

Repository Siting Annual Report

**Waste Isolation Pilot Plant Hazardous
Waste Facility Permit Number:
NM4890139088-TSDF**

Permit Part 2, Section 2.14.3

December 2025



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Acronyms and Abbreviations

AEC	Unites States Atomic Energy Commission
ATWIR	Annual Transuranic Waste Inventory Report
BRC	Blue Ribbon Commission
CBFO	Carlsbad Field Office
CBS	collaborative-based siting
CISF	Consolidated Interim Storage Facility
CY	calendar year
D&D	decontamination and decommissioning
DOE	Department of Energy
EM	Office of Environmental Management
EPA	Environmental Protection Agency
GRCC	Greater-Than-Class-C
HLW	high-level radioactive waste
INL	Idaho National Laboratory
LANL	Los Alamos National Laboratory
LWA	Land Withdrawal Act
MOC	Management and Operating Contractor
NAS	National Academy of Sciences
NE	Office of Nuclear Energy
NEPA	National Environmental Policy Act
NMED	New Mexico Environment Department
NNSA	National Nuclear Security Administration
Permit	Waste Isolation Pilot Plant Hazardous Waste Facility Permit
RCRA	Resource Conservation and Recovery Act
SIMCO	Salado Isolation Mining Contractors
SNF	spent nuclear fuel
SRS	Savannah River Site

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SSCVS	Safety Significant Confinement Ventilation System
TRU	transuranic
WIPP	Waste Isolation Pilot Plant

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1.0 Introduction

The purpose of this report is to provide the New Mexico Environment Department (**NMED**) with the Repository Siting Annual Report pursuant to Waste Isolation Pilot Plant (**WIPP**) Hazardous Waste Facility Permit (**Permit**) Part 2, Section 2.14.3, *Repository Siting Annual Report*. Permit Part 2, Section 2.14.3 states the following:

The DOE shall submit an annual report summarizing its progress toward siting another repository for TRU waste in a state other than New Mexico. The annual report shall summarize the steps the DOE has taken toward siting such a repository in another state and the report shall include documentation supporting the summary. Such documentation may include: with what disposal regulations another repository shall comply; consent-based or other siting process, timeline and milestones for identifying possible sites for another repository; National Environmental Policy Act actions, congressional authorizations and budget appropriation requests; communications with EPA and other federal agencies or Congress about activities to establish another repository; land acquisition(s); state and public engagement activities; feasibility studies; design, construction, and operation plans; and plans, timelines, and milestones for independent technical expert reviews of the activities related to establishing another repository for TRU waste.

Permit Attachment B, Resource Conservation and Recovery Act (**RCRA**) Part A Application Certification, delineates the RCRA roles and responsibilities of the Department of Energy (**DOE**) (through the Carlsbad Field Office [**CBFO**]) and SIMCO as co-operators. The co-operators' responsibilities include the development and submittal of this report. The review and content of this report is the result of a collaborative effort between DOE-Headquarters Office Environmental Management (**DOE-EM**), the DOE CBFO, and SIMCO and subject to review by DOE Headquarters. This report is the second submission to fulfill this annual requirement.

The first annual report required by Permit Part 2, Section 2.14.3, provided an extended discussion on the history, regulatory framework, experience of the WIPP Project and consent-based siting. Applying lessons learned from the DOE's experience siting and operating the WIPP facility, the nation's only transuranic (**TRU**) waste repository, will play an important role in any future efforts to site a second repository for TRU waste disposal outside of New Mexico.

The first report examined some of the key criteria for DOE to consider in potential future efforts to site another repository for TRU waste by evaluating the DOE Office of Nuclear Energy's (**DOE-NE's**) Consent-Based Siting Process for Federal Consolidated Interim Storage of Spent Nuclear Fuel. This siting process may serve as a model that could be used to identify sites outside of New Mexico that could be geologically and geographically suitable for future development of an additional deep repository for TRU

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waste disposition. Updated information on consent-based siting, now known as Collaboration Based Siting (**CBS**) is provided in this report.

Because any efforts to site a future repository would be expected to require prior Congressional authorization and funding, this report includes a needs assessment to analyze the schedule considerations and mission needs that would justify any such effort.

In order to develop information supporting evaluation of future TRU waste repository opportunities, SIMCO has subcontracted Deep Isolation of Berkley, CA to perform some research. Their research is broad and covers a wide range of investigations needed to develop technical criteria for such a repository, consider a collaborative-based approach to siting a second repository, site selection, and options for repository design and operations. A summary of Deep Isolation's preliminary investigation is summarized in Appendix 1. A summary of Deep Isolation's study on potential repository scenarios is included as Appendix 2.

2.0 Background

The WIPP facility is an underground geological repository located in a bedded salt formation 2,150 feet beneath the surface of the Chihuahuan Desert. The WIPP project was authorized by Congress as a defense activity to demonstrate the safe disposal of radioactive wastes resulting from the defense activities and programs of the United States (Public Law 96-164). The DOE mission regarding the WIPP Project is to provide safe characterization, transportation, and disposal of defense TRU waste in a manner that is protective of the workforce, public, and environment. Transuranic waste is defined statutorily as:

Waste containing more than 100 nanocuries of alpha-emitting transuranic isotopes per gram of waste, with half-lives greater than 20 years, except for (A) high-level radioactive waste; (B) waste that the DOE Secretary has determined, with the concurrence of the EPA Administrator, does not need the degree of isolation required by the disposal regulations; or (C) waste that the Nuclear Regulatory Commission has approved for disposal on a case-by-case basis in accordance with part 61 of title 10, Code of Federal Regulations. [Pub. L. 102-579 (1992)]

The WIPP Project is further authorized under the WIPP Land Withdrawal Act [**LWA**; (Public Law 102-579)] to dispose of 6.2 million cubic feet (175,564 m³) of defense-related TRU waste generated from atomic energy defense activities of the United States. Atomic energy defense activities [defined in the Nuclear Waste Policy Act, 42 U.S.C. 10101 et seq.] encompass DOE activities performed, in whole or in part, to carry out defense functions, including naval reactors development; weapons activities; defense nuclear materials production, safeguards, defense nuclear waste and materials by-product management; and defense research and development.

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The WIPP facility is located approximately 26 miles from Carlsbad, NM, and is the nation's only disposal site for defense-related TRU waste.

The first annual report, required by Permit Part 2, Section 2.14.3, contained relevant background information regarding the process of locating a TRU waste disposal site with emphasis on the experience and success accomplished with the WIPP Project. Utilizing lessons learned from the WIPP experience will be essential in future efforts to successfully site another repository for disposal of TRU waste.

The NMED offered suggestions for additions to the 2025 Annual Repository Siting Annual Report in their June 16, 2025, letter to the Permittees (NMED 2025). Responses addressing the suggestions are incorporated into the report to the extent practicable at this time.

3.0 WIPP Siting History

3.1 Why was the WIPP Chosen?

Siting for the WIPP facility traces its roots to the 1950s. In 1957, the National Academy of Sciences (**NAS**) recommended salt as the most promising geologic medium for disposal of radioactive waste for the following reasons (NAS 1957):

- Salt provides stable geology,
- Salt is easy to mine,
- Fractures are self-healing,
- Salt is impermeable,
- Salt is naturally plastic; “creep” will encapsulate the waste,
- Salt has high thermal conductivity,
- Salt provides effective long-term isolation,
- Bedded salt has high compressive strength,
- Bedded salt permits dissipation of larger quantities of heat than is possible in other types of rock,
- Rock salt is approximately equal to concrete for gamma-ray shielding, and
- Salt is abundant and therefore economically and geologically feasible.

In 1973, the U.S. Atomic Energy Commission (**AEC**) chose the underground salt bed 26 miles east of Carlsbad for exploratory work in the search for an underground radioactive waste repository site (ORNL 1973). The WIPP facility's location was selected because it met the NAS recommended criteria and was considered an ideal location based on the following:

- A facility was needed,
- Strong local community support,
- Geology,
- Remote location,

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- Demographics (e.g., sparsely populated), and
- Minimal surface and groundwater.

The WIPP repository is located approximately 2,150 feet below ground surface in a thick and relatively homogeneous strata of bedded salt locally known as the Salado formation. Regional geologic data indicate that this formation extends roughly from southeastern New Mexico on a northeasterly track to south central Kansas.

3.2 WIPP Facility Status

Due to the operation of the WIPP facility, DOE-EM has been able to safely and compliantly remove and dispose of TRU waste from generator/storage sites across the country, significantly furthering the national cleanup mission for protection of human health and environment. DOE-EM continues to make steady progress in drawing down inventories of TRU waste at sites, such as the Los Alamos National Laboratory (**LANL**) in New Mexico and the Idaho National Laboratory (**INL**) in Idaho. Most significantly, the Rocky Flats Environmental Technology Site was de-inventoried of TRU and TRU mixed waste (approximately 11,400 m³ emplaced at WIPP) and the facility was reclaimed. In 2025, the National TRU Program/Central Characterization Project worked collaboratively with LANL to safely expedite characterization and shipment of the cemented corrugated metal pipe (**CMP**) waste stream from LANL. Shipments of the CMP commenced in June 2025 and are ongoing. Approximately 792 Standard Waste Boxes (1,488.96 m³) of this waste stream are planned for shipment to the WIPP. The INL has significantly reduced its inventory as needed to meet the Idaho Settlement Agreement (DOE 1995). Approximately 42,511 m³ of waste has been emplaced from INL, received in about 7,100 shipments.

The WIPP also plays an important role for key DOE defense programs, such as those overseen by the National Nuclear Security Administration (**NNSA**), by providing disposal capacity for defense-related TRU waste generated as part of ongoing national security and scientific research missions.

Major infrastructure construction projects at the WIPP facility have been completed. This includes the new Safety-Significant Confinement Ventilation System (**SSCVS**) and the new Utility Shaft (Shaft #5). The SSCVS was completed and commissioned in 2025 after multiple tiers of rigorous readiness assessments. It can provide up to 540,000 cubic-feet-per-minute of fully filtered ventilation for the underground, allowing concurrent mining, waste emplacement, and ground control operations throughout the life of the facility. The new Utility Shaft will serve as an air intake entry point to support the mine and meet SSCVS airflow volume demands. The underground Salt Pocket refurbishment project is complete.

The Permittees have also been authorized by NMED and the EPA Office of Radiation and Indoor Air to utilize new Panels 11 and 12, which restore disposal space within the WIPP underground that has been lost over the operational life of the facility. Panels 11 and 12 will be replacement panels for space that could not be utilized in Panels 1-7 and

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from the abandonment of equivalent Panel 9. These new panels change the underground footprint of the WIPP facility but do not represent an expansion of DOE's WIPP mission or the permitted disposal capacity of the WIPP facility. The statutory limit for waste volume under the WIPP LWA and the type of waste accepted at the WIPP—defense TRU waste—remain unchanged.

4.0 Process for Siting a Second TRU Waste Repository

4.1 Introduction

Identifying and successfully siting another repository requires the alignment and reconciliation of complex challenges. These include developing technical criteria, identifying potentially suitable sites, collaborating with host communities, performing site characterization, identifying requisite design considerations, defining the regulatory framework, and evaluating the design and construction requirements for facility infrastructure and operation.

The process for identifying a second repository can be summarized as follows:

- Identify a need for a second repository
- Identify potential funding
- Apply lessons learned based on WIPP siting criteria, history, regulatory process and operations
- Define regulatory framework
- Issue or revise regulatory framework as needed
- Identify process for state, local, stakeholder and public involvement
- Identify technical criteria/geological requirements
- Identify potential disposal scenarios
- Identify potential site locations
- Identify requisite transportation routes
- Collaborate with host communities
- Characterize the site
- Design facility based on site/regulatory requirements

Some of the above steps can be initiated by setting aside available resources over an extended period, such as evaluating lessons learned from the WIPP experience and defining the regulatory framework.

The Blue Ribbon Commission (**BRC**) on America's Nuclear Future stated in its 2012 Report to the Secretary of Energy, "[e]xperience in the United States and in other nations suggests that any attempt to force a top down, federally mandated solution over the objections of a state or community—far from being more efficient—will take longer, cost more, and have lower odds of ultimate success." (BRC 2012)

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As a corollary, the DOE is currently seeking to site federal consolidated interim storage capability for commercial spent nuclear fuel. While not directly applicable to a second TRU waste repository, the process being used by DOE-NE provides a potential model for the identification of another site to host a future TRU waste repository. Accordingly, since the Repository Siting Annual Report requirement was added to the WIPP Permit, DOE-EM considered the extensive work performed by DOE-NE on this subject to gain insight into the proposed processes and lessons learned by DOE-NE. Such information is discussed in this report and may be considered in any future effort to site another TRU waste repository.

New Repository Needs Assessment

Effectively demonstrating the need for a second repository is a critical first step to securing the necessary Congressional authorization for a second TRU waste repository. This section assesses the need for a second repository by comparing the WIPP's LWA TRU waste facility disposal capacity with the projected TRU waste inventory and ongoing DOE defense programs.

The principal driver for a second TRU waste repository is TRU waste inventory projections. The DOE-EM analyzed the 2024 Carlsbad Field Office (**CBFO**) Annual Transuranic Waste Inventory Report (**ATWIR**) to determine when the inventory would support the need for opening a new repository. The ATWIR includes estimates reported by the TRU waste generator sites as of the data collection cutoff date of December 31, 2023 (DOE 2024). The ATWIR is a comprehensive inventory report including input provided by all active generator sites. TRU waste from all active generator/storage sites is accounted for in the ATWIR including the following:

- LANL TRU waste in storage at Waste Control Specialist
- Buried TRU waste at LANL,
- Future DOE DOE-NNSA pit production waste,
- Future TRU decontamination and decommissioning (**D&D**) waste from the DOE complex (based on generator sites' best annual estimates), and
- TRU waste at Hanford.

The ATWIR is annually updated and posted on the WIPP home page and has a complete list of generator/storage sites and respective waste inventory estimates.

Generator/storage sites are asked to annually report comprehensive estimates of existing and to-be-generated waste volumes for as far into the future as possible. The ATWIR identifies estimated waste volumes in five general categories. These include the following (numbers in parentheses indicate volumes estimated in the 2024 ATWIR):

- Emplaced and Temporary Storage (75,600 m³): TRU waste that has already been emplaced in the WIPP facility, staged for emplacement at the WIPP facility as of 12/31/23, or placed in temporary storage at Waste Control Specialists LLC, in Andrews, TX.

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- WIPP-bound Stored and Projected Through 2033 (39,000 m³): As of the data cutoff date, TRU waste that appears to have no significant technical or legal constraints limiting the waste from being eligible for disposal in the WIPP facility after all waste characterization and certification criteria have been satisfied. This includes waste already generated and in storage at generator sites as well as waste projected to be generated in the future, through calendar year (CY) 2033.
- WIPP-bound Projected Beyond 2033 (38,600 m³): WIPP-bound TRU waste projected to be generated beyond CY 2033.
- Potential Stored and Projected Through 2033 (8,160 m³): As of the data cutoff date, waste that has meaningful uncertainties regarding its eligibility, due to technical or legal considerations, for emplacement in the WIPP facility. This includes waste already in storage and projected to be generated in the future, through CY 2033.
- Potential Projected Beyond 2033 (13,600 m³): Potential TRU waste projected to be generated beyond CY 2033.

Potential Stored and Projected Waste Through 2033 and Potential Projected Waste Beyond 2033 is currently not eligible for disposal at WIPP and requires further regulatory processes. The TRU waste volumes in these categories can be summed, as shown in Table 1 below, to estimate how much TRU waste may be available for disposal at the WIPP facility. More details pertaining to these categories can be found in the ATWIR posted on the WIPP home page.

Table 1 – LWA TRU Waste Volume Estimates

ATWIR General Category	LWA TRU Waste Volume (m ³)
Emplaced and Temporary Storage	75,600
WIPP-bound Stored and Projected Through 2033	39,000
WIPP-bound Projected Beyond 2033	38,600
Potential Stored and Projected Through 2033	8,160
Potential Stored and Projected Beyond 2033	13,600
Total ATWIR Volume	174960
WIPP LWA Capacity Limit	175,564
Total ATWIR Volume - WIPP LWA Capacity Limit =	-604(0.3% below capacity)

The 2024 ATWIR projects that the ATWIR emplaced volume at the WIPP facility, combined with TRU waste currently planned to be shipped to the WIPP facility (i.e., WIPP-bound waste through 2033 and beyond), totals approximately 153,200 cubic meters. This is less than the WIPP facility LWA volume capacity limit of 175,564 cubic meters. Details regarding specific waste streams at each generator/storage site are included in the ATWIR and are updated annually.

As for the volume calculations over the LWA limit that were cited in the 2020 NAS report, *Review of the Department of Energy's Plans for Disposal of Surplus Plutonium in the*

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Waste Isolation Pilot Plant, they were calculated based on estimates available at that time. For example, the NAS report indicated that total “TRU waste from pit production = 57,550 m³.” (NAS 2020) The original Savannah River Site (**SRS**) waste volume estimates were based on a pit production rate of 80 pits per year (FR Vol 85, No. 215). The SRS waste estimates reported to the ATWIR team was about 52,000 m³. Since the time of the NAS report, SRS revised their pit production estimates to be based on a production rate of 50 pits per year. This resulted in a reduction of about 29,000 m³ to approximately 23,000 m³ projected through the year 2083. This volume can be found in the 2024 ATWIR by looking at the Waste Profile Report for SR-CH-PP in Appendix A (Pg 298) to see the volume of about 229 m³ projected up to 2033 and then using Table 4-4 (Pg 43) to see the volume of approximately 22,700 m³ projected beyond 2033 up to 2083, totaling about 23,000 m³. (DOE 2024) Note that the NAS report also addressed Greater-Than-Class-C (**GRCC**) low-level waste and GRCC-like waste, which are not considered by WIPP’s inventory team because they do not meet the definition of TRU waste. The volume estimates used by the NAS to “...illustrate the possible over-subscription of the LWA limits at WIPP...” were based on pre-2020 data that has been updated. The current data presented in Table 1 above demonstrates that there is currently sufficient capacity for the estimated ATWIR 2024 TRU waste inventory which includes pit production waste. Again, the ATWIR includes waste volume projected about 50 years into the future, as well as potential WIPP waste. As of the 2024 ATWIR cutoff date, some of the potential waste does not appear to be eligible for disposal at WIPP due to technical, regulatory, or legal considerations. However, DOE includes this volume in its projections to develop a conservatively comprehensive forecast.

A May 23, 2025, Executive Order, “Reinvigorating the Nuclear Industrial Base,” may reduce the quantities of plutonium waste destined for future disposal at WIPP. This order directed DOE to halt much of its dilute and dispose program for surplus plutonium:

“(c) The Secretary of Energy shall halt the surplus plutonium dilute and dispose program except with respect to the Department of Energy’s legal obligations to the State of South Carolina. In place of this program, the Secretary of Energy shall establish a program to dispose of surplus plutonium by processing and making it available to industry in a form that can be utilized for the fabrication of fuel for advanced nuclear technologies.”

Note that the impacts of the order on the ATWIR inventory have not yet been determined for waste not subject to DOE’s legal obligation to the State of South Carolina.

Taking account of potential WIPP waste, the total waste volumes in the ATWIR are less than the LWA volume limit by less than 0.3 percent, as shown in Table 1 above. Based on this data the total volume eventually sent to WIPP is expected to be well within the WIPP LWA limit

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Based on current knowledge, WIPP has adequate capacity for all known and potential defense-related TRU waste. Currently there is not a need for another repository.

Although there is sufficient capacity for the TRU waste currently identified in the ATWIR, DOE acknowledges that changes could occur over time. Site cleanup and related facility D&D activities are planned to be accomplished over decades; information gained or unexpected conditions encountered during site remediation, waste retrieval, and facility dismantling can add new waste streams or change estimated waste volumes.

Furthermore, there are present and future defense-related research and production activities with indefinite end points. For example, NNSA's Enterprise Blueprint published in 2024 (NNSA 2024) indicates that programmatic and facility upgrades are planned through 2050 to support ongoing operations for decades to come. Alternately, some waste currently identified as TRU waste may later be determined to be low-level waste during characterization or remediation activities, resulting in lower inventory estimates.

DOE must ensure ongoing and future activities related to the cleanup of defense-related TRU waste generated from decades of nuclear weapons development are completed as efficiently and safely as possible. At the same time, DOE will need to continuously engage in planning efforts to ensure sufficient disposal capacity for TRU waste. Accordingly, DOE will continue to monitor projected waste inventories to identify potential gaps in capacity and ensure sufficient lead time exists to successfully site and open a second dedicated defense-TRU-only repository, if needed.

4.2 Long Term TRU Waste Disposal Needs Cannot Impede Ongoing Cleanup Activities

Although processes and prerequisites to site another repository may be evaluated to support the long-term needs of generator/storage sites and defense related mission activities, this effort cannot interfere with DOE's ongoing activities to clean up the environmental legacy resulting from decades of nuclear weapons development. DOE will continue exploring ways to accelerate and optimize WIPP's repository usage in the near term to ensure safe, efficient, and full usage of its capacity as a national resource. The following are some examples of potential optimization strategies DOE will consider:

- Waste minimization initiatives. Encourage generator/storage sites to identify ways to reduce the volume of TRU waste such as job control/repacking waste.
- Compacting waste. The INL has successfully used super compaction to reduce the volume of waste destined for WIPP. This can be investigated at other sites.

DOE intends to explore other cost-effective ways of optimizing WIPP's disposal capacity to support its availability for future mission needs. DOE acknowledges that identifying another repository for waste exceeding the WIPP LWA TRU waste volume capacity limit is one alternative to be explored at the same time DOE continues to safely and efficiently complete ongoing cleanup activities. DOE continues to improve

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understanding of the WIPP geophysical and geochemical environment to help streamline potential the identification of future geologic repositories.

5.0 Summary of Supporting Documentation Delineated in Permit Part 2

This section addresses, to the extent possible at this early stage, requirements including supporting documentation delineated in Permit Part 2, Section 2.14.3, which states the following:

...The annual report shall summarize the steps the DOE has taken toward siting such a repository in another state and the report shall include documentation supporting the summary. Such documentation may include...

The list of possible aspects/supporting documentation delineated in Permit Part 2, Section 2.14.3, are addressed below.

5.1 With what disposal regulations shall another repository comply

An important first step in siting another repository would be to identify the applicable regulations and consider the appropriate regulatory framework.

The WIPP Siting History discussed in the first annual siting report provided the regulatory framework for a geologic TRU waste repository under current law and regulations. The WIPP experience provides a model for the potential regulations that would apply to the siting, construction, permitting, operating and closure of another repository.

The DOE evaluated the existing EPA disposal regulations, including standards applicable to WIPP and those applicable to high-level waste (**HLW**) repositories. The results of the evaluation are discussed below.

40 CFR Part 191

40 CFR Part 191 describes the EPA environmental standards for radiation protection applicable to the management and disposal of spent nuclear fuel (**SNF**), HLW, and TRU radioactive waste. The standards contain three parts: Subpart A—Environmental Standards for Management and Storage, Subpart B—Environmental Standards for Disposal, and Subpart C—Environmental Standards for Ground-Water Protection. The DOE has effectively implemented these standards for the WIPP facility in Carlsbad, NM. The DOE is the regulatory authority for 40 CFR Part 191 as it applies to the WIPP repository, although the WIPP LWA of 1992 (amended in 1996) specified an oversight role for EPA with regard to 40 CFR Part 191 Subparts B and C as described below.

Subpart A is implemented through DOE Order 458.1 Radiation Protection of the Public and the Environment. Subpart B is implemented by DOE in accordance with 40 CFR Part 194, which requires the EPA to periodically certify DOE compliance with the

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Subpart B and C standards. As part of Subpart B, 40 CFR §191.13 provides containment requirements (including release limits by radionuclide) over a 10,000-year period based on a performance assessment to assess the cumulative releases of radionuclides to the accessible environment. Subpart B also includes assurance requirements as 40 CFR §191.14 (including loss of credit for institutional controls after 100 years) and individual protection requirements as 40 CFR §191.15 (including dose limits). Subpart C contains standards for groundwater protection. Absent any future change in 40 CFR Part 191, the DOE will use these radiation protection standards for a second TRU waste repository developed under its authority.

The standards in 40 CFR Part 191 (containment and individual protection requirements) are appropriate for siting another repository. Therefore, 40 CFR Part 191 would not require change/interaction with EPA. However, EPA has indicated an intent to revise regulations to support a broader range of repository locations, however EPA has not provided a time frame for performing this work.

40 CFR Part 194

The EPA was assigned the responsibility to certify the DOE compliance with the standards in 40 CFR Part 191 Subparts B and C at the WIPP facility. This assignment is part of the LWA. The EPA promulgated 40 CFR Part 194 to define the compliance application contents and the process under which it will certify compliance. 40 CFR Part 194 will not apply to a non-WIPP repository. Comparable requirements would require additional negotiations and appropriate regulatory action.

DOE also examined the EPA standards for HLW repositories and found these to be excessive for TRU waste. However, because the HLW disposal standards would be bounding for TRU waste, TRU waste could be disposed in a future HLW waste repository.

In the current regulatory framework, long-term performance for a future geologic repository would be subject to the generic disposal standards that currently apply to WIPP (i.e., 40 CFR Part 191) and would apply to any SNF, HLW or TRU repositories (or, in principle, other disposal approaches) except Yucca Mountain (which has separate standards directed by the Energy Policy Act Pub. L. 102-486). However, a future repository could be subject to different standards. For example, the BRC and others have called for EPA to update its generic standards (ANS 2023) (BTI 2024). DOE-NE has established a Memorandum of Understanding with EPA to support technical information sharing that could inform such updated standards, subject to appropriations (EPA 2024). Therefore, while existing disposal regulations applicable to the WIPP facility serve as a known regulatory framework that could apply to a second repository, DOE will monitor any future regulatory actions applicable to TRU waste disposal activities and report such activity in a future annual report as appropriate.

There may also be site-specific implementation criteria developed to interpret and apply standards to any future repository, such as the criteria EPA promulgated in 40 CFR Part

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194 for the certification and re-certification for WIPP. In the current regulatory framework, the DOE would be the implementing agency for a future repository for defense-only waste; however, for a potential future repository this regulatory framework could differ significantly from that for the WIPP Project, even if the underlying disposal standards (40 CFR Part 191 or equivalent) are similar.

RCRA Treatment Standards

The WIPP LWA exempts TRU mixed waste from the RCRA treatment standards. This exemption was granted because the WIPP was demonstrated to be robust via a No Migration Variance petition (DOE 1990). The exemption is specific to the WIPP and cannot be assumed to be achievable with other sites. This could result in significant technical, regulatory and compliant challenges in siting and operating a future repository. The absence of a RCRA exemption for any future site would require either extensive and costly treatment of TRU mixed waste to comply with RCRA land disposal restrictions, engineered barriers, or a new, rigorous, and potentially challenging "No Migration Variance petition" process. Meeting these challenges could be costly and time consuming.

DOE Requirements

DOE has well established design and construction requirements for nuclear facilities. These are governed primarily by DOE performance directives and standards such as DOE O 420.1C, *Facility Safety*, and DOE O 430.1B, Ch-2, *Real Property Asset Management*. For a second TRU waste geological repository, the DOE may have to consider non-DOE requirements, such as Mine Safety and Health Administration safety requirements.

5.2 Collaboration-based siting or other siting process

The first Repository Annual Siting Report provides an extensive discussion on CBS. The following is a brief update.

The CBS process involves public participation in the siting process. The process emphasizes inclusive community and stakeholder engagement to gather public values, interests, and concerns with a goal to identify one or more volunteer sites for a Consolidated Interim Storage Facility (**CISF**). Communities and stakeholders engage with the DOE through a multi-phase process to explore the potential for hosting a CISF and to build consensus around the decision. The process relies on public input to inform the development of the siting process itself, which is revised based on feedback from various groups.

A 2025 commentary paper on WIPP provides a short history of WIPP from the siting process through current operations (Bowen, Matt; Khan, Hamna; Ponangi, Rama T. 2025). The paper is meant to provide lessons learned and commentary to be potentially considered in siting future repositories. The authors encourage DOE to provide more data to state and local officials who want to learn more about the safety and economic

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impacts of hosting a facility such as WIPP. The paper concludes in part, “A second deep geologic repository, however, would no longer be a “first of a kind” project in the United States, and the knowledge gained by the WIPP experience could temper some concerns. Today, state and local officials can visit an operating deep geologic repository to judge for themselves the risks and benefits—something that was not possible when WIPP was in development.”

Developing a process for addressing stakeholder input is the most relevant approach to identify a site to host any future TRU waste repository. An important early step would be to communicate with applicable regulators, affected populations, interested stakeholders and other members of the public. Such input is crucial to further defining the process and key components for decision making. The voice of potential volunteer communities for a future repository could be expected to influence timeframes, siting criteria, regulatory processes, required technical studies and reviews, consultation agreements and more.

Within a CBS framework, it is challenging to define these siting aspects—much less repository designs and other factors that can be determined with certainty only after a site is selected—before achieving input from a broad community. This limitation is reflected in the remaining topics in this section. Appendix 1 provides additional detail and discussion pertaining to DOE’s collaborative siting process.

5.3 Timeline and milestones for identifying possible sites for another repository

As discussed in the first report, the BRC acknowledged “there is an inherent tension between recommending an adaptive, consent-based process and setting out deadlines or progress requirements in advance” (BRC 2012) Nonetheless, the BRC agreed it is important to set flexible performance goals and milestones for major phases of program development and implementation to promote government accountability and public trust. It suggested “a range of, say, 15 to 20 years to accomplish site identification and characterization and to conduct the licensing process for a geologic repository” (BRC 2012).

The WIPP siting process may provide additional insight regarding achievable timeframes. Siting for WIPP began in the 1950s. In 1957, the NAS recommended salt as the most promising geologic medium for disposal of radioactive waste (NAS 1957). In 1973, the AEC chose the underground salt beds 26 miles east of Carlsbad for exploratory work in the search for an underground radioactive waste repository site (ORNL 1973). Once the WIPP site was identified, the LWA was issued, design and construction were completed, operational funding was appropriated, and finally necessary operating permits and authorization were issued, including a RCRA operating permit from NMED in 1999. The entire process took more than 40 years, including the initial NAS deliberations. This was without a CBS process. Lessons learned from

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geophysical and geochemical studies would be able to streamline/shorten the technical aspects of siting another repository.

No timeline is presently available for determining the need for a second repository.

5.4 National Environmental Policy Act

An early regulatory step by DOE would be to develop National Environmental Policy Act (**NEPA**) documentation for integration into the decision-making process. NEPA actions are a prerequisite to deciding to pursue a second repository.

5.5 Congressional authorizations and appropriation requests

Congressional authorization and appropriations would be required prior to initiating the siting process for a second repository. As discussed in detail in Section 4.2 above, a needs assessment plays an important role in determining the purpose and timing of any such action. Based on the ATWIR inventory estimates, a need has not been established, so no action can be taken to request budget appropriations.

5.6 Communications with EPA and other federal agencies or Congress about activities to establish another repository

DOE has not sought Congressional authorization or appropriations for a second repository in the past year, nor has it communicated with EPA or other federal agencies regarding new repository siting. DOE will monitor any efforts by EPA to update its generic disposal standards.

5.7 Land acquisition

Land for a second repository likely would be acquired either by purchase, land swap, or legislative permanent withdrawal from Federal or state purview for DOE use. Based on the WIPP model, land use requirements would need to be tailored to address the unique land use activities and uses of the location of a second repository. For example, the WIPP LWA act address, grazing, hunting and trapping, disposal of salt tailings, surface and subsurface mining and oil and gas activities, including drilling (Public Law 104-201)The LWA is also discussed in Section 3.2.

5.8 State and public engagement activities

DOE briefly discussed the 2024 Repository Siting Annual Report at the November 2025 WIPP Community Forum. The discussion included the requirements for the report and where to find the 2024 report online.

5.9 Feasibility studies; design, construction, and operation plans

As part of developing future repository scenarios, Deep Isolation, a subcontractor to SIMCO, examined the possibility of using deep boreholes to dispose of nuclear waste. Appendix 1 provides a summary of their research to date, primarily focusing on

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corroboration-based siting. In a letter to Congress dated March 18, 2025, the Nuclear Waste Technical Review Board ruled out most disposal methods (other than geologic disposal; however, they included deep borehole disposal as a method that could be pursued and that has seen “major advances in relevant technology” since 1980 (U.S. NWTRB 2025). They also reiterated that “[e]ven if disposal of some radioactive waste in deep boreholes is determined to be feasible, the need for a mined, geologic repository is not eliminated.”

5.10 Plans, timelines, and milestones for independent technical expert reviews of the activities related to establishing another repository for TRU waste

The following work is being planned and may be addressed in a future annual report:

- Update needs assessment
- Evaluate potential regulatory strategy

6.0 Conclusion

Since opening in 1999, the WIPP Project has been vital to DOE meeting its legal obligations to clean up nuclear sites across the country, including in New Mexico. Not only does the WIPP facility serve DOE in advancing its important cleanup mission, but it also aids other DOE programs in current and future national security and scientific research missions. Current projections show, based on available inventory data, that the WIPP facility possesses sufficient disposal capacity for all known defense-related TRU waste disposal needs. Currently there is no need for another repository, and therefore no need to begin the process to have a repository online once WIPP reaches capacity. DOE will continue to update and monitor defense TRU waste inventory estimates to identify any potential possible gaps in the WIPP disposal capacity with sufficient lead time to allow for the potential development of a second defense-related TRU waste repository.

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Appendix 1 Siting Framework and Collaborative Community Engagement Process

DECEMBER 11, 2025

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Abbreviations, Acronyms, and Initialisms

Term	Meaning
APM	adaptive phased management
BHA	legacy waste vault
BHK	fuel hardened capsules vault
DBD	deep borehole disposal
DGR	deep geologic repository
DOE	Department of Energy
EBS	engineered barrier system
EPA	Environmental Protection Agency
HADES	High Activity Disposal Experiment Site
HLW	high-level waste
IAEA	International Atomic Energy Agency
ILW	intermediate-level waste
KBS-3	Nuclear Fuel Safety Version 3
LLW	low-level waste
MGR	mined geologic repository
NEA	Nuclear Energy Agency
NWMO	Nuclear Waste Management Organization
NRC	Nuclear Regulatory Commission
NWTRB	Nuclear Waste Technical Review Board
ORNL	Oak Ridge National Laboratory
RFI	request for information
SFL	Swedish Final Repository for Long-Lived Waste
SFR	Swedish Final Repository for Radioactive Waste
SIMCO	Salado Isolation Mining Contractors
SKB	Swedish Nuclear Fuel and Waste Management Ltd.
SNF	spent nuclear fuel
TRU	transuranic
VLJ	operating waste repository
WIPP	Waste Isolation Pilot Plant

Executive Summary

This report summarizes a study commissioned by Salado Isolation Mining Contractors, LLC (SIMCO) to support potential siting of a second defense transuranic (TRU) waste repository. This effort stems from the Department of Energy's (DOE) potential need to manage excess inventory of TRU waste beyond the current capacity of the Waste Isolation Pilot Plant (WIPP) in New Mexico. The report draws on international siting efforts and best practices for collaborative-based community engagement to establish a framework for future TRU waste disposal strategies.

The report begins by outlining the U.S. Department of Energy's consent- and collaborative-based siting process, which draws on lessons learned from international efforts that emphasize active and inclusive community engagement. It serves as a strong foundation for developing a similarly translatable approach to siting a second TRU waste repository. Central principles of this framework include enabling flexible yet meaningful local community participation, fostering collaboration throughout the siting process, ensuring adequate resources for capacity-building, and maintaining trust through transparency and accountability.

Moreover, a comparative review of international repository programs, such as those in Sweden, Finland, and Canada, provides valuable insights into how deep geologic repositories (DGRs) are being sited across different geologic media and what factors should be considered for each specific host rock formation. The main geologic media considered in this deliverable are:

1. **Crystalline (Granite) Rock:** Due to its location in historic and tectonically stable formations, it is inherently favorable for long-term isolation of spent nuclear fuel (SNF) and long-lived radioactive waste. Hard crystalline rock provides mechanical stability and has low groundwater flow in unfractured sections. Although, it often contains fractures that require sealing by engineered barriers.
2. **Salt Formations:** Salt tends to have extremely low permeability, almost no groundwater, and the unique ability to *self-seal* via plastic creep of the salt rock. However, due to its solubility, interaction with substantial quantities of groundwater would increase the probability of radionuclide transport occurring.
3. **Argillaceous (Clay/Shale) Rock:** Clay in particular has an extremely low permeability and strong chemical retention of radionuclides, making it a favorable candidate as a potential host rock. However, clay is a relatively soft rock, which limits the size of underground openings and typically constrains the allowable waste heat load to avoid drying or cracking the clay.

Beyond properties of various geologic media, this document draws from Canada's recently completed consent-based siting process for a DGR at Wabigoon Lake Ojibway Nation and Ignace as a real-world precedent that synergizes safety criteria with social acceptability.

Based on geologic, safety, and societal factors, the document proposes a preliminary siting framework for a second TRU waste repository:

1. **Host Rock and Geologic Evaluation:** This tier draws on International Atomic Energy Agency's (IAEA) safety standards (SSG-14) and international design criteria. It defines geologic performance attributes such as isolation, thermal stability, and structural integrity across various potential host media including salt, crystalline rock, clay/shale, and volcanic tuff.
2. **Safety Evaluation:** Modeled after both the Canadian Nuclear Waste Management Organization (NWMO) and DOE's interim storage consent-based siting process, this tier includes

considerations related to radionuclide containment, repository constructability, risk of human intrusion, and transport safety.

3. **Societal Factors:** Lessons from NWMO's collaborative approach are used to define a framework grounded in consent-based principles, Indigenous engagement, community benefits, transparency, and environmental justice.

Through the integration of geologic, safety, and societal criteria, this report proposes a path forward for identifying and developing a second TRU waste repository in a manner consistent with modern expectations for safety, mission completion, and collaboration.

A. Introduction

The document is broken down into the following sections:

- Section A is this **Introduction**.
- Section B provides insights from **DOE's Collaborative-Based Siting Approach** and lessons learned.
- Section C investigates the types of **Geologic Media** and repository designs being pursued world-wide for disposal of TRU or similar long-lived waste streams.
- Section D identifies **Key Siting Factors for a Second TRU waste repository**, considering how safety and societal variables can be addressed through a collaborative process of community engagement.
- Section E recommends a **Preliminary Siting Framework** for evaluating and comparing candidate sites.
- Section F sets out **Conclusions and Recommendations**.
- Section G is a list of **References** used throughout the report deliverable.

B. DOE's Collaborative-Based Siting Approach

B.1. Summary of DOE's Collaborative-Based Siting Roadmap

DOE's collaborative-based siting roadmap [1] is structured around a three-stage, phased process designed to build community readiness, foster mutual learning, and enable informed, stepwise decision-making for siting a consolidated interim storage facility for spent nuclear fuel (SNF) and high-level radioactive waste (HLW). DOE's move toward a collaborative-based siting approach is rooted in a long-standing challenge of U.S. nuclear waste management due to the large quantities of SNF and HLW stored at multiple reactor and DOE sites. The absence of a consolidated interim storage facility (or permanent disposal site) increases cost, complicates transport/logistics, and raises questions about long-term safety and environmental stewardship. In response, Congress (in the Consolidated Appropriations Acts of 2021, 2022, 2023) directed DOE to pursue development of federal consolidated interim storage capability, and to do so using a siting process that emphasizes community participation, equity, transparency and institutional trust-building. While the DOE has been able to successfully collaborate with the communities in New Mexico to ensure the construction and operation of the Waste Isolation Pilot Plant (WIPP), other nuclear waste siting efforts (in the U.S. and globally) have encountered strong community opposition when local consent was weak or absent. Therefore, DOE's approach towards collaborative-based siting strives to re-structure the relationship among federal government, states, tribes, host communities, and the public.

Notably, DOE's process draws inspiration from Canada's Nuclear Waste Management Organization (NWMO) Adaptive Phased Management (APM) approach. Nuclear Waste Management Organization's siting strategy emphasizes collaborative site selection, Indigenous rights and knowledge integration, extended timelines for reflection and reversibility, and the alignment of repository development with community-defined values and long-term wellbeing. Nuclear Waste Management Organization's model centers on the principle that no site will be selected without the informed and willing consent of the host community – a principle DOE has now embedded into its own process. Canada's extensive use of capacity-building grants, local knowledge mobilization, and regional advisory councils is echoed in DOE's current funding mechanisms for community engagement and technical assistance.

In addition to Canada, DOE's roadmap also reflects practices seen in other countries like Finland, Sweden, France, and Switzerland, all of which have made substantial progress in repository development. For example, Finland's Onkalo facility, the world's first deep geological repository for SNF and HLW to enter operational licensing, benefited from transparent community partnerships and early public outreach. Sweden's Forsmark repository similarly emerged from a volunteer-based process, backed by sustained technical support and local referendum. France's Cigéo project in Bure incorporates phased reversibility and public deliberation as required by law, and Switzerland's siting program has used national dialogues and regional stakeholder panels to shape repository criteria and trust-building measures.

By learning from these global precedents in nuclear waste management, DOE's updated collaborative-based siting roadmap represents a modern, community-centered approach to nuclear waste facility siting. It acknowledges that siting success is not just about geology, engineering, environmental protection, and public safety, but also depends on respect for diverse values and long-term collaboration. This international alignment not only enhances credibility but also positions the U.S. to meet both its domestic waste management obligations and its international nonproliferation and stewardship commitments.

DOE's collaborative-based siting roadmap establishes a three-stage, multi-phase process that evolves from information gathering to partnership building and, ultimately, to negotiated implementation. The first stage, *Planning and Capacity Building*, is designed to prepare communities for engagement before any site selection occurs. During this initial stage, DOE funds capacity-building initiatives, community education programs, and partnerships with universities, nonprofits, and tribal organizations. The "Consent-Based Siting Consortia" program launched in 2022, whereby DOE provides grant funding to support local dialogue, stakeholder workshops, and technical assistance so that communities can make informed decisions about participation. DOE is not seeking volunteer host communities during this initial phase.

Once communities have developed baseline understanding and confidence, the process transitions into the *Site Screening and Assessment* stage. Communities that wish to explore hosting a facility may enter into structured collaboration with DOE to define additional site-specific screening and assessment criteria. Rather than imposing a uniform set of technical metrics, DOE invites communities to articulate their own priorities, which range from environmental safeguards and land-use considerations to cultural values and economic aspirations. In subsequent phases, these local criteria are integrated with DOE's scientific and engineering analyses to evaluate potential sites. Early phases of the evaluations focus on general suitability and data gathering, while later phases involve detailed geotechnical investigations, environmental assessments, and social impact studies. Throughout this stage, communities can withdraw participation at any time prior to signing a binding hosting agreement.

The final stage, *Negotiation and Implementation*, begins only after one or more sites have been thoroughly assessed and willing host communities identified. At this point, DOE plans to engage in formal negotiations with potential hosts, whether municipalities, tribal governments, or regional coalitions, to craft legally binding agreements that define all aspects of the partnership. These agreements will outline the terms of hosting, including the types and quantities of waste to be managed, the duration of storage, environmental protection measures, emergency preparedness responsibilities, and the financial and infrastructural benefits to the community. They will also define governance and oversight mechanisms, ensuring that the host community retains a role in monitoring facility operations and safety. Following these negotiations, regulatory licensing will be pursued through the Nuclear Regulatory Commission, coupled with development of detailed engineering design and construction. The roadmap includes provisions for long-term collaboration during operation, eventual closure, and decommissioning, which may extend across several decades.

A summary of the stages and phases and DOE's collaborative-based siting approach is provided below [1]:

B.1.a. Planning and Capacity Building

This initial stage focuses on establishing the foundation for a collaborative-based siting process. It includes building relationships, enhancing community capacity, and fostering a shared understanding of nuclear waste management and related topics.

- a. **Phase 1A – Planning and Capacity Building Stage:** This initial phase centers on gathering public input and developing the foundational structure for a collaborative-based siting process. Key activities include outreach, information sharing, and refining the overall approach based on early stakeholder feedback.
- b. **Phase 1B – Building Capacity:** Aligned with feedback received during Phase 1A, this phase emphasizes providing federal resources to support deeper engagement, mutual learning, and capacity building within communities. It is important to note that DOE is not seeking volunteer host communities during this phase. As of the publication of this document, the

collaborative-based siting process is currently in Phase 1B. This phase is expected to span two to three years and includes several key initiatives to prepare for subsequent phases.

B.1.b. Site Screening and Assessment (Phases 2, 3, and 4)

In this stage, communities may voluntarily engage in the siting process. Phases 2 through 4 involve progressively detailed evaluations of potential sites. To support meaningful participation, funding is provided to interested communities.

- a. **Phase 2 – Site Screening and Additional Criteria Development:** This phase involves the early identification and evaluation of communities that may wish to explore hosting a facility. Participating communities are encouraged to develop additional site-specific screening and assessment criteria that reflect their unique values and priorities. The anticipated duration for this phase is one to two years.
- b. **Phase 3 – Preliminary Site Assessment:** Building upon the criteria and community input developed in Phase 2, this phase includes initial technical evaluations and environmental assessments. These are conducted in parallel with continued engagement to further explore the suitability of potential host communities. The estimated duration is one to two years.
- c. **Phase 4 – Detailed Site Assessment:** This phase entails a thorough technical and environmental review of candidate sites to inform facility design, safety, and licensing efforts. Community participation and feedback continue to be a central part of the process. Activities in this phase are expected to take two to three years.

B.1.c. Negotiation and Implementation (Phases 5, 6A, and 6B)

The final stage involves selecting one or more qualified sites and negotiating a durable, collaborative-based agreement with willing host communities. This stage also includes activities related to regulatory licensing, facility construction, and eventual operation.

- a. **Phase 5 – Site Selection and Negotiation:** DOE identifies one or more preferred sites and enters formal negotiations with the host community or Tribe to develop a consent-based agreement. These agreements outline the terms of hosting the facility, including the type and quantity of waste, operational oversight, environmental protections, emergency planning, and community benefits.
- b. **Phase 6A – Licensing and Construction:** Covers licensing, detailed design, and construction of the facility under Nuclear Regulatory Commission (NRC) oversight.
- c. **Phase 6B – Facility Operation, Closing, and Decommissioning:** Encompasses facility operations, eventual closure, and decommissioning, with long-term collaboration between DOE and the host community until waste is transferred to a permanent disposal solution.

An illustration of DOE's phased approach to consent-based siting is provided in Figure 1.

→ **PLANNING AND CAPACITY BUILDING STAGE** (ANTICIPATED REMAINING DURATION 2-3 YEARS)

PHASE 1A: PLANNING (COMPLETE)

- ✓ Receive authority and funding
- ✓ Initiate outreach and engagement
- ✓ Issue request for information (RFI)
- ✓ Issue RFI summary analysis report
- ✓ Issue revised consent-based siting process
- ✓ Prepare for Phase 1B

PHASE 1B: BUILD CAPACITY (2-3 YEARS)

- ✓ Issue Funding Opportunity Announcement (FOA) to provide resources to communities interested in learning more
- Conduct robust outreach and engagement
- Enable mutual learning
- Refine consent-based siting process
- ★ DOE is not looking for volunteer hosts in this phase

📍 **SITE SCREENING AND ASSESSMENT STAGE** (ANTICIPATED DURATION 4-7 YEARS)

PHASE 2: SITE SCREENING AND ADDITIONAL CRITERIA DEVELOPMENT (1-2 YEARS)

- Conduct robust outreach and engagement
- Issue list of screening criteria and assessment criteria
- ★ DOE issues national call for volunteers
- Issue FOA for community-led development of additional site-specific criteria

➔ Qualified and interested communities decide to proceed (or not) to next phase

PHASE 3: PRELIMINARY ASSESSMENT (1-2 YEARS)

- Conduct robust outreach and engagement
- Issue FOA for DOE-led preliminary assessment evaluation of sites in collaboration with communities

➔ Qualified and interested communities decide to proceed (or not) to next phase

PHASE 4: DETAILED ASSESSMENT (2-3 YEARS)

- Conduct robust outreach and engagement
- Issue FOA for DOE-led detailed assessment evaluation of sites in collaboration with communities

➔ Qualified and interested communities decide to proceed (or not) to next phase

📍 **NEGOTIATION AND IMPLEMENTATION STAGE** (ANTICIPATED DURATION TO INITIAL OPERATION READINESS 4-5 YEARS)

PHASE 5: SITE(S) SELECTION AND NEGOTIATION (1 YEAR)

- Conduct robust outreach and engagement
- Issue FOA for communities to develop and negotiate terms and conditions of consent agreement(s)
- Consent agreement(s) are signed between hosts and DOE

PHASE 6A: LICENSING AND CONSTRUCTION (3-4 YEARS)

- Conduct robust outreach and engagement
- License and construct facility
- ★ Facility ready to operate

PHASE 6B - FACILITY OPERATION, CLOSING, AND DECOMMISSIONING (LENGTH OF OPERATION DEPENDS ON NEGOTIATED AGREEMENTS WITH HOST COMMUNITIES AND THE TIMELINE FOR PERMANENT DISPOSAL CAPABILITY).

- Conduct robust outreach and engagement
- ★ Facility starts operation
- Complete construction of additional expansion phases as needed
- Complete closure and decommissioning

Figure 1: DOE's Collaborative Based Siting Process [1]

B.2. Second TRU waste repository Roadmap

To ensure a transparent, equitable, and technically sound process, DOE may choose to adopt a collaborative-based siting approach aligned with the framework summarized in Section B.1. This framework emphasizes voluntary participation, informed community engagement, environmental justice, and phased decision-making – all of which are especially relevant when considering the siting of a repository that may impact host communities for generations to come.

A second TRU waste repository siting effort could proceed through a structured, stepwise process beginning with national planning and public dialogue, followed by capacity building in interested regions, screening of potential volunteer sites, and eventual site-specific technical and environmental evaluations. Each phase would be supported by stakeholder input, federal technical assistance, and clearly defined opportunities for communities to participate or withdraw from the process. The roadmap would culminate in a consultation and cooperation agreement with a selected host community and state, followed by licensing, construction, and long-term operation.

This roadmap, grounded in the principles of consent-based siting, provides a scalable and adaptive pathway for identifying a second TRU waste repository site capable of meeting regulatory standards, earning public trust, and fulfilling the nation's future TRU waste disposal needs. A proposed outline, akin to that used by the DOE for siting a consolidated interim storage facility for SNF and HLW, is presented below:

1. Planning and Stakeholder Engagement (Phases 1A and 1B):

- a. **Phase 1A – National Planning and Scoping:** This phase includes regulatory reviews, stakeholder mapping, and the release of a public Request for Information (RFI) to gather initial input.
- b. **Phase 1B – Capacity Building and Stakeholder Readiness:** This phase follows and is centered on capacity building, during which DOE offers funding and technical support to communities, tribes, and local governments to engage in education, training, and preliminary conversations about nuclear waste and repository options. Crucially, this stage does not involve identifying or soliciting potential host sites.

2. Site Selection Process (Phases 2, 3, and 4):

- a. **Phase 2 – Community-Led Site Screening and Criteria Development:** Interested communities are invited to participate in community-led site screening and the development of localized siting criteria. DOE and these communities collaboratively define what characteristics (e.g., technical, cultural, economic, etc.) are important in evaluating possible repository locations.
- b. **Phase 3 – Preliminary Site Assessment:** Preliminary site assessments begin, which involves technical screening and high-level environmental analysis conducted in parallel with continued public engagement. Communities may exit the process at any point based on their own assessments and evolving priorities.
- c. **Phase 4 – Detailed Site Assessment:** A detailed site assessment is conducted, in which one or more candidate sites undergo comprehensive geologic, hydrologic, environmental, and socio-economic evaluation. This phase includes the development of preliminary designs and licensing strategies and will require community partnership throughout.

3. Final Agreement and Implementation (Phases 5, 6A, and 6B):

- a. **Phase 5 – Site Selection and Consent Agreement Negotiation:** DOE would notionally enter formal negotiations with one or more host communities. These negotiations would aim to establish consultation and cooperation agreements covering safety, regulatory oversight, local benefits, and withdrawal provisions. The DOE may need to expand negotiations to include communities along transportation routes.
- b. **Phase 6A – Licensing and Construction:** Licensing and construction of the repository would commence given all preceding steps are completed. This phase would include the preparation of a full environmental impact statement and any required federal, state, and local agency approvals. Infrastructure development would begin only after successful conclusion of the consultation and cooperation agreement.
- c. **Phase 6B – Operations, Closure, and Decommissioning:** Encompasses long-term operations, closure, and decommissioning of the repository. This phase includes transportation, waste emplacement, continuous monitoring and reporting, and ultimately sealing and long-term stewardship. The process could span decades, with repository operations and oversight evolving through partnerships with host communities and regulators.

A proposed collaborative-based siting process for a second TRU waste repository is provided in Figure 2.

Planning and Stakeholder Engagement

Phase 1A: National Planning and Scoping

- Conduct detailed regulatory review
- Initiate stakeholder outreach
- Release a public RFI
- Finalize preliminary siting process

Phase 1B: Stakeholder Engagement

- Release announcement to inform the community about the process of siting a second TRU repository
- Allow communities to provide feedback to improve the consent-based siting process

Site Selection Process

Phase 2: Community-Led Site(s) Screening

- Initiate community-based site screening process
- Define key characteristics for potential repository site
- Release a public Funding Opportunity Announcement (FOA) for more detailed site-screening engagement
- Scope out potential volunteer communities

Phase 3: Preliminary Site(s) Evaluation

- Conduct technical screening and high-level environmental analysis
- Continue with public engagement throughout process
- Ensure communities preserve the right to exit site screening at any point
- Issue FOA for preliminary assessment

Phase 4: Detailed Site(s) Evaluation

- Conduct geologic, hydrologic, environmental, and socio-economic evaluation
- Develop preliminary designs and licensing strategies
- Maintain community partnership and transparency
- Issue FOA for detailed assessment

Final Agreement and Implementation

Phase 2: Site(s) Selection

- Negotiate terms and conditions of consent agreements
- Enter into formal agreement with one or more host communities

Phase 3: Licensing and Construction

- License and construct facility
- Prepare full environmental impact statement

Phase 4: Facility Operation, Closing, and Decommissioning

- Ensure safe emplacement operations
- Conduct continuous monitoring during repository operations
- Complete closure and decommissioning of facility

Figure 2: Proposed Collaborative-Based Siting Process for Second TRU waste repository

B.3. Key Findings from DOE's Collaborative-Based Siting Process

DOE's Collaborative-Based Siting Process Report [1] presents a robust and forward-looking framework that is deeply informed by decades of experience in the challenges, successes, and setbacks of nuclear waste management in the United States. The report draws on lessons from two major siting efforts: the successful establishment and operation of the WIPP Project in New Mexico and the attempt to license a deep geologic repository at Yucca Mountain in Nevada. These two experiences have shaped DOE's understanding of what is required – not only technically, but socially and politically – to establish enduring solutions for the safe disposal of long-lived radioactive waste.

The report integrates these experiences to articulate a new vision: one that shifts away from site imposition toward a community-driven, transparent, and equity-focused approach. The collaborative-based siting process introduced in the report is explicitly designed to be iterative, adaptive, and inclusive, reflecting the need to build trust over time and respond to diverse community concerns and aspirations. A summary of the key lessons and their implication on siting a second TRU waste repository are provided below [1]:

- 1. Collaborative-Based Siting Must Be Voluntary, Flexible, and Iterative:** A key tenet of this framework is the principle of *voluntariness*, which affirms that the success of any nuclear waste repository hinges on the willingness of a host community to engage in the siting process freely, without coercion or external pressure.
 - **Application to a second TRU waste repository:** This foundational value is critical for siting a second TRU waste repository, where potential host communities must not only be invited to learn and explore the opportunity but also retain the right to withdraw from consideration at any time before entering into an agreement. For this process to be meaningful, voluntariness must be protected throughout the lifecycle of siting, from initial outreach through final licensing, and institutionalized in both policy and practice.
- 2. Robust Public Engagement is a Prerequisite to Success:** A key element of a successful collaborative-based siting process is the call for early, transparent, and bidirectional public engagement. The DOE recognizes that communities need time, resources, and trusted forums to ask questions, express concerns, and contribute meaningfully to the design of the siting process itself.
 - **Application to a second TRU waste repository:** In the context of a second TRU waste repository, this translates into initiating the siting journey not with candidate sites or technical assessments, but with capacity-building efforts: regional workshops, technical briefings, and educational outreach designed to empower communities with the knowledge needed to make informed choices. These efforts are especially vital in regions which may have suitable geologic formations but little experience with federal nuclear programs.
- 3. Site-Specific Criteria Must Be Developed Collaboratively:** DOE's report advocates for a collaborative development of site selection criteria. Rather than imposing a fixed set of geologic or engineering standards from the outset, DOE supports a phased model in which interested communities themselves help define what constitutes a "suitable site." This local empowerment could include values-based criteria such as cultural, spiritual, or economic concerns, as well as physical and environmental characteristics.
 - **Application to a second TRU waste repository:** This approach would allow potential host communities for a second TRU waste repository to shape the siting narrative in ways that align with their long-term visions, addressing both geotechnical feasibility and social acceptability simultaneously.

4. **Capacity Building Precedes Any Call for Volunteers:** The process also calls for a significant investment in technical and financial support to ensure communities can participate on equal footing. DOE affirms that collaboration is not meaningful unless it is informed. This includes providing funding for local governments, nonprofits, or Indigenous groups to hire independent technical experts, conduct risk assessments, and engage in scenario planning.
 - **Application to a second TRU waste repository:** For a second TRU waste repository where concerns about worker safety, groundwater protection, and intergenerational impact may be amplified, such support mechanisms are essential to establishing public trust and ensuring a fair process.
5. **Trust is Fragile and Must Be Actively Cultivated:** Perhaps most importantly, DOE acknowledges that public trust must be actively cultivated and maintained, not assumed. This includes acknowledging past shortcomings, such as the long-standing public opposition to Yucca Mountain, and the regulatory and operational history of the WIPP facility.
 - **Application to a second TRU waste repository:** Trust-building efforts must begin with full transparency about and the remaining disposal capacity of and timeline for the completion of the WIPP facility mission, as well as how a second TRU waste repository would complement DOE future needs. Trust can be reinforced by building in procedural safeguards, documenting decisions and feedback loops, and institutionalizing opportunities for community withdrawal and renegotiation.
6. Finally, DOE’s siting model emphasizes a **phased, milestone-driven process**, with clearly defined transitions from planning to screening to technical evaluation and negotiation. Each phase includes decision gates and deliverables that allow communities and DOE to assess whether continued participation is mutually beneficial.
 - **Application to a second TRU waste repository:** This model provides a valuable roadmap, which starts with capacity building, followed by community-led screening criteria, then iterative technical assessment, and culminating in formal negotiations and potential consent agreements. This structure ensures that no community is locked into a process prematurely and that DOE maintains accountability and transparency throughout.

A summary of key lessons learned from DOE’s consent-based siting process and application to siting a second TRU waste repository is provided in Table 1.

Table 1: Summary of Relevant Lessons from DOE’s Collaborative-Based Siting Process

Collaborative-Based Principle	Application to TRU Waste Repository Siting
Voluntary Participation	Avoid identifying “likely” sites early; let communities self-nominate after capacity building.
Early Engagement	Begin with open-ended learning forums.
Community-Defined Criteria	Work with regions to develop their own definitions of suitability and exclusion.
Informed Consent via Technical Support	Provide funding for community-hired independent experts to assess TRU waste impacts and safety.
Historical Transparency	Disclose lessons from WIPP, including its successes and regulatory challenges.
Stepwise, Phased Approach	Mirror the 7-phase model with clear documentation and public input checkpoints.

C. Summary of Global Efforts on Repository Siting

C.1. Deep Geologic Disposal Overview

The safe and permanent disposal of TRU waste and other long-lived radioactive waste remains a central challenge for nuclear programs worldwide. While the United States has successfully constructed and operated the world's first geologic repository at the WIPP site, long-term strategies for additional disposal capacity necessitate a broader understanding of global repository efforts. Internationally, programs are advancing deep geological repositories in a range of host rock environments, informed by decades of technical research, underground laboratory testing, and safety case development. To inform future siting and design decisions for a potential second TRU waste repository, it is essential to review findings from global efforts on the types of geologic media (e.g., salt, clay, granite) and engineered repository configurations currently being pursued for the disposal of long-lived radioactive waste streams similar to TRU waste, often referred to internationally as intermediate level waste (ILW).

C.2. Repository Designs

The primary purpose of a repository system is its ability to contain and delay the movement of radionuclides to the extent necessary to meet the socially acceptable risk levels defined in national regulations [2]. Most disposal concepts are based on a multi-barrier approach, in which a combination of independent and often redundant natural and engineered barriers work together to restrict radionuclide dissolution and migration, thereby providing a high level of assurance that radiation exposures will remain well below regulatory limits.

Two primary deep geologic repository approaches have been considered in the international community: 1) mined geologic repository (MGR), and 2) deep borehole disposal (DBD). Both approaches aim to achieve the same overarching goal: safe, permanent isolation of radioactive waste from the biosphere, leveraging geologic stability and engineered safeguards to provide confidence over the multi-millennial timescales required for radionuclides to decay to safe levels. The choice between MGR and DBD depends on factors such as waste characteristics, cost of implementation, timeline of implementation, siting flexibility, national policy, geologic conditions, regulatory framework, and societal acceptance.

C.2.a. Mined Geologic Repository

The prevailing design worldwide is a mined repository with access via shafts or ramps and a network of drifts or rooms where waste is emplaced. Depths are typically in the range of 250–500 m for these facilities, and the exact layout depends on a variety of parameters, including geology, waste type, and anticipated waste volume. In crystalline or clay host rocks, designs usually feature a series of disposal tunnels branching off from main access drifts. For example, in the Nuclear Fuel Safety Version 3 (KBS-3) concept being implemented by Sweden and Finland, tunnels are driven parallel to each other in the bedrock, and spaced to allow heat dissipation; spent fuel canisters are placed either vertically in the tunnel floor (KBS-3V) or in horizontal positions along the tunnel (KBS-3H variant) [3]. Each section is then overlaid with bentonite and sealed once all emplacement operations are complete. In France's clay repository design, the concept is similar except that HLW canisters are placed in horizontal micro-tunnels (disposal cells) that are then backfilled with swelling clay [3]. Some designs (e.g., Yucca Mountain, UK concepts) consider an extended open period for monitoring or cooling, but even these plan for ultimate closure and sealing.

A conceptual layout for a mined repository is provided in Figure 3.

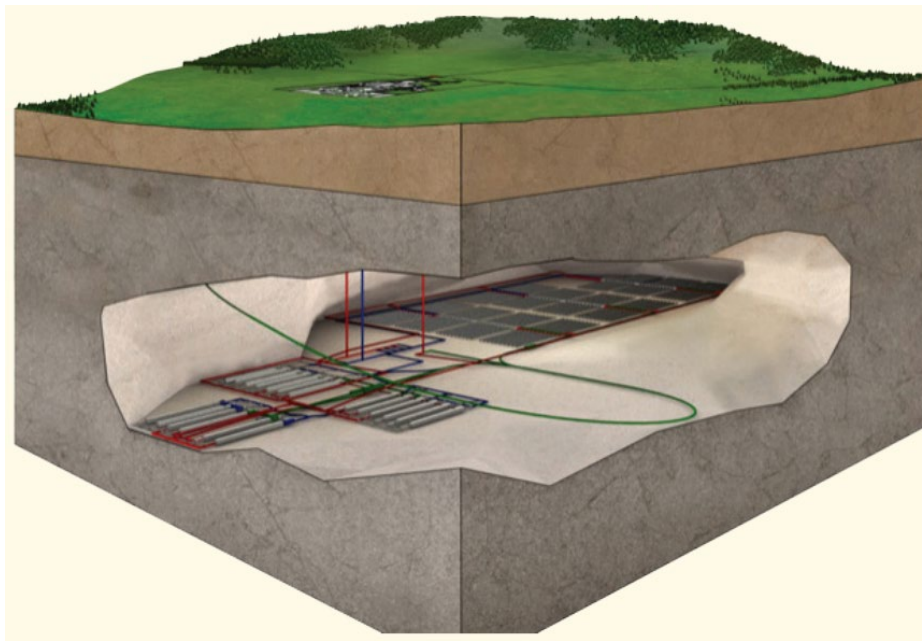


Figure 3: A conceptual mined repository design [2]

The MGR approach to deep geologic disposal leverages a robust engineered barrier system (EBS) to ensure safety of the public. Mined repositories may be particularly advantageous for countries with large national waste inventories, as the significant upfront investment in constructing a large, centralized underground facility can be justified by economies of scale over decades of operation. Another advantage is that these facilities, provided that the geologic conditions and regulatory siting framework are suitable, can be designed to accommodate a wide range of waste types in separate, purpose-built emplacement areas, allowing for the potential disposal of the full spectrum of waste. However, the complexity of developing a single national repository can lead to prolonged siting and construction timelines, potentially delaying final waste emplacement and creating a dependence on a single facility for the nation's long-term disposal needs.

C.2.b. Deep Borehole Disposal

Boreholes can be drilled to accommodate a wide range of depths, geometries and geologic conditions. Deep borehole disposal encompasses a full spectrum of waste disposal options, including horizontal, vertical, and slanted borehole configurations. While DBD of nuclear waste has not yet been implemented in the U.S., there is reasonable precedent for drilling the diameter, depth, and geometry of boreholes based on work in the oil, gas, carbon sequestration, and geothermal industries [4].

Horizontal boreholes for disposal of SNF and HLW are constructed by first drilling a vertical access shaft, then gradually curving into a horizontal path using directional drilling, resulting in a horizontal waste disposal section, or emplacement zone. Horizontal emplacement zones may vary in length (up to several kilometers) and vertical depth according to site- and waste-specific analyses, but horizontal boreholes are generally assumed to be between 1-1.5 km in depth with a horizontal waste disposal section between 1-1.5 km in length.

Vertical boreholes are constructed by drilling vertically at least 1 km deep prior to drilling of the vertical emplacement zone. The emplacement zone is expected to be at least 1 km long but may vary based on the specified canister design in use and volume of waste needing disposal. To preclude overpressurization from stacking loads (and potential gas mobility), multiple canisters may be stacked together before being separated with a spacer plug or packer, which are commonly used in the oil and gas industry.

Slanted boreholes represent another potential approach in which a vertical access shaft is first drilled from the surface, followed by a directionally drilled disposal section deviated from vertical at a specified inclination. Alternatively, the borehole could be directionally drilled from the surface at a predetermined inclination, with both the access portion and the disposal section constructed along the same deviated trajectory.

A conceptual layout for horizontal and vertical boreholes is provided in Figure 4.

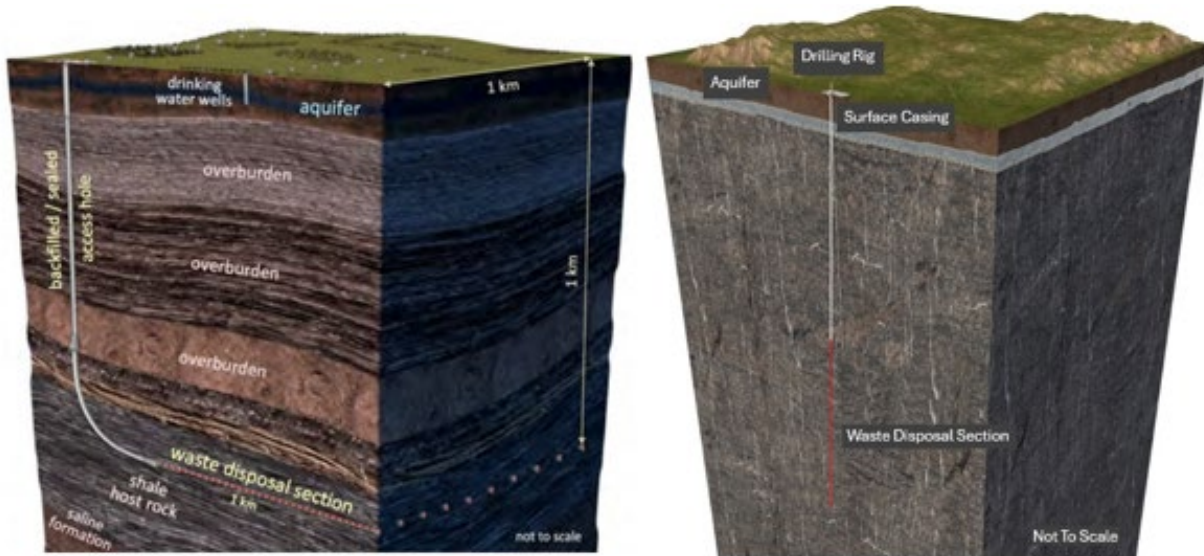


Figure 4: Conceptual horizontal borehole (Left). Conceptual vertical borehole (Right). Slanted borehole configuration not depicted.

Boreholes offer safety in depth, where an 1-3 km depth of disposal offers protection from the long-term effects of natural processes that may adversely affect repository integrity, as well as risks of human intrusion. The reducing (low oxygen) environment at depth may also inhibit canister corrosion and slows release of radionuclides. The geochemical environment, low radionuclide solubility, sorption characteristics, and hydrologic properties of many rock formations, coupled with long travel paths to the surface, mean the great majority of radionuclides never get near the biosphere, with the peak radiological dose exposure at the surface orders of magnitude lower than regulatory safe standards.

Moreover, the modular nature of the DBD approach allows for flexible siting of borehole repositories. Borehole disposal also has the potential to accelerate waste emplacement timelines and potentially reduce disposal costs due to lower overhead costs and potential cost-efficiencies when co-locating a borehole repository at the waste generating site. However, DBD is generally considered most suitable for smaller waste inventories and is typically targeted toward SNF or HLW. For countries with large national inventories or significant volumes of LLW requiring disposal, a borehole program may need to be supplemented by a mined geologic repository (and/or LLW facility) – a strategy sometimes referred to as a “mined plus” hybrid approach – to ensure full coverage of the waste management needs.

C.3. Geologic Media

C.3.a. Crystalline/Granite Rock Repositories

Many advanced national repository programs have selected crystalline rock formations, such as granite, granodiorite, or metamorphic gneiss, as the preferred host media for repositories [5]. Crystalline rock is part of some of the oldest and most tectonically stable continental crust, making it inherently favorable for the long-term isolation of SNF and other long-lived radioactive waste. In this proposed geologic media,

hard crystalline rock provides mechanical stability and has low groundwater flow in unfractured sections, though it often contains fractures that require sealing by engineered barriers [6]. The key advantages of crystalline rock include its mechanical strength and stability, which allow it to support large underground excavations and resist tectonic or seismic activity over geologic timescales [5]. In addition, the intact rock matrix exhibits extremely low porosity and permeability, which significantly reduces groundwater flow and radionuclide migration through unfractured rock volumes [7]. Groundwater chemistry in deep crystalline settings is often saline and reducing, conditions that limit metal canister corrosion and radionuclide solubility, further complementing engineered barrier systems [6].

Despite these benefits, challenges exist due to the fracture networks and discrete brittle fault zones commonly present in crystalline rock [8]. These features can serve as preferential pathways for groundwater flow and must be carefully managed to ensure repository safety. Modern repository designs mitigate these risks through comprehensive 3D site characterization, optimized repository layouts that avoid major conductive zones, and EBS components such as bentonite clay buffers, concrete plugs, and grouted seals to isolate waste and block water movement [9].

C.3.a.i. Sweden

A notable example of a crystalline rock repository for the disposal of long-lived ILW is the Swedish Final Repository for Long-Lived Waste (SFL), which has a nominal capacity of ~16,000 m³. Apart from its short-term LLW and ILW currently being disposed of at the Swedish Final Repository for Radioactive Waste (SFR), Sweden is planning a separate repository for long-lived LLW and ILW such as reactor core internals and certain legacy wastes. The conceptual design for SFL is expected to be an MGR located ~500 m depth in crystalline rock (likely granite) and consists of two vault sections tailored to specified waste types [10]:

- a. **Fuel Hardened Capsules Vault (BHK):** This vault is designed to accommodate metal reactor components and would use robust concrete barriers to encapsulate and surround the waste, creating an alkaline environment. It is expected to span 135 m in length and have a nominal cross-section of 20 m × 20 m.
- b. **Legacy Waste Vault (BHA):** This vault is designed to accommodate miscellaneous long-lived waste (e.g., legacy radwaste, irradiated hardware with different chemistry, etc.) and would use a bentonite clay barrier system. It is expected to span 170 m in length and have a nominal cross-section of 20 m × 20 m.

This dual approach (cementitious versus clay backfill) addresses the diverse waste forms present at SFL. The repository design also incorporates a spiral access ramp for transporting waste from the surface and a vertical shaft dedicated to ventilation and personnel access. At the end of SFL operations, projected around 2075, both the ramp and the shaft will be sealed to ensure long-term isolation of the waste vaults [10]. The sealing strategy is expected to employ a combination of concrete plugs and bentonite near the vaults, crushed rock backfill in the central portion of the ramp, and concrete seals with boulders at the top to provide additional protection and deter potential future human intrusion. As of 2021, SFL is still in the conceptual/safety assessment phase. Site selection has not begun; Swedish Nuclear Fuel and Waste Management Ltd. (SKB) will likely consider nuclear sites or other stable granitic areas with community consent.

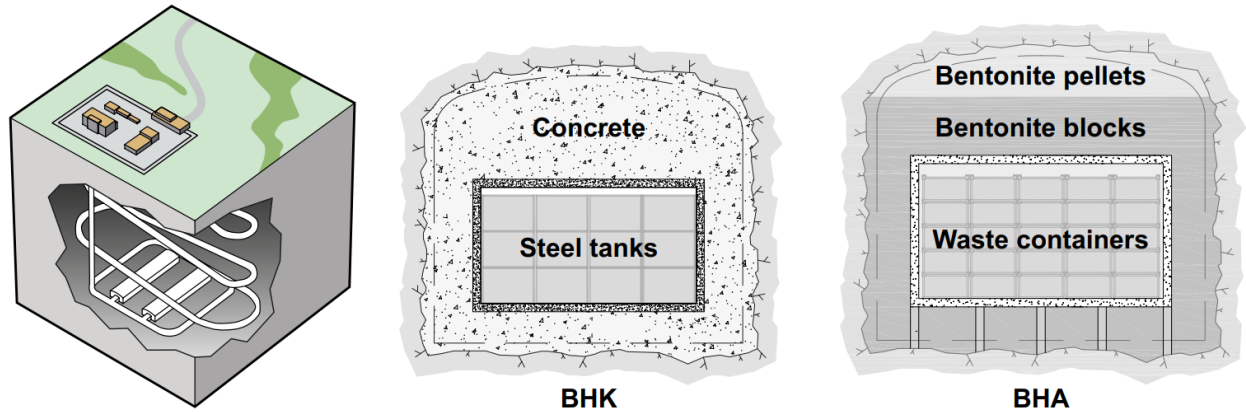


Figure 5: Proposed repository concept and layout for SFL [10]

Since no site has yet been selected for the SFL repository, it relies on data from SKB’s site investigation programs for both the SFR and the planned SFR extension. To ensure a representative geological description for a potential radioactive waste disposal site, the model adopts data from the Laxemar site in Oskarshamn Municipality, which offers a thorough dataset [10].

The Laxemar area overall offers a potentially geologically stable, low-permeability crystalline environment well-suited for a deep geological repository [11]. Its predictable structural features, favorable hydrogeochemical conditions, and long-term tectonic stability provide a robust natural barrier that complements engineered repository systems. However, the site also presents challenges that require careful consideration. The bedrock includes steeply dipping brittle fracture zones and limited contiguous volumes of high-quality rock, which can complicate repository layout and require selective avoidance and grouting to manage groundwater inflows [11]. The coastal setting also introduces factors such as potential density-driven groundwater flow and long-term sea-level or post-glacial changes, which must be incorporated into safety assessments. A comparable level of detailed used to characterize the Laxemar area may also be useful in siting a second TRU waste repository.

An overview of the lithology at Laxemar is provided in Figure 6.

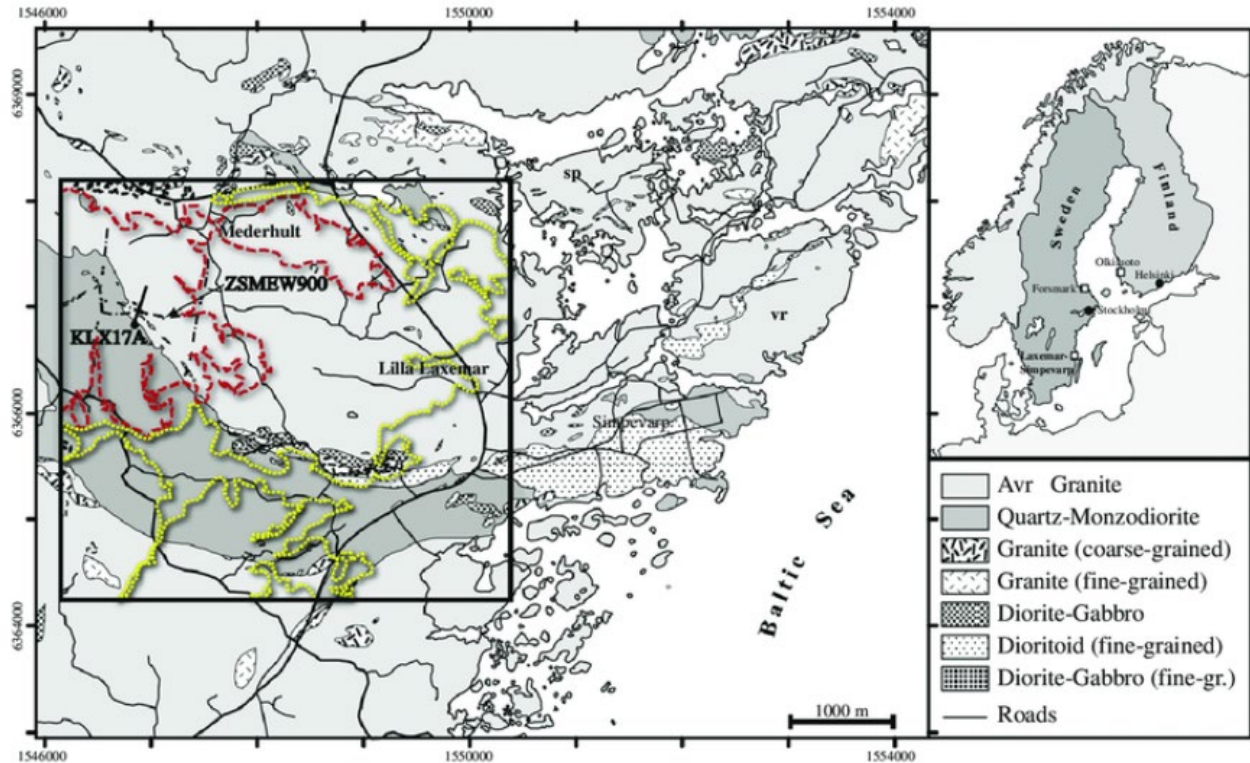


Figure 6: Overview of the lithology modeled deterministically in the Laxemar region for SE-SFL [12]

C.3.a.ii. Finland

In Finland, long-lived low- and intermediate-level operational and decommissioning wastes are disposed of on site at two nuclear power plant locations in engineered underground rock caverns/silos excavated in crystalline bedrock at roughly 60-100 m depth: the Operating Waste Repository (VLJ) located at Olkiluoto (8,000 m³ total capacity) and Loviisa Repository located at Loviisa (4,000 m³ total capacity) [13]. The VLJ repository is situated in crystalline bedrock, specifically the Paleoproterozoic bedrock, and has a total capacity of 8,000 m³. The Loviisa repository is located within Rapakivi granite bedrock, which is coarse grained and porphyritic, and has a total capacity of 4,000 m³. The designs of the Olkiluoto and Loviisa repositories differ primarily due to local geological conditions.

At Olkiluoto, the characteristics of the host rock massif favor a vertical silo-type cavern design, while at Loviisa, horizontal tunnel configurations are more suitable [14]. At the VLJ site, the local geology is composed mainly of micaceous gneiss interlayered with sparsely fractured tonalite, with the tonalitic section selected for detailed site characterization. The configuration of this tonalitic body, bounded by distinct fracture zones, supported the adoption of a vertical silo-type repository concept located 60 – 100 m below the surface [15]. In contrast, at Loviisa, the presence of sub-horizontal fracture zones above the planned disposal horizon made horizontal drift excavations at a depth of approximately 120 m the more suitable design choice [15]. As with other crystalline rock formations such as in the case of Laxemar, the presence of fractures at both the VLJ and Loviisa sites necessitates more complex, site-specific repository layouts to accommodate and mitigate the impact of the incongruent host rock structure.

An overview of the repository designs for VLJ Loviisa is provided in Figure 7.

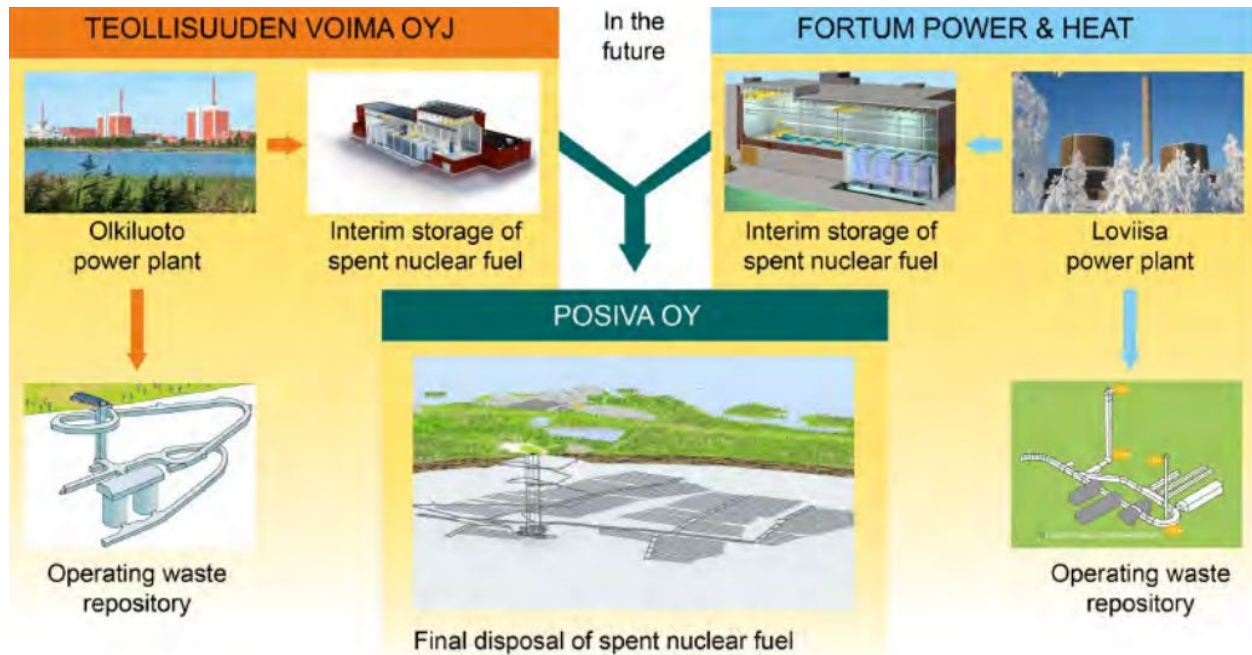


Figure 7: VLJ and Loviisa Repository Designs [16]

C.3.b. Salt Bed/Dome Repositories

Rock salt is a historically proven geologic medium for long-term waste isolation. Salt formations (either bedded salt layers or salt domes) have extremely low permeability, almost no groundwater, and the unique ability to self-seal via plastic creep of the salt rock [3]. Furthermore, salt is easy to mine. These properties make salt desirable for isolating long-lived waste: any excavated voids will slowly close, encapsulating waste, and the lack of water prevents corrosion or radionuclide transport. Salt's high thermal conductivity and elasticity are also advantageous for HLW heat dissipation and structural stability [3]. However, a drawback is that if groundwater were present, salt is soluble, and its radionuclide sorption capacity is much lower than that of clay or crystalline rock [3]. In salt repositories such as WIPP, long-term isolation instead relies primarily on the formation's extremely low permeability and self-sealing behavior rather than mineral sorption.

Salt repository designs should account for salt creep rate and ensure openings remain stable during operations. Typically, just-in-time mining is used to limit the amount of time a disposal panel must remain open, and roof support (e.g., rock bolts, etc.) is installed to delay closure while waste is emplaced. Once sealed, salt's creep properties create a long-term seal. Because intact salt is virtually impermeable, even small damage zones around excavations will re-anneal over time [3].

Any brine pockets or water in the salt need evaluation, as brine could mobilize radionuclides if present. Salt formations may contain interbedded sedimentary layers, such as thin clay seams, which can release water and potentially affect the structural integrity of the formation. Thus, site selection typically focuses on very dry formations. Salt overall offers a robust natural barrier, and no additional buffer (like bentonite) is required – the host rock itself performs that function by encapsulation.

C.3.b.i. United States (WIPP)

The most relevant example of a repository situated in bedded salt is the WIPP facility, which was excavated in the extensive Permian salt formation about 650 meters underground. The repository is laid out in panels, each containing seven parallel disposal rooms (~90 m long chambers mined out of the

salt) [3]. TRU waste packages are stacked in these rooms. As each room and panel is filled, it is sealed; over years and decades, the salt creep will gradually encapsulate the waste, entombing it without need for additional backfill [3]. Notably, the WIPP facility design takes advantage of minimal engineered barriers – the salt formation itself is the primary barrier, isolating the waste in a dry, self-sealing environment.

C.3.b.ii. Germany

Germany also has a long history of evaluating salt formations for final waste disposal. The nation's first deep repositories for LLW and ILW were in former salt mines (e.g., Asse and Morsleben salt domes), though these facilities faced challenges and are now being decommissioned [18]. For SNF and HLW, Germany spent decades investigating the Gorleben salt dome as a potential repository site [17]. Gorleben's thick salt diapir (with hundreds of meters of halite) was considered ideal, and extensive research was done from 1979–2000. However, due to political and public opposition, the project stalled. In 2020, Germany formally reset its site selection process, now comparing multiple rock types (salt, clay, granite) across 90 initial areas – notably excluding Gorleben – to select a final repository site [17]. Still, salt remains a candidate repository host rock: Northern Germany has many salt structures and ongoing research continues to study salt's behavior for HLW isolation.

C.3.c. Argillaceous (Clay/Shale) Repositories

Several countries – notably France, Belgium, and Switzerland – are pursuing repositories in argillaceous formations such as clay or shale (claystone) because of clay's extremely low permeability and strong chemical retention of radionuclides [5]. Plastic clays, such as Belgium's Boom Clay, have the ability to self-seal fractures and reduce groundwater flow to negligible rates. Even indurated claystones, such as France's Callovo-Oxfordian clay at the Cigéo site, exhibit very low diffusion coefficients for contaminants [19]. Clay formations naturally hinder radionuclide migration both by sorbing charged ions and by the extremely slow movement of porewater, often less than 1 mm per year. The trade-off is that clay is a relatively soft rock, which limits the size of underground openings and typically constrains the allowable waste heat load to avoid drying or cracking the clay.

C.3.c.i. France

France's national radioactive waste agency (Andra) has chosen a deep clay formation in the Meuse/Haute-Marne region for its repository, known as Cigéo. The host rock is a Callovo-Oxfordian claystone (argillite) about 130–160 m thick, lying between 420 m and 600 m below the surface [3]. This clay layer has extremely low permeability (effectively isolating groundwater) and was selected after decades of underground laboratory studies at Bure. The Cigéo repository design involves excavating main access tunnels followed by horizontal disposal cells (small-diameter tunnels) that extend out into the clay to contain waste canisters. Different sections of the repository are intended to handle different waste types: heat-generating HLW will be placed in steel-lined horizontal tunnels, while long-lived ILW will be in larger caverns or vaults in a separate section. After emplacing the waste packages, each HLW disposal tunnel is backfilled with bentonite or similar clay material before sealing [3]. This is analogous to the KBS-3 concept's approach of surrounding waste with clay, but here the natural host rock is also clay, providing a double layer of clay barriers. The French repository is required by law to be reversible for at least 100 years, meaning it must be possible to retrieve waste or modify the facility during an extended monitoring period [3]. Cigéo is in the licensing stage (construction authorization application submitted in 2023) and, if approved, is expected to begin operations around 2035.

C.3.c.ii. Switzerland

Like France, Switzerland has also chosen a clay formation for its combined HLW and ILW repository. After evaluating options for years, in 2022 Nagra announced the preferred site is Nördlich Lägern in northern Switzerland, which features the Opalinus Clay formation ~700 m deep [20]. Opalinus Clay is an impermeable, homogeneous claystone that has been studied extensively (e.g., at the Mont Terri underground lab). The Swiss repository (planned commissioning ~2060) will likely use a design similar to France's: mined tunnels in clay, with steel canisters for HLW emplaced horizontally and clay backfill. Three primary properties factored into the selection of Opalinus Clay for Switzerland's geologic repository are as follows [20]:

1. **Impermeability:** The Opalinus Clay formation is largely impermeable to water, which prevents deep groundwater from circulating through the formation. As a result, groundwater flowing in the rock layers above and below the formation is effectively isolated from the radioactive waste.
2. **Self-Sealing:** If fissures or microcracks were to form the Opalinus Clay possesses a self-sealing capability. When exposed to water, it swells and naturally closes any openings. This self-sealing behavior has been confirmed through laboratory testing and research at the Mont Terri Rock Laboratory.
3. **Binding Property:** Opalinus Clay has a strong ability to chemically bind radioactive substances over long periods. The clay is composed in part of sheet silicate minerals, which consist of microscopic platelets with a negative electric charge. These platelets attract and retain positively charged particles, including many of the radionuclides found in nuclear waste. As a result, these substances are effectively immobilized within the clay matrix, providing an additional layer of protection against migration.

C.3.c.iii. Belgium

Belgium has conducted extensive research and development on disposal in Boom Clay (a soft, water-saturated clay) at ~220–240 m depth. The Belgian concept envisions HLW and long-lived ILW in metal waste canisters emplaced in horizontal galleries in this formation. Due to the clay's ductility, one option is to preclude use of an engineered buffer at all and simply let the clay itself "creep" around the containers to close any gap. Alternatively, excavated clay could be compacted as backfill. Belgium has not yet selected a repository site. The Boom Clay is present under their Mol–Dessel nuclear site, where the High Activity Disposal Experiment Site (HADES) underground lab exists, but the Nuclear Energy Agency (NEA) "Clay Club" working group continues to study clay formation behavior for waste isolation. Netherlands, having similar deep clay, has also looked at designs akin to the Belgian concept. Clay-based repositories rely on the ultra-low permeability of the host rock to limit water and the sorptive chemistry to bind radionuclides. Engineered barriers (e.g., containers, bentonite liners) provide additional containment especially for the heat and initial isolation, but the geologic barrier (clay) is the primary line of defense in this approach [3].

C.3.d. Volcanic Ash Repositories

C.3.d.i. United States (Yucca Mountain)

A notable example of a repository concept in a unique geology is the proposed U.S. national repository at Yucca Mountain in Nevada. Yucca Mountain's lithology is a thick layer of welded volcanic tuff, a pyroclastic rock formed from ancient ash falls. One distinguishing feature is that the repository would be in the unsaturated zone – about 300 m below the surface but still ~300 m above the water table [3]. Being in unsaturated rock means water infiltration is extremely slow, and any percolating water would

have to travel a long path (and likely evaporate or get absorbed) before reaching waste level. The Yucca design took advantage of this dry setting: unlike other repositories, it was planned to be open and ventilated for decades to remove heat and not immediately backfilled.

Waste canisters (double-walled, with a stainless steel inner layer and a highly corrosion-resistant alloy outer layer) would sit on the floors of large horizontal drifts, spaced to control temperature [3]. Before closure, long titanium drip shields would be installed over the waste packages to deflect any water dripping from the drift ceilings and to protect against rockfall [3]. Because the tuff is fractured, which could allow potential water flow, these engineered barriers (corrosion-proof casks, drip shields) were crucial. The multi-barrier approach therefore relied on the dry climate and deep water table as the natural barrier with a robust engineered containment design.

A conceptual layout of the proposed Yucca Mountain design is provided in Figure 8.

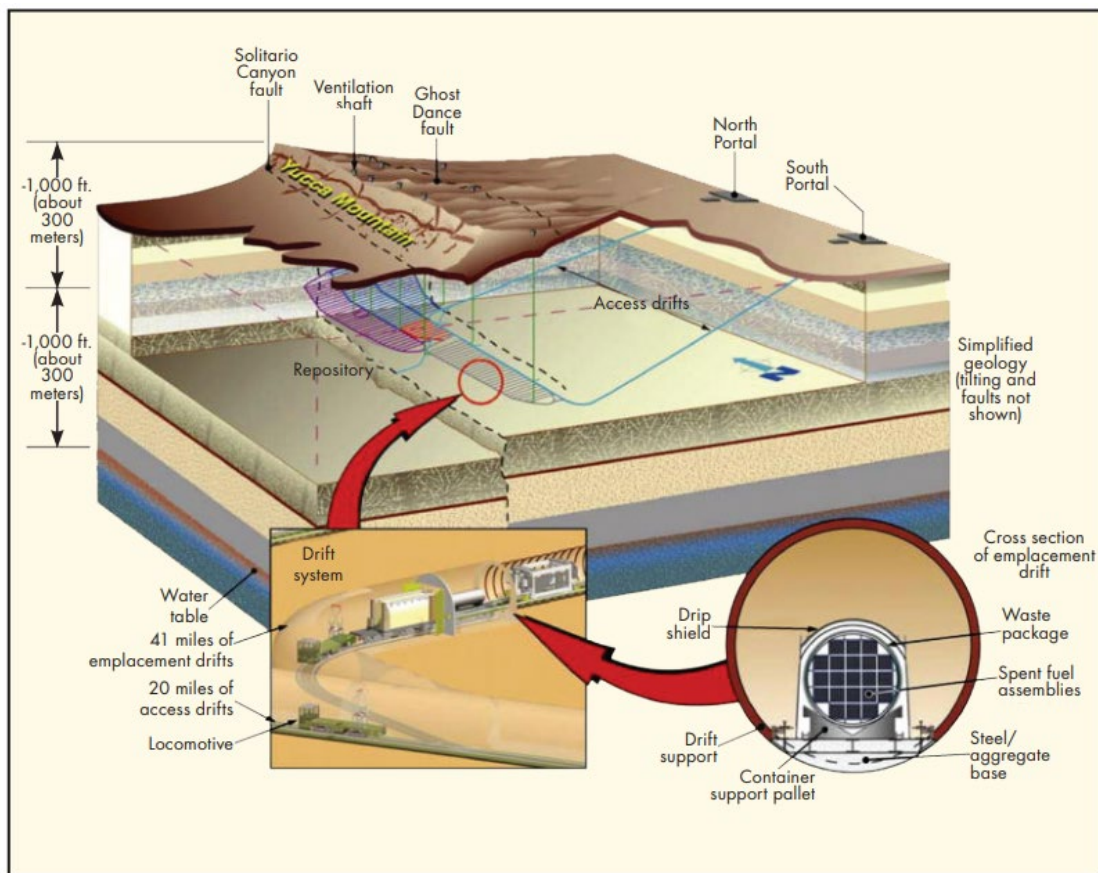


Figure 8: Proposed Yucca Mountain Repository Design [2]

C.3.e. Summary of Global Efforts

Table 2, sourced from a study conducted Oak Ridge National Laboratory (ORNL) [3], presents a comparative overview of the performance behaviors of several candidate host rock formations that have been the focus of international repository development efforts, namely salt, crystalline rock, argillaceous formations (clay and shale), and volcanic tuff. These geologic media have been studied extensively in various national programs due to their inherent geologic and hydrogeologic properties that contribute to the long-term containment and isolation of radioactive waste. The table highlights how each host rock performs across critical parameters such as permeability, thermal conductivity, self-sealing capability, and

sorption potential. Understanding these parameters is essential in evaluating a formation's ability to serve as a robust natural barrier.

Table 2: Favorable and unfavorable properties of potential host media relevant for disposal [3]

Property	Salt	Crystalline Rock	Argillaceous Formations
Thermal Conductivity	High	Medium	Low
Permeability	Very low	Very low (unfractured) Permeable (fractured)	Very low – low
Deformation Behavior	Visco-plastic (Creep)	Brittle	Plastic to brittle
Strength	Medium	High	Low - medium
Dissolution Behavior	High	Very low	Very low
Sorption Behavior	Very low	Medium – high	Very high

Table 3, sourced from a study conducted by the Nuclear Waste Technical Review Board (NWTRB) [2], summarizes the key technical and operational considerations associated with each host rock type. These include construction feasibility, predictability of geological structure, hydrological behavior, compatibility with engineered barriers, and sensitivity to thermal and chemical disturbances.

Table 3: Disposal Characteristics Associated with Various Host Rock Media [2]

	Salt	Crystalline Rock	Argillaceous Formations	Volcanic Tuff
Safety Properties Associated with the Host Rock and Natural Environment	<ul style="list-style-type: none"> - Absence of Flowing Water - Self-healing fractures - High thermal conductivity to remove heat -Low natural moisture content 	<ul style="list-style-type: none"> - Stable for mining - Provides compatible environment for engineered barriers - Low fracture density 	<ul style="list-style-type: none"> - Self-sealing fractures - Diffusion-controlled radionuclide migration - High Sorption Capacity 	<ul style="list-style-type: none"> - Arid climate reduces the amount of water entering the repository drifts - Closed hydrological basin limits the distance that radionuclides can travel
Safety Concerns Associated with the Host Rock	<ul style="list-style-type: none"> - Mining and heat induce moisture movement - Hydrogen gas buildup - Increased likelihood of human intrusion for natural resources - Corrosivity of any intruding water 	<ul style="list-style-type: none"> - Corrosion of metal canister - Stability of bentonite buffer - Changes to the geohydrological and geochemical conditions 	<ul style="list-style-type: none"> - Potential for permeable faults - Increased likelihood of human intrusion for natural resources 	<ul style="list-style-type: none"> - Uncertainty about the presence of fast flow paths - Potential for deliquescence-induced corrosion of the waste package - Oxidizing conditions, which allows for mobilization of radionuclides - Heat-induced moisture movements
Importance of Engineered Barriers	<ul style="list-style-type: none"> - High at WIPP (magnesium oxide to limit actinide solubility); (shaft closures to limit water migration prior to salt portion if shaft healing) 	<ul style="list-style-type: none"> - High (e.g., copper canisters and bentonite clay) 	<ul style="list-style-type: none"> - High (vitrified waste forms and/or corrosion resistant waste packages) 	<ul style="list-style-type: none"> - High (corrosion-resistant waste packages and drip shields)

D. Key Siting Factors for a Second TRU waste repository

D.1. Introduction and Context on Recent Siting Efforts

Apart from an adequate host rock media, selecting a site for a second TRU waste repository requires a balance between technical suitability and social acceptability, under a framework that meets federal regulations. The DOE demonstrated at the WIPP facility that success hinges on both robust science and community support. Moreover, DOE has indicated that siting a future repository will use a collaborative approach – encouraging communities to volunteer and engaging stakeholders as partners – rather than imposing a facility on an unwilling host. The approach will remain flexible across potential geologic media (salt, granite, clay/shale), focusing on fundamental siting factors that can be applied to any host rock.

Notably, Canada has recently advanced the siting of its planned DGR in partnership with the Wabigoon Lake Ojibway Nation and the Township of Ignace, following a process that integrated rigorous technical evaluation with a collaborative, consent-based approach. This model demonstrates how a scientifically grounded, yet community-driven siting framework can lead to a successful siting process. NWMO's experience offers a valuable reference for developing a similarly robust process for siting a second TRU waste repository in the United States. Therefore, this report bases this discussion largely on NWMO's recently implemented siting framework.

NWMO's siting takes on an iterative process in which each siting phase evaluates potential sites in greater detail than the previous phase. The first phase is the initial screening phase, in which a potential site will be evaluated based on the following generic criteria [21]:

- The proposed site should include a sufficiently large area to host both surface infrastructure and underground repository facilities.
- It should lie outside of designated protected zones, including national and provincial parks, heritage sites, and other legally safeguarded areas.
- The area should not contain currently known, economically viable natural resources to avoid the likelihood of future resource exploitation disrupting the repository.
- The site's geological and hydrogeological conditions must be suitable for deep geologic disposal; areas with characteristics that could compromise safety must be excluded.

If a potential site satisfies these initial screening criteria, it is then subject to further evaluation based on two key categories:

1. **Safety:** Assessing the site's ability to ensure protection of current residents in the surrounding area as well as future generations through long-term containment and isolation of radioactive waste.
2. **Societal Impact:** Evaluating how the development of a repository may affect the long-term sustainability, well-being, and quality of life of the host community, including economic, social, cultural, and environmental considerations.

These two factors will be explored in greater detail in the subsequent sections.

D.2. Safety Factors

A safety-oriented siting process as developed by NWMO is guided by a set of foundational principles designed to ensure long-term protection of the local community and the environment. These criteria are rooted in international best practices and are intended to ensure that any selected site can safely contain and isolate waste over timescales of hundreds of thousands of years. The siting process focuses on safety by evaluating a site's ability to meet the following requirements [21]:

1. **Isolation Characteristics of the Host Rock:** The characteristics of the rock at the site must support the long-term containment and isolation of the waste, protecting both humans and the environment from exposure, including from surface disturbances due to natural events or future human activities.
2. **Repository Construction, Operation, and Closure:** Site conditions must be suitable to allow for the safe construction, operation, and closure of the repository in accordance with regulatory and safety requirements.
3. **Human Intrusion:** The site must have a low potential for future human intrusion, such as from resource exploration, mining, or other land-use developments.
4. **Site Characterization:** The geological conditions must be practical to characterize and model at the scales required to demonstrate the repository's long-term safety and performance.
5. **Transport:** A secure and feasible transport route must exist, or be able to be developed, for transporting the waste from storage facilities to the repository site safely and in compliance with security regulations.

Systematically applying these safety-focused criteria, ranging from geological isolation and construction feasibility to intrusion resistance and transport logistics, ensures that only sites with robust, long-term safety potential are considered. Each of these factors are further discussed below.

D.2.a. Ensuring Long-Term Isolation Through Geologic Suitability

A foundational requirement for siting a repository is the ability of the host rock to isolate and contain the waste for extremely long time periods – on the order of hundreds of thousands to millions of years. This involves identifying rock formations that exhibit minimal permeability and demonstrate long-term geologic stability. The host rock must be capable of physically and chemically limiting the migration of radionuclides, even under assumed future climatic and geologic stressors. For example, seismic activity at the site should not jeopardize the repository's structural integrity, either during its operational phase or long after closure. Similarly, processes such as erosion, land uplift, and subsidence must not degrade the natural and engineered barriers that ensure waste isolation.

The host rock must also be situated at a safe distance from known zones of deformation or fault lines, particularly those with a potential for reactivation in future glacial cycles or tectonic shifts. The geo-mechanical behavior of the rock under repository conditions, such as stress redistribution and thermal evolution, must be predictable and remain within safe performance thresholds. The ability of the geosphere to buffer against climatic variability also acts as an input to the site selection criteria.

D.2.b. Feasibility of Repository Construction, Operation, and Closure

Beyond containment properties, the practical constructability of the repository is another central safety consideration. The strength and in-situ stress conditions of the host rock at the proposed repository depth must support the safe excavation and long-term stability of underground rooms or boreholes. Geological conditions should not pose unacceptable risks of rockfall, collapse, or excessive deformation.

Additionally, the depth and composition of overlying soils should not hinder access or construction activities, nor pose complications for engineered barrier placement.

The repository site must also include adequate surface area for necessary infrastructure such as access roads, ventilation facilities, waste handling buildings, and monitoring systems. These surface components must be able to function safely during the repository's decades-long operational period and be compatible with closure activities that will eventually seal off access and restore the site.

D.2.c. Mitigating the Risk of Human Intrusion

A fundamental principle of repository siting is to reduce the likelihood of future human intrusion. This includes avoiding locations with known economically exploitable resources such as oil, gas, coal, or metallic ores. Placing a repository in a formation with high resource potential raises the risk that future generations, unaware of its presence or importance, might inadvertently disturb the site through exploration or extraction. By eliminating such incentives for land disturbance, the chance of intrusion may be minimized.

D.2.d. Characterizability and Predictability of the Geologic Setting

Accurate site characterization is essential to demonstrate long-term safety. The host rock's structure, geometry, and hydrogeological behavior must be sufficiently well understood to allow for predictive modeling of the repository's performance. This includes characterizing fracture networks, groundwater flow paths, and the distribution of geochemical properties such as salinity, pH, and redox conditions.

Sites with complex, irregular geology, such as intense folding or faulting, can pose challenges to modeling and create uncertainties in the long-term safety case. Therefore, sites should be prioritized where the geology is continuous, predictable, and amenable to detailed surface and subsurface investigations using boreholes, seismic surveys, and geophysical techniques.

D.2.e. Safe and Secure Transport Infrastructure

Regarding transport safety, a viable route must exist or be feasibly developed for moving waste from interim storage facilities to the final repository site. These routes must be compatible with regulations governing the transport of radioactive materials and must be designed to support emergency response protocols in the event of an incident.

The surrounding infrastructure should allow for secure, monitored, and efficient fuel shipments over potentially long distances. In addition to road or rail access, transport plans must account for logistical challenges such as terrain, weather, and proximity to population centers. Siting in areas with established transport routes can significantly reduce complexity and enhance safety during operational phases.

D.3. Social Siting Factors

While ensuring technical safety, the site selection process implemented by NWMO also provides substantial weight to social, economic, and environmental considerations through a set of "factors beyond safety." These criteria reflect a holistic approach to siting, ensuring the repository not only meets regulatory and engineering requirements but also contributes positively to the well-being of host communities [21]. Each of these factors are further discussed below.

D.3.a. Sustained Well-Being of the Community

A central component is ensuring that the repository site contributes to the long-term well-being of the host community. This includes more than short-term economic benefits since it aims to create enduring positive outcomes that align with local goals. The repository should support employment, skill

development, and infrastructure investment over several decades. The repository implementor should assess the degree to which these benefits are consistent with the community's vision for its future and whether they will enhance the social and economic vitality of the area in a sustainable way. This criterion is particularly important in rural or Indigenous communities where long-term economic development opportunities may be limited, and the repository has the potential to be a stimulus to the local economy.

D.3.b. Alignment with Community Vision and Land Use Plans

Beyond economic contributions, the repository should align with the community's land use priorities and cultural values. A site should not be incompatible with existing development plans and not undermine other land-based activities valued by the community, such as agriculture, conservation, recreation, or tourism. This criterion ensures that the project does not disrupt established uses or create tension with the local identity and lifestyle. Respect for Indigenous cultural practices and traditional knowledge is also vital, especially in areas where land use is tied to spiritual and ancestral significance. In this way, the repository implementor may foster a cooperative and respectful relationship with potential host communities by emphasizing shared values and aspirations.

D.3.c. Environmental Integrity and Stewardship

Along with avoiding competing land use, successful siting of a repository focuses on preserving or enhancing the local environment. The goal is not just to prevent harm but to ensure that environmental stewardship is a core component of the project. This includes evaluating potential effects on biodiversity, water resources, air quality, and land integrity. Communities that place a high priority on environmental protection must see that these values are reflected in the project's planning and implementation. Thus, the repository implementor should be committed to working with local stakeholders to identify and protect sensitive ecosystems and to support community-led environmental initiatives wherever feasible.

D.3.d. Community Capacity to Participate and Support

Successful repository siting requires not only community consent but also the capacity for meaningful participation, which includes institutional, technical, and organizational capacity to engage in decision-making, regulatory processes, and long-term monitoring. This includes assessing the strength of local governance, access to information and training, and willingness to engage in a partnership model. The repository implementor may provide financing for independent technical resources and support to build capacity where gaps exist, recognizing that empowering communities leads to better outcomes and greater trust. The repository is seen not as an imposed infrastructure but as a shared endeavor with a willing and prepared partner.

D.3.e. Transport Infrastructure and Public Confidence

The viability and social acceptability of transport routes, which require robust and secure logistics, are critical to successful operations at the repository. Key aspects of social acceptability include examining existing road and rail infrastructure, the potential for upgrades, and how communities along these corridors perceive and accept the transport of nuclear materials. Building public confidence in the safety and transparency of transport operations is essential. This includes early and ongoing engagement with municipalities, emergency response planning, and the integration of community feedback into transport design and communication strategies.

D.4. Summary of Key Siting Criteria

Table 4 provides a summary of the key safety and societal considerations drawn from the successful implementation of NWMO's recent collaborative siting process. When integrated with the regulatory

framework outlined in the Workstream 1 deliverable of this study, these criteria offer a robust foundation for developing a comprehensive siting framework for a second TRU waste repository in the U.S.

Table 4: Key Safety and Societal Factors for Siting Framework

Category	Factor	Description
Safety Factors	Isolation Characteristics of Host Rock	Ensures long-term containment and isolation of radioactive waste from the biosphere.
	Repository Construction, Operation, and Closure Feasibility	Evaluates site conditions for safe engineering, operation, and decommissioning of the repository.
	Potential for Human Intrusion	Assesses risks related to future exploration, mining, or other disruptive land uses.
	Geological Characterization Feasibility	Determines whether the geologic features are predictable and can be modeled accurately.
	Transport Logistics and Safety	Confirms that nuclear materials can be transported securely and efficiently to the site.
Societal Factors	Sustained Well-Being of the Community	Focuses on the project’s ability to support local economic development and long-term prosperity.
	Alignment with Community Vision and Land Use	Assesses compatibility with community goals and existing or planned land uses.
	Environmental Integrity and Stewardship	Examines potential environmental impacts and opportunities for ecological enhancement.
	Community Capacity to Participate and Support	Evaluates the ability of the community to engage meaningfully and manage long-term responsibilities.
	Transport Infrastructure and Public Confidence	Considers the adequacy and public acceptability of transport routes and logistics.

E. Preliminary Siting Framework

E.1. Overview

Establishing a robust and adaptive framework to site a second TRU waste repository in the U.S. requires an integrated approach that reflects both international best practices and contemporary domestic requirements. This section outlines a three-tier siting strategy that synergizes (1) globally informed geologic criteria, (2) internationally harmonized safety standards, and (3) a proven community-driven engagement model, such as that used in Canada’s recent repository siting process and adopted by DOE.

E.2. Globally-Informed Geological Suitability Criteria

The first pillar of the framework builds upon global experience in repository siting as discussed in Section C. , especially in nations with advancing repository concepts and programs such as Sweden, Finland, Germany, and France. These countries have rigorously evaluated host rock types such as salt, crystalline rock, and argillaceous formations for their long-term isolation capabilities.

The U.S. framework may consider multiple geologic media while maintaining consistent evaluation principles. This includes adopting the structured datasets outlined in the International Atomic Energy Agency’s (IAEA) Safety Standard SSG-14: Geological Disposal Facilities for Radioactive Waste, which encompasses 14 key criteria across five major domains (e.g., geology, hydrology, seismicity, climate, and constructability).

E.3. Safety-Centered Evaluation Criteria

The second tier of the siting framework draws heavily from the successful, risk-informed, performance-based safety evaluation approach employed in Canada’s NWMO siting process. This methodology, which is also reflected in DOE’s collaborative siting framework for interim dry storage, prioritizes technical rigor and regulatory alignment while maintaining adaptability across a range of geologic and operational contexts. As discussed in Section D.2. , this safety evaluation ensures long-term containment, safe repository operations, minimized human intrusion, reliable site characterization, and secure transport operations.

E.4. Collaborative Community Engagement

The final tier of the siting framework builds upon the collaborative siting success demonstrated in Canada, particularly the selection of the Wabigoon Lake Ojibway Nation and the Township of Ignace for the country’s planned deep geological repository. As outlined in Section D.3. , this tier emphasizes the importance of consent-based siting and long-term community partnership as critical components of a sustainable and publicly accepted repository program. Canada’s approach offers valuable insights for the development of a second TRU waste repository in the United States, where public trust and durable partnerships will be equally essential.

Central to this societal pillar is the principle of voluntary community participation, ensuring that host communities are not imposed upon but are instead engaged willingly and proactively. Transparency, mutual learning, and inclusive decision-making processes help establish a foundation of trust and shared ownership over outcomes. Meaningful engagement with Indigenous peoples, guided by cultural sensitivity and respect for sovereignty, is especially vital in recognizing historical contexts and building genuine partnerships. The provision of community benefits – both economic and infrastructural – and the

negotiation of long-term partnership agreements help reinforce commitments to local well-being and accountability.

A preliminary framework for siting a second TRU waste repository, based on a culmination of geologic, safety, and societal factors, is presented in Figure 9.

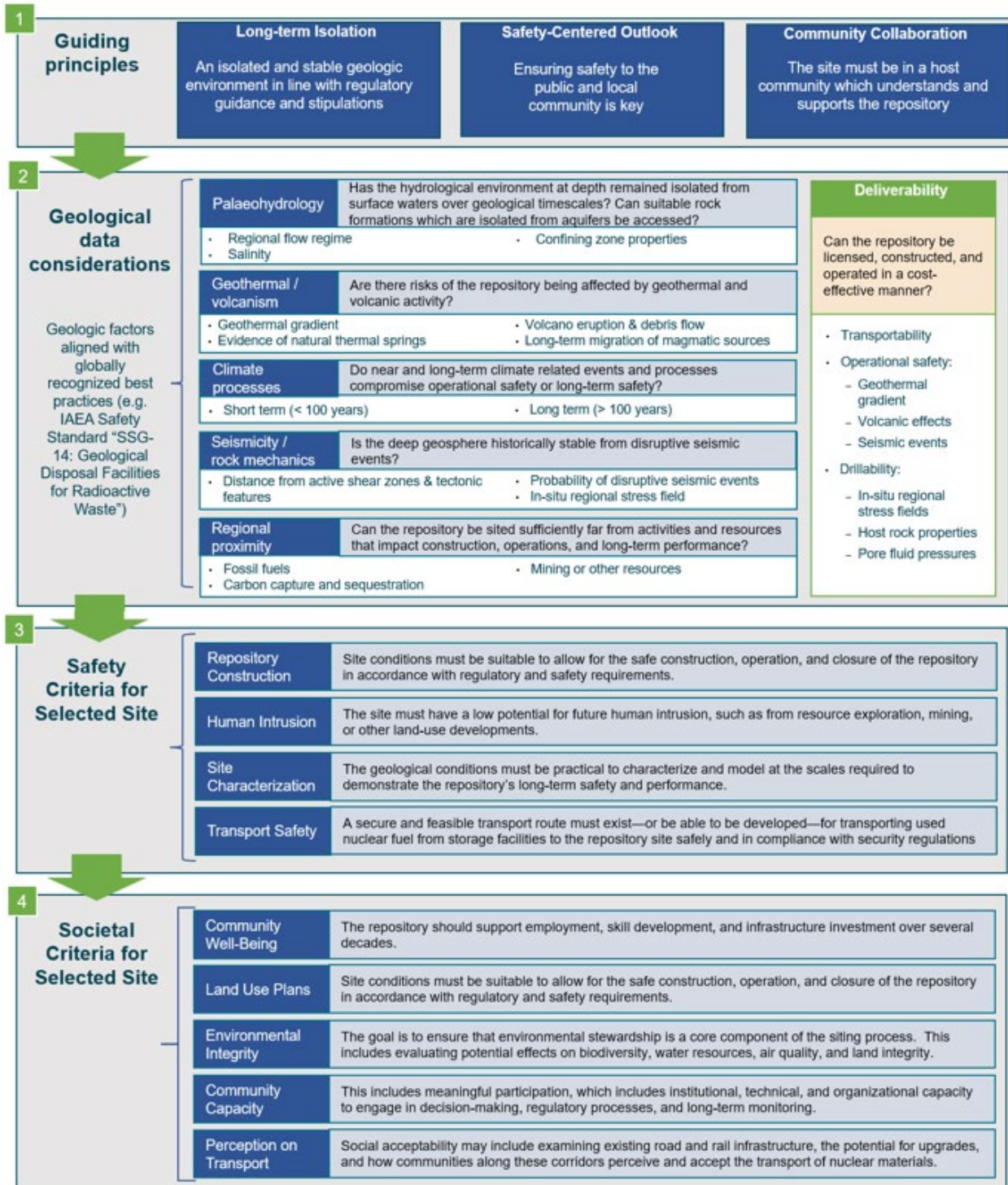


Figure 9: Preliminary Siting Framework for Siting Second TRU Waste Repository

F. Conclusions and Next Steps

F.1. Conclusion

There is strong precedent to support the foundation for developing a siting framework for a second TRU waste repository, both from recent developments in DOE's evolving approach to collaborative-based siting and from a wealth of international best practices.

The findings of this study show that multiple geologic host rock types, primarily salt, crystalline rock, and clay/shale, remain viable options for siting of a second TRU waste repository. Each formation offers distinct advantages, such as salt's self-healing properties, clay's sorption capacity, or crystalline rock's structural stability. Global repository programs have shown that with appropriate characterization and engineered barrier systems, each host medium can support a long-lived safety case. However, the U.S. must also account for the complexity of modern siting: safety is no longer viewed purely through a technical evaluation, but must incorporate social trust, transparency, and regional partnership.

To that end, the report recommends a three-tiered framework: geologic suitability, safety performance, and societal engagement, based on best practices from international efforts, including Canada's recently completed consent-based siting process. The integration of technical rigor and community consent offers the best pathway to develop a socially durable and technically robust TRU waste repository.

F.2. Next Steps

Moving forward, several important steps are recommended to begin implementing this framework:

- **Develop a national siting roadmap** that formalizes this community engagement and siting framework and integrates it into DOE's waste management planning. This roadmap should align with U.S. regulatory structures and may build on the collaborative-based siting initiative for consolidated interim storage.
- **Conduct early-phase geologic screening** using national-scale datasets to identify candidate regions that meet generic host rock criteria, such as thermal stability, hydrologic isolation, and lack of exploitable natural resources.
- **Engage stakeholders and Tribal Nations early**, prioritizing voluntary participation, education, and sustained communication. Canada's experience demonstrates that long-term partnership and community benefits are critical to siting success.
- **Update the TRU waste inventory characterization** to assess volume, form, thermal output, and packaging requirements. This data will be essential to informing repository design and capacity estimates.

These domestic and international advancements together provide a robust foundation upon which a second TRU waste repository strategy in the United States can be confidently built. By combining the extensive rigor of international best practices with the collaborative-based ethos of modern U.S. and global policy, this report presents a preliminary path to address the disposal of TRU waste at a potential second repository.

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2025 Repository Siting Annual Report

Appendix 2 Repository Scenarios

DECEMBER 11, 2025

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Abbreviations, Acronyms, and Initialisms

Term	Meaning
DOE	Department of Energy
HLW	high-level radioactive waste
ID	inner diameter
MGR	mined geologic repository
OD	outer diameter
RH	remote-handled
SIMCO	Salado Isolation Mining Contractors, LLC
SNF	spent nuclear fuel
TRU	transuranic
UCS	Universal Canister System
WIPP	Waste Isolation Pilot Plant

Executive Summary

This report summarizes a study commissioned by Salado Isolation Mining Contractors, LLC (SIMCO) to support potential siting of a second transuranic (TRU) waste repository. This report develops and compares repository scenarios for such a second TRU waste repository. The purpose of this work is to illustrate plausible options for mined and borehole configurations, identify the most salient trade-offs among them, and provide a structured foundation for future Department of Energy (DOE) and SIMCO decision-making.

The study reviews the principal attributes that influence repository concepts: depth, hydrology, geology, repository configuration, and waste packaging. Depth influences thermal, mechanical, and hydrologic conditions, with mined repositories generally around ~500 meters deep and borehole concepts extending to 1-5 km. Geologic media of interest are granite, sedimentary formations, and salt, each with distinct operational and performance characteristics. Repository configurations encompass mined geologic repositories (MGRs), vertical deep boreholes, horizontal deep boreholes, and slanted deep boreholes. Finally, waste packaging considerations highlight the trade-off between legacy WIPP containers, which are well suited to mined concepts, and Universal Canister System (UCS) designs, which provide borehole compatibility but may require repackaging or development of larger UCS classes.

From the wide range of possible attribute combinations, impractical or technically uncertain options were screened out. This process narrowed the design space to **seven¹ representative scenarios** that capture the most meaningful contrasts for TRU waste disposal:

- Mined repository (1. legacy containers; 2. UCS repackaging)
- Vertical borehole (3. legacy containers via larger UCS; 4. current UCS Class 1, 2, 3)
- Horizontal borehole (5. current UCS Class 1, 2, 3; limited to sedimentary/salt, ~2 km)
- Slanted borehole (6. legacy containers via larger UCS; 7. current UCS Class 1, 2, 3)

These scenarios were then compared across criteria of modularity, cost, surface footprint, technology maturity, and packaging requirements. The analysis shows that mined repositories benefit from regulatory precedent and continuity with WIPP operations but require large surface and subsurface footprints and offer limited modularity once constructed. Borehole repositories, by contrast, provide small footprints and high modularity but rely on less mature disposal concepts and may require new waste packaging solutions. Coupled with footprints, costs and durations for construction, operation, closure, and institutional control are likely to be greater for MGR solutions.

The report concludes that both MGRs and borehole repositories remain technically plausible options for a second TRU waste disposal facility. The choice between them involves balancing regulatory certainty and operational continuity against modularity and potential cost efficiencies. Packaging requirements represent a key differentiator, with mined repositories offering compatibility with existing containers and boreholes requiring either repackaging or development of new UCS classes.

Deep Isolation recommends that DOE and SIMCO advance this work by:

1. defining a reference inventory to anchor scenario evaluations,
2. applying preliminary safety and economic screening analyses,
3. engaging stakeholders regarding packaging and transportation assumptions, and
4. refining public-facing comparisons to support consent-based siting.

These steps will ensure that scenario development remains aligned with regulatory frameworks, technical feasibility, and stakeholder expectations as DOE plans for a second TRU waste repository.

¹ This number could be reduced to five if vertical and slanted boreholes are coupled together.

A. Introduction

A.1. Background

In 1999, the Waste Isolation Pilot Plant (WIPP) facility near Carlsbad, New Mexico began receiving shipments of transuranic (TRU) waste for disposal, making it the first nuclear waste repository of its kind in the world [1]. If TRU waste generation exceeds projections, it is possible that future inventories of TRU waste could exceed the legal capacity of the WIPP facility. The United States Department of Energy (DOE) has begun issuing annual reports on siting a second repository.

A.2. About this Document

The purpose of this document is to develop and compare a set of repository scenarios for TRU waste disposal at a second U.S. repository site. The scenarios are intended to illustrate plausible design options, highlight trade-offs between mined and borehole concepts, and provide a transparent foundation for DOE and SIMCO decision making.

This report builds upon and extends the findings of the 2024 Repository Siting Annual Report [1] and frames the technical options available for TRU waste disposal. This report focuses on conceptual design options and describes repository attributes, narrows to representative scenarios, and compares those scenarios against consistent evaluation criteria. This report is in five sections:

- Section A is this **Introduction**.
- Section B summarizes the **Repository and Waste Package Attributes** essential to the feasibility and performance of a second TRU waste repository.
- Section C describes **Scenario Development** for comparing different options for a second TRU waste repository.
- Section D sets out **Conclusions and Recommendations**.
- Section E provides **References** for the citations used throughout the report.

B. Repository and Waste Package Attributes

The feasibility and performance of a second TRU waste repository depend on a combination of natural and, to varying extents, engineered features. At the highest level, four attributes strongly influence repository concepts for a given waste form: disposal depth, the geologic medium, the repository configuration, and the waste packaging. Collectively, these attributes inform operational feasibility, cost, and long-term safety performance.

B.1. Depth

Depth is an essential factor of repository performance, influencing thermal, mechanical, hydrologic, and chemical conditions. Shallower repositories (e.g., hundreds of meters) are generally less costly to construct but require greater reliance on engineered barriers and long-term institutional controls. Deeper repositories (e.g., 1-5 km) provide greater natural isolation, longer pore fluid residence times, and reducing geochemical conditions that slow radionuclide migration [2].

In mined geologic repositories (MGR), depths typically range from 400 to 900 m, consistent with WIPP, Yucca Mountain, and international designs such as ONKALO in Finland [3] and Forsmark in Sweden [4]. By contrast, deep borehole disposal (DBD) can achieve greater depths with a smaller surface footprint. Vertical boreholes may reach depths of 5 km, if necessary, while horizontal borehole disposal is generally assumed for depths ranging from 1 to 2 km. Slanted boreholes may leverage depths between these two concepts depending on local geology.

Greater depth incurs engineering challenges, including higher hydrostatic and lithostatic pressures as well as elevated ambient temperatures. These conditions affect canister design, casing, seals, and emplacement methods. For instance, pressures at disposal depths beyond 1 km are in thousands of psi. To ensure proper emplacement operations and intended canister performance, a canister's shell thickness will need to increase with an increase in design depth to accommodate increased buckling loads at higher pressures. Thickness increases may in turn necessitate larger borehole diameters and higher costs, but buckling resistance can be bolstered by reducing disposal depth, changing materials, and/or reducing canister length. However, depth also confers substantial safety advantages by placing waste in formations with isolation from the biosphere. Depth selection therefore represents the balancing of operational and engineering ease, cost, and safety performance predicated on the waste form itself.

B.2. Geology

At repository-relevant depths, most geologic settings exhibit anoxic and reducing conditions, low permeability, and long groundwater residence times. All of these attributes bolster containment and retardations of radionuclides [2]. Among the geologic settings considered for TRU waste disposal, granitic, sedimentary, and salt formations have been the most widely studied and remain the primary candidates for mined or borehole disposal concepts.

B.2.a. Granitic

Granitic formations are widely distributed across continental crust and occur as nearly ubiquitous basement rock generally starting at depths of approximately 1.5 to 2 km. This ubiquity, combined with their structural stability, low porosity, and very low permeability, makes granite an attractive option for geologic repositories. Pore fluids within granitic basement rocks are generally highly isolated from the surface, with residence times exceeding one million years, providing confidence in natural long-term containment [5]. Granitic formations do occur at shallower depths, such as within the Canadian Shield and across much of Northern Europe, where they have been selected as repository host rocks. Internationally, granite hosts are central to the repository programs in Finland [3], Sweden [6], and Canada [7], providing precedent for their use in future concepts [8]. Granitic rocks at the Nevada Test Site were investigated by the Lawrence Livermore Laboratory in the late 1970's and early 1980's.

B.2.b. Sedimentary

Sedimentary formations, such as shale and clay-rich mudstones, are prevalent across the continental U.S. and typically occur at depths less than 2 km. High-clay content shales exhibit extremely low permeability, strong sorption capacity, and in some cases self-sealing behavior that further restricts groundwater flow. These attributes make shale and claystone particularly favorable for radionuclide

isolation. Internationally, France's Cigéo project [9] and Switzerland's Nördlich Lägern [10] repository concept both rely on sedimentary host rocks, underscoring their applicability. In the U.S., DOE's 2024 Repository Siting Annual Report [1] identified shale as a promising medium for further evaluation. Challenges regarding variability in stratigraphy and mechanical properties have been addressed at repository sites through small diameter boreholes for characterization. In 2010, Sandia National Laboratories analyzed the technical features and safety performance of a repository for high-level radioactive waste (HLW) or spent nuclear fuel (SNF) in suitable clay or shale formations, in the United States [11].

B.2.c. Salt

Salt formations have long been considered favorable for radioactive waste disposal, with the operational WIPP repository providing direct precedent [1]. Salt's self-sealing behavior, driven by creep and plastic deformation, gradually encapsulates voids and eliminates pathways for groundwater flow. Its high thermal conductivity further aids in dissipating heat, though thermal loads in TRU waste may be substantially lower than those of HLW or SNF. Salt is structurally stable under repository conditions and can provide robust natural containment. However, suitable salt formations are geographically limited, and, depending on site-specific attributes, their plasticity could pose engineering challenges for both mining and drilling operations as well as disposal operations spanning several decades [8]. By virtue of WIPP's success, these challenges are surmountable. However, careful planning of operational duration relative to salt creep rate is important to avoid loss of excavated footprint prior to repository closure. Underground salt (potash) mines have been successfully operated for nearly a century in the Permian Basin.

B.3. Repository Configuration

The design of a second TRU waste repository is influenced not only by depth and geology, but also by the overall repository configuration. Four primary configurations are considered in this report: MGRs, vertical boreholes, horizontal boreholes, and slanted boreholes. Each configuration presents distinct trade-offs in capacity, modularity, operational complexity, and reliance on engineered versus natural barriers for safety performance.

B.3.a. Mined Geologic Repository

MGRs are the most precedented nuclear waste repository concept, though each repository concept is unique and the total count of sophisticated MGR concepts remains low. Of the most significantly studied MGR concepts, the disposal depth generally ranges from 400 m to 900 m. The solution has been studied in salt through the operational WIPP repository, granite through the nearly operational ONKALO repository in Finland and Forsmark in Sweden, and in sedimentary formations through the likes of Cigéo in France and Nördlich Lägern in Switzerland. MGRs benefit from extensive international experience, proven construction methods, and regulatory familiarity. However, they may require long construction timelines, substantial surface and subsurface infrastructure, and decades of operation and monitoring prior to closure.

B.3.b. Vertical Borehole Repository

Vertical deep boreholes have been studied the longest of the three possible borehole configurations. Vertical boreholes offer a modular solution with the greatest versatility in depth, geology, and diameter. Depending on the diameter, vertical boreholes could extend to 5 km if needed. Vertical deep boreholes are possible in granitic, sedimentary, and salt geology, though granitic is most commonly envisioned [12].

Depending on borehole conditions and quantity of canisters in a borehole, intermediate plugs may be necessary to alleviate stacking loads to avoid damaging canisters, particularly those at the bottom of a given stacking arrangement. There is also some debate regarding the need for long-term seals to separate the emplacement zone from the rest of the borehole prior to backfilling. Though such seals have not been demonstrated in these conditions (i.e., diameter and depth), the technology appears scalable and, per Deep Isolation's safety sensitivity studies [5], safety performance is relatively insensitive to the presence of a seal at depth due to the safety afforded by the considerable disposal depth.

B.3.c. Horizontal Borehole Repository

Horizontal deep boreholes have been studied more recently, following advances in directional drilling technology. The concept generally involves a vertical borehole segment gradually deviating into a

horizontal segment for waste emplacement. The geology in the waste disposal zone is generally assumed to be sedimentary, and the emplacement depth is generally considered within a range of 1 to 2 km. A benefit to horizontal disposal is that the emplacement section could potentially extend several kilometers, reducing the quantity of boreholes needed, the surface footprint, and the need for thicker canisters at deeper depths.

The concept is newer than MGR or vertical borehole repositories, but Deep Isolation and its strategic partners have extensively studied the concept since 2016, addressing safety [13], economic [14], while also exploring regulatory uncertainties and logistical implementation. Challenges still facing the horizontal borehole concept include limitations of the diameter of waste packages and a lack of detailed regulatory guidance.

B.3.d. Slanted Borehole Repository

A slanted deep borehole repository combines aspects of both the vertical and horizontal concepts. A slanted borehole may begin at the surface or after some vertical depth is achieved, and general concepts assume an angle of 10 to 40 degrees from vertical. Though this option has not been studied extensively, it offers some intuitive benefits. Slanted boreholes may be easier to drill in more geologies and with larger diameters than horizontal boreholes. In fact, slanted drilling provides the opportunity to drill faster and cheaper if a more favorable fracture path can be exploited within the range of angles. In many ways, this enables the strategy employed to follow a stratification in sedimentary horizontal boreholes in other geologies like crystalline rock. Slanted borehole repositories also permit more waste disposal for a given vertical distance relative to vertical boreholes due to the lateral span.

B.4. Waste Packages

Waste packaging is an essential interface between repository design and operations. The waste package influences both what can be emplaced in a given configuration and the degree to which engineered barriers can be relied upon for operational and post-closure safety.

B.4.a. WIPP Packages

Per the WIPP waste acceptance criteria [15], TRU waste received for disposal at the WIPP facility may be in a variety of acceptable containers. These waste containers include 30-gallon drums and 55-gallon drums. These drums may be packaged into larger containers for shielding, structural, and logistical purposes as needed. These larger containers may axially stack drums (such as in Figure 1) or radially consolidate them such as in a box configuration. Without the extra packaging, 30-gallon drums are generally 20" in outer diameter (OD) and 29" in height. Meanwhile, 55-gallon drums are generally 24" in OD and 35" in height. Such containers for disposal at WIPP are made of steel.

In the WIPP facility, the more radioactive, remote-handled (RH) TRU waste is generally packaged into 55-gallon drums, and three drums can then fit into a single canister like the one shown in Figure 1. These mild steel RH-TRU canisters have a shell thickness of 0.25", making them suitable for MGR disposal but DBD applications need further study to assess the effects of pressure on the canisters at disposal depths. Other configurations of 30- or 55-gallon drums for MGR disposal may have different limiting disposal depths for DBD, prompting investigation of options before committing to a more robust UCS for legacy TRU waste.

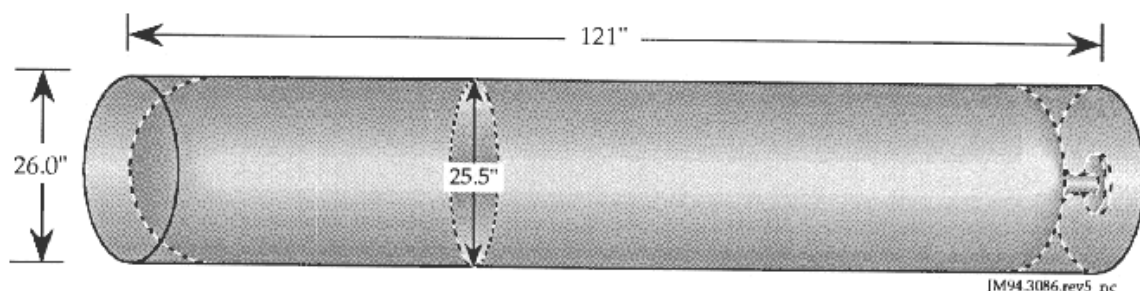


Figure 1: RH-TRU Canister for WIPP [16]

B.4.b. Universal Canister System

Deep Isolation has developed a Universal Canister System (UCS) to accommodate a variety of waste forms in storage, transport, and disposal configurations. The UCS is a right circular cylindrical container capable of withstanding disposal conditions such as hydrostatic pressures at depths up to 2 km. The current UCS design is made of 2205 duplex stainless steel and comes in three different sizes, referred to as *classes*. The Class 1 UCS has an inner diameter (ID) of 12.75" and thickness of 1". The Class 2 UCS has an ID of 14.5" and thickness of 1.125". The largest current class (Class 3) UCS has an ID of 17.5" and thickness of 1.375". All current UCS classes have a height around 180" to 190", depending on whether the lifting attachment is installed. The lifting attachment is capable of interfacing with standard oil and gas lifting equipment and nuclear handling equipment. These three classes have been designed and analyzed in accordance with applicable sections of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code [17], and further iterations on material, length, and/or radius would require revisiting of the design analyses. The current Class 1 UCS design has been validated for manufacturability through prototyping completed in 2024 (Figure 2).



Figure 2: Front View of Class 1 UCS Prototype

The UCS is designed for both deep borehole disposal and MGR disposal. The Class 3 UCS is not currently considered for horizontal DBD given its larger diameter, but current UCS classes and hypothetically larger UCS classes would be viable for vertical and slanted boreholes.

Since the OD of 30- and 55-gallon drums exceeds the ID of the Class 1, 2, and 3 UCS design, TRU waste currently packaged in these drums would either need to be repackaged into UCSs, or larger diameter UCS classes would need development. Locating the repackaging facility is a critical decision. Repackaging at the generator site may require refinements to the transportation system. Repackaging at the disposal facility will increase the facility's footprint and operating expenses.

B.4.c. Potential New UCS Classes

To avoid repackaging TRU waste from 30- or 55-gallon drums for DBD, a larger diameter UCS class could be developed. An optimized UCS design would likely include an increased diameter and a length sized to fit a discrete number of drums with minimal void space. Thus, a new UCS for TRU waste could be dimensionally similar (except with thicker walls) to the RH-TRU canister of Figure 1 or be either longer or shorter by measures of drum lengths. This packaging option would eliminate the need to repackage TRU waste from drums for DBD and is viable in a vertical or perhaps slanted borehole configuration.

While some design analyses would need to be performed for such a novel class of UCS, several design aspects, such as criticality and thermal safety, may be bounded by existing analyses. Other attributes, such as structural performance, could be optimized through adjustments in shell thickness and canister length, as desired. The continuous venting of a UCS through HEPA-type filters is not currently assumed but needs to be evaluated.

B.5. Other Design Attributes

While depth, geology, configuration, and packaging are the primary attributes for scenario evaluation in this report, additional design parameters such as waste package spacing within tunnels or boreholes, borehole-to-borehole spacing, and repository footprint dimensions can significantly affect capacity, thermal and radiological performance, and cost. These parameters are not addressed in detail within this report, but they would need to be optimized in later engineering design phases.

C. Scenario Development

Scenario development provides a structured method to compare repository concepts at a level useful for siting and planning discussions. Building from the attributes outlined in Section B, this section applies a series of filters to narrow a broad design space into a set of representative scenarios. These scenarios capture the major trade-offs between mined and borehole concepts for TRU waste disposal without overcommitting to site-specific or engineering-level design details.

C.1. Evaluating Possible Scenarios

At the broadest level, repository concepts can vary by depth, geology, configuration, and waste package. If considered independently, these parameters create a vast design space. For instance, boreholes could be placed at depths ranging from hundreds of meters to several kilometers in granitic, sedimentary, or salt formations using approved WIPP (legacy) containers or various UCS options.

To make this problem tractable, the impractical and/or technically uncertain combinations are screened out.

- **Depth:** MGRs are generally limited to 1 km maximum depth, while borehole designs are feasible at greater depths. Horizontal boreholes are considered to be constrained to 2 km maximum depth, and vertical and slanted boreholes are limited to 5 km depth maximum depth. Practically for TRU waste, however, 2 km appears a reasonable limit since the greater depths envisioned for DBD are associated with higher-activity waste such as HLW or spent nuclear fuel.
 - The depths discussed for deep borehole disposal are generally derived from safety with respect to SNF and HLW. Depending on the inventory, TRU waste may enable safe DBD at shallower depths akin to that of a MGR, reducing costs and improving the viability of thinner-shelled disposal canisters.
- **Geology:** While mined repositories and vertical and slanted boreholes are broadly geology agnostic, horizontal boreholes are most compatible with sedimentary formations and potentially with salt.
- **Containers:** For borehole options, the drums and containers housing drums in WIPP require analysis to quantify their limiting depth in direct borehole disposal. Therefore, pending those analyses, borehole solutions may either require repackaging of TRU waste directly into existing UCS designs or designing larger diameter UCSs to directly load 30- and/or 55-gallon drums. For mined solutions, the legacy containers as well as any form of UCS could be suitable.

This initial screening reduces the number of viable combinations while retaining diversity of options across geologies, depths, and packaging strategies.

C.2. Key Scenario Selection

Given the high parameter space identified in the simplified evaluation in Section C.1, a reasonable approach to narrowing scenarios is to maintain a wide range of options, then provide a short list of scenarios for a given filter. For instance, if a given geology or assumption is constrained, the resulting viable scenario count is greatly reduced. Another approach is to further simplify the options provided by the attributes of depth, geology, and container. Applying this approach, discussed in Section C.1, results in the following:

- Eliminate the depth filter, noting limitations to MGR and horizontal DBD options.
- Eliminate the geology filter, noting limitations to horizontal DBD options.
- Simplify the container filter into a binary selection. Either TRU waste is packaged in the current TRU containers or a smaller-diameter existing UCS. For borehole options, the current TRU container selection necessitates a novel, larger diameter UCS design, but this can be elaborated without making another filter.
 - The current TRU containers may be suitable for borehole disposal to a suitable depth. However, without supporting analyses, this option is excluded from these scenarios but should be evaluated prior to committing to a repository-waste package pairing.

Applying the approach listed above results in the following seven (7) key scenarios:

MGR: Geology agnostic; depth limited to 1 km

- Legacy container
- New container

Vertical DBD: Geology and depth agnostic

- Legacy container (via novel, larger UCS design)
- Existing UCS design (via repackaging from drums)

Horizontal DBD: Geology limited to sedimentary and perhaps salt; depth limited to 2 km

- Existing UCS design (via repackaging from drums)

Slanted DBD: Geology and depth practically agnostic

- Legacy container (via novel, larger UCS design)
- Existing UCS design (via repackaging from drums)

This scenario set balances both breadth and tractability. Seven scenarios capture the major design distinctions while avoiding the unwieldy number of permutations that a full parameter sweep would produce.

C.3. Key Scenario Comparison and Trade-Offs

Reducing to seven key scenarios allows for more meaningful and digestible comparisons across a consistent set of criteria, and if needed, the vertical and slanted DBD scenarios could be consolidated to potentially reduce the key scenarios to five (5).

Table 1 summarizes how mined, vertical/slanted, and horizontal borehole concepts perform relative to container choice, modularity, cost, footprint, and technology maturity. These dimensions were selected because they highlight the differences most relevant to DOE and SIMCO at this early scenario screening stage.

Table 1: Second TRU Waste Repository Scenario Comparison

Repository	Container	Modularity	Cost	Footprint	New Technology
MGR	Legacy Drums	Limited once built	Similar to WIPP	Moderate to large	None
	Standard UCS	Limited once built	Similar to WIPP	Moderate to large	(Re)packaging into UCS
Vertical / Slanted DBD	Larger UCS	High	Low	Small	Developing larger UCS
	Standard UCS	High	Low	Small	(Re)packaging into UCS
Horizontal DBD	Standard UCS	High	Lowest provided reasonable packaging costs	Small; moderate subsurface footprint	(Re)packaging into UCS

The comparison in Table 1 emphasizes several important trends. MGRs, whether using legacy containers or some form of UCS, are characterized by larger surface and subsurface footprints and limited modularity relative to boreholes once constructed. Vertical and slanted boreholes, by contrast, offer high modularity and small footprints, but these solutions for TRU waste introduce packing challenges in that waste would either need to be repackaged into existing UCS designs or a larger UCS class would need development. Horizontal boreholes could provide the lowest cost and smallest surface footprint in highly-prevalent sedimentary formations, though horizontal boreholes may require TRU waste repackaging into existing UCS designs in order to be viable.

In summary, Table 1 illustrates the fundamental trade-off between continuity and precedent (MGR) and modularity and efficiency (borehole repositories). While all seven scenarios are technically plausible in

some capacity, the differences in packaging requirements, geologic constraints, cost, and modularity will be important to future screening and decision making. As noted in Section C.2. reduced packaging efforts. It should also be noted that unlike an MGR, which has specifically been implemented for defense TRU waste disposal, deep borehole disposal has not been demonstrated to date, so proof-of-principle demonstration and the costs such demonstration incurs should be pursued prior to or early in investigation of deep borehole disposal application for defense TRU waste disposal.

D. Conclusions and Next Steps

D.1. Conclusions

In this report, Deep Isolation applies attributes of repository configurations to develop seven key conceptual repository scenarios. These scenarios are then compared for identification of their unique benefits and trade-offs.

This report develops and compares a set of plausible repository scenarios for disposal of TRU waste in a second national repository. Beginning with a broad range of attributes (depth, geology, repository configuration, and waste packaging) the analysis applies screening filters to reduce impractical and redundant combinations, ultimately highlighting a set of five representative scenarios. These scenarios span both mined and borehole disposal concepts and illustrate the key trade-offs which DOE and SIMCO will face as planning progresses.

The principal conclusions are as follows:

- **Mined geologic repositories** provide the most U.S. regulatory precedent and continuity with the WIPP facility siting and operations. MGRs are technically proven and broadly adaptable to different geologies, but they require larger surface and subsurface footprints, offer limited modularity once constructed, and generally require more time and higher cost to construct, operate, and close.
- **Borehole repositories** (vertical, horizontal, and slanted) potentially offer high modularity, smaller footprints, and potential cost advantages, but they require further development of waste packaging (i.e., repackage from drums into UCS or design larger UCS to fit drums).
- **Depth** remains a key factor. While MGRs are constrained to 1 km or shallower, borehole options can exploit greater depths if needed to provide strong natural barriers and/or optimized throughput. Depth selection will directly influence canister design, drilling costs, operations, and long-term performance.
- **Packaging** is a key differentiator. MGRs can accommodate legacy drum-based containers, whereas borehole repositories may require either repackaging from drums to the UCS or a larger UCS design to house drums. Such changes would need to consider resulting cost, logistical, safety, and licensing changes.
- **All short-listed scenarios are technically plausible**, but their relative practicality will ultimately depend on integration with inventory assumptions, siting opportunities, stakeholder acceptance, and funding.

D.2. Recommendations

Based upon this scenario development, Deep Isolation recommends the following next steps for DOE and SIMCO consideration:

1. **Define a reference inventory.** Establish a baseline TRU waste inventory (or a few bounding cases).
2. **Evaluate viability of DBD with existing TRU containers.** Conduct structural analyses to determine operational limitations and limiting depths for borehole disposal using existing TRU containers. These results could provide an alternative to repackaging legacy TRU waste into the UCS for DBD.
3. **Conduct preliminary screening analyses.** Apply simplified safety and economic assessments to the five or seven scenarios to identify the most and least viable, with the aim of narrowing to a smaller set for detailed study.
4. **Engage stakeholders on packaging approaches.** Survey waste generator sites and potential host communities regarding preferences and concerns around legacy container disposal versus UCS repackaging, as packaging assumptions strongly influence repository design.

5. **Refine scenario comparisons for outreach.** Develop public-facing materials that clearly explain the trade-offs highlighted in this report with insights from subsequent analyses in preparation for future siting discussions.

By taking these steps, DOE and SIMCO will be positioned to advance from high-level scenario framing toward a more detailed evaluation of repository concepts. The goal is not to select a single solution at this stage, but rather to provide a transparent basis for narrowing options, engaging stakeholders, and aligning future studies with regulatory, economic, sociopolitical, and technical needs.

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