as defined in 10 CFR Part 60 or 63, is not considered a land disposal facility.

Near-Surface Disposal facility
A land disposal facility in which radioactive waste is disposed of in or within the upper 30 meters of the Earth's surface.

Units Conversion Table

Multiply	By	To Obtain
English/Metric Equivalents		
feet (ft)	0.3048	meters (m)
cubic feet (ft^3)	0.02832	cubic meters (m^3)
pounds (lb)	0.4536	kilograms (kg)
roentgen equivalent man (rem)	0.01	sievert (Sv)
millirem (mrem)	0.01	millisievert (mSv)
curie (Ci)	3.7×10^{10}	becquerel (Bq)
Metric/English Equivalents		
meters (m)	3.281	feet (ft)
cubic meters (m^3)	35.31	cubic feet (ft^3)
kilograms (kg)	2.205	pounds (lb)
sievert (Sv)	100	roentgen equivalent man (rem)
millisievert (mSv)	100	millirem (mrem)
becquerel (Bq)	2.7×10^{-11}	curie (Ci)

Draft Regulatory Basis for the Disposal of Greater-than-Class C (GTCC) and Transuranic Waste

Executive Summary

Introduction and Background

Under its regulations in Part 61 of Title 10 of the *Code of Federal Regulations* (10 CFR), the U.S. Nuclear Regulatory Commission (NRC) classifies low-level radioactive waste (LLRW) into three classes, namely Class A, Class B, and Class C, based on the radiological hazard as determined by the concentration of radionuclides prescribed for each class. Class C is the most hazardous of the three categories, and LLRW streams that contain radionuclide concentrations exceeding the limits for Class C waste are referred to as "greater-than-Class C" (GTCC) waste. GTCC waste may be generated by a variety of facilities both within and outside of the nuclear fuel cycle. Under the NRC's current regulations, GTCC waste must be disposed of in a geologic repository unless "proposals for disposal of such waste in a disposal site . . . are approved by the Commission." However, to date, the Commission has not received nor approved any such request.

By letter dated January 30, 2015, the Texas Commission on Environmental Quality (TCEQ) provided questions to the NRC staff regarding Texas' authority to license the disposal of GTCC waste. Subsequent to this inquiry, the Commission directed the NRC staff to prepare a regulatory basis for the disposal of GTCC waste through means other than deep geologic disposal, including near-surface disposal; and the regulatory basis should analyze whether disposal of GTCC waste presents a hazard such that the NRC should retain authority over its disposal. The Commission further directed the staff to develop a proposed rule for licensing the disposal of GTCC waste if the staff concludes that some or all GTCC waste is potentially suitable for near-surface disposal.

Consistent with this direction and the NRC's rulemaking process, the staff has prepared this draft regulatory basis which:

- Explains how a change in the regulations could resolve the issue;
- Identifies different approaches that could address the regulatory issue and evaluates the cost and benefits of rulemaking and the alternatives;
- Provides the scientific, policy, legal, and/or technical information used to support the evaluation;
- Explains limitations on the scope and quality of the regulatory basis, such as known uncertainties in the data or methods of analysis; and
- Discusses stakeholder interactions in developing the technical portion of the regulatory basis and stakeholder views, to the extent known;

Consistent with NRC policy and procedures, this draft regulatory basis does not include proposed regulatory text or a section-by-section analysis of current versus proposed regulations.

Analysis of GTCC Waste Hazards

Based on its analysis of the content and associated hazard for GTCC waste streams, the NRC staff found that a majority of GTCC waste are both potentially suitable for near-surface disposal and could be regulated by an Agreement State. Two particular GTCC waste streams (i.e., *sealed sources associated with neutron irradiators* and *remote-handled other waste from decontamination activities* at the West Valley Demonstration Project) are not suitable for near-surface disposal due to challenges in ensuring adequate long-term protection of the inadvertent intruder and the potential for significant exposures due to operational accidents.

Potential Revisions to the NRC's Regulations

Under the NRC's current regulations, GTCC waste must be disposed of in a geologic repository, although the Commission may approve, on a case-by-case basis, disposal in a near-surface disposal facility. To allow for the near-surface disposal of GTCC waste as a matter of course and to provide specific regulatory requirements for such disposal, the NRC must revise its regulations. A potential rulemaking authorizing the near-surface disposal of GTCC waste could include radiological protection requirements to protect individuals during the facility's operational period and after the closure of the disposal facility, to protect the inadvertent intruder and offsite individuals. A potential rulemaking could also address regulatory concerns, such as Agreement State licensing, the control of special nuclear material (SNM) during operations and the definition of transuranic (TRU) waste.

Other Considerations

The staff considered other factors in developing this draft regulatory basis, including alternatives for implementation. Specifically, the staff considered three alternatives:

1. No regulatory change. This alternative would allow the Commission to continue to consider disposal of GTCC waste on a case-by-case basis in a LLRW land disposal facility. Under this alternative, the NRC would take no action related to the disposal of GTCC waste in a land disposal facility until the NRC received interest from a potential applicant. Under the current regulatory structure, the applicant would apply directly to the NRC for a 10 CFR Part 61 license and the NRC would review the application for acceptability. If the application is approved, the Commission can authorize GTCC waste disposal at a land disposal facility that can be licensed by either the NRC or an Agreement State. After issuing the license, the relevant regulatory authority (either NRC or the Agreement State) would be responsible for regulatory oversight, including conducting inspection and any necessary enforcement activities.

2. Develop new guidance. Under this alternative, the NRC would develop new guidance to describe the information and analyses needed to support an application for the disposal of GTCC waste in a near-surface land disposal facility. All other conditions would be the same as for Alternative 1, except a potential applicant may benefit from the availability of guidance in determining the viability of submitting a license application.

3. Conduct rulemaking. Under this alternative, the NRC would promulgate regulations and develop guidance specifically for the near-surface disposal of GTCC waste at a LLRW disposal facility. This alternative would establish the regulatory framework to address

the unique disposal and regulatory oversight requirements for GTCC waste. The regulatory requirements would also provide the flexibility for Agreement States to regulate the disposal of GTCC waste to the extent allowable under section 274 of the Atomic Energy Act.

For this analysis, the staff assumes that only one of the four currently licensed LLRW disposal facilities would seek to accept and dispose of GTCC waste. In evaluating these alternatives, the staff also considered potential impacts on the following entities: (1) licensees; (2) the NRC; (3) State, local, or Tribal governments; and (4) other Federal agencies.

Summary and Conclusion

The NRC staff has analyzed various GTCC waste streams to determine whether, for each waste stream, disposal in a near-surface disposal facility is potentially suitable and, if so, whether a facility that can accept that waste stream must be regulated by the NRC or if it can be regulated by an Agreement State. Based upon its evaluation of the hazards and other considerations, the NRC staff determined that:

1. Most of the GTCC waste streams analyzed are potentially suitable for near-surface disposal (i.e., approximately 80 percent of the overall volume), subject to additional controls and analysis, such as changes to ensure protection to the inadvertent intruder and the offsite individual(s).

2. Most GTCC waste could be safely regulated by an Agreement State (i.e., approximately 95 percent of the volume of GTCC waste determined to be potentially suitable for near-surface disposal), although certain regulatory changes to the 10 CFR Part 150 regulations are recommended if the regulatory goal is to accommodate Agreement State regulatory oversight.

Draft Regulatory Basis for the Disposal of Greater-than-Class C (GTCC) and Transuranic Waste

1. Introduction

The U.S. Nuclear Regulatory Commission (NRC) classifies low-level radioactive waste (LLRW) based upon its radiological hazard. Specifically, under its regulations in Part 61 of Title 10 of the *Code of Federal Regulations* (10 CFR), the NRC categorizes LLRW into three classes, namely Class A, Class B, and Class C, based on the radiological hazard as determined by the concentration and type of radionuclides prescribed for each class. Under the NRC classification system, Class A waste is the least hazardous and Class C waste is the most hazardous. There are currently four operating LLRW disposal facilities in the United States: (1) Barnwell, South Carolina; (2) Clive, Utah; (3) Richland, Washington; and (4) Andrews County, Texas. All four are regulated by their respective Agreement State[1] and all accept Class A, Class B, and Class C wastes except the Utah facility, which only accepts Class A waste.

LLRW streams that contain radionuclide concentrations exceeding the limits for Class C waste are referred to as "greater-than-Class C" (GTCC) waste. Some GTCC waste streams also contain radionuclides that are categorized as "special nuclear material" (i.e., enriched uranium or plutonium).

The NRC's 10 CFR Part 61 regulations authorize the disposal of Class A, Class B, and Class C waste streams in land disposal facilities.[2] Under the NRC's current regulations at 10 CFR 61.55, GTCC waste must be disposed of in a geologic repository unless a proposal for disposal of such waste in a land disposal facility licensed under 10 CFR Part 61 is approved by the Commission. Currently, there is no land disposal facility licensed to accept GTCC waste.

By letter dated January 30, 2015, the Texas Commission on Environmental Quality (TCEQ) raised questions to the NRC regarding whether the State of Texas has authority to license the disposal of GTCC waste, GTCC-like waste,[3] and transuranic waste (TRU) streams at the Waste Control Specialist, LLC (WCS) LLRW disposal facility in Andrews County, Texas (Agencywide Documents Access and Management System (ADAMS) Accession No. ML15034A174). Specifically, the TCEQ raised the following questions:

- Does Texas' role as an Agreement State authorize promulgation of State rules that could license GTCC waste streams for disposal?
- Considering the fact that the U.S. Department of Energy (DOE) currently holds, or is required to take possession of, all GTCC and GTCC-like material, and considering that some of that material exhibits TRU characteristics and may currently be commingled to include GTCC, GTCC-like, and material exhibiting TRU characteristics, could the State

[1] Section 274b of the Atomic Energy Act authorizes the Commission to enter into an agreement with the Governor of a State whereby the Commission relinquishes its regulatory authority, and the State assumes that authority, for the regulation of certain radioactive materials. A State that has entered into such an agreement with the NRC is defined as an "Agreement State."

[2] *See* Section 2.3, "NRC's LLRW Disposal Regulations."

[3] Please see Section 2.1 for discussion on GTCC-like waste.

of Texas authorize the disposal of these materials? If not, is there some pathway to allow for disposal?

The Commission directed the NRC staff, in the staff requirements memorandum (SRM) to SECY-15-0094, "Historical and Current Issues Related to Disposal of Greater-than-Class C Low-Level Radioactive Waste" (ADAMS Accession No. ML15356A623) to:

- Assess the hazards associated with the near-surface disposal of GTCC waste and determine whether some or all GTCC waste is potentially suitable for near-surface disposal. If the staff concludes that some or all GTCC waste is potentially suitable for near-surface disposal, the staff is directed to develop a proposed rule to include disposal criteria for licensing the disposal of such waste.
- Determine if the NRC should retain regulatory authority over GTCC waste disposal in accordance to the radiological hazards inherent in GTCC waste or whether that authority can be relinquished to an Agreement State.
- Conduct a public workshop during the development of the regulatory basis to receive input from the State of Texas and other interested stakeholders.
- Address TRU waste in 10 CFR 61.2, "Definitions."

2. History and Existing Regulatory Framework

This section briefly discusses the history and existing regulatory framework relative to the land disposal of LLRW. Specifically, this section discusses the statutes, regulations, and Commission policies that are relevant to development of this draft regulatory basis on GTCC waste disposal.

2.1 Background on GTCC Waste

GTCC waste is generated by nuclear power reactors and other supporting nuclear fuel cycle facilities as well as by facilities and licensees outside of the nuclear fuel cycle and includes: (1) plutonium-contaminated nuclear fuel cycle wastes; (2) activated metals; (3) sealed sources; and (4) radioisotope product manufacturing wastes (i.e., wastes "occasionally generated as part of the manufacture of sealed sources, radiopharmaceutical products and other materials used for industrial, education, and medical applications").[4] One of the facilities outside of the nuclear fuel cycle that possesses GTCC waste is the West Valley Demonstration Project (WVDP) in western New York, which operated in the early 1970s. GTCC waste at the WVDP was incidentally generated as part of the reprocessing of high level waste (HLW) and is buried in the NRC-licensed disposal area (NDA) of the WVDP. If DOE decides to exhume the buried waste at the NDA, DOE estimated that 2,110 cubic meters (m^3) (74,500 cubic feet (ft^3)) of GTCC waste could be generated. Additionally, if a decision is made to exhume the buried waste at the state-licensed disposal area at the West Valley site (SDA),[5] DOE estimated that 2,125 cubic meters (m^3) (75,000 cubic feet (ft^3)) of GTCC waste could be generated.

[4] *See* "NRC Advance Notice of Proposed Rulemaking, 10 CFR Part 60, 'Definition of 'High-Level Radioactive Waste,'" 52 FR 5992, 6000-6001 (February 27, 1987).

[5] The State-licensed disposal area is located at the West Valley site but is not part of the West Valley Demonstration Project.

"GTCC-like waste" refers to DOE owned or generated LLRW and DOE non-defense-generated TRU waste that have characteristics similar to those of GTCC waste.[6] A distinction is made between GTCC waste generated by NRC licensees and Agreement State licensees, which is referred to as "commercial" GTCC waste, and DOE GTCC-like waste. However, DOE's definition of GTCC-like waste also includes recovered sealed sources that the agency has taken title to from NRC and Agreement State licensees. Currently, there are no land disposal facilities licensed to accept either GTCC or GTCC-like waste.

2.2 Statutes Relevant to LLRW Land Disposal

The first major legislative effort to resolve LLRW disposal concerns, the Low-Level Radioactive Waste Policy Act (the 1980 Act),[7] assigned responsibility for the disposal of commercial LLRW to the States. The 1980 Act also authorized the States to form compacts to provide for the establishment and operation of regional disposal facilities. Additionally, the 1980 Act defined LLRW as radioactive waste that is not classified as HLW, TRU waste, spent nuclear fuel, or byproduct material as defined in Section 11e.(2) of the AEA (tailings or wastes produced by the extraction of uranium or thorium).

The 1980 Act was superseded in its entirety by the Low-Level Radioactive Waste Policy Amendments Act of 1985 (LLRWPAA)[8] as the 1980 Act was perceived as not adequately delineating the LLRW disposal responsibilities between the States and the Federal government.[9] The LLRWPAA is the overall statutory authority governing LLRW disposal and provides a definition of LLRW. To understand the definition of LLRW, and the scope of radioactive waste in general, reference should also be made to the Nuclear Waste Policy Act of 1982, as amended (NWPA).[10] The application of the LLRWPAA and the NWPA results in a division of most radioactive waste into two broad categories, HLW and LLRW. Under the NWPA, HLW is defined as the "highly radioactive material resulting from the reprocessing of spent nuclear fuel" and "other highly radioactive material that the [NRC], consistent with existing law, determines by rule requires permanent isolation."[11] An example of HLW, as classified by the NRC in its implementing regulations is "irradiated reactor fuel."[12] The NWPA requires that HLW be permanently disposed in a deep geologic repository.[13]

While there is a definition for HLW, LLRW, on the other hand, is defined to a large extent by what it is not. The LLRWPAA defines LLRW as radioactive waste that is not HLW, spent fuel, or

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[6] *See* Section 2.4.3, "Disposal of DOE GTCC-like Waste."
[7] Low-Level Radioactive Waste Policy Act of 1980, Pub. L. 96-573, 94 Stat. 3347 (1980).
[8] 42 U.S.C. §§ 2021b *et seq*.
[9] *See* June 4, 1985 letter from NRC Chairman Nunzio J. Palladino to the Honorable Strom Thurmond, Chairman of the Committee on the Judiciary, ADAMS Accession No. ML051720671.
[10] 42 U.S.C. §§ 10101 *et seq*.
[11] 42 U.S.C. § 10101(12).
[12] 10 CFR §§ 60.2 and 63.2.
[13] 42 U.S.C. § 10101(18) (definition of the term "repository"). The purposes of the NWPA are set forth in 42 U.S.C. § 10131(b). 42 U.S.C. § 10131(b)(1) ("to establish a schedule for the siting, construction, and operation of repositories that will provide a reasonable assurance that the public and the environment will be adequately protected from the hazards posed by high-level radioactive waste and such spent nuclear fuel as may be disposed of in a repository"); and 42 U.S.C. § 10131(b)(2) ("establish the Federal responsibility, and a definite Federal policy, for the disposal of such waste and spent fuel").

certain categories of byproduct material.[14] Like the NWPA, the LLRWPAA includes a provision allowing the Commission to classify other radioactive waste streams as LLRW.[15] The LLRWPAA further revised the 1980 Act's definition of LLRW to no longer exclude transuranic waste from the statutory definition of LLRW (see Section 2.3.2 of this regulatory basis).

The LLRWPAA requires that the disposal of LLRW result in the "permanent isolation" of the LLRW.[16] The principal objective of LLRW disposal is protection of public health and safety for long periods of time when the waste may remain hazardous as the half-lives of some of the radionuclides that comprise LLRW are on the order of thousands of years and longer.

Section 3 of the LLRWPAA divides the regulatory authority for LLRW disposal between the Federal government and the States. A State is responsible for "providing, either by itself or in cooperation with other States, for the disposal" of LLRW generated within the State that consists of or contains Class A, Class B, or Class C waste, as defined by the version of 10 CFR 61.55 in effect on January 26, 1983, except for those Class A, Class B, or Class C waste streams that are owned or generated by the DOE, owned or generated by the United States Navy (as a result of the decommissioning of Navy vessels), and any such Federally owned or generated waste resulting from atomic weapon research, development, testing, or production.[17]

Section 3(b)(1) of the LLRWPAA directs that the Federal government is responsible for regulating the disposal of GTCC waste streams, as defined in 10 CFR 61.55 in effect on January 26, 1983, and other Federally owned or generated LLRW streams, which are identified above.[18] Further, Section 3(b)(2) of the LLRWPAA requires that all GTCC waste "that results from activities licensed by the Nuclear Regulatory Commission under the Atomic Energy Act of 1954, as amended, shall be disposed of in a facility licensed by the Nuclear Regulatory Commission that the Commission determines is adequate to protect the public health and safety."[19]

2.3 NRC's LLRW Disposal Regulations

On December 27, 1982, the NRC promulgated its first comprehensive set of regulations for LLRW disposal in 10 CFR Part 61, "Licensing Requirements for Land Disposal of Radioactive Waste," (47 FR 57446, 57463; Dec. 27, 1982). The NRC based its definition of "waste" upon the1980 Act's definition of LLRW. Specifically, under 10 CFR 61.2, "Definitions," the term "waste" is defined as:

> those low-level radioactive wastes containing source, special nuclear, or byproduct material that are acceptable for disposal in a land disposal facility. For the purposes of this definition, low-level radioactive waste means radioactive waste not classified as high-

[14] 42 U.S.C. § 2021b(9) (definition of "low-level radioactive waste").
[15] 42 U.S.C. § 2021b(9)(A)(ii).
[16] 42 U.S.C. § 2021b(7) (definition of "Disposal").
[17] 42 U.S.C. § 2021c(a)(1).
[18] 42 U.S.C. § 2021c(b)(1).
[19] 42 U.S.C. § 2021c(b)(2).

level radioactive waste, transuranic waste, spent nuclear fuel, or [certain classes of byproduct material].[20]

The 10 CFR Part 61 regulations also set forth definitions of the terms "land disposal facility" and "near-surface disposal facility" and distinguished these facilities for disposal of Class A, Class B, and Class C wastes from the geologic repository mandated by the NWPA. The term "land disposal facility" is defined as "the land, building, and structures, and equipment which are intended to be used for the disposal of radioactive wastes";[21] the definition expressly excludes a geologic repository.[22] The term "near-surface disposal facility," in turn, is defined as a type of land disposal facility, namely, one "in which radioactive waste is disposed of in or within the upper 30 meters of the earth's surface."[23]

Under 10 CFR Part 61, the operational phase of a near-surface disposal facility involves the licensee's receipt of LLRW, storage of LLRW (typically, above-ground or in an uncovered trench or other disposal unit prior to the trench or unit being permanently sealed), and disposal of LLRW.[24] Near-surface disposal methods can include: burial in the form of trenches; engineered land disposal techniques (such as below-ground vaults); earth-mounded disposal units;[25] and boreholes. After the licensed facility no longer accepts LLRW for disposal, the site would need to be closed and stabilized.[26]

The 10 CFR Part 61 regulations also include a series of performance objectives that must be met by licensees. Specifically, Subpart C of 10 CFR Part 61 sets forth one general and four specific performance objectives for LLRW land disposal facilities. The general performance objective, set forth in 10 CFR 61.40, "General requirement," states that "[l]and disposal facilities must be sited, designed, operated, closed, and controlled after closure so that reasonable assurance exists that exposures to humans are within the limits established in the performance objectives in §§ 61.41 through 61.44."[27] The first specific performance objective, 10 CFR 61.41, "Protection of the general population from releases of radioactivity," includes the requirement that any radioactive effluents released into the environment from the land disposal facility "must not result in an annual dose exceeding an equivalent of 25 millirems to the whole body, 75 millirems to the thyroid, and 25 millirems to any other organ of any member of the public."[28]

The second specific performance objective, 10 CFR 61.42, "Protection of individuals from inadvertent intrusion," requires that the "design, operation, and closure of the land disposal facility must ensure protection of any individual inadvertently intruding into the disposal site and occupying the site or contacting the waste at any time after active institutional controls over the

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[20] 10 CFR § 61.2 (definition of "Waste").
[21] 10 CFR § 61.2 (definition of "Land disposal facility").
[22] *Id*.
[23] 10 CFR § 61.2 (definition of "Near-surface disposal facility").
[24] 10 CFR § 61.7(c)(2).
[25] The terminology of "disposal unit" is interchangeable with "disposal cell."
[26] 10 CFR § 61.7(c)(3); 10 CFR § 61.7(b)(2) ("A cornerstone of the system is stability—stability of the waste and the disposal site so that once emplaced and covered, the access of water to the waste can be minimized. Migration of radionuclides is thus minimized, long-term active maintenance can be avoided, and potential exposures to intruders reduced").
[27] 10 CFR § 61.40.
[28] 10 CFR § 61.41.

disposal site are removed."[29] In this regard, the NRC's regulations require an institutional control of access to the site for a period of up to 100 years following closure of the land disposal facility.[30] The NRC defines an "inadvertent intruder" as "a person who might occupy the disposal site after closure and engage in normal activities, such as agriculture, dwelling construction, or other pursuits in which the person might be unknowingly exposed to radiation from the [LLRW] waste."[31] The third specific performance objective, 10 CFR 61.43, "Protection of individuals during operations," requires that licensee's operations at the land disposal facility meet the NRC's general radiation protection standards set out in 10 CFR Part 20.[32]

The fourth specific performance objective, 10 CFR 61.44, "Stability of the disposal site after closure," requires that the disposal facility "must be sited, designed, used, operated, and closed to achieve long-term stability of the disposal site and to eliminate to the extent practicable the need for ongoing active maintenance of the disposal site following closure so that only surveillance, monitoring, or minor custodial care are required."

Section 61.55 establishes the LLRW classes (i.e., Class A, Class B, and Class C), with each class based on the concentrations of certain radionuclides. As prescribed by its 10 CFR Part 61 regulations, the NRC has determined that Class A, Class B and Class C waste streams are acceptable for "near-surface" disposal. Additional requirements in 10 CFR 61.52(a)(2) are placed on Class C waste, prohibiting disposal at shallow depths (i.e., a minimum of 5 meters below the top surface of the cover) unless an intruder barrier is utilized that prevents intrusion for 500 years.

2.3.1 Current NRC Regulatory Position on GTCC Waste Disposal

Radioactive waste that exceeds the concentration limits for Class C waste in the classification tables in 10 CFR Part 61 is referred to as "GTCC waste."[33] The Commission considered the concept of GTCC waste in a 1987 advance notice of proposed rulemaking (ANPR) that concerned the definition of HLW (52 FR 5992; February 27, 1987). Although the ANPR did not use the term "GTCC waste," it described such waste as "exceeding Class C concentrations" and other similarly phrased terms. The ANPR noted that such waste was both a form of LLRW (as HLW was defined by source, such as spent fuel) and that it "may have concentrations approaching those of HLW" and as such, the Commission was considering whether these wastes should be classified as HLW.[34] The ANPR also raised the issue of whether these wastes could be disposed of in a 10 CFR Part 61 land disposal facility.[35] The ANPR sought public comment and in the following year, the Commission issued a proposed rule (53 FR 17709; May 18, 1988).

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[29] 10 CFR § 61.42.
[30] 10 CFR § 61.7(b)(4).
[31] 10 CFR § 61.2 (definition of "Inadvertent intruder").
[32] 10 CFR § 61.43. This regulation provides that the release of radioactive effluents from the land disposal facility is governed by the requirements of 10 CFR § 61.41 rather than those of 10 CFR Part 20.
[33] Although the term "GTCC waste" is not defined in 10 CFR Part 61, "GTCC waste" is defined in the definition section of NRC's spent fuel storage regulations, 10 CFR § 72.3, as "low-level radioactive waste that exceeds the concentration limits of radionuclides established for Class C waste in § 61.55 of this chapter."
[34] 52 FR at 5994.
[35] *Id*., at 5995.

In its 1988 proposed rule, the Commission used the term "GTCC waste" and stated that it "proposes to require disposal of all GTCC wastes in a deep geologic repository unless disposal elsewhere has been explicitly approved by the Commission."[36] The Commission characterized this proposal as a "technically conservative approach" because of the absence of an existing "intermediate disposal facility"[37] that could accept commercially generated GTCC waste and that there was no assurance that such an intermediate disposal facility would ever be constructed, "in which case a repository would be the only type of facility generally capable of providing safe disposal for GTCC wastes."[38] The Commission further stated that its proposal would "obviate any need to reclassify certain GTCC wastes as HLW."[39]

In 1989, the NRC issued a final rule that adopted the substance of the regulatory approach identified in the 1988 proposed rule, namely, that GTCC waste be disposed of in a geologic repository unless the Commission has approved of an alternative disposal path to be licensed in accordance with 10 CFR Part 61 (54 FR 22578; May 25, 1989). The statements of consideration for the 1989 final rule set forth the Commission's position that the disposal of GTCC waste in an intermediate disposal facility could be carried out under the Commission's regulations in 10 CFR Part 61 rather than under its 10 CFR Part 60 regulations, "Disposal of High-Level Radioactive Wastes in Geologic Repositories." In this regard, the Commission stated that because the term "land disposal facility" is "defined broadly (so as to include any facility other than a geologic repository), the reference to licensing under Part 61 is proper and in conformance with the existing regulatory structure."[40] To date, the 1989 rulemaking is the last substantive amendment to 10 CFR 61.55.[41] Thus, the current version of 10 CFR 61.55(a)(2)(iv) prescribes that disposal in a deep geologic repository is the default disposal path for GTCC waste, although allowing for a Commission-approved alternative disposal in a 10 CFR Part 61 land disposal facility.[42]

2.3.2 Transuranic Waste

The AEA defines TRU waste as "material contaminated with elements that have an atomic number greater than 92, including neptunium, plutonium, americium, and curium, and that are in concentrations greater than 10 nanocuries per gram [nCi/g], or in such other concentrations as the [NRC] may prescribe to protect the public health and safety."[43] In 1979, EPA, through simple calculations on resuspended plutonium in soil, concluded that a limit of 100 nCi/g would keep doses below 500 mrem/yr so that the bounding limit could be increased by an order of magnitude (SNL, 1999), and thus, EPA and DOE changed the activity concentration for the definition of TRU waste to 100 nCi/g (PECOS, 2010). Subsequently, in 40 CFR 191.02, EPA's definition of TRU waste encompassed concentrations greater than 100 nCi/g of alpha-emitting transuranic isotopes with half-lives greater than 20 years.

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[36] 53 FR at 17710.
[37] The ANPR describes "interim disposal" as being between "shallow land burial" and geologic repository disposal. 52 FR at 5996.
[38] 53 FR at 17710.
[39] *Id*.
[40] 54 FR 22578, 22581.
[41] In a November 2, 2001 rulemaking, the "land disposal facility" definition of 10 CFR § 61.2 and 10 CFR § 61.55(a)(2)(iv) were amended to add references to a 10 CFR Part 63 geologic repository. 66 FR 55731, 55792.
[42] *See* Section 2.4.5, "Applications Received Under Current Regulations."
[43] 42 U.S.C. § 2014(ee).

A number of GTCC waste streams contain TRU radionuclides that are long-lived (e.g., Pu-238 with an 88-year half-life, Am-241 with a half-life of 430 years, and Pu-239 with a half-life of 24,000 years) and as such, can contribute to significant radiation exposures over a long period of time. Several GTCC waste streams identified by the NRC staff exceed the TRU limits for Class C waste as set forth in 10 CFR 61.55, Table 1 (concentration not to exceed 100 nCi/g). Under the current 10 CFR Part 61 regulations, waste streams consisting of alpha-emitting TRU radionuclides with half-lives greater than 5 years and a concentration greater than 100 nCi/g are not considered to be generally acceptable for near-surface disposal.[44]

The current 10 CFR 61.2 definition of "waste" excludes TRU waste (see Section 4.2.1 for further details on the definition of TRU waste). With the enactment of the LLRWPAA in 1985, the 1980 Act was superseded in its entirety. The LLRWPAA's definition of LLRW does not expressly exclude TRU waste, thus allowing a rulemaking to revise the 10 CFR 61.2 "waste" definition to include TRU waste.

2.4 Agreement State and DOE Roles

This section discusses Agreement State licensing of GTCC waste disposal, the DOE role, and potential limitations on Agreement State authority over specific quantities and types of radioactive materials specified in NRC's regulations with respect to criticality and physical security.

2.4.1 Agreement State Regulation of GTCC Waste

In SRM-SECY-15-0094, the Commission directed the staff to determine whether the NRC should retain regulatory authority over GTCC waste disposal in accordance to the radiological hazards inherent in GTCC waste or whether that authority can be relinquished to an Agreement State. Section 274 of the AEA provides a role for the States in the regulation of certain radioactive materials.[45] Section 274b. authorizes the Commission to enter into an agreement with the Governor of a State whereby the Commission relinquishes its regulatory authority, and the State assumes, for the protection of the public health and safety from radiation hazards, that authority (thus becoming an "Agreement State"), for one or more of the following categories of materials within the State: (1) byproduct materials; (2) source materials; and (3) special nuclear material (SNM)[46] in quantities not sufficient to form a critical mass.[47] If the Commission ultimately approves a rulemaking allowing for the near-surface disposal of all or some GTCC waste streams, then an Agreement State seeking to license and regulate facilities that can accept such GTCC waste streams will need to promulgate State regulations that the NRC determines are both adequate (in terms of meeting the regulatory objective) and compatible with the revised NRC 10 CFR Part 61 regulations.[48]

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[44] 10 CFR § 61.55(a)(3)(iii)) ("If the concentration exceeds the value in Table 1, the waste is not generally acceptable for near-surface disposal").
[45] 42 U.S.C. § 2021.
[46] Section 11aa. of the AEA generally defines SNM as "plutonium, uranium enriched in the isotope 233 or in the isotope 235." 42 U.S.C. § 2014(aa).
[47] 42 U.S.C. § 2021(b)(1)-(3).
[48] For a more complete explanation of the NRC's Agreement State program, including a description of the "adequacy" and "compatibility" standards and other requirements that an Agreement State may need to meet, please see the NRC's Agreement State Program Policy Statement, 82 FR 48535 (October 18, 2017).

Section 274c. prescribes the types of regulatory authority that must be retained by the NRC. Specifically, the NRC must retain its regulatory authority for: the construction and operation of nuclear reactors, nuclear fuel cycle facilities and uranium enrichment facilities; the export from or import into the United States of source, byproduct, or SNM; or the disposal into the ocean or sea of any source, byproduct, or special nuclear material.[49] Section 274c.(4) also provides that the Commission may not relinquish its regulatory authority with respect to "the disposal of such other byproduct, source, or special nuclear material as the Commission determines by regulation or order should, because of the hazards or potential hazards thereof, not be so disposed of without a license from the Commission."[50] In SRM-SECY-15-0094, the Commission directed the NRC staff to analyze whether, in accordance with section 274c.(4) of the Atomic Energy Act, disposal of GTCC waste presents a hazard such that the NRC should retain authority over its disposal. Additionally, the NRC cannot relinquish to an Agreement State its regulatory authority that concerns the "common defense and security" aspect of the NRC's mission, namely, ensuring the physical security of licensed radioactive material, the primary purpose of which is to prevent sabotage or diversion of that material.[51]

2.4.2 Role of DOE

Section 3(b)(1)(D) of the LLRWPAA designates the disposal of GTCC waste as a Federal responsibility.[52] Section 3(b)(3) of the LLRWPAA requires DOE to submit to the Congress a comprehensive report with recommendations ensuring the safe disposal of all GTCC waste no later than one year after its enactment.[53] In February 1987, the DOE completed this action by issuing a report to Congress entitled, "Recommendations for Management Greater-Than-Class C Low-Level Radioactive Waste, DOE/NE-0077." In the 1987 report, DOE acknowledged its responsibility for the disposal of commercially generated GTCC waste, as described in Section 3(b)(1)(D) of the LLRWPAA.[54]

In addition, Section 631 of the Energy Policy Act of 2005 prescribed further requirements for the DOE regarding the development of a GTCC waste disposal program, including the designation of an entity within the DOE that would be responsible for completing activities to provide a facility for safely disposing of all GTCC waste; to prepare a report containing a cost estimate and schedule for the preparation of an environmental impact statement and record of decision for a permanent disposal facility for GTCC waste; to submit to Congress a report describing all alternatives under consideration for the safe disposal of all GTCC waste; and to await action by Congress before making a final decision on the GTCC waste disposal alternative or alternatives

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[49] 42 U.S.C. § 2021(c)(1)-(3).
[50] *Id.*, at § 2021(c)(4).
[51] *Id.*, at § 2021(b) (expressly limiting relinquished regulatory authority to "the protection of the public health and safety from radiation hazards"); *Id.*, § 2021(m) ("no agreement entered into under [AEA] subsection [274]b., … shall affect the authority of the Commission under [AEA] subsection 161b. or i. to issue rules, regulations, or orders to protect the common defense and security"). *See* Section 4.3.1 "Control of SNM during Operations," (discussion of rulemaking alternative that would allow Agreement State licensees to avoid NRC regulatory oversight with respect to possession of certain quantities of SNM).
[52] 42 U.S.C. § 2021c(b)(1)(D).
[53] 42 U.S.C. § 2021c(b)(3).
[54] DOE/NE-0077, "Recommendations for Management of Greater-Than-Class-C Low-Level Radioactive Waste," Report to Congress In Response to Public Law 99·240, February 1987, pg. iii, https://www.energy.gov/sites/prod/files/2018/09/f55/GTCC-1987-Report-to-Congress-DOE-NE-0077.pdf,

to be implemented.[55] In response to the directions in the Energy Policy Act, DOE published in 2011 its "Draft Environmental Impact Statement [EIS] for the Disposal of Greater-Than-Class C Low-Level Radioactive Waste and GTCC-Like Waste," which considered the potential environmental impacts associated with using an existing facility or constructing and operating a new facility or facilities for the disposal of GTCC waste.[56]

2.4.3 Disposal of DOE GTCC-like Waste

DOE's Draft EIS used the term "GTCC-like," and provided the following explanation:

> The NRC LLRW classification system does not apply to radioactive wastes generated or owned by DOE and disposed of in DOE facilities. However, DOE owns or generates LLRW and non-defense-generated TRU radioactive waste, [footnote omitted] which have characteristics similar to those of GTCC LLRW and for which there may be no path for disposal. DOE has included these wastes for evaluation in this EIS because similar approaches may be used to dispose of both types of radioactive waste. For the purposes of this EIS, DOE is referring to this waste as GTCC-like waste.[57]

On February 25, 2016, DOE issued its "Final Environmental Impact Statement for the Disposal of Greater-Than-Class C (GTCC) Low-Level Radioactive Waste and GTCC-Like Waste" (FEIS).[58] In the FEIS, DOE stated that its preferred alternative for the disposal of GTCC waste is disposal in the DOE's Waste Isolation Pilot Plant (WIPP) geologic repository near Carlsbad, New Mexico and/or land disposal at generic commercial facilities.[59] Presently, WIPP is only authorized to accept defense generated TRU waste pursuant to the "Waste Isolation Pilot Plant Land Withdrawal Act."[60] Unless there is a legislative change, GTCC waste disposal at WIPP is not an option. Moreover, the NRC would have no regulatory role over any LLRW disposal at WIPP. This draft regulatory basis addresses GTCC waste disposal in a commercially licensed near-surface disposal facility.

In its November 2017 report to Congress, DOE stated that GTCC-like waste "has no identified path to disposal."[61] In its previous *Federal Register* notice that announced the availability of the FEIS, DOE made a similar statement, namely, "there may be no path to disposal" for GTCC-like

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[55] Pub. L. No. 109-58, § 631, 119 Stat. 594, 788.
[56] "Draft Environmental Impact Statement for the Disposal of Greater-Than-Class C (GTCC) Low-Level Radioactive Waste and GTCC-Like Waste" (DOE/EIS-0375-D) (February 2011). A copy of the document is available online at: https://www.energy.gov/sites/prod/files/2015/10/f27/GTCC_EIS_February2011_Summary.pdf.
[57] DOE/EIS-0375-D, at S-9 to S-10.
[58] "Final Environmental Impact Statement for the Disposal of Greater-Than-Class C (GTCC) Low-Level Radioactive Waste and GTCC-Like Waste," (DOE/EIS-0375) (January 2016). A copy of the document is available online at: https://www.energy.gov/nepa/downloads/eis-0375-final-environmental-impact-statement
[59] DOE/EIS-0375, page 2-69.
[60] Pub. L. No. 102-579, 106 Stat. 4777, as amended by the "Waste Isolation Pilot Plant Land Withdrawal Amendment Act," Pub. L. No. 104-201, §§ 3181 *et seq*., 110 Stat. 2851.
[61] DOE Report to Congress, § II, p. 2.

waste and further noted that the "NRC LLRW waste classification system in 10 CFR 61.55 does not apply to radioactive waste generated or owned by DOE and disposed of in DOE facilities."[62]

The NRC staff understands the DOE statements that there may be no path, or no identified path, to disposal for GTCC-like waste as meaning that there is no disposal facility, either federal or commercial, that currently possesses the requisite waste acceptance criteria to allow it to accept GTCC-like waste. From a statutory perspective, the NRC recognizes that the DOE has the requisite authority, under Section 161g. and 161j. of the AEA,[63] to dispose of GTCC-like waste in either a federal or commercial land disposal facility, provided that the facility has the requisite waste acceptance criteria. In the case of an Agreement State licensed facility, promulgation of an NRC rulemaking or other express approval by the Commission authorizing the near-surface disposal of GTCC waste, as well as satisfaction of the requirements of Section 274 of the AEA, would be a necessary prerequisite for an Agreement State licensed facility to accept GTCC and GTCC-like waste for disposal (see Section 2.4.4 and Section 3.2. of this regulatory basis for further discussion of Agreement State regulatory authority).

The NRC staff further notes that any disposal by DOE of GTCC-like waste in a commercial facility licensed by an Agreement State would be subject to the requirements in subparagraph 4(b)(1)(B) of the LLRWPAA, which states that:

> Low-level radioactive waste owned or generated by the Federal Government that is disposed of at a regional disposal facility or non-Federal disposal facility within a State that is not a member of a compact shall be subject to the same conditions, regulations, requirements, fees, taxes, and surcharges imposed by the compact commission, and by the State in which such facility is located, in the same manner and to the same extent as any low-level radioactive waste not generated by the Federal Government.[64]

2.4.4 NRC Regulations Concerning Agreement State Authority

The NRC's regulations in 10 CFR Part 150, "Exemptions and Continued Regulatory Authority in Agreement States and in Offshore Waters in under Section 274," implement Section 274 of the AEA. Several 10 CFR Part 150 regulations are germane to any prospective rulemaking authorizing the near-surface disposal of GTCC waste and associated relinquishment of NRC regulatory authority to an Agreement State.

As some GTCC waste streams contain SNM, any relinquishment of regulatory authority must comply with the AEA Section 274b.(3) provision that such relinquishment be limited to SNM in quantities not sufficient to form a critical mass. The NRC implements this requirement through 10 CFR 150.11, "Critical mass." Specifically, the NRC defines "special nuclear material in quantities not sufficient to form a critical mass" as:

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[62] 81 FR 11550 (March 4, 2016).
[63] 42 U.S.C. §§ 2201(g) and (j).
[64] 42 U.S.C. § 2021d(b)(1)(B).

> uranium enriched in the isotope U-235 in quantities not exceeding 350 grams of contained U-235;[65] uranium-233 in quantities not exceeding 200 grams; plutonium in quantities not exceeding 200 grams; or any combination of them in accordance with the following formula: For each kind of special nuclear material, determine the ratio between the quantity of that special nuclear material and the quantity specified above for the same kind of special nuclear material. The sum of such ratios for all kinds of special nuclear materials in combination shall not exceed unity.[66]

Therefore, under its current regulations, the NRC cannot relinquish to an Agreement State the regulatory authority to license a near-surface disposal facility that can accept GTCC waste streams that have U-233, plutonium, enriched U-235, or a combination of these isotopes or elements[67] above the 10 CFR 150.11 mass thresholds. The NRC staff has concluded that a conservative and prudent approach in any potential rulemaking is to limit the scope of Agreement State licensing to those near-surface disposal facilities that can accept only those GTCC waste streams that do not exceed the mass thresholds of 10 CFR 150.11.

Additionally, 10 CFR 150.14 and 150.15 contain requirements that could limit the types and quantities of GTCC waste that could be regulated solely by an Agreement State. Section 150.14 provides that persons in Agreement States "possessing, using or transporting special nuclear material of low strategic significance in quantities greater than 15 grams of plutonium or uranium-233 or uranium-235 (enriched to 20 percent or more in the U-235 isotope) or any combination greater than 15 grams when computed by the equation [$Total\ mass\ (grams) = g\ U235 + g\ Pu + g\ U233$] shall meet the physical protection requirements of § 73.67 of 10 CFR Part 73."[68] The 10 CFR 150.14 mass thresholds are the same as the 10 CFR Part 73 minimum thresholds for one form of SNM "of low strategic significance" or a "Category III quantity" of SNM.[69]

Under 10 CFR 150.14, an Agreement State licensee will need to obtain some form of NRC authorization if the licensee chooses to receive and store (i.e., storage incident to disposal) GTCC waste containing quantities of SNM that, by itself or together with other SNM stored on the site, exceed the 10 CFR 150.14 mass thresholds. If the 10 CFR 150.14 mass thresholds are exceeded, then the licensee is responsible for meeting the physical protection requirements of 10 CFR 73.67, "Licensee fixed site and in-transit requirements for the physical protection of special nuclear material of moderate and low strategic significance." Section 73.67 is a "common defense and security" regulation. As only the NRC can ensure compliance with 10 CFR 73.67, through its inspection and enforcement processes, an Agreement State licensee seeking to receive and store GTCC waste containing quantities of SNM that exceed the 10 CFR 150.14 mass thresholds would need to enter into the appropriate regulatory arrangement with the NRC—the NRC would issue either a license or an order to cover the regulatory oversight for the licensee's 10 CFR 73.67 compliance.

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[65] 10 CFR § 150.11(a). The NRC staff interprets the term "contained" in relation to the gram amount for U-235 to mean that the U-235 is in a package or other container.
[66] *Id.*
[67] Subject to the ratio formula described in 10 CFR § 150.11.
[68] 10 CFR § 150.14 (alteration added).
[69] 10 CFR § 73.2 (definition of "Special nuclear material of low strategic significance," subparagraph (1)).

Likewise, two provisions of 10 CFR 150.15 may also restrict the scope of potential Agreement State regulation of certain GTCC waste streams. Section 150.15 lists those persons in Agreement States who are subject to NRC licensing and regulatory requirements with respect to certain activities. Included in the list are those persons who engage in the "transfer, storage or disposal of radioactive waste material resulting from the separation in a production facility of special nuclear material from irradiated nuclear reactor fuel,"[70] and those who seek to store and dispose of reactor-related GTCC waste.[71] Section 4.3 of this draft regulatory basis describes potential amendments to 10 CFR Part 150.

2.4.5 Applications Received Under Current Regulations

Section 7 ("Cost/Impact Considerations") describes the alternatives considered by the NRC staff. Two of the three alternatives, the no regulatory changes (i.e., status quo) alternative and the guidance development alternative, would not involve any changes to the NRC's current 10 CFR Part 61 regulations. The third alternative is rulemaking, which is discussed in detail in Section 4. The applicable regulation, 10 CFR 61.55, states,

> Waste that is not generally acceptable for near-surface disposal is waste for which form and disposal methods must be different, and in general more stringent, than those specified for Class C waste. In the absence of specific requirements in this part, such waste must be disposed of in a geologic repository as defined in part 60 or 63 of this chapter unless proposals for disposal of such waste in a disposal site licensed pursuant to this part are approved by the Commission.[72]

This regulation would remain in effect if the NRC does not engage in rulemaking and would govern any site-specific application for a land disposal facility that could accept GTCC waste. If the NRC were to receive a site-specific application, the Commission would need to determine whether the proposed GTCC waste streams could be safely disposed of in a land disposal facility. To make that determination, the NRC staff would need to develop mechanisms for evaluating the application and making the requisite technical findings. Next, if the application were approved, a site-specific 10 CFR Part 61 license would need to be prepared.[73] Under the no regulatory changes alternative, the NRC would have no established process for approving and licensing the initial site-specific GTCC disposal application. Under the guidance development alternative, some of these mechanisms (e.g., procedures) may be in place at the time an application is received, although such mechanisms would not have the force and effect, and the predictability, of a regulation. Under either the no regulatory changes or guidance development options, the NRC staff's experience with processing an initial site-specific application could be applied to any subsequent applications.

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[70] 10 CFR § 150.15(a)(4).
[71] 10 CFR § 150.15(a)(8) ("Greater than Class C waste, as defined in Part 72 of this chapter, that originates in, or is used by, a facility licensed under part 50 of this chapter and is licensed under Part 30 and/or Part 70 of this chapter").
[72] 10 CFR 61.55(a)(2)(iv).
[73] As part of this process, the NRC staff would need to prepare the appropriate National Environmental Policy Act analysis and offer an opportunity for a hearing.

This scenario becomes more complex if the prospective applicant is already licensed by an Agreement State and does not want to obtain an NRC license in addition to its Agreement State license (currently, all four LLRW disposal facilities are located in Agreement States). Under this variant, the Commission would first determine whether the current AEA Section 274b. agreement between the NRC and the Agreement State encompasses the relinquishment of regulatory authority over a land disposal facility that can accept GTCC waste. If the Commission determines that the current Section 274b. agreement encompasses the relinquishment of such authority, then, in accordance with AEA Section 274c.(4), the Commission would determine whether each proposed GTCC waste stream was of such a hazardous nature that only the NRC should license its disposal. This Commission determination would be informed by the NRC staff's technical analyses and findings (Section 3 and Appendix B of this draft regulatory basis provides the staff's initial analyses and findings). If the Commission determines that the proposed GTCC waste streams are both suitable for disposal in a land disposal facility and that such a facility can be licensed by an Agreement State, then the NRC would transmit its approval to the Agreement State along with any associated conditions or requirements to ensure that the Agreement State meets the applicable AEA Section 274 requirements.

Although the Agreement State would become responsible for licensing and regulating the facility under this more complex scenario, the NRC would need to resolve several related issues, perhaps resulting in some form of NRC involvement during the license term. For instance, the NRC may need to establish a mechanism (e.g., issuance of an NRC order) for ensuring the material is physically protected consistent with the standards of 10 CFR 73.67, a "common defense and security" regulation, if the Agreement State licensee's operations will result in the mass thresholds of 10 CFR 150.14 being exceeded. Also, if the Agreement State licensee seeks to accept for disposal GTCC waste that results from: 1) the separation of SNM from irradiated nuclear reactor fuel or 2) reactor-related GTCC waste, and assuming the NRC approved the Agreement State licensing of these activities, then the NRC must expressly exempt the Agreement State licensee from 10 CFR 150.15(a)(4) or (a)(8), respectively. Another example of an issue that may require resolution arises if the Agreement State licensee seeks to dispose of GTCC waste streams containing TRU waste. The current 10 CFR 61.2 definition of "waste" excludes TRU waste as a form of LLRW. Under the NRC's current Agreement State procedures, the Agreement State regulatory counterpart should be "essentially identical" to the 10 CFR 61.2 "waste definition," meaning that any Agreement State regulatory definition of "waste" would also have to exclude TRU waste.[74] The regulatory issues identified in this paragraph are illustrative; other regulatory issues may become apparent during the NRC's review of a site-specific application. In conclusion, challenging regulatory issues may arise, or remain unresolved, under the status quo or the guidance development alternatives.

[74] The NRC classifies its 10 CFR 61.2 definition of "waste" regulation as a "Compatibility Category B" (transboundary) regulation, which requires that the Agreement State regulation be essentially identical to its NRC counterpart. *See* NRC, "Compatibility Categories and Health and Safety Identification for NRC Regulations and Other Program Elements," SA-200, p. 6 (June 2012) and NRC, "Review Summary Sheets for Regulation Adoption for New Agreement States/Programs (10 CFR Part 61), p. 4 (September 10, 2008).

3. Analysis of GTCC Waste Hazards and Agreement State Regulatory Issues

The NRC currently has no specific technical safety and security requirements for the near-surface disposal of GTCC waste. The current regulations at 10 CFR 61.55(a)(2)(iv) provide for the Commission to approve, on a case-by-case basis, the disposal of GTCC waste in a 10 CFR Part 61 land disposal facility. The NRC staff evaluated the potential hazards associated with the near-surface disposal of GTCC waste, including the site-specific considerations that should be made for determining the suitability of GTCC waste in a given near-surface disposal facility. This section describes the evaluation results and identifies potential revisions to NRC regulations necessary to ensure the safe and secure near-surface disposal of GTCC waste. The NRC staff has considered both GTCC and GTCC-like waste streams in its hazards evaluation. In the remainder of this regulatory basis, the term "GTCC waste" includes both GTCC waste and GTCC-like waste; the term GTCC-like waste is only used when a distinction between these two types of waste is relevant.

DOE FEIS

In its February 2016 FEIS, the DOE considered the potential environmental impacts associated with constructing and operating a new facility or facilities, or using an existing facility, for the disposal of an estimated total volume of 12,000 m^3 (420,000 ft^3) of GTCC waste anticipated to be generated through 2083. The FEIS categorized the GTCC waste into activated metals, sealed sources, and other waste and analyzed four methods of disposal: geologic repository, above grade vault, enhanced near-surface trench, and intermediate depth borehole. As for the waste types, activated metals are largely generated from the decommissioning of nuclear reactors while sealed sources are widely used in equipment to diagnose and treat illnesses, sterilize medical devices, irradiate blood for transplant patients, nondestructively test structures and industrial equipment, and explore geologic formations to find oil and gas. The remaining GTCC waste is referred to as other waste and consists of contaminated equipment, debris, scrap metal, and exhumed waste and soil. Sources for other waste can include those from production of Mo-99 and the environmental cleanup of WVDP.

The FEIS considered GTCC waste streams with a total aggregate volume of approximately 12,000 m^3 (DOE elected to round-off certain values to arrive at the value of 12,000 m^3). DOE separated the GTCC waste streams into two different groups: one group consists of waste that is already generated or expected to be generated by existing facilities (as used in this draft regulatory basis, "existing GTCC waste") and a second group consists of waste that may be generated out to the year 2083 ("potential GTCC waste").

3.1 Identification of Significant Hazards of GTCC Waste Disposal

GTCC waste streams vary considerably in volume, constituent radionuclides, radionuclide concentrations, and the form of the waste (e.g., activated metal, sealed sources, exhumed waste and soil). Accordingly, potential revisions to 10 CFR Part 61 must consider several issues in evaluating the hazards of GTCC waste disposal in a near-surface disposal facility. Disposal of GTCC waste can be hazardous both during the operational period, when waste containers are stored at a disposal facility in an open disposal unit,prior to the disposal unit being sealed, and after the disposal facility is closed. Operational hazards are addressed by

operating procedures, active measures (e.g., remote handling of waste containers to minimize radiation exposure), passive measures (e.g., barriers and signage to maintain safe distances from waste containers), and, to the extent that SNM is present in sufficient quantities to form a critical mass, safety controls to prevent an accidental criticality. Measures to control post-closure hazards, particularly after the 100-year institutional control period, are of a passive nature (e.g., man-made or natural physical barriers to prevent or limit inadvertent intrusion, the natural hydrogeologic and geochemical conditions of a site that can limit and delay transport of radionuclides to offsite individuals).

In conducting its GTCC waste hazards evaluation, the NRC staff separated the GTCC waste described in the FEIS into 17 GTCC waste streams as a means of identifying the hazards associated with each waste stream (see Appendix A for a "cross-walk" between the GTCC waste streams described in the FEIS and the NRC staff's categorization of those waste streams). The separation into 17 waste streams ensures the hazards evaluation appropriately associates the hazards with the specific characteristics and inventory of each waste stream (see Appendix B for a more detailed description of the hazards evaluation).

Some of the GTCC waste streams described in the FEIS contain TRU waste (i.e., TRU radionuclides in concentrations more than 100 nCi/g). Table 3-1 presents the estimated volumes for the 17 waste streams separated according to GTCC and GTCC-like waste streams and identifies those waste streams containing TRU wastes. The overall waste volume (by adding the totals of the Table 3-1 columns) is 11,285 m^3, with approximately 70 percent of this volume of waste containing TRU waste. DOE's FEIS overall estimate of 12,000 m^3 of waste material was based on rounding off volume estimates to two significant figures prior to adding specific waste stream amounts and explains the discrepancy between the Table 3-1 overall waste volume (i.e., 11,285 m^3) and the FEIS value. Approximately 40 percent of the GTCC waste will be generated by existing facilities or activities, whereas the remaining 60 percent is potential GTCC waste (e.g. commercial reactors yet to be licensed, exhumation of GTCC waste at the NDA and the SDA that has yet to be decided). The single largest amount of existing and potential GTCC waste comes from activities associated with the WVDP that includes decontamination and decommissioning of facilities as well as potential waste exhumation at the NDA.

Table 3-1 Estimated Volumes for Waste Streams Associated with GTCC and GTCC-like Wastes (based on DOE 2016)

Waste Source		Estimated Waste Volumes (cubic meters)			
		GTCC			GTCC-Like
		Activated Metals	Sealed Sources	Other Wastes	Other Wastes
EXISTING FACILITIES AND ACTIVITIES					
Commercial Reactors	RH[1]	880			
Sealed Sources (Cs-137)	CH		1,000		
Sealed Sources (neutron irradiators)	CH		1,800*		
West Valley Decontamination (MPPB)	CH				710*
	RH				540*
POTENTIAL FACILITIES AND ACTIVITIES (Potential Waste)					
Reactors	RH	370			
Mo-99 Production (MURR)	RH			35*	
Mo-99 Production (Medical Isotope Production System – MIPS)	RH			355*	
West Valley Exhumation (NDA)	RH	210*			
West Valley Exhumation (NDA)	RH			1,900*	
Exhumation (SDA)	CH			400	
Exhumation (SDA)	RH	525			
Exhumation (SDA-SNAP)	CH			1,200*	
West Valley Decommissioning (MPPB and WVTF)	CH				220*
	RH				760*
Pu-238 Production	CH				120*
	RH				260*
TOTALS	CH		2,800	1,600	1,050
	RH	1,985		2,290	1,560

[1] Waste containers that are either contact-handled (CH) or remote-handled (RH)
[*] Indicates a waste stream that includes TRU waste (TRU radionuclides in concentrations greater than 100 nCi/g)

3.1.1 Key Assumptions in Hazards Analysis

In considering the hazards associated with the disposal of GTCC waste in a near-surface disposal facility, the NRC staff relies upon the following assumptions:

1. *Quantities of SNM (prior to disposal) are not sufficient to form a critical mass*

   Most of the GTCC waste streams contain SNM that could require more operational controls than is typically afforded other classes of LLRW, such as prevention of criticality accidents. If the quantity of SNM is not sufficient to form a critical mass, the hazard of this material is greatly reduced. For the purposes of the staff's analysis, the NRC staff assumes that any licensed facility would not possess quantities of SNM at any time, prior to disposal, that exceed the critical mass threshold limit in 10 CFR 150.11.

   Table 3-2 provides, for each GTCC waste stream, the volume of GTCC waste material that would exceed the 10 CFR 150.11 mass thresholds. The majority of waste streams require a significant quantity of material (i.e., more than 10 m^3 of GTCC waste material) to be present at the facility prior to disposal to exceed any of the 10 CFR 150.11 mass threshold limits. As such, from a criticality prevention perspective, most GTCC waste streams could be safely stored.

2. *The characteristics of GTCC waste must meet 10 CFR Part 61 requirements*

   The GTCC waste streams evaluated by the NRC staff contain concentrations of radionuclides that could require more operational controls than is typically afforded other classes of LLRW, such as radiation protection for handling and storage. The NRC staff assumes that the requirements of 10 CFR 61.56, "Waste characteristics," concerning the preparation of LLRW for disposal will remain in place if rulemaking is pursued. Compliance with these requirements should ensure the protection of health and safety of personnel at the disposal site and that the LLRW does not structurally degrade and affect the overall stability of the site.

3. *GTCC waste must be disposed at a minimum depth of 5 meters below the surface of the earth <u>and</u> with a 500-year intruder barrier in place*

   GTCC waste could present an unacceptable hazard to an inadvertent intruder based on an excavation exposure scenario (e.g., GTCC waste buried within the depth for excavation of a dwelling). In accordance with 10 CFR 61.52(a)(2), Class C waste must be disposed so that the top of the waste is a minimum of 5 meters below the top surface of the cover *or* the disposal unit must include intruder barriers that are designed to prevent access to the waste by an inadvertent intruder for at least 500 years. Because GTCC waste contains radioactive materials in greater concentrations than is present in Class C waste, the NRC staff considers it reasonable that disposal of GTCC waste must meet both of these Class C requirements. Thus, the NRC staff assumes that GTCC waste would be disposed at a minimum depth of 5 meters below the surface of the earth *and* must also be disposed with a 500-year intruder barrier in place.

Table 3-2 Volume Limitations for Storage of GTCC Waste during Operations Based on the Amount of SNM Present in GTCC Waste Streams

		GTCC Volume (m^3)	Minimum Volume (m^3) of GTCC waste that would exceed thresholds in	
			10 CFR 150.11	10 CFR 150.14
EXISTING FACILITIES AND ACTIVITIES				
Commercial Reactors (activated metal)	RH[1]	880	8,000	620
Sealed Sources (Cs-137)	CH	1,000	Unlimited[2]	Unlimited[2]
Sealed Sources (neutron irradiators)	CH	1,800	2	0.2
West Valley Decontamination (other waste)	CH	710	2	0.6
	RH	540	0.5	0.06
POTENTIAL FACILITIES AND ACTIVITIES (Potential GTCC Waste)				
Commercial Reactors (activated metal)	RH	370	8,000	620
Mo-99 Production (MURR)	RH	35	23	2
Mo-99 Production (MIPS)	RH	355	0.08	4
West Valley Exhumation (NDA) (activated metal)	RH	210	2	0.6
West Valley Exhumation (NDA) (other waste)	RH	1,900	14	4
Exhumation (SDA) (other waste)	CH	400	100	9
Exhumation (SDA) (activated metal)	RH	525	16	1,000
Exhumation (SDA-SNAP) (other waste)	CH	1,200	150	11
West Valley Decommissioning (other waste)	CH	220	4	0.4
	RH	760	9	0.8
Pu-238 Production (other waste)	CH	120	100	8
	RH	260	850	64

[1] Waste containers that are either contact-handled (CH) or remote-handled (RH)
[2] There is no SNM present, so the volume is unlimited

3.1.2 Hazards during the Operational Period

Two GTCC waste streams contain significant quantities of TRU waste in concentrations greater than 10,000 nCi/g (see Table 3-3). These two waste streams, *sealed sources associated with neutron irradiators* and *remote-handled other waste from decontamination activities* at the WVDP, have the potential to pose a significant radiological hazard during operations (e.g., handling accidents). Aside from these two waste streams, the potential radiological hazards arising from the receipt and storage of the other GTCC waste streams can be adequately controlled to allow for the remaining GTCC waste streams (15 of the 17 GTCC waste streams) to be considered for near-surface disposal provided appropriate facility design and procedures are applied.

3.1.3 Inadvertent Intruder Hazards During the Post-Closure Period

The potential for post-closure hazards begin after the facility is permanently closed. Inadvertent intrusion can occur after the 100-year institutional control period, during which the site controls, if properly implemented, would preclude an inadvertent intrusion from occurring. A number of GTCC waste streams contain TRU radionuclides that are long-lived (e.g., Pu-238 with a half-life of 88 years, Am-241 with a half-life of 430 years, Pu-239 with a half-life of 24,000 years) and, as such, can contribute to significant radiation exposures to an inadvertent intruder when present in large enough concentrations. Table 3-3 identifies the waste streams from the highest concentrations of TRU radionuclides to the lowest.

Thirteen of the 17 GTCC waste streams exceed the 100 nCi/g limit for TRU radionuclides in Table 1 of 10 CFR 61.55, which is the limit for Class C waste. Two of these 13 waste streams contain TRU radionuclides in concentrations exceeding 10,000 nCi/g. Thus, these two waste streams are more than 100 times greater than the Class C limit for TRU waste. A large amount of the hazard results from the presence of Am-241, which, due to its half-life, will remain hazardous beyond 500 years for an inadvertent intruder. The NRC staff has identified two GTCC waste streams as too hazardous for near-surface disposal: *sealed sources associated with neutron irradiators*, with a volume of 1,800 m^3; and *remote-handled other waste from decontamination activities* at the WVDP, with a volume of 540 m^3 and concentrations exceeding 10,000 nCi/g. Accordingly, the disposal options for these two streams would be either a deep geologic repository or in a deeper than near-surface waste disposal cell at a land disposal facility site licensed in accordance with 10 CFR Part 61.

Due to the radiological hazards of GTCC waste, any future rulemaking should include a requirement that a near-surface disposal facility applicant seeking to dispose of GTCC waste must include an inadvertent intruder dose assessment that accounts for the characteristics of the waste, depth of burial, and the intruder barriers specific to the facility as part of its 10 CFR 61.13 technical analysis. Specifically, the staff recommends that such an assessment would have to demonstrate that the annual dose to an inadvertent intruder would not exceed a proposed 5 mSv (500 mrem) limit. The NRC staff has assumed for the well drilling scenario that the GTCC waste would be disposed as a single layer of waste packages (i.e., an inadvertent intruder would only drill through a single waste package). If GTCC waste is disposed in multiple layers of waste packages, then the estimated doses are expected to increase due to the additional amount of waste that would be brought to the surface by the drilling activity.

Table 3-3 GTCC Waste Streams Sorted by Concentration of TRU Radionuclides

Waste Streams	Waste Stream	Volume (m^3)	Waste Type	Contact (CH) or Remote (RH) Handled	TRU Concentrations[1] [half-lives > 5 years] (nCi/g)
Waste Streams with TRU radionuclides equal to or less than 100,000 nCi/g					
Sealed Sources – Small	sealed sources	1,800	GTCC	CH	85,900 (Am-241:54%, Pu-238: 43%)
WVDP Decontamination	other waste	540	GTCC-like	RH	13,300 (Am-241: 41%)
Waste Streams with TRU radionuclides equal to or less than 10,000 nCi/g					
Exhumation – SDA-SNAP	other waste	1,200	GTCC Potential	CH	9,600 (Pu-238: 100%)
WVDP Decommissioning	other waste	220	GTCC-like Potential	CH	6,700 (Am-241: 52%)
WVDP Decontamination	other waste	710	GTCC-like	CH	5,700 (Am-241: 60%)
WVDP Decommissioning	other waste	760	GTCC-like Potential	RH	3,500 (Am-241: 53%)
WVDP Exhumation – NDA	activated metals	210	GTCC Potential	RH	3,200 (Am-241: 57%)
Pu-238 Production	other waste	260	GTCC-like Potential	RH	1,900 (Pu-238: 99%)
Waste Streams with TRU radionuclides equal to or less than 1,000 nCi/g					
WVDP Exhumation – NDA	other waste	1,900	GTCC Potential	RH	530 (Am-241: 56%)
Exhumation – SDA	other waste	400	GTCC Potential	CH	310 (Pu-238: 70%)
Mo-99 Production – MURR	other waste	35	GTCC Potential	RH	300 (Pu-239: 100%)
Pu-238 Production	other waste	120	GTCC-like Potential	CH	160 (Pu-239: 37%, Am-241: 32%)
Mo-99 Production – MIPS	other waste	355	GTCC Potential	RH	150 (Pu-239: 97%)
Waste Streams with TRU radionuclides equal to or less than 100 nCi/g					
Exhumation – SDA	activated metals	525	GTCC Potential	RH	24 (Pu-238: 45%)
Reactors	activated metals	880	GTCC	RH	3
Reactors	activated metals	370	GTCC Potential	RH	3
Sealed Sources – Large	sealed sources	1,000	GTCC	CH	0

[1] Concentrations of TRU based on DOE 2016 except for reactors that is based on McCartin et al 2018 due to discrepancies in DOE 2016 for deriving values for that waste stream.

3.1.4 Offsite Individual Hazards during the Post-Closure Period

The 10 CFR Part 61 regulations require an applicant for a land disposal facility to demonstrate that offsite members of the public will be protected from radiological hazards by performing a site-specific technical analysis. The release rate of radioactivity into the environment from the disposed waste will be determined by the type of waste, the engineered barriers, and the characteristics of the disposal site.

The FEIS analysis completed by DOE reported a very large range of radioactive doses to a member of the public, from as large as 10,000 mrem/yr to doses below 25 mrem/yr. This broad range reflects the fact that facility design (e.g., trench, vault), region of the country (e.g., dry and arid versus wet and humid) and the waste type (e.g., sealed sources, activated metals), cause the estimated doses to a member of the public to vary significantly. Most GTCC waste streams would be anticipated to meet the 10 CFR 61.41 performance objective when the waste is disposed in a near-surface disposal facility with long-term favorable hydrogeologic and geomorphic conditions (e.g., low infiltration and high geochemical sorption conditions). The results in the FEIS and the NRC staff analysis highlight the importance of a site-specific analysis to demonstrate compliance with 10 CFR 61.41. Impacts to an offsite individual can be delayed for very long periods of time as a result of engineered and natural system barrier performance.

None of the 17 GTCC waste streams are considered too hazardous for near-surface disposal with respect to the offsite individual. The NRC staff analysis shows that near-surface disposal of large quantities of GTCC waste may be appropriate in some circumstances but not under all site conditions (see Appendix B for detailed analyses). Because some radionuclides in the waste are long-lived, the magnitude of impacts is generally driven by the wasteform,[75] engineered barriers, and the physical conditions of the site. Thus, site-specific characteristics at a GTCC waste disposal site will have a strong influence on the timing and magnitude of any potential offsite doses. A well-designed and well-sited near-surface disposal facility should be able to reduce the magnitude of radiological doses from the more radiologically hazardous GTCC waste streams. In particular, disposal at greater depths and/or disposal facilities with specific characteristics (e.g., low infiltration rates) may be required to limit releases for some waste streams to meet the 10 CFR 61.41 dose limits.

3.2 Agreement State Regulatory Items

As part of this draft regulatory basis, the NRC staff considered the 10 CFR Part 150 requirements related to criticality and physical protection that could potentially limit the quantities and types of GTCC waste streams that can be accepted at an Agreement State regulated near-surface disposal facility. As described in Section 2 of this draft regulatory basis, the NRC cannot relinquish regulatory authority for SNM in quantities sufficient to form a critical mass nor can it relinquish authority relating to common defense and security matters.

[75] "Wasteform" is the terminology used to refer to the engineered or inherent physical, chemical, and mechanical properties of the waste that provide stabilization and help to limit releases of radioactivity to the environment.

10 CFR 150.11 Critical Mass Thresholds

The NRC staff has assumed that a near-surface disposal facility licensed by an Agreement State would not possess, prior to disposal, a quantity of SNM sufficient to form a critical mass (i.e., in excess of the 10 CFR 150.11 mass thresholds). Application of the 10 CFR 150.11 mass thresholds effectively removes *other waste from Mo-99 production using MIPS*, one of the 15 GTCC waste streams deemed suitable for near-surface disposal from consideration for Agreement State regulation given that relatively small quantities of this waste stream will exceed a 10 CFR 150.11 mass threshold. Specifically, a volume of 0.08 m^3 of this waste stream will exceed the mass threshold pertaining to uranium enriched in the isotope U-235. Thus, an Agreement State-licensed near-surface disposal facility receiving and storing this waste stream would need to dispose of it before any further quantity of this waste stream or other waste containing SNM could be received and stored at the facility (see Table 3-2).[76]

Section 150.11 could be amended to expand the scope of Agreement State regulatory authority by either increasing the mass thresholds or by allowing an alternative concentration approach. Such an amendment, however, may raise complex technical and regulatory issues given the need to ensure that the Agreement State licensee only receives or possesses SNM in quantities not sufficient to form a critical mass in accordance with AEA section 274b.(3). Moreover, the NRC staff has determined that amending 10 CFR 150.11 is of limited utility as only one GTCC waste stream (*other waste from Mo-99 production using MIPS*) is excluded from near-surface disposal by application of the current 10 CFR 150.11 mass thresholds. For the purposes of this regulatory basis, the NRC staff has assumed that 10 CFR 150.11 will not be amended in any future rulemaking. This approach preserves the current clear delineation of what quantities of SNM that an Agreement State can regulate in accordance with AEA section 274b.(3). Furthermore, adherence to the current 10 CFR 150.11 mass threshold avoids an Agreement State licensee coming into possession of Category I quantities of SNM (formula quantity) or Category II quantities of SNM (moderate strategic significance) at its disposal facility, thereby obviating the need for compliance with many 10 CFR Part 73 regulations.

10 CFR 150.14 Mass Thresholds

An Agreement State licensee may potentially be subject to the mass thresholds of 10 CFR 150.14, which relate to a Category III quantity of SNM (low strategic significance). In contrast to the 10 CFR 150.11 mass thresholds, the much lower 10 CFR 150.14 mass thresholds may impair any policy objective of allowing Agreement State regulatory oversight of near-surface disposal facilities that can accept GTCC waste. The GTCC waste streams that would exceed the 10 CFR 150.14 mass thresholds are from the WVDP and account for approximately 25 percent of the overall volume of GTCC waste. If the 10 CFR 150.14 mass thresholds are exceeded by an Agreement State licensee, that licensee must then comply with the physical security requirements of 10 CFR 73.67 by either obtaining an NRC license or entering into some other regulatory arrangement with the NRC. A rulemaking that amends 10 CFR 150.14 could provide Agreement State licensees the option of complying with the applicable Agreement State's compatible regulations for 10 CFR Part 37, "Physical protection of Category 1 and

[76] Similarly, a volume of 0.5 m^3 of *remote-handled other waste from decontamination activities* at the WVDP will exceed the 10 CFR § 150.11 mass threshold. As described in Section 3.1.2, the NRC staff, however, has determined that this waste stream and a second waste stream, *sealed sources associated with neutron irradiators*, are not suitable for near-surface disposal given the significant quantities of TRU waste present in these waste streams.

Category 2 quantities of radioactive material," in lieu of complying with 10 CFR 73.67. Although the 10 CFR Part 37 regulations concern the physical protection of licensed materials, including certain categories of SNM, those regulations were issued as health and safety regulations, and therefore, an Agreement State can promulgate compatible regulations based upon such requirements. Such an amendment would avoid the necessity of NRC regulatory oversight and alleviate any "dual regulation" perceptions that could occur under the existing NRC regulations. Section 4.3 of this draft regulatory basis provides further discussion of a potential amendment to 10 CFR 150.14. For the purposes of this draft regulatory basis, the NRC staff has assumed that any rulemaking authorizing the near-surface disposal of GTCC waste will include the appropriate amendments to 10 CFR 150.14.

3.3 Potential Suitability of GTCC Waste for Near-Surface Disposal and Agreement State Regulatory Oversight

The NRC staff has determined that 15 of the 17 GTCC waste streams identified in the FEIS are potentially suitable for near-surface disposal. The staff's rationale for determining that the two GTCC waste streams, *sealed sources associated with neutron irradiators* (volume of 1,800 m^3) and *remote-handled other waste from decontamination activities* at the WVDP (volume of 540 m^3), are not suitable for near-surface disposal is based on the long-term protection of the inadvertent intruder, potential for significant exposures due to operational accidents, and the potential for an increased need for physical security to prevent theft and diversion of SNM. For these two waste streams, disposal in either a deep geologic repository or a land disposal facility with "intermediate depth" disposal capacity would be appropriate for protecting the inadvertent intruder; however, increased protection from operational accidents and from theft and diversion would still be necessary for the waste prior to disposal.

Of the 15 waste streams deemed potentially suitable for near-surface disposal, the NRC staff determined that 14 waste streams are potentially suitable for Agreement State regulatory oversight, based upon the assumptions identified and described in Section 3.1.1, and provided that the Agreement State meets all applicable requirements of Section 274 of the AEA and the NRC Agreement State program, including promulgation of State regulations that are determined by the NRC to be both adequate and compatible with 10 CFR Part 61. The waste stream not deemed suitable for Agreement State regulatory oversight is *other waste from Mo-99 production using MIPS*. This waste stream was deemed not suitable for Agreement State regulation because of the likelihood that its presence at a near-surface disposal facility would result in the facility exceeding the critical mass threshold of 10 CFR 150.11.

The combined volume of GTCC waste potentially suitable for near-surface disposal is 8,945 m^3 (representing 15 of the 17 waste streams evaluated by the NRC staff) and, of this amount, approximately 8,590 m^3 could be regulated by an Agreement State (representing 14 of the 15 waste streams suitable for near surface disposal). As directed by the Commission in SRM-SECY-15-0094 and in conjunction with the Commission's reference to Section 274c.(4) of the AEA, the NRC staff has concluded that the hazards or potential hazards of these 14 waste streams do not warrant restricting the regulatory oversight for their disposal to only that of the NRC. Under the proper conditions, as described in this draft regulatory basis, Agreement State regulatory oversight over the disposal of these 14 waste streams is appropriate. Table 3-4 presents all the GTCC waste streams and explicitly identifies the two waste streams that are not

suitable for near-surface disposal and the additional waste stream not suitable for Agreement State regulation.

Table 3-4 Suitability of GTCC Waste Stream for Near-Surface Disposal and Agreement State Regulatory Oversight

		GTCC Volume (m^3)	Potentially Suitable for Near-Surface Disposal	Potentially Suitable for Agreement State Regulation
EXISTING FACILITIES AND ACTIVITIES				
Commercial Reactors (activated metal)	RH[1]	880		
Sealed Sources (Cs-137)	CH	1,000		
Sealed Sources (neutron irradiators)	CH	1,800	No	No
West Valley Decontamination of MPPB (other waste)	CH	710		
	RH	540	No	No
POTENTIAL FACILITIES AND ACTIVITIES (Potential GTCC Waste)				
Commercial Reactors (activated metal)	RH	370		
Mo-99 Production (MURR)	RH	35		
Mo-99 Production (MIPS)	RH	355		No
West Valley Exhumation (NDA) (activated metal)	RH	210		
West Valley Exhumation (NDA) (other waste)	RH	1,900		
Exhumation (SDA) (other waste)	CH	400		
Exhumation (SDA) (activated metal)	RH	525		
Exhumation (SDA-SNAP) (other waste)	CH	1,200		
West Valley Decommissioning of MPPB and WVTF (other waste)	CH	220		
	RH	760		
Pu-238 Production (other waste)	CH	120		
	RH	260		

1 Waste containers that are either contact-handled (CH) or remote-handled (RH)

Potential Revisions to the NRC's Regulations

Based on its hazard assessment, the NRC staff has evaluated potential revisions to the NRC's regulations regarding the near-surface disposal of GTCC waste. There are three categories of regulatory interest: (1) safety criteria (Section 4.1), (2) identification of potential revisions to remove restrictions on GTCC disposal (Section 4.2), and (3) identification of potential revisions to accommodate Agreement State regulatory oversight of near-surface disposal facilities that can accept GTCC waste (Section 4.3).

4.1 Safety Criteria for Near-Surface Disposal of GTCC

The NRC staff has considered potential revisions to 10 CFR Part 61 with respect to safety during operations, protection of the inadvertent intruder, protection of an offsite individual, and stability of the disposal site after closure. The current safety requirements are reflected in the specific 10 CFR Part 61, Subpart C performance objectives, namely, 10 CFR 61.41 (protection of the general population from releases of radioactivity), 10 CFR 61.42 (protection of the inadvertent intruder), 10 CFR 61.43 (protection of individuals during operations), and 10 CFR 61.44 (stability of the disposal site after closure). These performance objectives correspond to regulations in 10 CFR 61.13, "Technical analyses" that require disposal facility applicants to provide technical analyses demonstrating that each of the four performance objectives will be met.

4.1.1 Safety during the Operational Period

With respect to the protection of individuals during operations, 10 CFR 61.13(c), requires an applicant to assess the potential exposures arising from routine operations and likely accidents during the handling, storage, and disposal of LLRW to provide reasonable assurance that exposures will be controlled to the requirements of the NRC's radiation protection regulations in 10 CFR Part 20.[77] Applicants for near-surface disposal facilities accepting GTCC wastes with significant amounts of plutonium and radionuclides with a potential for significant external exposures (e.g., Co-60) will need to analyze accidents and develop additional detailed operating procedures as part of its radiation protection program over that expected at a disposal facility that receives only Class A, Class B, and Class C wastes. The NRC staff has determined, however, that the current regulation is broad enough to encompass a requirement that an applicant provide such additional accident analyses and detailed operating procedures in the radiation protection program. Therefore, no amendments to 10 CFR 61.13 or other NRC regulations are envisioned to be necessary to satisfy the 10 CFR 61.43 performance objective in regard to the receipt, storage, and disposal of those GTCC waste streams that the NRC staff determined to be potentially suitable for near-surface disposal.

[77] Additionally, the applicable performance objective, 10 CFR § 61.43, requires the application of the as low as is reasonably achievable (ALARA) radiological protection standard. ALARA is defined, in part, as "making every reasonable effort to maintain exposures to radiation as far below the dose limits in this part as is practical consistent with the purpose for which the licensed activity is undertaken," taking into account a variety of factors, such as the state of technology. 10 CFR § 20.1003 (definition of "ALARA").

4.1.2 Protection of the Inadvertent Intruder During the Post-Closure Period

The NRC staff's inadvertent intruder analyses (see Section 3.1.3 and Appendix B, Section B.3.3) found it likely that a number of the GTCC waste streams would result in unacceptable doses for an excavation scenario (greater than 10 rem) at the end of the 100-year institutional control period. Similarly, the NRC staff found that the disposal of certain GTCC waste streams would likely result in large doses for a well drilling exposure scenario (greater than 1 rem). The NRC staff has determined that 15 of the 17 GTCC waste streams evaluated are potentially suitable for disposal in a near-surface disposal facility, provided that: (1) the facility is designed and constructed to greatly reduce the likelihood of a successful excavation scenario and (2) an applicant prepares and submits, to either the NRC or the appropriate Agreement State regulatory agency, a site-specific, technical analysis demonstrating that the inadvertent intruder can be protected following the institutional control period.

The staff recommends that 10 CFR Part 61 be revised to require conditions that could make an excavation exposure scenario (e.g., GTCC waste buried within the depth for excavation of a dwelling) highly unlikely by amending the regulation to require that GTCC waste must be disposed at a minimum depth of 5 meters below the surface of the earth and with a 500 year intruder barrier in place. Such a requirement would preclude the types of excavation exposure scenarios considered during the development of the waste classification system in 10 CFR Part 61.

Additionally, the 10 CFR 61.42 performance objective could be amended to require applicants to provide an appropriate site-specific inadvertent intruder dose analysis under 10 CFR 61.13(b). The staff expects that this analysis will provide sufficient information for ensuring that the level of protection afforded the inadvertent intruder from the disposed GTCC waste is commensurate with the disposal of Class A, Class B, and Class C waste streams. This change could incorporate a 500 mrem/yr dose limit, which is consistent with the value used in developing the waste classification system in 10 CFR Part 61, and the tables in this regulatory basis.

4.1.3 Protection of the Offsite Individual

To protect an offsite member of the public, the 10 CFR 61.41 performance objective requires that concentrations of radioactive material that may be released into the general environment do not result in an annual dose equivalent exceeding an equivalent of 25 mrem to the whole body, 75 mrem to the thyroid, and 25 mrem to any other organ. In accordance with 10 CFR 61.13(a), an applicant must submit a site-specific analysis of release and transport of radionuclides from disposed waste to the environment that may eventually result in a radiological dose to a member of the public. Section 61.13(a) requires:

> Pathways analyzed in demonstrating protection of the general population from releases of radioactivity must include air, soil, groundwater, surface water, plant uptake, and exhumation by burrowing animals. The analyses must clearly identify and differentiate between the roles performed by the natural disposal site characteristics and design features in isolating and segregating the wastes. The analyses must clearly demonstrate that there is reasonable assurance that the

exposure to humans from the release of radioactivity will not exceed the limits set forth in § 61.41.

As described by these requirements, the analysis to evaluate the protection of an offsite member of the public is site-specific because results can be strongly influenced by local hydrogeological and geomorphic conditions.

Because GTCC wastes can have much higher radioactivity levels than Class A, Class B, and Class C wastes, an applicant for a near-surface disposal facility that can accept GTCC waste will need to consider certain factors beyond those previously analyzed in past performance assessments associated with Class A, Class B, and Class C wastes. For example, the performance assessment may need to analyze both the generation of heat in certain sealed sources and activated metals, which can be significant, and the generation of hydrogen gas. Similarly, criticality could be a concern if sufficient fissile material is disposed in a single disposal unit and the material is subject to redistribution after disposal (see Appendix C for further information on criticality safety). These concerns, as well as the disposal site characteristics and design features used in isolating and segregating the GTCC waste and other LLRW would be evaluated in the technical analysis required by 10 CFR 61.13(a).

In particular, applicants for a near-surface disposal facility that can accept GTCC waste will need to evaluate the potential impacts that may result from the higher radioactivity levels, including those potential impacts on facility design or waste acceptance criteria. Thus, the applicant's 10 CFR 61.13(a) technical analysis will need to demonstrate compliance with the 10 CFR 61.41 performance objective by evaluating the variability in doses resulting from different disposal system designs and, most especially, the disposal site itself (e.g., the site's natural characteristics). The NRC staff considers the current 10 CFR 61.13 requirements for technical analyses are broad enough to encompass the analysis needed for higher radioactivity levels generated by the various GTCC waste streams. Therefore, no amendments to 10 CFR 61.13 or other NRC regulations are necessary to satisfy the 10 CFR 61.41 performance objective with regard to the receipt, storage, and disposal of GTCC waste at a near-surface disposal facility. The NRC staff, however, will consider incorporating clarifications to the scope of the technical analysis that would be consistent with recent proposals that clarified the scope of a performance assessment in 10 CFR Part 61 (see SECY-16-0106, "Final Rule: Low-Level Radioactive Waste Disposal (10 CFR Part 61) (RIN 3150-AI92)" (ADAMS Accession No. ML16188A290) and the associated SRM (ADAMS Accession No. ML17251B147)) if that rulemaking is not finalized prior to the promulgation of rulemaking for GTCC waste disposal. These clarifications will be made within the proposed rule and draft guidance documents that will accompany any proposed rulemaking.

4.1.4 Stability of the Disposal Site after Closure

Stability of the disposal site after closure (10 CFR 61.44) can be addressed as part of the evaluation for intruder protection 10 CFR 61.42 performance objective, which generally involves assessment of intruder doses resulting from disturbance of buried LLRW. As discussed in Section 4.1.1, GTCC waste cannot be buried at depths likely to be disturbed by an excavation exposure scenario, which is within 5 m of the earth's surface. Any LLRW disposed closer to the land surface (e.g., less than 5 m) is more likely to be disturbed by geomorphic processes such as erosion than LLRW disposed more deeply. The inadvertent intruder analysis used to

establish the 10 CFR 61.52(a)(2) requirement that Class C waste be disposed at depths greater than 5 m also applies to GTCC waste. Therefore, a detailed analysis of site stability for GTCC waste disposal is not considered necessary due to the increased stability provided by depths greater than 5 m. Similarly, the existing 10 CFR Part 61 waste stability requirements (i.e., 10 CFR 61.56(b)(1)-(2)) for Class A, Class B, and Class C wastes are sufficient to apply to GTCC waste.

4.2 Regulatory Framework on GTCC Disposal at 10 CFR Part 61

Two 10 CFR Part 61 provisions restrict the disposal of GTCC waste in a near-surface disposal facility. First, the definition of the term "waste" at 10 CFR 61.2 excludes TRU waste and thereby does not allow GTCC wastes containing TRU to be disposed of at a 10 CFR Part 61 facility. Second, 10 CFR 61.55(a)(2)(iv) requires the disposal of GTCC waste in a 10 CFR Part 60 or 63 geologic repository unless the Commission approves, on a case-by-case basis, an alternative disposal site licensed pursuant to 10 CFR Part 61. These two provisions need to be revised to allow GTCC waste, including TRU waste, to be disposed in a near surface disposal facility based on regulatory criteria (i.e., without the express case-by-case approval of the Commission).

4.2.1 Classifying TRU Waste as a Form of LLRW

Those GTCC waste streams containing alpha-emitting TRU radionuclides with half-lives greater than five years and a concentration greater than 10 nCi/g, but not exceeding 100 nCi/g, would be considered "TRU" waste as defined under Section 11ee. of the AEA, but as a health and safety matter, have characteristics that fall within the limits set by 10 CFR Part 61 for Class C waste.[78] Under 10 CFR 61.55(a)(3)(ii) and (iii), waste streams containing alpha-emitting TRU radionuclides with half-lives greater than five years and a concentration greater than 100 nCi/g constitute GTCC waste and, as such are not generally acceptable for near-surface disposal. The NRC staff, however, has determined that such waste streams are potentially suitable for near-surface disposal with the proper controls (*See* Section 3). Therefore, 10 CFR 61.55(a)(3)(iii) could be revised to allow the near-surface disposal of GTCC waste streams containing TRU radionuclides with concentrations greater than 100 nCi/g. Additionally, the NRC's current definition of "waste" in 10 CFR 61.2 is not consistent with the LLRWPAA's definition of LLRW. Therefore, this definition could be amended to remove the exclusion of TRU waste thereby effectively redefining TRU waste as a category of LLRW.

A potential rulemaking could consider adding a definition for the term "GTCC waste" (see further discussion in Section 4.2.2 on defining GTCC waste) that would encompass those waste streams containing radionuclides, including alpha-emitting transuranic radionuclides with half-lives greater than five years, that exceed the concentrations in Tables 1 and 2 of 10 CFR 61.55. In addition, a potential rulemaking could also add a definition for "transuranic waste" that would be consistent with the current EPA and DOE definitions for TRU waste (i.e., encompassing transuranic radionuclides with half-lives greater than 20 years). LLRW containing alpha-emitting TRU radionuclides in concentrations not exceeding 100 nCi/g and with half-lives greater than five years would continue to be treated as either Class A, Class B, or Class C waste.

[78] 42 U.S.C. § 2014(ee). This AEA provision also authorizes the NRC to define TRU "in such other concentrations as the [NRC] may prescribe to protect the public health and safety."

Two specific GTCC waste streams (i.e., *remote-handled other waste from decontamination activities* at the WVDP and *sealed sources associated with neutron irradiators*) are anticipated to represent the main waste streams of significant hazards for TRU waste with respect to protection during operations, inadvertent intruder, and offsite individuals. As can be seen in Table 3-3, these two waste streams represent the waste streams with the highest concentration of TRU radionuclides (i.e., alpha-emitting transuranic radionuclides in concentrations greater than 10,000 nCi/g with half-lives greater than five years). Current requirements for safety and security during operations, the performance objectives for the off-site individual after closure, and the proposed new requirement for an intruder assessment are appropriately restrictive that additional requirements to limit GTCC waste (e.g., specification of a limiting concentration of GTCC waste containing TRU waste) are not necessary.

4.2.2 Restriction of Near-Surface Disposal of GTCC

Disposal of GTCC waste in a geologic repository is established as the default path for GTCC waste at 10 CFR 61.55(a)(2)(iv). This provision would need to be revised to expressly allow the disposal of GTCC waste in a near-surface disposal facility based on regulatory technical criteria (i.e., the requirement for Commission site-specific approval would be removed). Similarly, rulemaking would be needed to revise 10 CFR 61.55(a)(3)(iii) "Classification determined by long-lived radionuclides," which states that a waste stream is not generally acceptable for near-surface disposal if the concentration of radionuclides in the waste exceeds the value in Table 1 of 10 CFR 61.55; and 10 CFR 61.55(a)(4)(iv), which states that a waste stream is not generally acceptable for near-surface disposal if the concentration of radionuclides in the waste exceeds the value in Column 3 of Table 2 of 10 CFR 61.55.

Currently, the only definition of GTCC waste in NRC regulations is in 10 CFR Part 72, "Licensing Requirements for the Independent Storage of Spent Nuclear fuel, high-level Radioactive Waste, and Reactor-Related Greater than Class C Waste." In 10 CFR Part 72, GTCC waste is defined as "low-level radioactive waste that exceeds the concentration limits of radionuclides established for Class C waste in § 61.55 of this chapter."[79] As discussed in Section 4.2.1, adding a definition for the term "GTCC waste" could be considered in any potential rulemaking. Such a definition could be added to 10 CFR 61.2 or 10 CFR 65.55(a)(2)(iv) could be amended to use the term "GTCC waste" and the subparagraph revised in a manner similar to current 10 CFR 61.55(a)(2)(i)-(iii). Additionally amending 10 CFR 61.57, "Labeling," to include a reference to GTCC waste could be considered.

4.3 Continued NRC Regulatory Authority in Agreement States

The NRC regulations at 10 CFR Part 150 require that: (1) persons in Agreement States who possess more than a Category III quantity of SNM comply with the physical security requirements of 10 CFR 73.67 (10 CFR 150.14) and (2) subject to NRC licensing and regulatory authority those persons in Agreement States who engage in listed activities involving certain categories of radioactive waste material (10 CFR 150.15). This section discusses these requirements and potential revisions, as appropriate, which could provide flexibility for Agreement State licensing and regulatory oversight of a GTCC waste disposal facility.

[79] 10 CFR § 72.3 (definition of "Greater than Class C waste or GTCC waste").

4.3.1 Control of SNM during Operations

Operations at a near-surface disposal facility could involve the handling and storage of GTCC waste packages containing SNM. As described in Section 3.2, an Agreement State near-surface disposal facility licensee would become subject to NRC regulatory oversight if the licensee receives or possesses SNM in quantities that exceed the 10 CFR 150.14 mass thresholds. If the Agreement State licensee receives or possesses SNM above the 10 CFR 150.14 mass thresholds, then in accordance with 10 CFR 150.14, the licensee must satisfy the physical security requirements of 10 CFR 73.67, a regulation that can only be enforced by the NRC. Most likely, an Agreement State licensee would either need to obtain an NRC license or become subject to an NRC order, to allow for NRC oversight, inspection and enforcement of the 10 CFR 73.67 requirements. Therefore, to avoid the necessity of an Agreement State licensee having to obtain an NRC license or be subject to an NRC order, a potential rulemaking could amend 10 CFR 150.14 to change the requirement to give Agreement State licensees the option of complying with the applicable Agreement State's compatible regulations for 10 CFR Part 37 in lieu of those of 10 CFR 73.67. Although the 10 CFR Part 37 regulations concern physical protection of licensed materials, including certain categories of SNM, the 10 CFR Part 37 regulations were issued as health and safety regulations, rather than "common defense and security" regulations. Thus, an Agreement State can develop regulations that are compatible with the 10 CFR Part 37 regulations, and if approved by the NRC, the Agreement State can then enforce such compatible regulations. Although the requirements in 10 CFR Part 37 are generally more rigorous than 10 CFR 73.67, an Agreement State licensee exercising such a 10 CFR Part 37 Agreement State compatible regulation "option" would not be subject to regulation by the NRC.

4.3.2 Categories of Activities Generating GTCC Waste

The NRC's regulation at 10 CFR 150.15 requires that persons engaging in certain categories of activities are subject to NRC licensing and regulatory requirements. A potential rulemaking could amend 10 CFR 150.15 to remove two categories of persons from the scope of the regulation, thereby allowing for the two corresponding specific categories of GTCC waste to be received, stored, and disposed of in an Agreement State licensed near-surface disposal facility and relieving the licensee from having to comply with NRC licensing and regulatory requirements. The two categories are those persons who seek to store or dispose of GTCC waste resulting from the "separation in a production facility of special nuclear material from irradiated nuclear reactor fuel" (10 CFR 150.15(a)(4)), and those persons who seek to store or dispose of reactor-related GTCC waste (10 CFR 150.15(a)(8)).

5. Backfit and Issue Finality Analysis

Currently, no commercially-licensed land disposal facilities are authorized to dispose of GTCC wastes. New requirements associated with permitting such disposal would only affect a site opting to accept GTCC wastes in the future. Burdens resulting from any new regulatory requirements would only be undertaken following a voluntary determination by a disposal facility to accept such wastes. In the cost/impact analysis in Section 7 of this draft regulatory basis, the NRC staff provides a general overview of cost and notes that the costs and benefits will be further refined in a regulatory analysis should rulemaking be pursued. The NRC staff does not anticipate that any potential regulations authorizing the near-surface disposal of GTCC waste

would cause any commercially licensed land disposal facility to cease operating or prevent any new land disposal facility from being developed given that NRC is not planning to require current or future LLRW disposal facilities to accept GTCC waste and is instead providing a voluntary, potential increase in the range of wastes that facility may accept for disposal should the rulemaking be finalized.

The NRC's backfit and issue finality provisions appear in the regulations at 10 CFR 50.109, 52.39, 52.63, 52.83, 52.98, 52.145, 52.171, 70.76, 72.62, and 76.76. The potential requirements in this rule do not involve any provisions that would impose backfits on nuclear power plant licensees as defined in 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities," licensees under 10 CFR Part 70, "Domestic Licensing of Special Nuclear Material," 10 CFR Part 72, "Licensing Requirements for the Independent Storage of Spent Nuclear Fuel and High-Level Radioactive Waste, and Reactor-Related Greater Than Class C Waste," certificate holders under 10 CFR Part 76, "Certification of Gaseous Diffusion Plants," nor do they violate the issue finality provisions in 10 CFR Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants". These backfitting and issue finality provisions apply to proposed rule changes to the regulations governing licensees or certificate holders under those parts. The potential changes to 10 CFR Part 61 do not impose modifications of or addition to the systems, structures, components, or design of these facilities; nor would they require these licensees to modify the procedures or organization required to design, construct, or operate their facilities. Thus, the changes are not backfits. As a result, no backfit analysis is required for this rulemaking.

6. Stakeholder Involvement

In SRM-SECY-15-0094, the Commission directed the staff to conduct a public workshop during the development of this regulatory basis "to receive input from the State of Texas and any other interested stakeholders." As a first step in public outreach, the NRC staff issued, on February 14, 2018, a *Federal Register* notice (FRN) (83 FR 6475) requesting stakeholder comments in identifying the various technical issues that should be considered in the development of a regulatory basis for the disposal GTCC and TRU waste through means other than deep geologic disposal. The staff held two public meetings during the public comment period, February 22, 2018, in Rockville, Maryland; and March 23, 2018, in Phoenix, Arizona. The public meetings were attended by more than 100 stakeholders, which included representatives from the nuclear industry, DOE, the Environmental Protection Agency, environmental groups, Agreement States, and a congressional staffer. In addition, the NRC staff made presentations on GTCC waste disposal at various technical and stakeholder symposiums, e.g., Waste Management 2018 (March), the (April) spring and (October) fall meetings of the Low-Level Radioactive Waste Forum, the 2018 Electric Power Research Institute International Low-Level Waste Conference, and the 2018 Organization of Agreement States Meeting.

The 60-day comment period for the GTCC FRN ended on April 16, 2018. The NRC received 12 comment submissions in response to the notice, which included more than 100 individual comments. The comment submissions are publicly available by searching under Docket ID NRC-2017-0081 at https://www.regulations.gov.

Most commenters were in favor of the NRC developing regulatory requirements regarding the disposal of GTCC waste in a 10 CFR Part 61 disposal facility. This draft regulatory basis includes the staff's consideration of the oral and written comments received in response to the FRN and public meetings.

7. Cost/Impact Considerations

This section discusses the costs and benefits of alternative approaches for the implementation of the proposed changes presented in Section 4, "Potential Revisions to the NRC's Regulations." The alternatives include: (1) no regulatory changes; (2) develop new guidance; and (3) conduct rulemaking. This section discusses potential impacts on five entities or groups: (1) land disposal facility licensees; (2) Agreement States; (3) Tribal Nations; (4) the DOE; and (5) the NRC. Potential environmental impacts also are discussed. The analyses presented in this section are primarily qualitative and based on the NRC staff's best assessment of impacts. Although there is some quantitative costing of the alternatives, the values are preliminary estimates of the incremental costs to compare the evaluated alternatives. After receipt of public comments on this draft regulatory basis, the staff will consider this input on the cost and impact of the proposed changes. If the rulemaking alternative is selected, the staff will prepare a regulatory analysis to support the proposed rule.

7.1 Applicability

The revised regulations or policies would apply to all new and currently operating near-surface LLRW disposal facilities that opt to accept GTCC waste for disposal. In addition, to the extent Agreement State compatibility applies, an Agreement State would need to agree to accept the waste and may be required to update their requirements if they decided to regulate the disposal of GTCC waste.

7.2 Affected Entities

The staff estimates that these alternatives will potentially affect the following five entities. The impacts to each of these entities are quantified when possible and an uncertainty analysis, contained in Appendix D, is performed to report benefit and cost estimate confidence levels and to identify those variables that most affect the variation in the results distribution.

7.2.1 Licensees

Currently, there are four LLRW disposal facilities in the United States and all are located in, and regulated by, Agreement States. The licensee and facility locations are:

1. Energy*Solutions* - Barnwell, South Carolina
2. Energy*Solutions* - Clive, Utah (only accepts Class A waste for disposal)
3. U.S. Ecology - Richland, Washington
4. Waste Control Specialists - Andrews County, Texas

Because the disposal of GTCC waste is a Federal responsibility, the NRC cannot require an NRC or Agreement State licensee to accept disposal of GTCC waste at its facility. Thus, there

would be no impact on a new or existing disposal site unless the licensee voluntarily requested authorization to dispose of GTCC waste and in the case of an Agreement State licensee, the Agreement State agreed to allow for the disposal of the waste. It is likely that a disposal facility only would seek to dispose of GTCC waste if the facility determined that it would be to its financial benefit.

7.2.2 Agreement States

The Agreement States that license the four currently operating LLRW disposal facilities are South Carolina, Utah, Washington, and Texas. There are, however, a total of 32 Agreement States with the authority to regulate the disposal of low-level radioactive waste. If the Commission approves the near-surface disposal of all or some GTCC waste streams and for Agreement State regulatory oversight for such disposals, then an Agreement State may license a new or existing near-surface disposal facility that can accept GTCC waste provided that all the requirements of Section 274 of the AEA have been satisfied.

7.2.3 Tribal Nations

A Tribal Nation may be a stakeholder in any licensing of a near-surface disposal facility that can accept GTCC waste in accordance with Subpart F of 10 CFR Part 61.

7.2.4 The DOE

The DOE is responsible by law for the disposal of GTCC waste. Permitting the near-surface disposal of GTCC waste would provide DOE an alternative to the current expectation that GTCC waste would be disposed of in a geologic repository.

7.2.5 The NRC

The NRC is authorized to regulate the disposal of commercially-generated LLRW. The NRC's LLRW regulations are set forth in 10 CFR Part 61, "Licensing Requirements for Land Disposal of Radioactive Waste." The NRC can relinquish its regulatory authority relating to the disposal of commercially-generated LLRW to an Agreement State pursuant to Section 274 of the AEA.

7.3 Analysis Assumptions

Assumptions used are identified throughout this document. For reader convenience, major assumptions are listed below.

7.3.1 General Assumptions

The NRC has never issued a license for the near-surface disposal of GTCC waste. Therefore, the incremental costs and benefits included in this analysis for the implementation of a method to allow this type of disposal are preliminary and provided for comparison purposes.

For Alternatives 1 and 2, the NRC staff considered two possible approaches–(1) in which the NRC issues a 10 CFR Part 61 license for the near-surface disposal of GTCC waste and (2) in

which the NRC approves, in accordance with Section 274 of the AEA, an Agreement State to issue the license for a land disposal facility to accept GTCC waste.

For Alternative 3, the NRC staff assumes that an Agreement State would license the near-surface disposal facility following the NRC's promulgation of the rule, and that all requirements of AEA Section 274 and the NRC's Agreement State program have been met, including the Agreement State's promulgation of compatible regulations.

The estimated costs are intended to provide information on how to best implement the authority for the near-surface disposal of GTCC waste. These cost estimates do not include other costs related to the actual operation of a disposal facility (such as siting and construction) or the packaging, transportation, and disposal of the GTCC waste. GTCC waste currently is stored at a variety of locations, and the storage costs to be incurred until future disposal are not included in any cost estimates.

The NRC staff interprets 10 CFR 61.55(a)(2)(iv) as requiring Commission approval of any case-by-case request for the disposal of GTCC waste, even if such waste were to be disposed in a land disposal facility licensed by an Agreement State.

The timing for GTCC disposal activities is uncertain and may depend upon the alternative selected. Other factors that may impact timing include: (1) obtaining Commission approval for the land disposal of GTCC waste (Alternatives 1 and 2); (2) an Agreement State's interest in licensing a near-surface disposal facility that can accept this waste (Alternatives 1, 2, and 3), as well as characterization studies and the preparation of an application; (3) the evaluation of the application by the NRC or Agreement State staff, including the preparation of either an environmental impact statement or environmental assessment or Agreement State equivalent; and (4) those activities related to issuing a license (such as providing an opportunity for a hearing). With respect to the preparation of either an environmental impact statement or environmental assessment or Agreement State equivalent, the NRC staff assumes that such document will only be prepared when and if a site-specific application is received. The preparation costs are identified as "environmental compliance" costs and these costs are assumed to be the same for each alternative.

The NRC staff assumes that only one of the existing LLRW disposal facilities would express interest in accepting and disposing of GTCC waste because of the comparably small volume of GTCC waste that has been or is expected to be generated. The staff also evaluates the opportunity cost if no disposal facility elects to accept GTCC waste for disposal.

7.3.2 Disposal Facility Assumptions

For this analysis, the NRC staff assumes that an existing near-surface disposal facility expresses interest in accepting GTCC waste. Only the costs to license the facility to accept GTCC waste for disposal is analyzed in this regulatory basis document.

7.4 Evaluation of Alternatives

This section considers rulemaking and two other alternatives (no regulatory changes and development of guidance) that could be used to achieve the goal of allowing GTCC waste to be

disposed in a near-surface LLRW disposal facility. The following subsections discuss each alternative.

7.4.1 Alternative 1—No Regulatory Changes

Under the "no regulatory changes" alternative, the NRC staff assumes only one applicant for GTCC disposal (from an existing LLRW disposal facility) would submit a request directly to the NRC for a license. As provided under 10 CFR 61.55(a)(2)(iv), the primary disposal pathway for GTCC waste is disposal in a 10 CFR Part 60 or 63 geologic repository and holders of GTCC waste would continue to store GTCC waste until such a repository is available. However, this provision allows a person to request, and for the Commission to approve, the disposal of GTCC waste in a LLRW land disposal facility on a case-by-case basis. In this regard, if the Commission approves the request and after the site-specific application is evaluated and approved by the NRC staff, the Commission can authorize GTCC waste disposal at a land disposal facility that can be licensed by either the NRC or an Agreement State.

The "no regulatory changes" alternative means that the NRC would take no further action related to the disposal of GTCC waste in a land disposal facility until the NRC received a site-specific request and application. The Commission, after input from the NRC staff, would determine whether to approve the request. If the request and application are approved, either the NRC staff would issue a 10 CFR Part 61 license or the Agreement State would issue the license after complying with any Commission conditions or requirements . After issuing the license, the relevant regulatory authority (either NRC or the Agreement State) would be responsible for regulatory oversight, including conducting inspection and any necessary enforcement activities.

Under this alternative, the NRC would not undertake any regulatory changes to 10 CFR Part 61 or other parts of the regulations and would not revise or issue new guidance to address the disposal of GTCC waste. The "no regulatory changes" alternative would avoid the costs that the guidance and rule alternative would impose. This alternative serves as a baseline to measure the incremental costs and benefits of the other alternatives.

Assessment of land disposal facility that can accept GTCC waste licensed by the NRC

This alternative would defer any costs for the regulator or applicant until a potential applicant expressed interest, rather than committing costs that the other two alternatives would incur regardless of whether any person expressed interest through the filing of an application for GTCC waste disposal. On balance, the actual licensing process may be relatively efficient because of the limited amount of GTCC waste volume and the NRC staff's expectation that only one facility may pursue a license for this activity in the foreseeable future.

This alternative would provide opportunities for public involvement during the licensing process if the NRC staff prepares an environmental impact statement and if a hearing is requested. The NRC staff expects that this alternative would achieve similar results to those achieved by the other alternatives, although reaching those results after the NRC receives an application could take longer because the technical acceptance criteria would need to be developed to conduct the review.

The advantages and disadvantages of this alternative are provided in Table 7-1. The estimated costs to license the disposal facility for GTCC waste based on current regulations and guidance are provided in Table 7-2.

Because there are no actions performed unless an applicant elects to pursue the disposal of GTCC waste at its facility, no costs will be incurred until an applicant submits a request to the Commission for the disposal of GTCC waste in a land disposal facility.

Table 7-1 Alternative 1 – Advantages and Disadvantages

Advantages	Disadvantages
1. Resources are not expended unless a request for the near-surface disposal of GTCC waste is received by the NRC. 2. Costs for implementation could be lower if only limited types of GTCC waste (e.g., GTCC waste not containing TRU radionuclides or SNM) are considered for disposal. 3. Implementation may be faster for a limited GTCC waste disposal proposal than for a proposal to dispose of all types of GTCC waste at a given facility.	1. The NRC currently has no established process for evaluating and approving an application for a land disposal facility that can accept GTCC waste under the case-by-case review process of 10 CFR 61.55(a)(2)(iv). Similarly, the NRC has no established process for approving an Agreement State licensing such a facility. 2. An application approval under the case-by-case review process of 10 CFR 61.55(a)(2)(iv) is not as transparent as rulemaking, which has established opportunities for public involvement, particularly during the development of any proposed requirements. 3. Multiple applications or separate requests to expand types of GTCC waste that can be disposed could lead to higher costs.

Table 7-2 Alternative 1 Costs for the NRC to License a Facility to Dispose of GTCC Waste in a Near-Surface Land Disposal

Year	Activity	Implementation Costs [a,b]		
		Undiscounted	7% NPV [c]	3% NPV
2023	Licensee develop and submit application to NRC for disposal of GTCC	($491,000)	($374,000)	($436,000)
2024		($327,000)	($233,000)	($282,000)
2025	Licensee participation in license hearing and public meetings	($122,000)	($82,000)	($103,000)
2025	Licensee review and comment on GTCC license conditions	($18,000)	($12,000)	($15,000)
2025	Licensee revise operational procedures for GTCC disposal	($46,000)	($31,000)	($38,000)
Disposal Licensees Total		**($1,004,000)**	**($732,000)**	**($874,000)**
2025	Agreement State participation in license hearing and public meetings	($58,000)	($38,000)	($48,000)
Agreement State Total		**($58,000)**	**($38,000)**	**($48,000)**

Year	Activity	Implementation Costs [a,b]		
		Undiscounted	7% NPV [c]	3% NPV
2025	Tribal consultation on environmental compliance	($24,000)	($16,000)	($20,000)
2025	Tribal participation in license hearing and public meetings	($19,000)	($13,000)	($16,000)
	Tribal Nations Total	**($43,000)**	**($29,000)**	**($36,000)**
2025	DOE participation in license hearing and public meetings	($76,000)	($50,000)	($63,000)
	DOE Total	**($76,000)**	**($50,000)**	**($63,000)**
2024	NRC review disposal request submittal	($177,000)	($126,000)	($153,000)
2025		($177,000)	($118,000)	($149,000)
2024	NRC environmental compliance costs	($85,000)	($60,000)	($73,000)
2025		($28,000)	($19,000)	($24,000)
2025	NRC participation in license hearing and public meetings	($200,000)	($133,000)	($167,000)
2026	NRC finalize and issue license	($52,000)	($32,000)	($42,000)
2026	NRC prepares and issue GTCC inspection procedures	($46,000)	($29,000)	($38,000)
	NRC Total	**($766,000)**	**($518,000)**	**($645,000)**
TOTAL		**($1,946,000)**	**($1,367,000)**	**($1,667,000)**

[a] The analysis assumes that one disposal facility begins developing its GTCC near-surface disposal application in year 2023 and submits the application for NRC review in year 2024. This timing was selected to provide a direct comparison to estimated licensing costs for the other alternatives.

[b] Estimates are in 2019 dollars and are rounded to the nearest thousand dollars.

[c] NPV is defined as net present value.

Assessment of a land disposal facility accepting GTCC waste licensed by an Agreement State

Under the 10 CFR 61.55(a)(2)(iv) case-by-case review process, the Commission could approve an alternative allowing for an Agreement State to license a land disposal facility that can accept GTCC waste. Under this approach, the Commission would need to determine whether the proposed GTCC waste streams could be safely disposed of in a land disposal facility in accordance with AEA Section 274c.(4). To make that determination, the NRC staff would need to develop mechanisms for evaluating the application and making the requisite technical findings. While this alternative provides for a regulatory solution for Agreement State licensing for facilities disposing of GTCC waste, the process would be developed in parallel with licensing activities, which may result in additional costs. The initial evaluation of the application and any eventual approval of an Agreement State's licensing of such a land disposal facility would be a case of first impression, although any subsequent application could rely upon some of the groundwork established during the review of the initial application.

The NRC staff assumes that if an Agreement State sought to license a disposal facility for GTCC waste under an Agreement State license, then the NRC would need to evaluate whether other regulatory steps were appropriate, such as establishing a mechanism (e.g., issuance of an NRC order to the licensee) for ensuring the material is physically protected consistent with the

requirements of 10 CFR 73.67, a “common defense and security” regulation, if the Agreement State licensee’s operations will result in the mass thresholds of 10 CFR 150.14 being exceeded.

7.4.2 Alternative 2—New Guidance

Under this alternative the NRC would develop and issue guidance that describes the acceptable methods for meeting the performance objectives and other requirements of 10 CFR Part 61 and that describes the site-specific request and application process. This alternative does not change the current provisions in 10 CFR Part 61, which states that the preferred GTCC waste default disposal track is disposal in a 10 CFR Part 60 or 63 geologic repository.

Under this alternative, the NRC would not undertake any regulatory changes to 10 CFR Part 61 or other parts of its regulations. Therefore, the activities following the applicant’s submission of its site-specific request and application is expected to be similar to those modeled in Alternative 1.

The NRC staff’s development and issuance of GTCC guidance would use a notice and comment process in which the NRC staff would issue the draft guidance document for public comment. After the public comments are considered and incorporated, if appropriate, the staff would issue the guidance.

This alternative would provide opportunities for public involvement during the licensing process if the NRC staff prepares an environmental impact statement and if a hearing is requested. Under this alternative, the NRC staff expects that the licensing process, after Commission approval under 10 CFR 61.55(a)(2)(iv), may be more straightforward than for Alternative 1 because the appropriate requirements and methodologies are identified in the issued guidance. The NRC staff estimated that the resources necessary for preparation of an application and licensing activities for the involved parties are between 10 percent and 30 percent less (with a mean value of 20 percent) than is required for Alternative 1. This reduction in costs is due to the additional clarity for the technical analyses in areas such as operational accidents, intruder analyses, post-closure individual dose assessment, and thermal impacts on engineered barriers due to heat-generating waste. If the request and application are approved, either the NRC would issue a 10 CFR Part 61 license or the Agreement State would issue the license after complying with any Commission conditions or requirements . After issuing the land disposal facility license, the relevant regulatory authority (either NRC or the Agreement State) would be responsible for regulatory oversight, including conducting inspection and any necessary enforcement activities.

The risk of pursuing this alternative is realized if no applicant decides to submit a request for the disposal of GTCC waste in a land disposal facility.

Assessment of land disposal facility that can accept GTCC waste licensed by the NRC

The advantages and disadvantages of Alternative 2 are provided in Table 7-3 and the estimated costs for the NRC to license the disposal facility for GTCC waste based on current regulations and with new guidance are provided in Table 7-4.

Table 7-3 Alternative 2 – Advantages and Disadvantages

Advantages	Disadvantages
1. Guidance provides clarity as to what the NRC would require, allowing the prospective applicant to determine earlier if preparing an application is feasible. 2. Implementation, after receipt of an application, would be more straightforward than the no regulatory changes alternative because potential requirements would already be developed. 3. Guidance may be completed sooner and at less cost than rulemaking. 4. In comparison to rulemaking, this alternative limits the risk of expending resources if no applicant submits a request for the land disposal of GTCC waste (as resources were only expended on the development and issuance of guidance).	1. Committing NRC resources to develop guidance although there may be limited interest in applications for GTCC waste land disposal. 2. Approving an application under the case-by-case review process of 10 CFR 61.55(a)(2)(iv) is not as transparent as rulemaking, which has established opportunities for public involvement, particularly during the development of any proposed requirements. 3. Establishing a licensing process that is useful for Agreement State licensing may introduce additional costs such that the incremental costs between new guidance and rulemaking are diminished. 4. Establishing regulations reduces the potential for inconsistent implementation through the use of case-by-case reviews if more than one applicant applies. Guidance documents are not binding upon a licensee, and as such, do not have the same regulatory effect as a regulation. 5. Reviewing multiple applications or separate requests to expand types of GTCC waste that can be disposed could lead to higher costs.

Table 7-4 Alternative 2 Costs for the NRC to License a Facility to Dispose of GTCC Waste in a Near-Surface Land Disposal

Year	Activity	Implementation Costs [a,b]		
		Undiscounted	7% NPV	3% NPV
2021	Disposal licensees review and comment on draft guidance	($28,000)	($24,000)	($26,000)
2021	Disposal licensees read issued guidance	($28,000)	($24,000)	($26,000)
2023	Licensee develop and submit application to NRC for disposal of GTCC	($392,000)	($299,000)	($349,000)
2024		($262,000)	($187,000)	($226,000)
2025	Licensee participation in license hearing and public meetings	($99,000)	($66,000)	($83,000)
2025	Licensee review and comment on GTCC license conditions	($18,000)	($12,000)	($15,000)
2025	Licensee revise operational procedures for GTCC disposal	($37,000)	($24,000)	($31,000)
Disposal Licensees Total		**($864,000)**	**($637,000)**	**($756,000)**

Year	Activity	Implementation Costs [a,b]		
		Undiscounted	7% NPV	3% NPV
2021	Agreement State review and comment on draft guidance	($10,000)	($9,000)	($10,000)
2025	Agreement State participation in in license hearing and public meetings	($49,000)	($32,000)	($41,000)
	Agreement State Total	**($59,000)**	**($41,000)**	**($50,000)**
2021	Tribal review and comment on draft guidance	($4,000)	($3,000)	($4,000)
2025	Tribal consultation on environmental compliance	($24,000)	($16,000)	($20,000)
2025	Tribal participation in license hearing and public meetings	($19,000)	($13,000)	($16,000)
	Tribal Nations Total	**($47,000)**	**($32,000)**	**($40,000)**
2021	DOE review and comment on draft guidance	($9,000)	($8,000)	($8,000)
2025	DOE participation in license hearing and public meetings	($76,000)	($50,000)	($63,000)
	DOE Total	**($84,000)**	**($58,000)**	**($72,000)**
2020	Develop and issue draft guidance for GTCC disposal	($77,000)	($72,000)	($75,000)
2021		($52,000)	($45,000)	($49,000)
2022	Finalize and issue guidance for GTCC disposal	($77,000)	($63,000)	($71,000)
2023		($52,000)	($39,000)	($46,000)
2024	NRC review disposal request submittal	($142,000)	($101,000)	($122,000)
2025		($142,000)	($95,000)	($119,000)
2024	NRC environmental compliance costs	($85,000)	($60,000)	($73,000)
2025		($28,000)	($19,000)	($24,000)
2025	NRC participation in license hearing and public meetings	($159,000)	($106,000)	($133,000)
2026	NRC finalize and issue license	($52,000)	($32,000)	($42,000)
2026	NRC prepares and issue GTCC inspection procedures	($46,000)	($29,000)	($38,000)
	NRC Total	**($912,000)**	**($662,000)**	**($791,000)**
TOTAL		**($1,966,000)**	**($1,430,000)**	**($1,709,000)**

[a] The analysis assumes that one disposal facility begins developing its GTCC near-surface disposal application in year 2023 and submits the application for NRC review in year 2024. This timing was selected to provide a direct comparison to estimated licensing costs for the other alternatives.

[b] Estimates are in 2019 dollars and are rounded to the nearest thousand dollars.

[c] NPV is defined as net present value.

Table 7-5 presents the costs if no disposal facility elects to pursue near-surface land disposal of GTCC waste.

Table 7-5 Alternative 2 Costs if No Facility Elects to Dispose of GTCC Waste in a Near-Surface Land Disposal

Year	Activity	Implementation Costs [a]		
		Undiscounted	7% NPV [b]	3% NPV
2021	Disposal licensees review and comment on draft guidance	($28,000)	($24,000)	($26,000)
2021	Disposal licensees read issued guidance	($28,000)	($24,000)	($26,000)
	Disposal Licensees Total	**($55,000)**	**($48,000)**	**($52,000)**
2021	Agreement State review and comment on draft guidance	($10,000)	($9,000)	($10,000)
	Agreement State Total	**($10,000)**	**($9,000)**	**($10,000)**
2021	Tribal review and comment on draft guidance	($4,000)	($3,000)	($4,000)
	Tribal Nations Total	**($4,000)**	**($3,000)**	**($4,000)**
2021	DOE review and comment on draft guidance	($9,000)	($8,000)	($8,000)
	DOE Total	**($9,000)**	**($8,000)**	**($8,000)**
2020	Develop and issue draft guidance for GTCC disposal	($77,000)	($72,000)	($75,000)
2021		($52,000)	($45,000)	($49,000)
2022	Finalize and issue guidance for GTCC disposal	($77,000)	($63,000)	($71,000)
2023		($52,000)	($39,000)	($46,000)
	NRC Total	**($258,000)**	**($220,000)**	**($240,000)**
TOTAL		**($336,000)**	**($288,000)**	**($314,000)**

[a] Estimates are in 2019 dollars and are rounded to the nearest thousand dollars.
[b] NPV is defined as net present value.

Assessment of land disposal facility that can accept GTCC waste licensed by an Agreement State

Under this licensing approach, the NRC would provide for a regulatory solution for Agreement State licensing for facilities disposing of GTCC waste by establishing guidance (e.g., procedures) to direct and assist both the NRC and Agreement State staffs in evaluating an application that would allow for an Agreement State to license a land disposal facility that can accept GTCC waste under the 10 CFR 61.55(a)(2)(iv)case-by-case review process . As a result, the NRC staff expects that the licensing process, after Commission approval under 10 CFR 61.55(a)(2)(iv), may be more straightforward than for Alternative 1 because the appropriate procedures and methodologies could be identified in the issued guidance.

7.4.3 Alternative 3—Conduct Rulemaking

Under this alternative, the NRC would promulgate regulations and develop guidance specifically for the near-surface disposal of GTCC waste in a near-surface disposal facility. This alternative would establish a regulatory framework for addressing the unique disposal and regulatory oversight requirements for GTCC wastes. The regulatory requirements would also provide the

basis for Agreement States to regulate the disposal of GTCC waste to the extent allowable under section 274 of the AEA.

Assessment of Alternative 3

Under this alternative, the rule would inform potential applicants for near-surface disposal facilities what would be required of them to ensure the safe disposal of GTCC waste. A rulemaking, as described in this draft regulatory basis, would also amend certain NRC regulations to accommodate Agreement State licensing of near-surface disposal facilities that can accept GTCC waste. For example, a potential amendment would allow an Agreement State licensee to receive and store GTCC waste containing SNM in excess of the 10 CFR 150.14 mass thresholds without NRC regulatory oversight by allowing the licensee to comply with the Agreement State compatible regulations for 10 CFR Part 37 in lieu of 10 CFR 73.67.

A rule would provide a clear regulatory path for the alternative disposal of most GTCC waste in a location other than a geologic repository and with the greatest level of transparency. Rulemaking would also ensure greater regulatory consistency of GTCC waste disposal in the near surface should multiple applications be received.

The rulemaking alternative would take longer and require more resources than the other evaluated alternatives and, like Alternative 2, runs the risk that there will be no interested applicants. However, this alternative would provide information that a potential applicant could use to more accurately estimate potential costs and provide the applicant with a higher level of confidence in determining whether their application would be acceptable.

This alternative would provide opportunities for public involvement during the rulemaking process. Although the upfront costs for the rulemaking alternative are estimated to be greater than for the other alternatives, the NRC staff estimated that the resources necessary for preparation of an application and licensing activities for the involved parties are between 10 percent and 50 percent less (with a mean value of 30 percent) than is required for Alternative 1. This reduction in costs is due to the additional clarity established by the rule and associated guidance for the technical analyses in areas such as operational accidents, intruder analyses, post-closure individual dose assessment, and thermal impacts on engineered barriers due to heat-generating waste.

The advantages and disadvantages of this alternative are provided in Table 7-6 and the estimated incremental costs when compared to Alternative 1 are provided in Table 7-7.

Table 7-6 Alternative 3 – Advantages and Disadvantages

Advantages	Disadvantages
1. Establishes requirements for the near-surface disposal of GTCC waste on a generic basis, thereby improving the quality of facility applications. • Promotes greater regulatory stability, predictability, and clarity for the disposal of GTCC waste. • Would provide Agreement State regulators a regulatory framework to develop compatible regulations. • Would provide efficiency gains in licensing process to all potential licensees because regulations could be generically applied. • Provides greater level of transparency than other alternatives because of public involvement through notice and comment rulemaking. 2. Allows an Agreement State licensee to receive and store GTCC waste containing SNM in excess of the 10 CFR 150.14 mass thresholds without NRC regulatory oversight by allowing the licensee to comply with the Agreement State compatible regulations for 10 CFR Part 37 in lieu of 10 CFR 73.67. 3. Provides less risk of challenges during licensing actions because regulatory framework would be clearer than other alternatives. 4. Allows for existing Agreement State LLRW disposal facility licensees to be regulated only by the Agreement State and thus, avoid duplicative costs and other potential issues that could result from the NRC and the Agreement State both having regulatory oversight over the same facility.	1. Commits NRC resources to develop rulemaking and associated guidance, when there may be limited interest by applicants willing to accept and dispose of GTCC waste. 2. Requires more NRC resources to implement than the other alternatives.

Table 7-7 Alternative 3 Costs for the NRC to License a Facility to Dispose of GTCC Waste in a Near-Surface Land Disposal

Year	Activity	Implementation Costs [a,b]		
		Undiscounted	7% NPV	3% NPV
2021	Disposal licensees review and comment on proposed rule and draft guidance and participate in public meetings	($41,000)	($36,000)	($39,000)
2023	Disposal licensees reads final rule and final guidance	($41,000)	($32,000)	($37,000)
2023		($360,000)	($275,000)	($320,000)

Year	Activity	Implementation Costs [a,b]		
		Undiscounted	7% NPV	3% NPV
2024	Disposal licensee develops and submits application to Agreement State for disposal of GTCC	($240,000)	($171,000)	($207,000)
2025	Disposal licensee develops and revises operational procedures for GTCC disposal	($37,000)	($24,000)	($31,000)
	Disposal Licensee Total	**($720,000)**	**($538,000)**	**($634,000)**
2021	Agreement State reviews and comments on proposed rule and draft guidance and participate in public meetings	($20,000)	($18,000)	($19,000)
2023	Agreement State reads final rule and final guidance	($24,000)	($18,000)	($21,000)
2024	Review application submitted by licensee for disposal of GTCC	($320,000)	($228,000)	($276,000)
2025	Agreement State develops requirements for GTCC disposal and issues regulation	($158,000)	($105,000)	($132,000)
2025	Agreement State environmental compliance costs	($79,000)	($53,000)	($66,000)
2025	Agreement State prepares and issues GTCC disposal inspection procedures	($25,000)	($17,000)	($21,000)
2025	Amend agreement with NRC	($115,000)	($76,000)	($96,000)
2025	Agreement State coordination and other required licensing actions	($72,000)	($48,000)	($60,000)
2026	Agreement State issues license amendment for GTCC disposal	($25,000)	($16,000)	($21,000)
	Agreement State Total	**($839,000)**	**($579,000)**	**($713,000)**
2021	Tribal review and comment on proposed rule and draft guidance and participate in public meetings	($6,000)	($6,000)	($6,000)
2025	Tribal consultation on environmental compliance	($24,000)	($16,000)	($20,000)
2025	Tribal participation in license hearing and public meetings	($10,000)	($6,000)	($8,000)
	Tribal Nation Total	**($40,000)**	**($28,000)**	**($34,000)**
2021	DOE review and comment on proposed rule and draft guidance and participate in public meetings	($30,000)	($27,000)	($29,000)
2023	DOE read final rule and final guidance	($22,000)	($17,000)	($20,000)
	DOE Total	**($52,000)**	**($43,000)**	**($48,000)**
2020	Develop and issue proposed rule for public comment	($433,000)	($405,000)	($421,000)
2021		($289,000)	($252,000)	($272,000)
2020	Prepare and issue draft guidance to complement the proposed rule	($77,000)	($72,000)	($75,000)
2021		($52,000)	($45,000)	($49,000)
2022	Develop and issue final rule	($232,000)	($190,000)	($212,000)

Year	Activity	Implementation Costs [a,b]		
		Undiscounted	7% NPV	3% NPV
2023		($232,000)	($177,000)	($206,000)
2022	Develop and issue final guidance	($65,000)	($53,000)	($59,000)
2023		($65,000)	($49,000)	($57,000)
2025	Review amended agreement with Agreement State	($226,000)	($141,000)	($184,000)
NRC Total		**($1,574,000)**	**($1,329,000)**	**($1,460,000)**
TOTAL		**($3,225,000)**	**($2,518,000)**	**($2,889,000)**

[a] The analysis assumes that one disposal facility begins developing its GTCC near surface disposal application in year 2023 and submits the application for NRC review in year 2024, as previously discussed in Table 7-2.
[b] Estimates are in 2019 dollars and are rounded to the nearest thousand dollars.
[c] NPV is defined as net present value.

Table 7-8 presents the costs if no disposal facility elects to pursue near-surface land disposal of GTCC waste.

Table 7-8 Alternative 3 Costs if No Facility Elects to Dispose of GTCC Waste in a Near-Surface Land Disposal

Year	Activity	Net Implementation Costs [a]		
		Undiscounted	7% NPV	3% NPV
2021	Disposal licensees review and comment on proposed rule and draft guidance and participate in public meetings	($41,000)	($36,000)	($39,000)
2023	Disposal licensees reads final rule and final guidance	($41,000)	($32,000)	($37,000)
Disposal Licensee Total		**($83,000)**	**($68,000)**	**($76,000)**
2021	Agreement State reviews and comments on proposed rule and draft guidance and participate in public meetings	($20,000)	($18,000)	($19,000)
2023	Agreement State reads final rule and final guidance	($24,000)	($18,000)	($21,000)
Agreement State Total		**($44,000)**	**($36,000)**	**($41,000)**
2021	Tribal review and comment on proposed rule and draft guidance and participate in public meetings	($6,000)	($6,000)	($6,000)
Tribal Nation Total		**($6,000)**	**($6,000)**	**($6,000)**
2021	DOE review and comment on proposed rule and draft guidance and participate in public meetings	($30,000)	($27,000)	($29,000)
2023	DOE read final rule and final guidance	($22,000)	($17,000)	($20,000)
DOE Total		**($52,000)**	**($43,000)**	**($48,000)**
2020	Develop and issue proposed rule for public comment	($433,000)	($405,000)	($421,000)
2021		($289,000)	($252,000)	($272,000)
2020		($77,000)	($72,000)	($75,000)

Year	Activity	Net Implementation Costs [a]		
		Undiscounted	7% NPV	3% NPV
2021	Prepare and issue draft guidance to complement the proposed rule	($52,000)	($45,000)	($49,000)
2022	Develop and issue final rule	($232,000)	($190,000)	($212,000)
2023		($232,000)	($177,000)	($206,000)
2022	Develop and issue final guidance	($65,000)	($53,000)	($59,000)
2023		($65,000)	($49,000)	($57,000)
NRC Total		**($1,445,000)**	**($1,243,000)**	**($1,352,000)**
TOTAL		**($1,631,000)**	**($1,396,000)**	**($1,523,000)**

7.5 Comparison of Alternatives

The comparison of the implementation costs for each alternative, with the premise that there is only one applicant for a disposal facility that can accept GTCC waste, is provided in Table 7-9. This table shows that the implementation costs for Alternatives 1 and 2 are within $60,000 and are expected to achieve the same licensing results as the costlier rulemaking alternative.

Table 7-9 Comparison of Alternatives for a Facility to Receive a License to Dispose of GTCC Waste in a Near-Surface Land Disposal

Alternative	Total Costs [a]		
	Undiscounted	7% NPV [b]	3% NPV
Alternative 1	($1,946,000)	($1,367,000)	($1,667,000)
Alternative 2	($1,966,000)	($1,430,000)	($1,709,000)
Alternative 3	($3,225,000)	($2,518,000)	($2,889,000)

[a] Estimates are in 2019 dollars and are rounded to the nearest thousand dollars.
[b] NPV is defined as net present value.

Table 7-10 displays the costs if no applicant expresses interest in a disposal facility that can accept GTCC waste.

Table 7-10 Costs if No Disposal Site Opts to Accept GTCC Waste

Alternative	Total Costs [a]		
	Undiscounted	7% NPV [b]	3% NPV
Alternative 1	$0	$0	$0
Alternative 2	($336,000)	($288,000)	($314,000)
Alternative 3	($1,631,000)	($1,396,000)	($1,523,000)

[a] Estimates are in 2019 dollars and are rounded to the nearest thousand dollars.
[b] NPV is defined as net present value.

Table 7-10 shows that there is a ($288,000) opportunity cost for Alternative 2 and a ($1,396,000) opportunity cost for Alternative 3 using a 7 percent discount factor if no applicant expresses interest in a disposal facility that can accept GTCC waste. These costs reflect the upfront costs for developing guidance and for rulemaking, respectively.

Table 7-11 shows how the costs are distributed between the affected entities based on which alternative is selected, if one applicant expresses an interest in a disposal facility that can accept GTCC waste. The estimates for each entity presented are for the 7-percent discounted case.

Table 7-11 Costs by Affected Entity if a Disposal Site Opts to Accept GTCC Waste

Affected Entity	Total Costs (7% NPV) [a]		
	Alternative 1	Alternative 2	Alternative 3
Licensee	($732,000)	($637,000)	($538,000)
Agreement State	($38,000)	($41,000)	($579,000)
Tribal Nations	($29,000)	($32,000)	($28,000)
DOE	($50,000)	($58,000)	($43,000)
NRC	($518,000)	($662,000)	($1,329,000)
Total	**($1,367,000)**	**($1,430,000)**	**($2,517,000)**

[a] Estimates are in 2019 dollars and are rounded to the nearest thousand dollars.

7.6 Cumulative Effects of Regulation

The NRC has implemented a program to address the possible cumulative effects of regulation in the development of regulatory bases for rulemakings. The cumulative effects of regulation are an organizational effectiveness challenge that results from a licensee or other affected entity implementing several complex positions, programs, or requirements within a prescribed implementation period and with limited available resources, including the ability to access technical expertise to address a specific issue. The NRC is requesting feedback from the public at the draft regulatory basis stage on the cumulative effects that may result from any NRC rulemaking to amend 10 CFR Part 61 as described in this draft regulatory basis.

7.7 Environmental Analysis

The DOE analyzed the environmental impact of disposal of GTCC waste in the near surface in its FEIS (DOE 2016). That FEIS estimated the total volume of such waste to be approximately 12,000 m^3. Only about one-half of that waste has been generated to date, with the remainder to be generated through 2083. The FEIS classified the waste as the following waste types: activated metals from decommissioning of nuclear reactors; sealed sources widely used in the medical industry to diagnose and treat illnesses and other uses; and other waste that consists of contaminated equipment, debris, scrap metal, and decommissioning waste. The FEIS suggested two disposal pathways, which are land disposal (near surface) at (1) generic commercial facilities and (2) DOE's WIPP geological repository in Carlsbad, New Mexico. In October 23, 2018, DOE issued an EA for the disposal of GTCC waste and GTCC-like waste at the WCS land disposal facility located in Andrews County, Texas. The FEIS and the EA identify and describe the potential environmental impacts of such disposal actions.

The issuance of this draft regulatory basis is categorically excluded from further analysis under the National Environmental Policy Act of 1969, as amended, pursuant to 10 CFR 51.22(c)(16),

as this draft regulatory basis is an informational and procedural document that does not impose any legal requirements.

7.8 NRC Strategic Plan

The proposed rulemaking (Alternative 3) would support the NRC's 2018–2022 Strategic Plan (NUREG-1614) (NRC 2018) in relation to the strategic goal of safety and the cross-cutting strategies of regulatory efficiency and openness.

For the safety goal, the proposed rulemaking would support NRC Safety Strategy 2, "Further risk-inform current regulatory framework in response to advances in science and technology, policy decisions, and other factors, including prioritizing efforts to focus on the most safety-significant issues." The rule would develop performance-based requirements for GTCC waste disposal that would be commensurate with the potential accident-related consequences to public health and safety. In addition, the rulemaking would support NRC Safety Strategy 3, "Enhance the effectiveness and efficiency of licensing and certification activities to maintain both quality and timeliness of licensing and certification reviews," by developing a performance-based regulatory framework that would significantly support an NRC licensing initiative with a future regulatory benefit, considering Commission and congressional interest in GTCC waste disposal.

7.9 Regulatory Flexibility Act

The Regulatory Flexibility Act, enacted in September 1980, requires agencies to consider the effect of their regulatory proposals on small entities, analyze alternatives that minimize effects on small entities, and make their analyses available for public comment.

None of the potential applicants, e.g., the four existing LLRW Agreement State licensees, fall within the definition of "small entities" set forth in the size standards established by the NRC in 10 CFR 2.810, "NRC Size Standards." Therefore, a proposed rulemaking would not have a significant economic effect on a substantial number of small entities.

7.10 Peer Review of Regulatory Basis

The Office of Management and Budget's "Final Information Quality Bulletin for Peer Review" (OMB 2014) requires each Federal agency to subject "influential scientific information" to peer review before dissemination. The Office defines "influential scientific information" as "scientific information the agency reasonably can determine will have or does have a clear and substantial impact on important public policies or private sector decisions." This draft regulatory basis document does not contain "influential scientific information." Therefore, there is no need for a peer review.

8. Summary

The NRC staff has analyzed the various GTCC waste streams identified in DOE's FEIS to determine whether, for each waste stream, disposal in a near-surface disposal facility is appropriate and, if so, whether a facility that can accept that waste stream must be regulated by

the NRC or if it can be regulated by an Agreement State. Table 8-1 provides the GTCC waste volumes as discussed in this summary. The staff determined most GTCC waste streams are potentially suitable for near-surface disposal and can be regulated by an Agreement State, as summarized below.

1. Most of the GTCC waste streams analyzed are potentially suitable for near-surface disposal (i.e., approximately 80 percent of the overall volume).

   Fifteen of the 17 GTCC waste streams analyzed by the NRC staff, constituting approximately 80 percent of the overall volume, are potentially suitable for near-surface disposal. The two waste streams determined not to be potentially suitable for near-surface disposal account for approximately 20 percent of the overall volume of GTCC waste and both waste streams have TRU radionuclides in concentrations exceeding 10,000 nCi/g. One of these waste streams is *sealed sources associated with neutron irradiators* (volume of 1,800 m^3) and the other is *remote-handled other waste from decontamination activities* at the WVDP (volume of 540 m^3). The 15 waste streams determined to be potentially suitable for near-surface disposal represent 8,945 m^3 of waste. The NRC staff has determined that successful compliance with the 10 CFR Part 61 regulatory requirements is dependent on waste inventories, site conditions, and facility design and operations.

   Given the relatively greater radiological hazards associated with GTCC waste, however, the NRC staff made its determination of potential suitability based on additional controls and analysis to support an application for GGTC waste disposal that would ensure protection to the inadvertent intruder and the offsite individual(s). In particular, the NRC staff has determined that an applicant for a near-surface disposal facility that can accept GTCC waste must: (i) prepare and submit, as part of its application, a site-specific intruder assessment demonstrating that the 10 CFR Part 61, Subpart C performance requirements for inadvertent intruder protection will be met; and (ii) must dispose of GTCC waste at a minimum depth of 5 meters below the surface of the earth and include a 500-year intruder barrier. Additionally, NRC staff intends on clarifying the scope of the technical analysis used to support compliance with 10 CFR 61.41, “Protection of the general population from releases of radioactivity,” by taking advantage of recent proposals regarding the scope of a performance assessment in 10 CFR Part 61 [consistent with SRM-SECY-16-0106, “Final Rule: Low-Level Radioactive Waste Disposal (10 CFR Part 61) (RIN 3150-AI92)” (ADAMS Accession No. ML17251B147)].

2. Most GTCC waste could be safely regulated by an Agreement State (i.e., approximately 95 percent of the volume of GTCC waste determined to be potentially suitable).

   Most GTCC waste streams determined to be potentially suitable for near-surface disposal (approximately 95 percent) could be safely regulated by an Agreement State. Regulatory changes to 10 CFR 150.14 and 150.15, however, are recommended to avoid “dual regulation” of the same licensee by both the Agreement State and the NRC. Specifically, the NRC’s regulations at 10 CFR 150.11 and 10 CFR 150.14 place certain restrictions on an Agreement State for licensing SNM. For purposes of determining the scope of Agreement State licensing of GTCC waste streams that contain SNM, it was assumed that: (i) all waste present at the site, prior to disposal, would comply with the 10 CFR 150.11 mass thresholds; and (ii) 10 CFR 150.14 would be revised so that an

Agreement State licensee receiving and storing GTCC waste at a near-surface disposal facility would have the option of complying with the Agreement State compatible regulations for 10 CFR Part 37 in lieu of 10 CFR 73.67. Based on these assumptions, the NRC staff determined that only one of the 15 waste streams deemed potentially suitable for near-surface disposal should not be regulated by an Agreement State. The determination was based on the anticipated difficulties in complying with the 10 CFR 150.11 mass thresholds for this waste stream (i.e., an anticipated waste stream from a potential facility for *other waste from Mo-99 production using MIPS*). This waste stream accounts for 355 m^3 of GTCC waste or approximately 4 percent of the overall amount of GTCC waste determined to be potentially suitable for near-surface disposal.

As discussed in Section 4.3, revisions to 10 CFR 150.14 are recommended to avoid the potential for dual regulation for security of SNM of low strategic significance. If 10 CFR Part 150.14 is not revised, then an Agreement State licensee accepting GTCC waste (potentially up to 210 m^3 of GTCC waste) or GTCC-like waste (potentially, up to 1,690 m^3 of GTCC-like waste), would need to obtain an NRC license in addition to its Agreement State license, or alternatively, the NRC will need to issue an order to cover the licensee's compliance with the physical security requirements of 10 CFR 73.67. Similarly, if a rulemaking is pursued, the NRC staff recommends that revisions to 10 CFR 150.15(a)(4) (requiring NRC licensing for persons in Agreement States engaging in the transfer, storage, or disposal of radioactive waste material resulting from the separation of SNM from irradiated fuel) and 10 CFR 150.15(a)(8) (requiring NRC licensing for persons in Agreement States storing power reactor related GTCC waste under 10 CFR Part 72) be considered if the objective is to relieve an Agreement State licensee of having to obtain an NRC license in addition to its Agreement State license for these categories of GTCC waste.

In conclusion, the NRC staff determined that, with respect to GTCC waste, 6,875 m^3 of GTCC waste is potentially suitable for near-surface disposal and 6,520 m^3 of this amount can be licensed by an Agreement State, assuming the quantity of SNM for all waste at the facility prior to disposal complies with the 10 CFR 150.11 mass thresholds. However, 210 m^3 of the 6,520 m^3 of GTCC waste, if accepted by an Agreement State licensee, could subject that licensee to NRC regulatory oversight for purposes of 10 CFR 73.67 compliance. Any Agreement State seeking to license a near-surface disposal facility that can accept the potentially suitable GTCC waste streams will need to show that its radiological protection program meets all applicable NRC Agreement State program requirements, such as demonstrating that its program is adequate to protect public health and safety and is compatible with the NRC's regulatory program.

In addition, the NRC staff has found that 2,070 m^3 of GTCC-like waste is potentially suitable for near-surface disposal and can be licensed by an Agreement State, assuming the quantity of SNM for all waste at the facility prior to disposal complies with the 10 CFR 150.11 mass thresholds. However, 1,690 m^3 of the 2,070 m^3 of GTCC-like waste, if accepted by an Agreement State licensee, could subject that licensee to NRC regulatory oversight for purposes of 10 CFR 73.67 compliance per 10 CFR 150.14.

Table 8-1 GTCC Waste Volumes

Waste Volume Categories	GTCC Waste (meters^3)	GTCC-like Waste (meters^3)
Overall Volume	8,675 (11 waste streams)	2,610 (6 waste streams)
Waste Considered Unsuitable for Near-Surface Disposal	1,800 (1 waste stream)	540 (1 waste stream)
Waste Considered Potentially Suitable for Near-Surface Disposal	6,875 (10 waste streams)	2,070 (5 waste streams)
Waste exceeding the thresholds in 10 CFR Part 150.11	355 (1 waste stream)	0
Waste Requiring Compliance with 10 CFR 73.67 under current 10 CFR Part 150.14	210 (1 waste stream)	1,690 (3 waste streams)

9. References

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Appendix A
Description of Waste Streams in the NRC's Hazards Evaluation

In February 2016, the Department of Energy (DOE) issued a final environmental impact statement (FEIS)[80] to consider the potential environmental impacts associated with constructing and operating a new facility or facilities, or using an existing facility, for the disposal of an estimated total volume of 12,000 m^3 (420,000 ft^3) of greater-than-Class C (GTCC) and GTCC-like waste anticipated to be generated through 2083 (DOE 2016; pages 1-3). The term "GTCC-like waste" is a term used by DOE to describe radioactive waste that is owned or generated by the DOE (including low-level radioactive waste [LLRW] and non-defense transuranic [TRU] waste) and that has characteristics similar to those of GTCC LLRW.

The FEIS categorized the GTCC waste into activated metals, sealed sources, and other waste. *Activated metals* are largely generated from the decommissioning of nuclear reactors. *Sealed sources* are widely used in equipment to diagnose and treat illnesses, sterilize medical devices, irradiate blood for transplant patients, nondestructively test structures and industrial equipment, and explore geologic formations to find oil and gas. The remaining GTCC waste is referred to as *other waste* and consists of contaminated equipment, debris, scrap metal, and decommissioning waste. Sources for other waste can include those from production of Mo-99 to the environmental cleanup activities at the West Valley Demonstration Project (WVDP), which includes cleanup of the Main Plant Process Building (MPPB) and the West Valley tank farm (WVTF,) as well as potential exhumation of the NRC Disposal Area. Additionally, DOE separated the waste streams into two different groups to draw a distinction between waste that either was already generated or would be generated by existing facilities and activities (termed Group 1 in the FEIS) and waste that may be generated by future activities for which clear decisions have not been made (termed Group 2 in the FEIS).

Although, the FEIS did not provide a table of specific sources of waste in a single table, the FEIS did provide information regarding the various sources of the waste included in the FEIS. The NRC used the information in the FEIS to separate the waste into 17 distinct waste streams (see Table A-1). The separation of the GTCC waste into 17 waste streams helped ensure the hazards evaluation appropriately associates the hazards with the specific waste streams.

[80] DOE, "Final Environmental Impact Statement for the Disposal of Greater-Than-Class C (GTCC) Low-Level Radioactive Waste and GTCC-Like Waste," DOE/EIS-0375 (February 2016).

Table A-1 Description of the Waste Streams in NRC's Hazards Evaluation

Waste Stream Category	DOE FEIS Waste Type	NRC Hazards Evaluation		
		Volume (m^3)	Waste Stream Source	Waste Stream Number
DOE FEIS **Group 1** (**current** activities and facilities)				
Activated Metals	GTCC	880	Commercial reactors (remote handled)	1
Sealed Sources	GTCC	1000	Cs-137 irradiators (contact handled)	2
		1800	Neutron irradiators (contact handled)	3
Other	GTCC-like	710	WVDP Decontamination of the MPPB (contact handled)	4
		540	WVDP Decontamination of the MPPB (remote handled)	5
DOE FEIS **Group 2** (**future** activities and facilities)				
Activated Metals	GTCC	370	Commercial reactors (remote handled)	6
		210	WVDP Exhumation of NRC Disposal Area (remote handled)	7
		525	Exhumation of State Disposal Area (remote handled)	8
Other	GTCC	1,900	WVDP Exhumation of NRC Disposal Area (remote handled)	9
		1,200	Exhumation of State Disposal Area (SNAP) (contact handled)	10
		400	Exhumation of State Disposal Area (contact handled)	11
		35	Mo-99 Production - MURR (remote handled)	12
		355	Mo-99 Production - MIPS (remote handled)	13
	GTCC-like	220	WVDP Decommissioning of MPPB and WVTF (contact handled)	14
		760	WVDP Decommissioning of MPPB and WVTF (remote handled)	15
		120	Pu-238 Production (contact handled)	16
		260	Pu-238 Production (remote handled)	17

Note: MURR – Missouri University Research Reactor; MIPS – Medical Isotope Production System; and SNAP – Systems for Nuclear Auxiliary Power

Appendix B
GTCC Waste Hazards Relative to 10 CFR Part 61 Requirements

B.1 Introduction

Greater-than-Class C (GTCC) waste may be generated by activities at facilities regulated by the NRC. These facilities include nuclear power reactors, facilities supporting the nuclear fuel cycle, and other facilities and licensees outside of the nuclear fuel cycle. GTCC waste includes but is not limited to: (1) transuranic (TRU) radionuclides (e.g., isotopes of plutonium) that contaminate nuclear fuel cycle wastes; (2) activated metals; (3) sealed sources; and (4) radioisotope product manufacturing wastes (i.e., wastes "occasionally generated as part of the manufacture of sealed sources, radiopharmaceutical products and other materials used for industrial, education, and medical applications")[81].

The hazards associated with GTCC waste disposal at near-surface disposal facilities would be present during operational and post-closure periods. These hazards could result in additional radiological exposures to occupational workers and members of the public. The NRC staff developed this appendix to provide a more detailed summary of the analysis in the main body of the draft regulatory basis. Although more detailed than the main body of the draft regulatory basis, this appendix is itself a more detailed summary of a technical report, "Technical Analyses of the Hazards of Disposal of Greater-Than-Class C (GTCC) Waste" (NRC, 2019), hereinafter, referred to as "Technical Analyses," which describes the analysis performed by the NRC staff and incorporates the analysis performed by the NRC contractor (The Center for Nuclear Waste Regulatory Analyses). The technical report provides a comparison and evaluation of the results reached by both the NRC and contractor staffs. The primary considerations in evaluating the hazards from GTCC waste disposal were:

- For the operational phase, different waste types and normal and accident exposure scenarios,
- For the post-closure phase for the inadvertent intruder, different waste types and forms, the depth to waste, and exposure scenario parameters, and
- For the post-closure phase for the offsite individual, different waste types, engineered barrier performance, and natural barrier performance.

GTCC waste is low-level radioactive waste (LLRW) with concentrations of radionuclides that exceed the limits established by the NRC for Class C waste in Section 61.55 of Title 10 of the *Code of Federal Regulations* (10 CFR). In addition to the concentrations being higher than in Class C waste, the radionuclides that are present can be different. Although concentrations for radionuclides are reflected in the 10 CFR Part 61 waste classification tables (i.e., Table 1 and Table 2 of 10 CFR Part 61), not all the radionuclides present in GTCC waste were analyzed when 10 CFR Part 61 was developed. Of the radionuclides that were analyzed, not all of them resulted in concentration limits in the regulation. During the development of the 10 CFR Part 61 regulations in the early 1980s, the NRC and contractor staff generally believed that all of significant isotopes relevant to LLRW disposal were reflected in Table 1 and Table 2 of 10 CFR 61.55. For the current hazards analysis supporting this draft regulatory basis, the staff

[81] *See* NRC Advance Notice of Proposed Rulemaking, 10 CFR Part 60, "Definition of 'High-Level Radioactive Waste," 52 FR 5992, 6000-6001 (February 27, 1987).

considered the GTCC waste streams as described in the final environmental impact statement (FEIS) (DOE, 2016). For estimating the surface contamination of activated metals from commercial nuclear power reactors, it was necessary for the staff to modify the inventory used by the DOE based on actual data. Those modifications are discussed in Section B.2.

The 10 CFR Part 61 regulations apply to land disposal of radioactive waste. Most land disposal of LLRW in the United States is in the near-surface (approximately the uppermost 30 meters [100 feet] of the Earth below the land surface). The site suitability requirements provided in 10 CFR 61.50(a) are for near-surface disposal. The site suitability requirements for other than near-surface disposal were never developed because disposal of waste deeper than 30 meters was envisioned as being possible but not probable. The distinction of 30 meters depth between near-surface and other than near-surface is not significant. This depth (30 meters) was generally believed to be a practical limit as to how deep excavation would occur for disposal of waste. In general, it has held true, with the exception of the WCS facility in Andrews County, Texas where some cells for waste disposal extend beyond 30 meters even though the disposal method is an excavated pit type of facility.

Near-surface disposal methods include shallow-land burial (trenches up to 5 meters deep), engineered land disposal techniques (such as below-ground vaults), earth-mounded concrete bunkers disposal cells, and boreholes. The predominant disposal method in the U.S. is below-ground trench disposal. Disposal trenches can range from approximately 2 meters to around 40 meters below the land surface. Although the method of disposal could be an important variable to consider in the hazards assessment, most present-day disposal takes place in some form of trench design. While boreholes may be a viable disposal technology, they have not yet been demonstrated to be economically feasible for disposal of the quantities GTCC waste being evaluated. Select cases to evaluate borehole disposal were assessed and are summarized in Technical Analyses. The main variables with respect to design that were evaluated in the analysis were the depth of disposal of the waste and presence of a robust intruder barrier, though the amount, concentration, and form of waste disposed can play an important role in determining the hazards of GTCC waste disposal.

B.1.1 10 CFR Part 61 Requirements

This section provides an overview of the pertinent 10 CFR Part 61 regulatory requirements relevant to the hazards assessment for GTCC waste disposal. The summary that follows is a condensed overview of the requirements. The reader is directed to 10 CFR Part 61 for additional detail.

To ensure the safe disposal of LLRW, the regulations in Subpart C of 10 CFR Part 61 set forth one general and four specific performance objectives for LLRW land disposal facilities. The general performance objective, set forth in 10 CFR 61.40, “General requirement,” states that “[l]and disposal facilities must be sited, designed, operated, closed, and controlled after closure so that reasonable assurance exists that exposures to humans are within the limits established in the performance objectives in §§ 61.41 through 61.44,” which prescribe the four specific requirements. Thus, if the four specific performance objectives are met, then the general performance objective is met.

To achieve the performance objectives, the NRC regulations in Subpart D, 10 CFR Part 61, set forth the technical requirements for a near-surface disposal facility. Section 61.50, “Disposal site suitability requirements for land disposal,” provides the minimum site selection requirements

for a near-surface disposal facility. This regulation states that the "primary emphasis in disposal site suitability is given to isolation of wastes, a matter having long-term impacts, and to disposal site features that ensure that the long-term performance objectives of Subpart C of this Part are met, as opposed to short-term convenience or benefits." Other siting requirements include, but are not limited to, ensuring that: (1) the site is capable of being characterized, modeled, analyzed and monitored; (2) the selected site is in a place where projected population growth and future developments are not likely to affect the ability of the facility to meet the Subpart C performance requirements; (3) the site is well-drained and free of areas of flooding; (4) the site must provide sufficient depth to the water table that groundwater intrusion into the disposed LLRW will not occur; and (5) the selected site will not be in a location where tectonic processes, such as significant earthquakes, are likely to occur.

Section 61.51, "Disposal site design for land disposal," sets forth the design requirements for a near-surface disposal facility. This regulation states that "site design features must be directed toward long-term isolation and avoidance of the need for continuing active maintenance after site closure." Section 61.52, "Land disposal facility operation and disposal site closure," includes requirements for the disposal of Class A and Class C wastes, that void spaces between LLRW packages are filled with earth or other material, and that LLRW must be emplaced and covered in a manner that limits the radiation dose rate at the surface to ensure compliance with the dose limits set forth in 10 CFR Part 61.41. Other Subpart D provisions include environmental monitoring, the 10 CFR 61.55 waste classification system, 10 CFR 61.56, "Waste characteristics," labeling the LLRW by its appropriate class, and institutional requirements.

B.2 GTCC Waste Inventory

The FEIS considered the potential environmental impacts associated with constructing and operating a new facility or facilities, or using an existing facility, for the disposal of an estimated total volume of 12,000 m^3 (420,000 ft^3) of radioactive waste that is described as either GTCC waste or GTCC-like waste that is anticipated to be generated through 2083 (DOE 2016; pages 1-3). For descriptive purposes, Tables B-1 and B-2, below, identify waste streams according to GTCC and GTCC-like; however, throughout the rest of this appendix, the term "GTCC waste" is used as inclusive of both GTCC and GTCC-like waste and, as appropriate, the term "GTCC-like waste" is used when a distinction between these two types of waste is relevant to the discussion.

DOE separated the waste streams into two different groups based on the likelihood for the wastes to be generated by 2083 (Group 1 and Group 2, explained further in (DOE 2016, pages 1-3)). Group 1 represents GTCC waste associated with existing and currently planned facilities and activities, whereas, Group 2 GTCC waste represents waste from facilities and activities that may occur in the future. In this document, GTCC waste refers to both Groups 1 and 2; however, in some instances, when Group 2 waste is specifically identified it is referred to as "potential" waste in this document. The particular radionuclides present can be considerably different in different types of GTCC waste. Both aspects can influence the estimated hazards associated with the waste.

Based on the information provided in the FEIS, the NRC identified 17 specific waste streams. These waste streams account for different radionuclide inventories for the waste streams as well as the types of container used for a specific waste stream (i.e., remote-handled [RH] and contact-handled [CH] waste containers). Table B-1 presents the estimated volumes for these 17 waste streams, which represents a volume of 11,285 m^3 for GTCC waste. DOE's FEIS

estimate of 12,000 m^3 of GTCC waste represents an overall volume based on rounding off the values to two significant figures in multiple steps (DOE 2018, Table 1.4.1-2 footnote a). The volumes reported in this document are rounded once. Therefore, the volume found in the FEIS is not the same as the value provided in this document, which was not subject to the same rounding approach used in the FEIS.

The total waste volumes reported in Table B-1 is 11,285 m^3 with GTCC waste comprising 8,675 m^3 of the amount and GTCC-like comprising the rest (2,610 m^3). The single largest amount of waste comes from the WVDP, which is estimated to generate 4,340 m^3 of waste and includes 2,110 m^3 of waste from potential exhumation of waste at the NRC licensed disposal area (NDA). Potential exhumation of the State-Licensed Disposal Area (SDA) at the West Valley site is estimated to generate another 2,125 m^3 of GTCC waste (if a decision was made to undertake this activity). The second largest source of waste is from sealed sources and represents 2,800 m^3 of waste. Activated metal waste from commercial reactors totals 1,250 m^3 of waste, which includes 370 m^3 of potential activated metal GTCC waste from Commercial reactors that may be built in the future.

TRU radionuclides are present in some GTCC waste streams in concentrations greater than the 10 CFR Part 61.55 Table 1 limits. In some cases, TRU radionuclides are more than 100 times larger than the values found in Table 1. There is more than 8,500 m^3 of waste containing alpha-emitting TRU radionuclides with half-lives greater than 5 years that exceed the 100 nCi/g (Class C) limit in 10 CFR Part 61 (see Table B-2).

Table B-2 shows that the 17 waste streams vary considerably in volume, radionuclide content, and the form of the waste (e.g., activated metal, sealed sources, exhumed waste and soil). The hazards associated with the radionuclides evaluated in this appendix were considered during operations (i.e., workers and members of the public) and after closure of the near-surface disposal facility (i.e., inadvertent intruder and offsite individuals). The significance of a specific radionuclide to the hazard assessment varies based on the characteristics of the specific waste stream, the amount of waste that is disposed, facility design and site characteristics. The Technical Analyses contains a complete description of the specific radionuclides included for each of the 17 waste streams. Additionally, the hazards of various waste streams are also related to the contents of the waste package and the container type. For example, the external exposure at the surface of a waste package affecting operational handling activities is a direct consequence of the waste package contents (e.g., gamma emitting radionuclides) and the design of the package. The consequences of an inadvertent intruder drilling through one or more waste packages is affected by the concentration of waste within the waste package; for the purposes of its hazards assessment, the NRC staff has assumed that the GTCC waste would be disposed as a single layer of waste packages (i.e., an inadvertent intruder would only drill through a single waste package).

Table B-1 Estimated Volumes of GTCC Waste Streams (based on DOE 2016)

Waste Source		Estimated Waste Volumes (cubic meters)			
		GTCC			GTCC-Like
		Activated Metals	Sealed Sources	Other Wastes	Other Wastes
EXISTING FACILITIES AND ACTIVITIES					
Commercial Reactors	RH	880			
Sealed Sources (Cs-137)	CH		1,000		
Sealed Sources (neutron irradiators)	CH		1,800		
WVDP Decontamination of MPPB	CH				710
	RH				540
POTENTIAL FACILITIES AND ACTIVITIES (Potential Waste)					
Reactors	RH	370			
Mo-99 Production (MURR)	RH			35	
Mo-99 Production (MIPS)	RH			355	
West Valley Exhumation (NDA)	RH	210			
West Valley Exhumation (NDA)	RH			1,900	
Exhumation (SDA)	CH			400	
Exhumation (SDA)	RH	525			
Exhumation (SDA-SNAP)	CH			1,200	
WVDP Decommissioning of MPPB and WVTF	CH				220
	RH				760
Pu-238 Production	CH				120
	RH				260
TOTALS	CH		2,800	1,600	1,050
	RH	1,985		2,290	1,560

Table B-2 GTCC Waste Streams Sorted by Concentration for TRU Radionuclides

Waste Streams [including designated label as used in figures]	Waste Stream	Volume (m^3)	Waste Type	Contact (CH) or Remote (RH) Handled	TRU[1] Concentrations [half-lives > 5 years] (nCi/g)
Waste Streams with TRU radionuclides equal to or less than 100,000 nCi/g					
Sealed Sources – Small [NeutronIRCH]	sealed sources	1,800	GTCC	CH	85,900 (Am-241:54%, Pu-238: 43%)
WVDP Decontamination [LikeWVDeconRH]	other waste	540	GTCC-like	RH	13,300 (Am-241: 41%)
Waste Streams with TRU radionuclides equal to or less than 10,000 nCi/g					
Exhumation – SDA-SNAP [WVSNAPOCH]	other waste	1,200	GTCC Potential	CH	9,600 (Pu-238: 100%)
WVDP Decommissioning [LikeWVDecomOCH]	other waste	220	GTCC-like Potential	CH	6,700 (Am-241: 52%)
WVDP Decontamination [LikeWVDeconCH]	other waste	710	GTCC-like	CH	5,700 (Am-241: 60%)
WVDP Decommissioning [LikeWVDecomORH]	other waste	760	GTCC-like Potential	RH	3,500 (Am-241: 53%)
WVDP Exhumation – NDA [WVNDAAMRH]	activated metals	210	GTCC Potential	RH	3,200 (Am-241: 57%)
Pu-238 Production [LikePu238ORH]	other waste	260	GTCC-like Potential	RH	1,900 (Pu-238: 99%)
Waste Streams with TRU radionuclides equal to or less than 1,000 nCi/g					
WVDP Exhumation – NDA [WVNDAORH]	other waste	1,900	GTCC Potential	RH	530 (Am-241: 56%)
Exhumation – SDA [WVSDAOCH]	other waste	400	GTCC Potential	CH	310 (Pu-238: 70%)
Mo-99 Production – MURR [Mo99MurrRH]	other waste	35	GTCC Potential	RH	300 (Pu-239: 100%)
Pu-238 Production [LikePu238OCH]	other waste	120	GTCC-like Potential	CH	160 (Pu-239: 37%, Am-241: 32%)
Mo-99 Production – MIPS [Mo99MipsRH]	other waste	355	GTCC Potential	RH	150 (Pu-239: 97%)
Waste Streams with TRU radionuclides equal to or less than 100 nCi/g					
Exhumation – SDA [WVSDAAMRH]	activated metals	525	GTCC Potential	RH	24 (Pu-238: 45%)
Reactors [ReactorAMRH]	activated metals	880	GTCC	RH	3
Reactors [ReactorAMRH1]	activated metals	370	GTCC Potential	RH	3
Sealed Sources – Large [Cs137SSCH]	sealed sources	1,000	GTCC	CH	0

[1] Concentration of TRU based on DOE 2016 except for reactors that are based on McCartin et al 2018 due to discrepancies in DOE 2016 for deriving values for that source term.

B.3 Hazards Assessment

The range of waste stream characteristics associated with GTCC waste result in several potential considerations when evaluating the hazards of GTCC waste disposal in the near-surface. Disposal of GTCC waste can be hazardous during the operational period and after the near-surface disposal facility is closed. Operational hazards are addressed by operating procedures and safety systems. The operational safety systems can be both active (e.g., visual observation of remote handling of waste containers) and passive (e.g., security fence to maintain safe distances from waste containers). Hazards that occur after the facility is permanently closed rely solely on the passive design of the facility and site to ensure safety (i.e., intervention is not relied on for demonstrating compliance with the post-closure performance objectives). The NRC has considered the following areas when evaluating the hazards of GTCC waste disposal:

1. During operations, the potential for GTCC waste containing special nuclear material (SNM) to be present, prior to disposal, such that it could form a critical mass (from accidents or other mechanisms),
2. During operations, the potential for GTCC waste to pose a significant hazard to individuals (workers or members of the public) during routine operations and accidents,
3. Following closure, the potential for GTCC waste to pose a significant hazard to an inadvertent intruder, and
4. Following closure, the potential for GTCC waste to pose a significant hazard to an offsite individual.

B.3.1 Criticality Hazard

Many of the GTCC waste streams evaluated in the FEIS include radionuclides that are SNM. Rather than performing criticality calculations for a number of scenarios and configurations of material that may be highly uncertain, the NRC staff utilized a simpler approach that assumed the SNM to be in quantities of material not sufficient to form a critical mass as defined by the mass thresholds set forth in 10 CFR 150.11. Quantities below the threshold limits are not considered to present a criticality hazard.

As discussed in Section 3.1.1, two waste streams require only a very small quantity of material to exceed the 10 CFR 150.11 mass thresholds, namely, *remote-handled other waste from decontamination activities* at the WVDP– limiting quantity of 0.5 m^3, and *other waste from Mo-99 production using MIPS* – limiting quantity of 0.08 m^3. The NRC staff considers these two waste streams would need to evaluate the significance of an inadvertent criticality (see Appendix C for further information on criticality safety).

B.3.2 Operational Safety

Safety during operations is assured by properly assessing the hazards to which people may be exposed and implementing a radiation protection program and safety systems to mitigate those hazards. The NRC's regulation 10 CFR 61.13(c) requires land disposal facility applicants to perform a technical analysis demonstrating that the 10 CFR 61.43 performance objective for protection of individuals during operations will be met.

To evaluate the potential hazards to workers and the public during operations, the NRC staff identified two aspects of GTCC waste that are expected to impact radiation protection at a

potential near-surface disposal facility for compliance with the 10 CFR Part 20 requirements for workers and the general public. First, the FEIS identified several waste streams that contain sufficiently high amounts of radioactivity that remote handling is required due to the dose rate at the container's surface. Table B-3 identifies those waste streams having containers with contact dose rates significantly larger than what might be handled as Class C waste at a land disposal facility. For the purposes of this analysis, the NRC staff has identified those waste streams with concentrations of radionuclides that result in a contact dose rate that would be 10 or more times than Class C waste (e.g., 700 Ci/m^3 for Co-60, which results in a contact dose rate of 5,000 rem/hr, is used as a reference concentration for a land disposal facility). Two waste streams (activated metal waste current commercial reactors and activated metal waste from potential reactors to be built in the future) had values more than 10 times larger than the reference land disposal facility.

The FEIS evaluated accidents that might lead to a loss of waste containment or shielding of waste packages that could result in exposure to workers or members of the public as a result of operational events and natural phenomena (DOE 2016, Appendix C). DOE stated that physical damage to waste containers could result from low-speed vehicle collisions, dropping of containers, or containers being crushed by falling objects. It is anticipated that only minor releases would be likely due to operational procedures at a disposal facility (e.g., low onsite speed limits) (DOE 2016, page C-7). DOE also considered a fire event, high-winds and tornados, and a major earthquake in its accident analysis. DOE estimated potential accidental releases that accounted for an airborne release fraction from the container, the portion of the release that was respirable, and the potential for further filtration of any potential release (e.g., filtration system within a waste handling building). The most severe releases did not have any filtration after release from the container and were the result of a fire (release fraction of 0.0005), tornado (release fraction of 0.0001), and earthquake (release fraction of 0.00072) (DOE 2016; Table C-4).

DOE estimated the dose to a hypothetical individual that is assumed to be located 100 m (330 ft) downwind from the release point. The highest doses estimated were 16 rem (fire affecting a standard waste box), 10 rem (earthquake affecting 18 pallets with 4 contact handled drums per pallet), and 3 rem (tornado driven missile hitting a standard waste box) (DOE 2016, Table 6.2.4-1). DOE estimated these large consequences for contact-handled waste material that is packaged in containers that are not as sturdy as remote-handled waste containers (DOE 2016, page C-7). DOE estimated a very low frequency for these large consequence accidents (~10^{-5} per year – DOE 2016, Table C-3). Although the potential consequences of these accidents are large (e.g., 16 rem dose for an individual located 100 meters from the release point), the risk is very low. Moreover, 10 CFR Part 20 also establishes as-low-as-reasonably-achievable (ALARA) principles that would apply to the design and operating procedures for a disposal facility to ensure the low likelihood of occurrence and to reduce potential releases and exposure should an accident occur. Additional training and operational procedures may be necessary to ensure the proper response and protection (e.g., for emergency response personnel) should those accidents occur.

An important consideration when evaluating potential consequences of GTCC waste accidents will be the release of TRU radionuclides (e.g., plutonium). TRU radionuclides can have a significant effect on radiation exposures when released in the air during accidents, such as during a fire. Table B-3 identifies those waste streams containing TRU radionuclides in concentrations at least ten times greater than the 10 CFR Part 61 Class C limit of 100 nCi/g for TRU radionuclides. Eight of the 17 waste streams analyzed by the NRC staff exceed the Class C concentration limit by more than ten times, with five of the waste streams originating

Table B-3 Relevance of Specific Waste Stream Inventories to the Impact on Potential Occupational Exposures and Offsite Exposures from Operational Releases

Waste Streams		Volume (m^3)	Contact Dose Rate (Rem/hr)	TRU Concentrations (nCi/g)
Example Part 61 LLW values (Class C)			**5,000 (Cs-137)**	**100**
EXISTING FACILITIES AND ACTIVITIES				
Reactors	RH	880	92,000 (Co-60)	
Sealed Sources; Cs-137 Irradiators (GTCC)	CH	1,000		
Sealed Sources; Neutron Irradiators (GTCC)	CH	1,800		85,900
West Valley Decontamination of MPPB (GTCC-Like)	CH	710		5,700
	RH	540		13,300
POTENTIAL FACILITIES AND ACTIVITIES (Potential Waste)				
Reactors (GTCC)	RH	370	92,000 (Co-60)	
Mo-99 Production; MURR (GTCC)	RH	35		
Mo-99 Production; MIPS (GTCC)	RH	355		
West Valley Exhumation GTCC – NDA (Act. Metal)	RH	210		3,200
West Valley Exhumation GTCC – NDA (Other)	RH	1,900		
Exhumation GTCC – SDA (Other)	CH	400		
Exhumation GTCC – SDA (Act. Metal)	RH	525		
Exhumation; SDA-SNAP (GTCC)	CH	1,200		9,600
West Valley Decommissioning of MPPB and WVTF (GTCC-Like)	CH	220		6,700
	RH	760		3,500
Pu-238 Production (GTCC-Like)	CH	120		
	RH	260		1,900

from the WVDP. Two waste streams contain very large quantities of TRU waste in concentrations greater than 10,000 nCi/g and are *remote-handled other waste from decontamination activities* at the WVDP site and *sealed sources associated with neutron irradiators*. These two waste streams have inventories of TRU radionuclides comparable to the contact-handled waste evaluated in the FEIS that DOE estimated could result in a 16 rem individual dose from an assumed fire scenario. Handling of significant amounts of plutonium will need to consider ALARA principles in the design and operating procedures for a near-surface disposal facility to ensure the low likelihood of occurrence for accidents and to reduce a potential release should an accident occur. Applicants for near-surface disposal facilities accepting wastes with significant amounts of plutonium and radionuclides with a potential for significant external exposures (e.g., Co-60) will most likely need to analyze accidents and

provide more detailed operating procedures than is typically done for Class A, Class B, and Class C waste disposals. As a result of large amounts of radioactivity in some GTCC waste containers, the impacts of accidents are larger and the margin for operational or system error is significantly smaller compared to Class A, Class B, and Class C wastes; therefore, the management controls and other systems must be more robust.

B.3.3 Intruder Protection

This section provides a more detailed discussion of the analyses of intruder hazards resulting from the disposal of GTCC wastes. The Technical Analyses provides a more in-depth discussion of the calculations including the parameter values selected and the models that were used.

After a near-surface disposal facility is permanently closed, the potential for radiation exposures emanating from the disposed radioactive material may result from an inadvertent intruder engaging in disruptive activities at the site. The performance objective at 10 CFR 61.42 requires protection of an inadvertent intruder from LLRW disposed in the near-surface. The NRC and contractor staff performed analyses to evaluate potential doses to an inadvertent intruder (Technical Analyses). The intruder exposure scenarios evaluated considered shallow excavation down to 5 m, consistent with the original, early 1980s analyses to develop concentrations limits for 10 CFR Part 61, as well as drilling of a well deeper than 5 m for retrieval of natural resources (e.g., water). The well drilling exposure scenario was not evaluated explicitly when the 10 CFR Part 61 regulations were developed because the excavation exposure scenario was more conservative.

Two different approaches were used to evaluate potential impacts to an intruder. First, the published methodology described in NUREG-0782 (the draft environmental impact statement for the development of 10 CFR Part 61) was replicated by the NRC staff using modern tools (Ridge et al., 2019). Using the output concentrations for different isotopes (corresponding to a limiting dose to the most limiting organ or whole body using International Commission on Radiological Protection (ICRP) 2), the equivalent dose for a new waste stream can be calculated. Drilling doses were calculated accounting for the different exposure times (shorter) and different dilution factors (larger) compared to that used in the excavation exposure scenario. Decay and in-growth were taken into account. The second approach used to evaluate potential impacts to an intruder involved development of a modern intruder dose assessment. This work was completed by staff from the CNWRA using the software tool BDOSE (Simpkins et al., 2008). This second set of calculations was independently parameterized and modern dosimetry was used. The Technical Analyses provides a more detailed description of both sets of calculations.

The original analyses to develop the 10 CFR Part 61 regulations used pathway analyses combined with doses to critical organs using ICRP 2 dose methodology. Both acute and chronic exposure scenarios were considered. Acute exposure scenarios involved direct disturbance of the waste. For example, the individual installing the well is rarely the long-term resident after the well is installed. Chronic exposure scenarios involved more indirect contact with the waste such as an individual living in the residence after it was constructed. Different exposure times and parameters defining the concentrations of the waste the individuals would be exposed to were assigned for the acute and chronic exposure scenarios. Though a wide variety of exposure scenarios were evaluated in the analysis, the concentrations presented in the waste classification tables were based on only selected exposure scenarios. For example, the concentrations are independent from water-dependent pathways. The concentrations

provided in Tables 1 and 2 of 10 CFR 61.55 represent the limiting concentration for the limiting scenario (of the subset of exposure scenarios considered) to the limiting organ. This approach is quite a bit different from what may be done in a modern analysis where all credible pathways are considered and individual organ doses are not calculated. Instead, total effective dose equivalent (TEDE) is the common metric used and the results for acute and chronic exposure scenarios are usually not mixed.

Figures B-1 and B-2 show the inadvertent intruder doses,[82] for an excavation exposure scenario and a well-drilling scenario respectively, as a function of time for the 17 different GTCC waste streams analyzed by the NRC staff. For the 17 waste stream identifiers in Figures B-1 and B-2, please see Table B-2 for a more complete description). Compliance with an intruder dose limit of 0.5 mSv (500 mrem) will be challenging for shallow disposal (i.e., less than 5 m) where excavation is a viable inadvertent intruder scenario. In particular, those waste streams that have significant inventories of long-lived radionuclides (e.g., radioactive half-lives of 500 years or longer) that would not decay significantly over the 100-year institutional control period are particularly challenging. The times shown on Figures B-1 and B-2 commence after the end of the institutional control period.

The results shown assume that, at the time of disturbance, that most LLRW is not recognizable as being something hazardous. Some GTCC waste streams, however, may be recognizable as a hazard (e.g., irradiated stainless steel) for a long time even when exposed to conditions of the natural environment. When 10 CFR Part 61 was developed, the exposure scenario where the person recognizes that they have disturbed something unexpected and hazardous was termed a “discovery” scenario and the exposure time was reduced from a nominal value of 500 hr to 6 hr. Even with credit for discovery, most of the waste streams would result in doses to the inadvertent intruder above 500 mrem at the end of the 100 year institutional control period.

Figure B-1 shows that none of the waste streams result in doses to an intruder that are under 500 mrem by 100 years, and few are under 500 mrem by 500 years. The current regulations require deeper disposal for Class C waste (i.e., 5 meters or more below the top surface of the cover) *or* installation of an inadvertent intruder barrier that functions for 500 years. As shown in Figure B-1, the requirement to install an inadvertent intruder barrier that functions for 500 years without the corresponding 5 meters or deeper requirement would not be sufficient for GTCC waste.

[82] It should be noted that these are not doses *per se* but rather the curves represent the results for the GTCC waste streams to exceed the radionuclide specific organ dose limits. Different organ dose limits were used in the original analyses (e.g. 3000 mrem to the thyroid, 1500 mrem to the liver). Essentially it is being assumed that the different organ dose limits used represent a reasonably consistent level of impact to human health. For example, a radionuclide at a concentration that is at 90 percent of the concentration limit provided in the waste classification tables has a similar impact to a different radionuclide at 90 percent of its corresponding limit even though it impacts a different organ. All the results are then scaled to 500 mrem whole body dose for illustration purposes. It would be impracticable to plot the organ doses for each waste stream and all the different radionuclides and the results would not be readily comparable to the more modern assessment. Staff acknowledges the shortcomings associated with the approach but believes being able to evaluate the results between different waste streams was important for the assigned task.

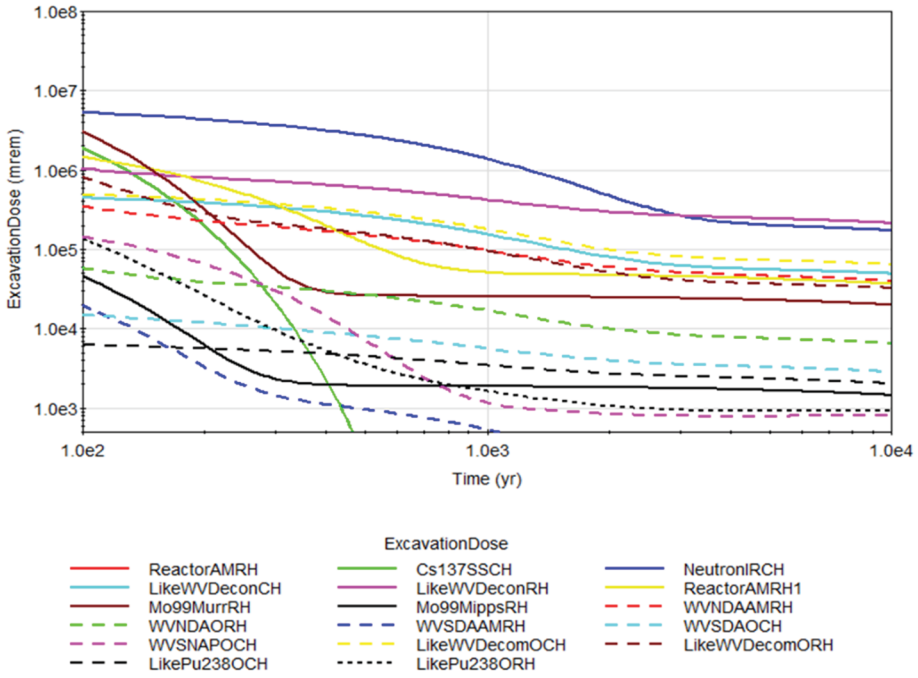

Figure B-1 Doses to an Inadvertent Intruder from the Excavation Exposure Scenario

Figure B-2 provides the estimated doses to an inadvertent intruder resulting from disturbance of waste by installing a well through the waste in a disposal facility. The approach used here is similar to the original 10 CFR part 61 analysis that took the limiting result for each isotope

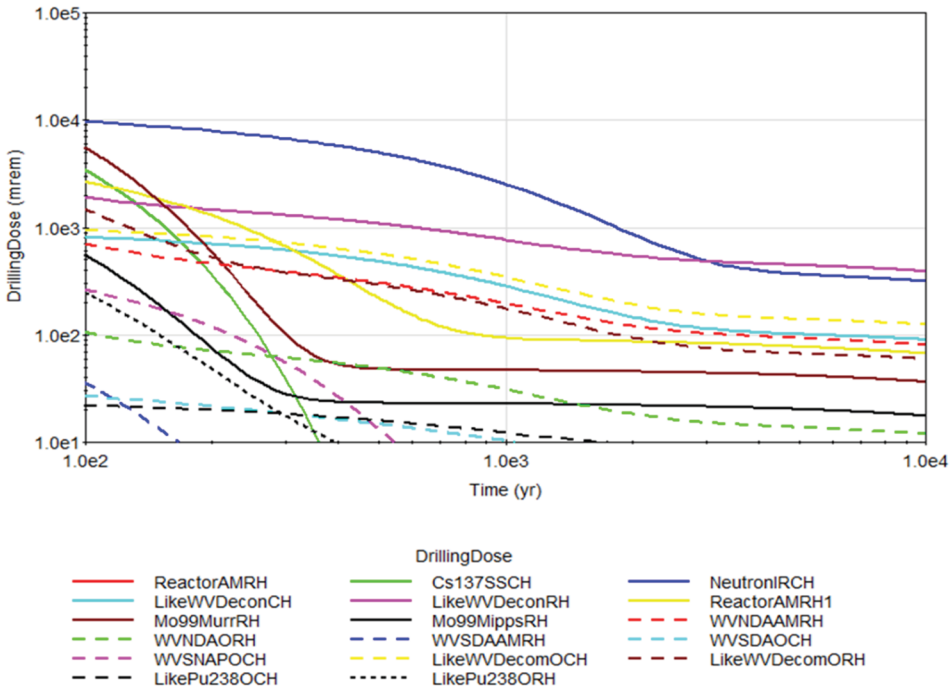

Figure B-2 Doses to an Inadvertent Intruder from the Well Drilling Exposure Scenario

between acute and chronic exposure scenarios. The NRC staff has assumed for the well drilling scenario that the GTCC waste would be disposed as a single layer of waste packages (i.e., an inadvertent intruder would only drill through a single waste package). If GTCC waste is disposed in multiple layers of waste packages, then the estimated doses would increase due to the additional volume of waste being brought to the surface by the drilling activity. The estimated doses for the well-driller exposure scenario are approximately a factor of 1000 less than the doses for the excavation exposure scenario primarily because of the lesser amount of waste exhumed and the dilution of waste with the other materials exhumed due to the drilling activity. At 100 years, the results for most of the waste streams are above 500 mrem; however, by 500 years, most of the doses are below 500 mrem. The highest doses at 1,000 years are over 2,000 mrem from *sealed sources associated with neutron irradiators* for the waste labeled NeutronIRCH and over 800 mrem for the waste labeled LikeWVDeconRH, which is the *remote-handled other waste from decontamination activities* at the WVDP.

The results shown in Figures B-1 and B-2 are for the average of each type of waste. There may be variability in the concentrations of some waste streams. While the results for the average waste stream is potentially suitable for near-surface disposal, some portion of the waste stream may be more highly-concentrated and the results would be unacceptable. With respect to GTCC waste disposal, the main points of the analyses results are:

- Most GTCC waste cannot be disposed of at shallow depths (i.e., within 5 m of the surface of the earth).
- Drilling through a buried disposal unit containing GTCC waste prior to 500 years after emplacement may result in doses larger than 500 mrem.
- Though the radiological impacts from GTCC waste are strongly influenced by shorter-lived radionuclides, some GTCC waste has enough long-lived radioactive isotopes that the hazards can remain for long-time periods (e.g., thousands of years).

Further measures to reduce and/or eliminate potential intruder exposure scenarios, such as greater disposal depth or enhanced barriers, are necessary to reduce the doses to the inadvertent intruder. Site-specific analysis of potential intruder doses can provide key information for understanding the effectiveness of barriers because actual site conditions can be taken into account. Given the current regulatory requirements, the simplest changes to ensure protection of the inadvertent intruder from GTCC waste disposal would include:

- A revision to 10 CFR 61.13 that requires applicants to conduct a dose assessment for an inadvertent intruder analysis that considers the time period after the end of the 100-year institutional control period. This dose assessment would ensure that any GTCC waste being disposed in a near-surface disposal facility was being analyzed for intruder protection.
- If a requirement for a site-specific intruder dose assessment for the disposal of GTCC waste streams is added to the regulations, the staff recommends specifying an intruder dose limit of 500 mrem TEDE.
- A minimum disposal depth requirement of 5 m below the surface of the earth *and* a requirement for a barrier to inadvertent intrusion that is effective for a minimum of 500 years.

The NRC staff expects that these potential requirements should be readily implementable and consistent with existing requirements or current practices of most operating commercial low-level waste disposal facilities.

B.3.4 Offsite Individual Protection

Protection of an offsite member of the public is specified in the performance objective set forth in 10 CFR 61.41. To effectively comply with this requirement, an applicant should submit a site-specific analysis of release and transport of radionuclides from disposed waste to the environment, which may eventually lead to a radiological dose to a member of the public. The evaluation of whether an offsite member of the public is protected would be based, in large part, on a site-specific analysis because of the strong influence of local hydrogeological conditions.

When assessing the performance, and demonstrating the safety, of a potential near-surface disposal facility containing GTCC waste, in particular GTCC waste associated with long-lived TRU radionuclides, the NRC staff expects that the site-specific features, events, and processes of the natural environment at a disposal site will be important and that key features, events, and processes associated with the disposal site's environment will need to be considered. Typically, the more advantageous the features and processes of the natural system are in isolating waste, the less performance will be needed from the man-made barriers.

In their FEIS, DOE evaluated doses to a potential offsite member of the public. Their results show that for some types of facility designs and hydrogeological conditions the doses to offsite members of the public may meet 10 CFR Part 61 dose limits, whereas for other facility designs and hydrogeological conditions the doses would not meet established limits. The results of the analyses are strongly dependent on the selected values for numerous parameters (e.g., infiltration rates, distribution coefficients (Kd), consumption parameters).

NRC and contractor staff performed analyses to evaluate potential doses to an offsite individual. As noted in Section B.3.3, the concentration limits developed in 10 CFR 61.55 are based on protection of the inadvertent intruder and did not consider water-dependent pathways. The offsite individual analysis discussed here is limited to assessing transport via groundwater to a water well that is used for extracting water for domestic purposes (e.g., drinking water) (Technical Analyses). Because Part 61 has requirements associated with site stability, waste characteristics, and site selection, water-dependent and other pathways are generally of lesser significance but could be important at a particular site. The purposes of the analysis described here were to identify the order of magnitude of the potential doses to an offsite individual, the timing of those doses, and the anticipated radionuclides that are key contributors to offsite doses.

It can be difficult to evaluate the doses to an offsite individual with a generic (i.e. not site-specific) analysis because the magnitude of doses, their timing, and the key radionuclides are strongly influenced by the site-specific hydrogeological conditions, especially the site mineralogy and geochemistry, which controls transport times, the infiltration rate (i.e., the rate at which precipitation enters the subsurface), and the properties of the aquifer (i.e., how much dilution and dispersion there is during transport). Rather than performing deterministic analysis using specific site conditions, the analysis by the staff was performed probabilistically to identify the important parameters and conditions.

Estimated doses to a member of the public caused by radioactive releases from LLRW disposal facilities are influenced by features and processes of the natural environments in which waste is

disposed. The significance of the natural environment in isolating and containing waste and to overall performance has previously been recognized. The regulations in 10 CFR 61.13(a), for example, require an analysis of the releases of radioactivity through various environmental pathways. When assessing the performance and demonstrating the safety of a potential near-surface disposal facility containing GTCC waste, particularly GTCC waste associated with long-lived TRU radionuclides, the NRC staff expects that the site-specific features, events, and processes of the natural environment will need to be considered. The importance of features, events, and processes are expected to vary depending upon the disposal method and the particular disposal site characteristics.

Precipitation, wind, and temperature are some of the meteorological processes that can affect the release and transport of radionuclides from the waste disposal site. The frequency and intensity of rainfall is of especial importance for assessing the safety of the hypothetical receptor offsite. The 10 CFR Part 61 regulations reflect the importance of the amount of water available for mobilizing the radionuclides within the waste and of minimizing the waste-water contact (e.g., the requirements in 10 CFR Part 61, Subpart D). Meteorological processes are site-specific and their impact may vary depending on the disposal method. The evolution of meteorological processes over long time periods can be a significant part of overall performance due to long-lived transuranic radionuclides often associated with GTCC waste.

Hydrogeologic processes can also affect the movement of radionuclides through air, water, and soil pathways. As previously mentioned, releases through the water pathways tend to be the predominant release from land disposal facilities and differences in the flow velocity profile of groundwater at various spatial scales will affect the rate of the radionuclide release. In addition, various physical mechanisms can influence the rate of release including advection, whereby the transport of radionuclides occurs with the general movement of water, dispersion, whereby different flow paths of the water cause mixing and dilution of the radionuclides, and diffusion, whereby radionuclides move from areas of high contaminate concentrations to areas of low contaminate concentrations.

Geochemical processes include physical-chemical interactions between liquid, solid, and gas phases within the disposal site and surrounding environment and can include dissolution-precipitation, sorption-desorption, oxidative-reductive, and gas-solution interactions (NRC, 2015). A radionuclide's rate of movement out of the waste form and through the surrounding environment is strongly dependent on its phase (solid, liquid, or gas), which is influenced by geochemical processes. Distribution coefficients describe the solid-water partition coefficient, or the mass of chemical absorbed to soil to the amount dissolved in water, and are strongly influenced be the acidity of the water. The capacity of hydrogeological units to adsorb radionuclides moving with the groundwater can have a significant effect on how quickly contaminates can reach areas beyond the land disposal facility.

Disruptive plausible future events include tectonic, igneous, and other processes such as flooding that may significantly impact the performance of the land disposal facility. Site suitability requirements entail evaluations that determine if there is reasonable assurance that disruptive events would not endanger public health and safety. For example, 10 CFR 61.50 requires potential land disposal facility sites to avoid locations where evaluation results demonstrate tectonic processes such as faulting, folding, seismic activity, or volcanism may occur with such frequency and extent to significantly affect the site's ability to meet performance objectives. Actual site conditions and the disposal method need to be considered when determining the frequency and extent of disruptive events.

Figure B-3 shows the horsetail plot, which is a presentation of each realization of a probabilistic simulation for the staff's analysis. Each plotted time series represents the outcome from a different set of sampled parameter values. For example, the assumed thickness of the waste ranges between 0.1 m and 1.0 m, similar to the thickness of waste in a single layer of waste packages. For the ranges of parameters considered, the range in peak dose spans approximately six orders of magnitude. Figure B-4 is a multivariate comparison of the simulated peak dose and the log base 10 of the ratio of infiltration rate to groundwater flow rate. This ratio represents an effective dilution factor when contaminants flow from the waste through the vadose zone and that flux of radionuclides enters an underlying aquifer. The largest peak doses are associated with sites with relatively high infiltration rates and relatively low aquifer flow rates.

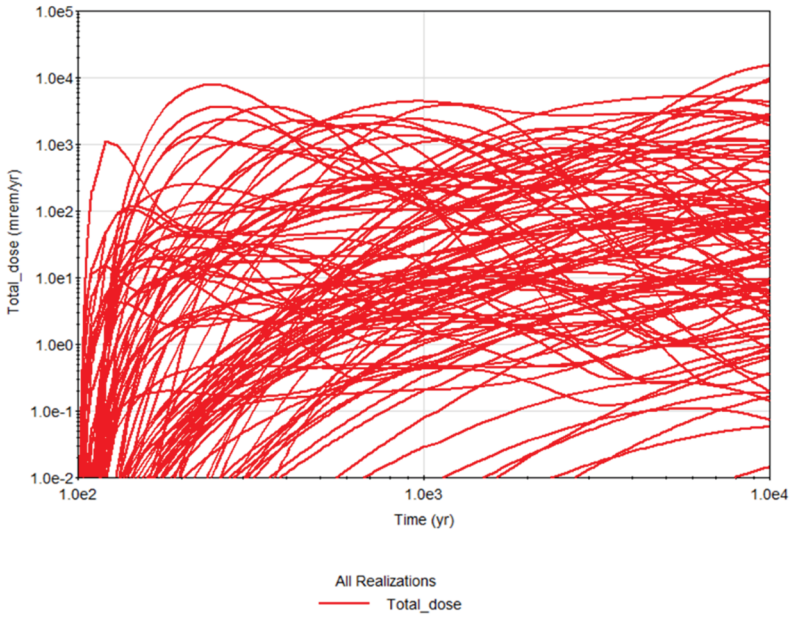

Figure B-3 Doses to an Offsite Individual from GTCC Waste (Example for the overall waste stream)

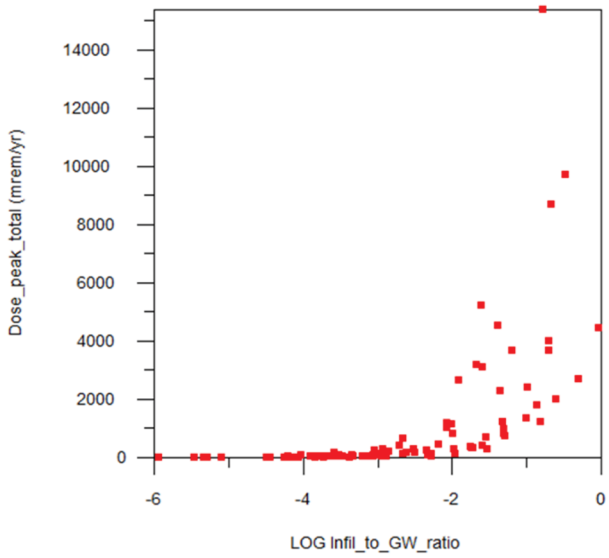

Figure B-4 Multivariate Plot of the Key Ratio Driving the Peak Dose Results

Figure B-5 is a comparison of the mean result from a probabilistic simulation for each different waste type. The range in peak doses span roughly three orders of magnitude. The highest doses at 500 and 1,000 years are close to 1,000 mrem for the waste labeled LikeWVDeconRH, which is the *remote-handled other waste from decontamination activities* at the WVDP. At 10,000 years, the waste labeled NeutronIRCH, which is the waste from *sealed sources associated with neutron irradiators*, has the highest dose (1,000 mrem). The inventory of radioactivity associated with different waste types is an important source of variability in the results. However, the variability resulting from hydrogeological parameters is significantly larger, which was recognized when 10 CFR Part 61 was originally developed. The waste classification system concentrations in Table 1 and Table 2 of 10 CFR Part 61 applied concentration limits to protect the inadvertent intruder. A licensee or applicant must demonstrate the protection of an offsite member of the public by performing site-specific analysis. If a dose limit of 25 mrem TEDE is used, based on the mean result for each waste stream, approximately one third of the waste streams would meet the criteria, approximately one third would be above the criteria but not by a significant margin, and the remainder would have mean peak doses exceeding hundreds of mrem. By comparison, at the 50 percentile result, all but one waste stream would meet the 25 mrem per year TEDE. These results highlight the importance of site-specific analysis to demonstrate compliance with 10 CFR 61.41. The key radionuclides contributing to the dose were Tc-99, I-129, C-14, and Np-237. Most of these isotopes in GTCC waste are below the concentrations associated with Class C waste. These results highlight that the waste classification concentrations do not ensure protection of the offsite individual. At longer timeframes, the isotopes of uranium contributed to the results.

The site-specific parameters will also influence the timing of when peak impacts are expected to occur. For low infiltration rates and moderately to strongly-sorbing geologic materials the travel times of some contaminants through the environment can be very long (e.g. greater than tens of thousands of years).

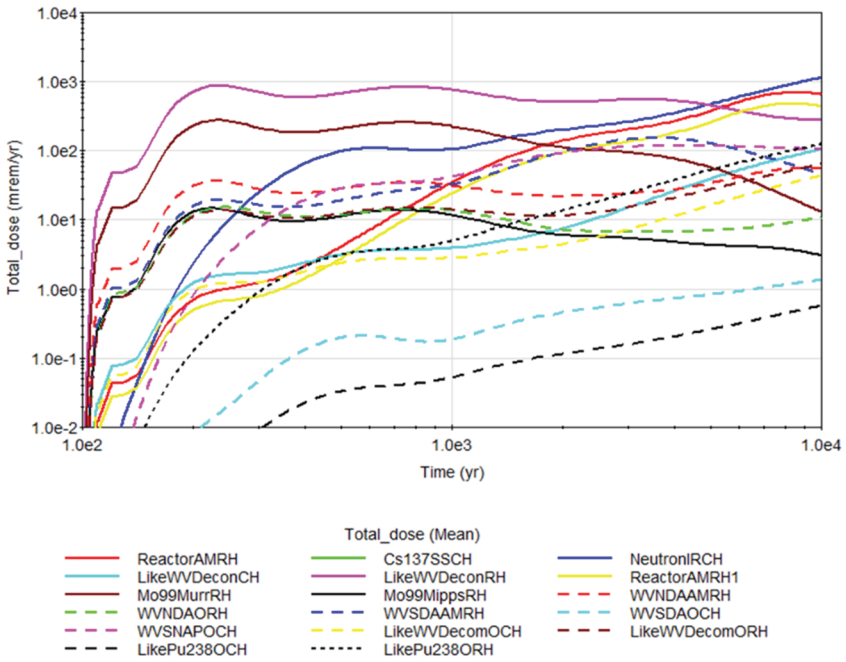

Figure B-5 Mean Dose Result for Each GTCC Waste Stream

Staff examined the output of the probabilistic results to determine when peak offsite doses are likely to occur:

- Approximately 80 percent of the time, the peak dose from GTCC waste would be larger after 1,000 years compared to prior to 1,000 years,
- Approximately 30 percent of the time, the peak dose would be ten times larger, and
- Approximately 5 percent of the time the peak dose would be 100 times larger or more.

With respect to GTCC waste disposal, the main messages to take from the analysis results for the offsite individual are:

- Hydrogeological and wasteform performance variability results in a broader range in peak dose results than different GTCC waste stream inventories.
- The difference in performance of a “poor” site compared to a “good” site can be significant with respect to protecting the offsite individual.
- GTCC waste stream are not generically safe or unsafe with respect to protection of offsite individuals.

Further measures to ensure protection of offsite individuals with respect to GTCC waste disposal are not necessary because 10 CFR Part 61 already implements a site-specific analysis approach. Whereas doses to a hypothetical inadvertent intruder are generally decreasing with time, doses to an offsite individual from GTCC waste disposal are generally increasing with time up to 10,000 years after disposal (see Figure B-5).

B.4 Summary

GTCC waste streams can vary considerably in volume, constituent radionuclides, radionuclide concentrations, and the form of the waste (e.g., activated metal, sealed sources, exhumed waste and soil). Accordingly, the range of waste stream characteristics represented in the 17 GTCC waste streams result in a variation in the hazards associated with each of the waste streams considered in the analysis. As can be seen in Tables B-4 (activated metals), B-5 (sealed sources), and B-6 (other waste), there is significant variation of hazards over the various waste streams. It is expected that disposal of GTCC waste would require more scrutiny than is typically afforded Class A, Class B, and Class C waste; however, these types of concerns are to be expected given the characteristics of GTCC waste. Although operations at a disposal facility for GTCC waste (e.g., radiation protection for handling and storage, criticality accidents) may require more scrutiny than afforded a LLRW facility, these types of operational issues are not considered to pose unique hazards that cannot be addressed with appropriate design and procedures. An important assumption of this hazards assessment was the quantity of SNM present in GTCC waste at the facility, prior to disposal, would be no greater than the threshold mass limits at 10 CFR 150.11.

The post-closure concerns extend for long times for the inadvertent intruder and the offsite individual (e.g., 10,000 years) for some of the waste streams due to the presence of long-lived radionuclides in the GTCC waste. For these waste streams, disposal at greater depths and/or disposal facilities with specific characteristics (e.g., low infiltration rates) may be required to limit releases to acceptable amounts. Two specific waste streams (i.e., *remote-handled other waste from decontamination activities* at the WVDP and *sealed sources associated with neutron irradiators*) represent the only two waste streams that show characteristics that are of significant concern for operations, the inadvertent intruder, and the offsite individual.

Table B-4 Hazards for Activated Metals Waste Streams

Waste Streams and Volume		Presence of Significant Operational Hazards			Presence of Significant Post-Closure Hazards			
		Criticality	Accidents (nCi/g)	Contact Dose (Rem/hr)	Intruder Driller at 100 & 500 yrs		Offsite Individual at 1,000 & 10,000 yrs	
EXISTING FACILITIES AND ACTIVITIES								
Reactors GTCC (880 m^3)	RH			Yes 92,000 (Co-60)				Yes
POTENTIAL FACILITIES AND ACTIVITIES (Potential GTCC Waste)								
Reactors GTCC (370 m^3)	RH			Yes 92,000 (Co-60)				Yes
WVDP Exhumation GTCC – NDA (210 m^3)	RH		Yes (3,200)					
Exhumation GTCC – SDA (525 m^3)	RH							

Table B-5 Hazards for Sealed Sources

Waste Streams and Volume		Presence of Significant Operational Hazards			Presence of Significant Post-Closure Hazards			
		Criticality	Accidents (nCi/g)	Contact Dose (Rem/hr)	Intruder Driller at 100 & 500 yrs		Offsite Individual at 1,000 & 10,000 yrs	
EXISTING FACILITIES AND ACTIVITIES								
Cs-137 Irradiators GTCC (1,000 m^3)	CH				Yes			
Neutron Irradiators GTCC (1,800 m^3)	CH		Yes (85,900)		Yes	Yes		Yes
POTENTIAL FACILITIES AND ACTIVITIES (Potential GTCC Waste)								
None								

Table B-6 Hazards for Other Waste Streams

Waste Stream and Volume		Presence of Significant Operational Hazards			Presence of Significant Post-Closure Hazards			
		Criticality	Accidents (nCi/g)	Contact Dose (Rem/hr)	Intruder Driller at 100 & 500 yrs		Offsite Individual at 1,000 & 10,000 yrs	
EXISTING FACILITIES AND ACTIVITIES								
WVDP Decontamination (710 m^3 – CH) (540 m^3 – RH)	CH		Yes (5,700)					
	RH	Yes	Yes (13,300)		Yes	Yes	Yes	Yes
POTENTIAL FACILITIES AND ACTIVITIES (Potential GTCC Waste)								
Mo-99 Production (MURR) 35 m^3	RH				Yes		Yes	
Mo-99 Production (MIPS) - 355 m^3	RH	Yes						
WVDP Exhumation NDA 1,900 m^3	RH							
Exhumation SDA 400 m^3	CH							
Exhumation SDA-SNAP 1,200 m^3	CH		Yes (9,600)					
WVDP Decommissioning (220 m^3 – CH) (760 m^3 – RH)	CH		Yes (6,700)					
	RH		Yes (3500)		Yes			
Pu-238 Production (120 m^3 – CH) (260 m^3 – RH)	CH							
	RH		Yes (1,900)					

B.5 References

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Appendix C
Disposal Facility Criticality Safety

criticality: The state of a nuclear chain reacting medium when the chain reaction is self-sustaining (IAEA, 2007).

GTCC waste streams include a wide range of materials and radionuclides. Generally, a GTCC waste stream contains all known fissile materials, i.e., U-233, U-235, Pu-239 and Pu-241. If these fissile materials are present in a sufficient mass and if the fissile materials are in a certain configuration, a self-sustaining chain reaction can occur that generates heat and radiation. This chain reaction is referred to as a "criticality event." Although the source of the energy of a GTCC waste derived criticality event is the same as that of an inadvertent criticality accident (e.g., involving fissile material at a nuclear facility), the energy released from a GTCC waste derived criticality event would be at a much lower level of energy generation because the fissile material contained within the GTCC waste is of a much lower density. Waste materials are typically not placed in containers in a configuration that would likely result in a criticality event. However, water (a moderator that will assist the chain reaction) entering the waste container coupled with any reconfiguration of fissile material within the container increases the likelihood that a criticality event will occur. Although remote, there is a possibility over long time periods for the movement of fissile material within and possibly out of a waste package and subsequent accumulation into a new configuration that could lead to a criticality event. The conceivable water ingress and fissile material reconfiguration scenarios may include leakage and deformation of container(s) from potential accidents while waste packages are present on the surface prior to disposal. The design and construction of the disposal facility should include consideration of the potential conditions that may result in accidental criticality events if a sufficient mass of material is present such that a criticality event is credible.

References

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Appendix D
Uncertainty Analysis

To determine the robustness of the costs and net benefits (i.e., benefits minus costs), the NRC staff examined how the costs change because of uncertainties associated with the NRC staff's analytical assumptions and input data. The NRC staff used Monte Carlo simulations to examine the impact of uncertainty on the estimated net benefits. These Monte Carlo simulations were performed using the @RISK® software program. [83]

Monte Carlo simulations involve introducing uncertainty into the analysis by replacing the point estimates of the variables used to estimate base case costs and benefits with probability distributions. By defining input variables as probability distributions instead of point estimates, the influence of uncertainty on the results of the analysis (in other words, the net benefits) can be effectively modeled.

The probability distributions chosen to represent the different variables in the analysis were bounded by the range-referenced input and the NRC staff's professional judgment. When defining the probability distributions for use in a Monte Carlo simulation, summary statistics are needed to characterize the distributions. These summary statistics include the minimum, most likely, and maximum values using a triangular distribution to reflect the relative spread and skewness of the distribution defined by the three estimates.

The NRC performed the Monte Carlo simulation by repeatedly recalculating the results, 5,000 times. For each iteration, the values were chosen randomly from the probability distributions that define the input variables. The values of the output variables were recorded for each iteration, and these resulting output variable values were used to define the resultant probability distribution.

Figures D-1, D-2, and D-3 display the histograms of the incremental benefits and costs of Alternatives 1, 2, and 3 respectively, assuming one applicant expresses an interest in a disposal facility that can accept GTCC waste. The cost data for Alternatives 1 and 2 were performed based on the NRC issuing a 10 CFR Part 61 license. The histograms display the cost estimates using a 7 percent and at 3 percent discount factor.

[83] Information about this software is available at http://www.palisade.com.

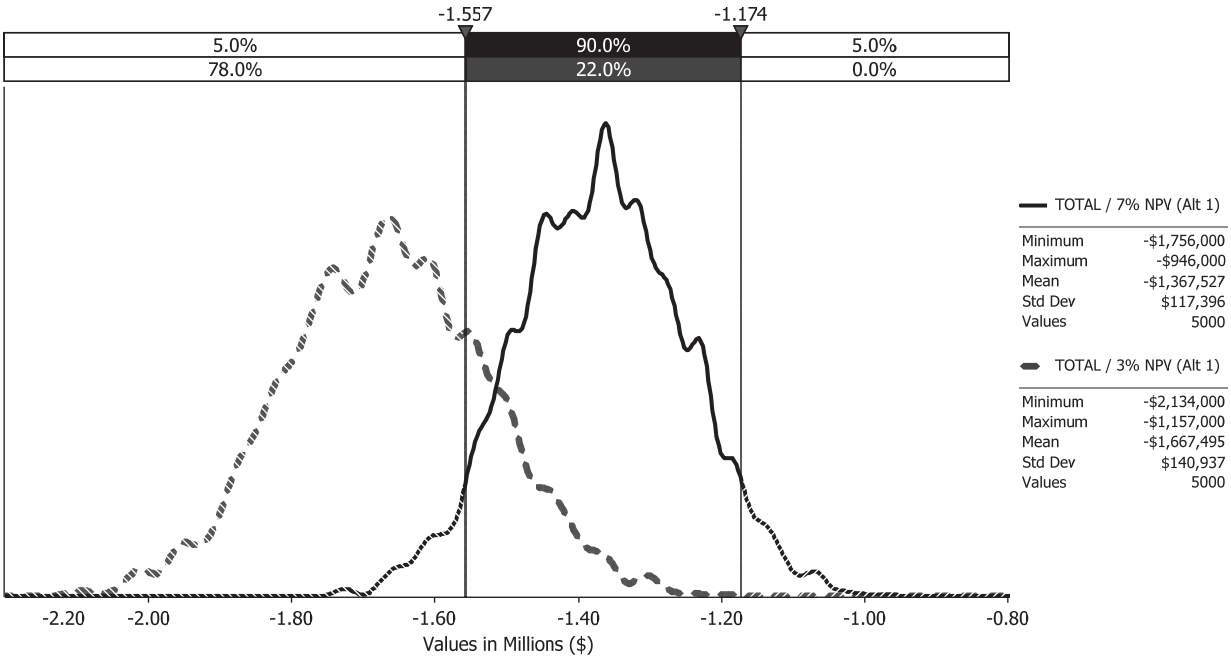

Figure D-1 Alternative 1 Total Cost Discounted at 7-Percent and 3-Percent Assuming One Licensee

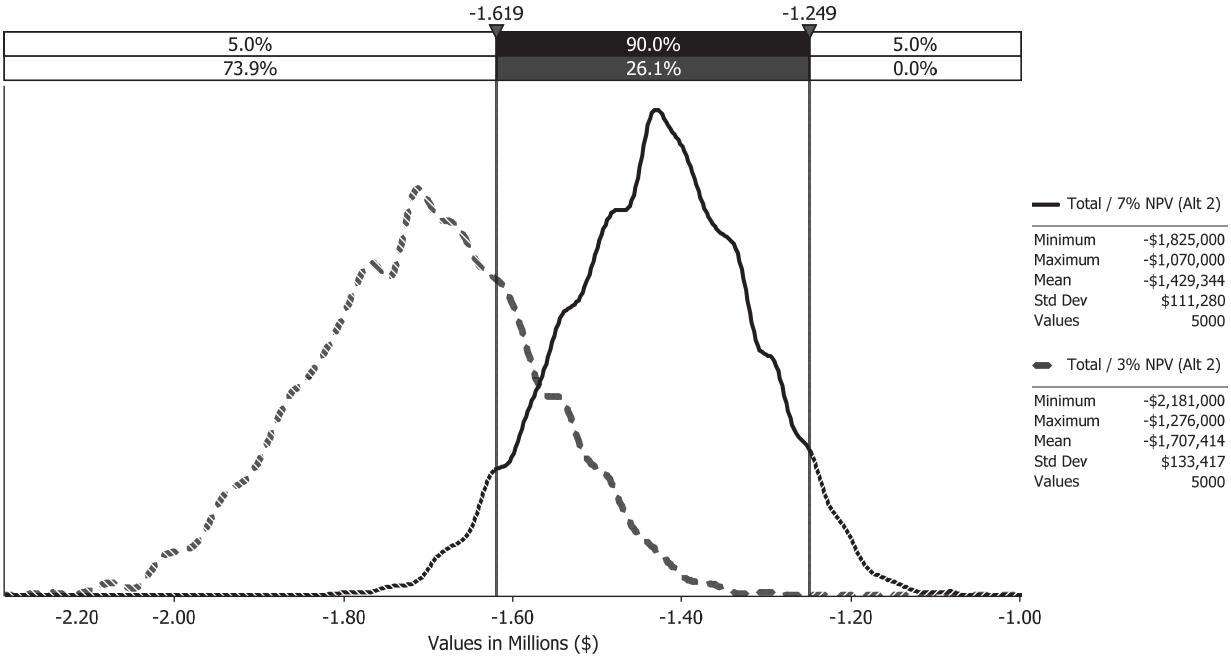

Figure D-2 Alternative 2 Total Cost Discounted at 7-Percent and 3-Percent Assuming One Licensee

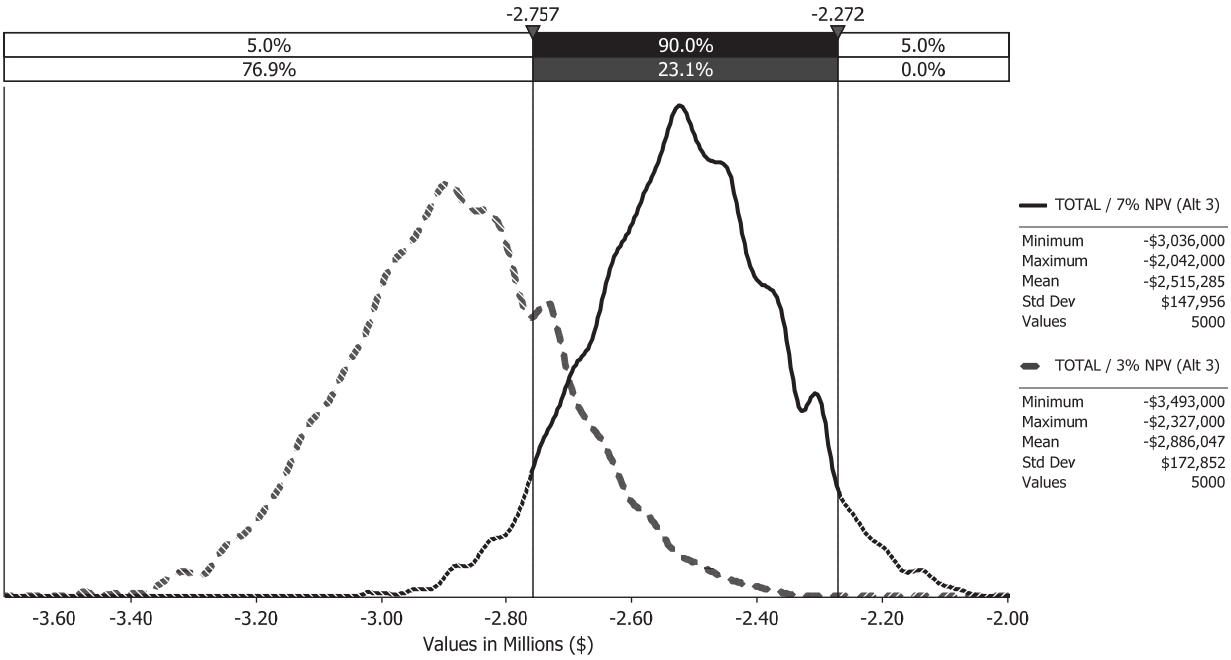

Figure D-3 Alternative 3 Total Cost Discounted at 7-Percent and 3-Percent Assuming One Licensee

Figures D-4, D-5, and D-6 identify the key variables whose uncertainty drives the largest impact on total costs for these alternatives, assuming one applicant expresses an interest in a disposal facility that can accept GTCC waste. These figures rank the variables based on their contribution to cost uncertainty.

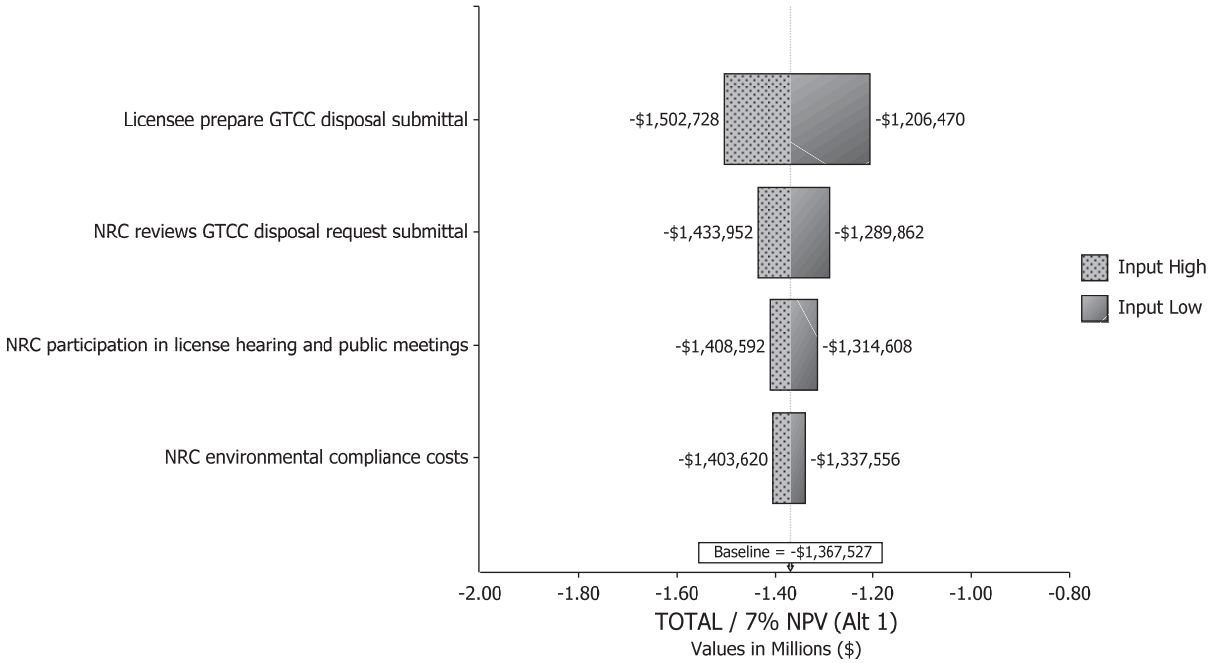

Figure D-4 Key Variables Whose Uncertainty Drives the Largest Impact on Costs for Alternative 1 (7-percent NPV)

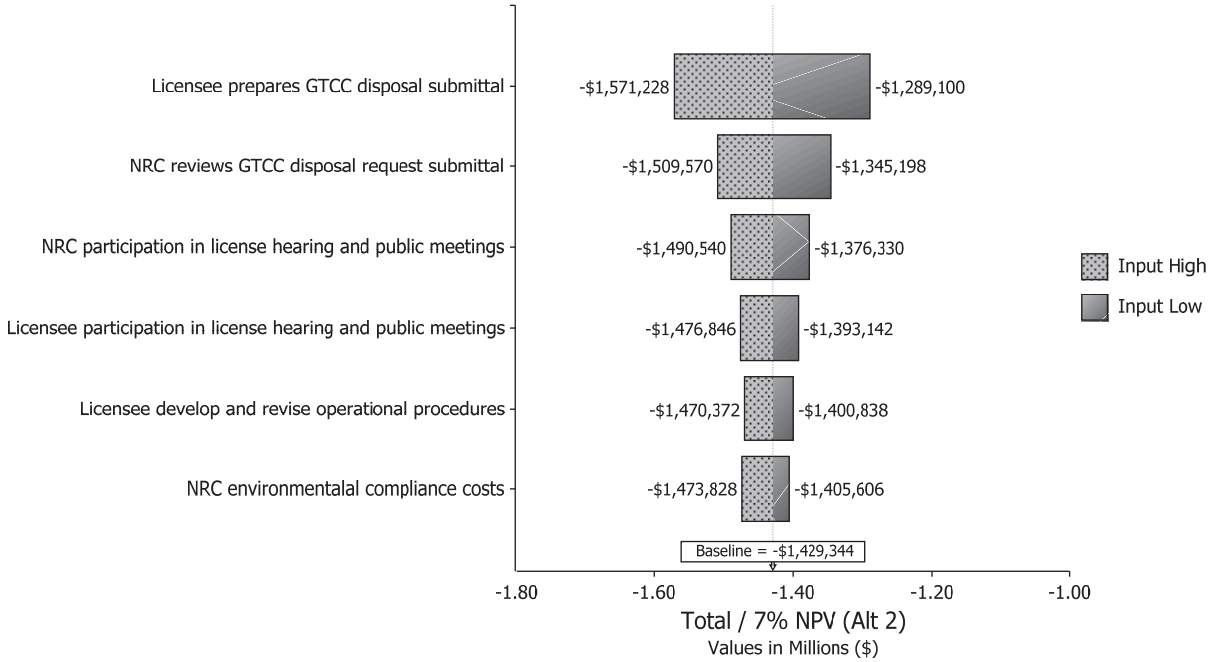

Figure D-5 Key Variables Whose Uncertainty Drives the Largest Impact on Costs for Alternative 2 (7-percent NPV)

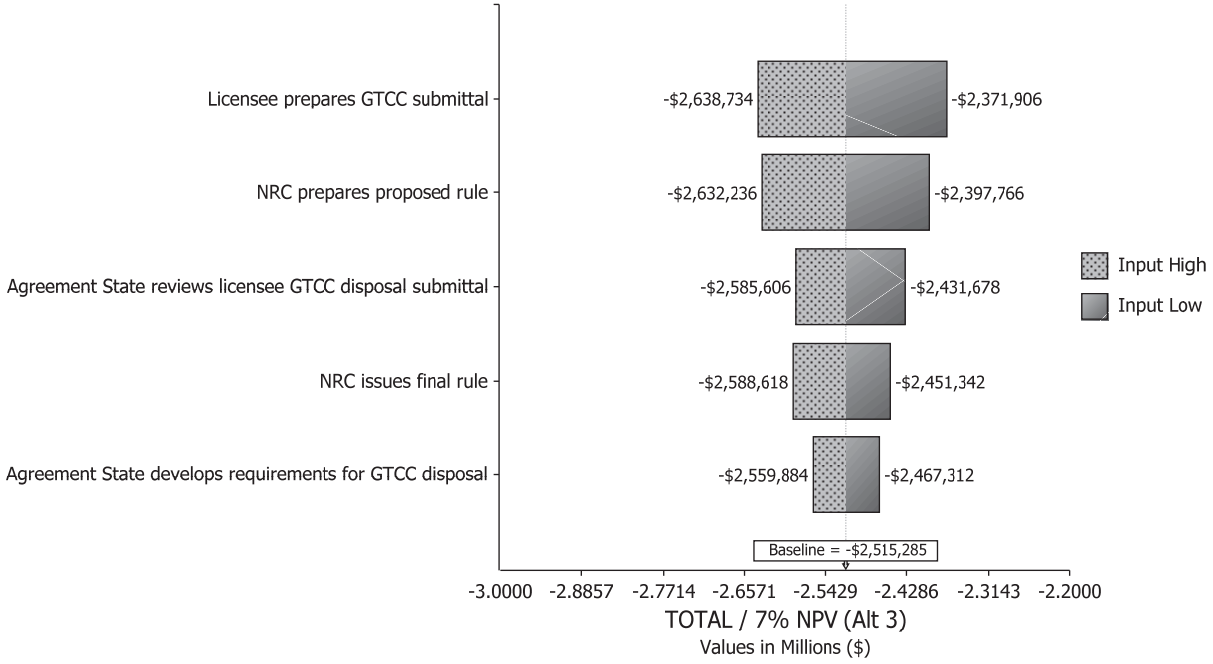

Figure D-6 Key Variables Whose Uncertainty Drives the Largest Impact on Costs for Alternative 3 (7-percent NPV)

Examining Figures D-4, D-5, and D-6 provide insight into which inputs have the largest impacts on the results of this quantitative analysis. Figures D-4 and D-5 show that the parameters having the greatest cost impact on Alternatives 1 and 2 respectively are the applicant costs of preparing its application for a land disposal facility that can accept GTCC waste and the NRC's

review of the application when using a 7-percent discount factor. The influence of a variable on the output is not only a function of the value of that variable but also of the spread of its distribution. In Figure D-6, the parameters having the greatest cost impact on Alternative 3 are the applicant costs of preparing its application for a land disposal facility that can accept GTCC waste and the NRC rulemaking costs. The other parameters shown have less impact on the results.

A direct comparison of the resulting output distributions for Alternatives 1 and 2 in Figure D-7 (based on a 7 percent discount rate and assuming one interested applicant) shows that the expected costs are very similar.

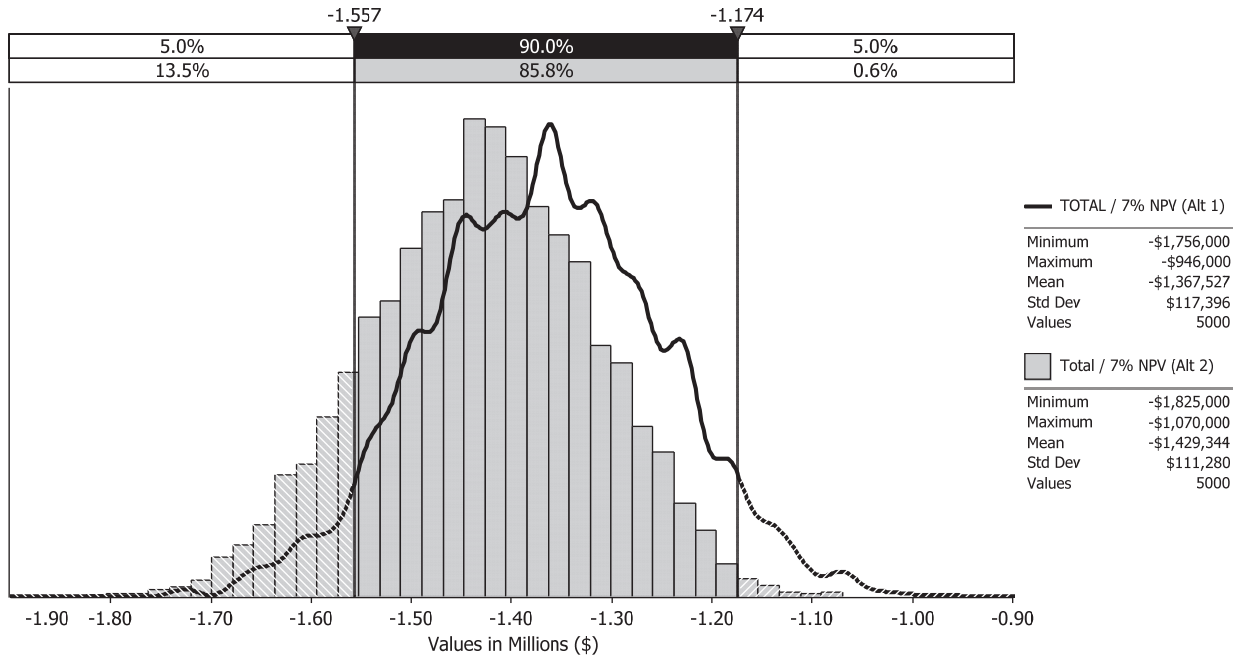

Figure D-7 Alternatives 1 and 2 Cost Distribution Comparison

A similar comparison of the resulting output distributions for Alternatives 1 and 3 in Figure D-8 (based on a 7 percent discount rate and assuming one interested applicant) shows that the costs for Alternative 3 are more expensive than Alternative 1 even when considering uncertainty.

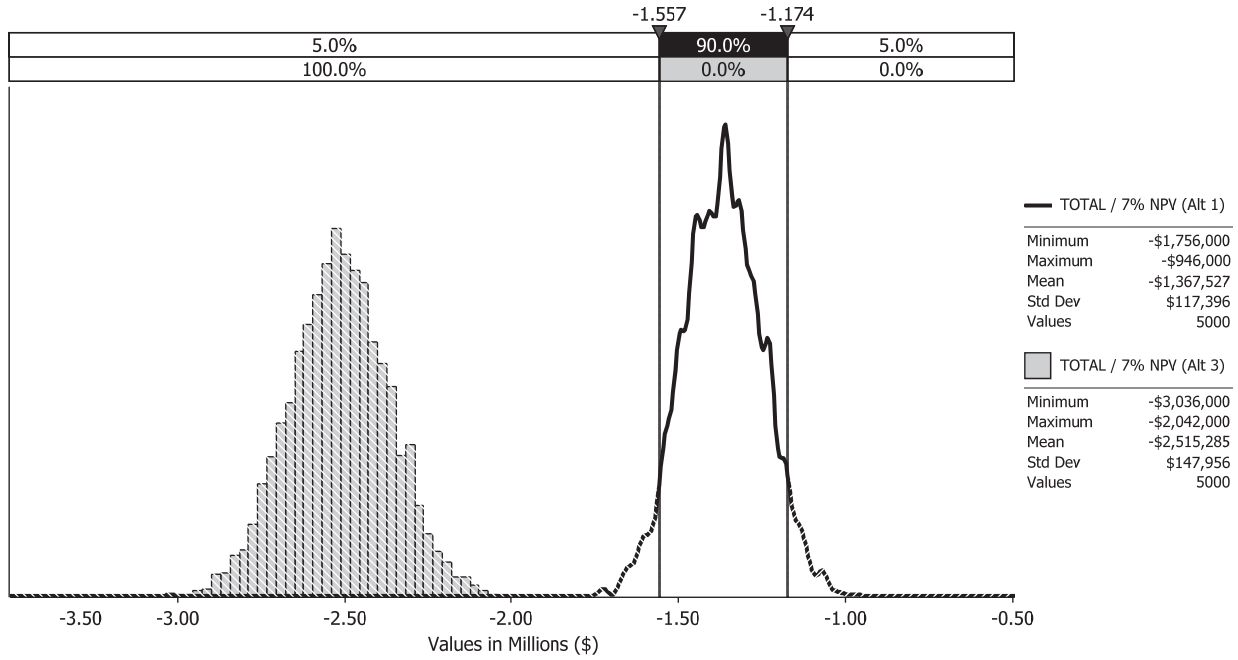

Figure D-8 Alternatives 1 and 3 Cost Distribution Comparison

Therefore, based on these comparisons, Alternative 2 provides a similar result as Alternative 1 at approximately the same cost and with only a small opportunity cost if there is no interested applicant.

Table D-1 Uncertainty Analysis Inputs

Description	Mean	Distribution	Low	Best	High
General Data					
Base year	2019				
Principal discount rate	7%				
Alternative discount rate	3%				
Industry hourly rate	$115				
State hourly rate	$90				
Tribal hourly rate	$81				
DOE hourly rate	$118				
NRC hourly rate	$129				
Alternative 1 Input Values					
Disposal Licensee Data	**Mean**	**Distribution**	**Low**	**Best**	**High**
Prepare and submit GTCC disposal submittal for NRC review (hrs)	7,125	triangular	4,500	7,500	9,375
Licensee participation in license hearing and public meetings (hrs)	1,067	triangular	640	960	1,600
Licensee review and comment on GTCC license conditions (hrs)	160	triangular	40	120	320
Develop and revise operational procedures (hrs)	400	triangular	300	400	500
Agreement States Data					

Agreement State participation in license hearing and public meetings (hrs)	640	triangular	320	640	960
Tribal Nation Data					
Tribal consultation on environmental compliance (hrs)	290	triangular	160	240	470
Tribal participation in license hearing and public meetings (hrs)	240	triangular	160	240	320
DOE Data					
DOE participation in license hearing and public meetings (hrs)	640	triangular	320	640	960
NRC Data					
NRC reviews GTCC disposal request submittal (hrs)	2,750	triangular	1,500	3,000	3,750
NRC environmental compliance costs (hrs)	875	triangular	375	750	1,500
NRC participation in license hearing and public meetings (hrs)	1,550	triangular	800	1,600	2,250
NRC finalize and issue license (hrs)	400	triangular	240	320	640
NRC prepares and issue GTCC inspection procedures (hrs)	360	triangular	160	320	600

Alternative 2 Input Values					
Alternative 2 Specific Data	**Mean**	**Distribution**	**Low**	**Best**	**High**
Licensing process efficiency gained through issued guidance	20%	triangular	10%	20%	30%
Disposal Licensee Data					
Industry review and comment on draft guidance (hrs)	240	triangular	80	240	400
Industry read issued guidance (hrs)	240	triangular	80	240	400
Prepare and submit GTCC disposal submittal for NRC review (hrs)	5,700	triangular	3,600	6,000	7,500
Licensee participation in license hearing and public meetings (hrs)	867	triangular	500	800	1,300
Licensee review and comment on GTCC license conditions (hrs)	160	triangular	40	120	320
Develop and revise operational procedures (hrs)	320	triangular	240	320	400
Agreement States Data					
Agreement State review and comment on draft guidance (hrs)	112	triangular	16	64	256
Agreement State participation in license hearing and public meetings (hrs)	540	triangular	300	500	820
Tribal Nation Data					
Tribal review and comment on draft guidance	48	triangular	16	32	96
Tribal consultation on environmental compliance (hrs)	290	triangular	160	240	470
Tribal participation in license hearing and public meetings (hrs)	240	triangular	160	240	320
DOE Data					
DOE review and comment on draft guidance	73	triangular	40	60	120

Alternative 2 Input Values					
Alternative 2 Specific Data	**Mean**	**Distribution**	**Low**	**Best**	**High**
DOE participation in license hearing and public meetings (hrs)	640	triangular	320	640	960
NRC Data					
Develop draft guidance for GTCC disposal	1,000	triangular	750	1,000	1,250
Finalize and issue guidance for GTCC disposal	1,000	triangular	750	1,000	1,250
NRC reviews GTCC disposal request submittal (hrs)	2,200	triangular	1,200	2,400	3,000
NRC environmental compliance costs	875	triangular	375	750	1,500
NRC participation in license hearing and public meetings (hrs)	1,233	triangular	600	1,300	1,800
NRC finalize and issue license (hrs)	400	triangular	240	320	640
NRC prepares and issue GTCC inspection procedures	360	triangular	160	320	600

Alternative 3 Input Values					
Alternative 3 Specific Data	**Mean**	**Distribution**	**Low**	**Best**	**High**
Licensing process efficiency gained through rulemaking	30%	triangular	10%	30%	50%
Disposal Licensee Data					
Industry review and comment on proposed rule and draft guidance and participate in public meetings	360	triangular	120	360	600
Industry read final rule and final guidance	360	triangular	120	360	600
Develop and submit application to Agreement State for disposal of GTCC	5,233	triangular	3,200	5,300	7,200
Develop and revise operational procedures	320	triangular	240	320	400
Agreement State Data					
Agreement State review and comment on proposed rule and draft guidance and participate in public meetings	227	triangular	80	160	440
Agreement State read final rule and final guidance	267	triangular	80	240	480
Review application submitted by licensee for disposal of GTCC	3,550	triangular	1,700	3,750	5,200
Agreement State develops requirements for GTCC disposal informed by rule	1,750	triangular	750	1,500	3,000
Agreement State environmental compliance costs	875	triangular	375	750	1,500
Agreement State issues license amendment for GTCC disposal	280	triangular	120	240	480
Agreement State prepares and issues GTCC disposal inspection procedures	360	triangular	160	320	600
Agreement State amends agreement with the NRC	1,000	triangular	600	900	1,500

Alternative 3 Input Values					
Alternative 3 Specific Data	**Mean**	**Distribution**	**Low**	**Best**	**High**
Agreement State completes any other required licensing actions and revisions to Compact Agreement	800	triangular	300	700	1,400
Tribal Nation Data					
Tribal review and comment on proposed rule package	78	triangular	36	54	144
Tribal consultation on environmental compliance (hrs)	290	triangular	160	240	470
Tribal participation in license hearing and public meetings (hrs)	120	triangular	80	120	160
DOE Data					
DOE review and comment on proposed rule package	257	triangular	120	200	450
DOE read final rule and final guidance	187	triangular	80	120	360
NRC Data					
Prepare proposed rule	5,600	triangular	4,200	5,600	7,000
Prepare and issue draft guidance for public comment	1,000	triangular	750	1,000	1,250
Issue final rule	3,600	triangular	2,700	3,600	4,500
Issue final guidance with rule	1,000	triangular	750	1,000	1,250
NRC amends agreement with State	1,000	triangular	600	900	1,500