Greater-Than-Class C Low-Level Radioactive Waste Characteristics and Disposal Aspects

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Protecting People and the Environment

Introduction and Background

- Low-level radioactive waste (LLRW) is defined in the US regulations as radioactive waste not classified as high-level radioactive waste, transuranic waste, spent nuclear fuel, or uranium mill tailings
- NRC developed a classification system categorizing LLRW as Class A, Class B, or Class C
- Greater-Than-Class C (GTCC) waste is LLRW that exceeds the Class C concentration limits. GTCC waste types include:
  - Activated metals - irradiated metal components as well as filters and resins from reactor operations and decommissioning
    - Common radionuclides include Ni-63, Ni-59, C-14, Tc-99, and Pu-239
  - Sealed sources - radioactive material that is sealed in a capsule ranging in size from a few millimeters to tens of centimeters
    - Common radionuclides include Cs-137, Am-241, Pu-238, and Pu-239
  - Other waste – wide range of physical forms and radionuclides from a wide range of sources (e.g., scrap metal, filters, rubble, sludges)
    - Can include Pu-239, Pu-240, Pu-238, Am-241, Cs-137, Sr-99

Introduction and Background

- Much of GTCC LLRW is aligned with IAEA's definition of intermediate level waste (ILW) due to the properties of long-lived radionuclides in the waste and due to thermal output from most of the GTCC LLRW being less than 2 kW/m^3
- The US Government, specifically the US Department of Energy (DOE), is responsible for disposal of GTCC waste
- DOE published their final environmental impact statement (FEIS) for disposal of this waste in February 2016
- This presentation uses data and information provided in the FEIS, but should not be considered a summary of the information in that document
- DOE owns or generates non-commercial LLRW which have characteristics similar to those of GTCC LLRW and has described this waste as GTCC-like waste
- NRC does not have regulatory authority over GTCC-like waste, and this presentation is focused on commercially generated GTCC LLRW

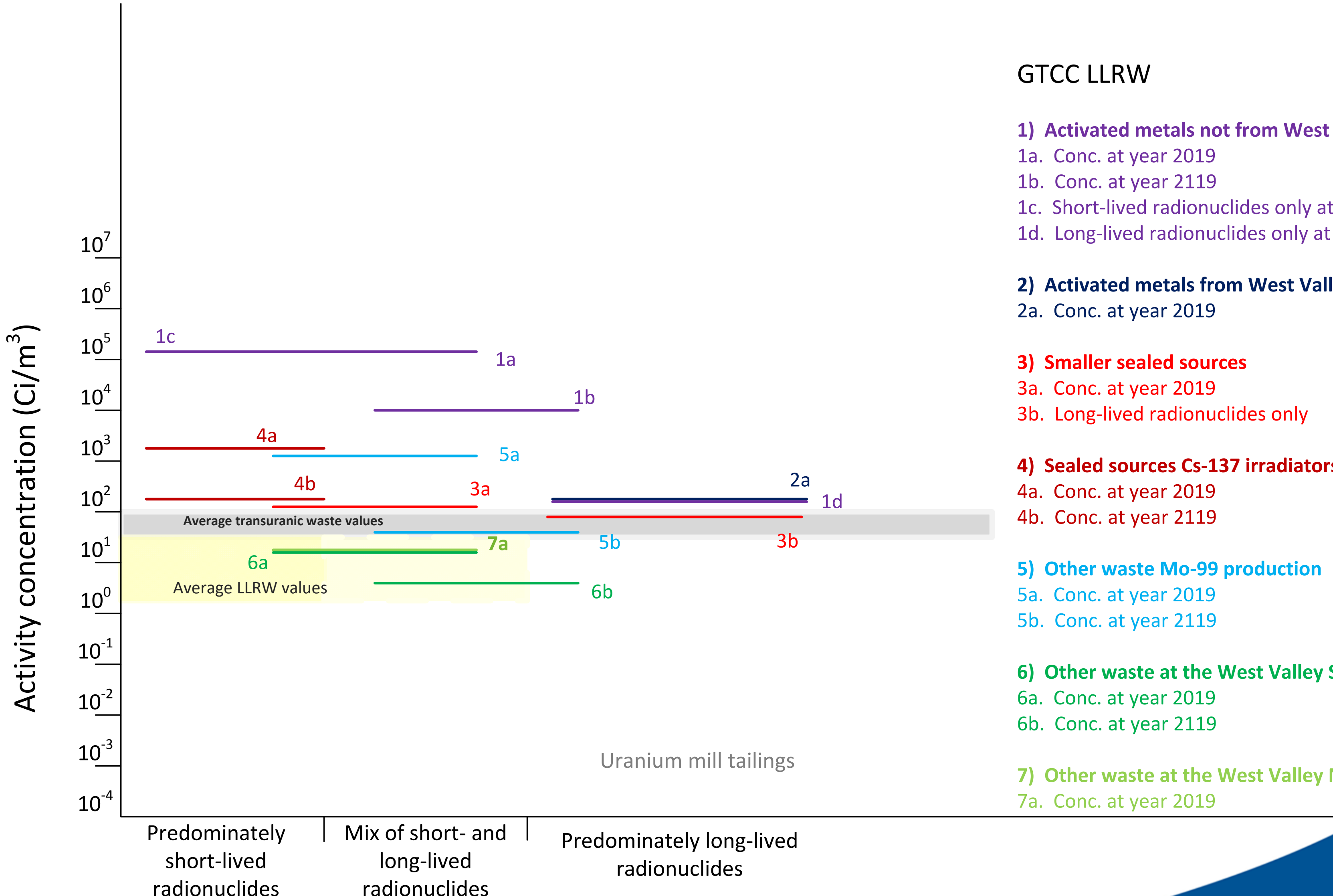
Introduction and Background

- All GTCC LLRW created from NRC licensed activities, i.e., commercially generated GTCC waste, must be disposed of in an NRC licensed facility
- US regulations, i.e., 10 CFR part 61.55(a)(2)(iv), states that GTCC waste is generally not acceptable for near-surface disposal and must be disposed of in a geologic repository unless a proposal for disposal is approved by the NRC after being evaluated on a case-by-case basis
- There may be some instances where GTCC waste would be acceptable for shallower than geologic disposal if the NRC found it to be safe and acceptable after a case by case technical evaluation
- Shallower than deep geologic disposal could either be near-surface disposal (30 m below the earth's surface or less) or deeper than near-surface disposal (i.e., intermediate depth disposal)

Safety Case

- The radionuclides, activity concentrations, physical and chemical properties and other characteristics of GTCC LLRW vary considerably and will influence the appropriate regulatory approach to the disposal of GTCC LLRW including the disposal depth
- If a proposal and a safety case for GTCC LLRW disposal were to be developed, features, events, and processes (FEPs) would need to be identified, categorized, and screened in the following subject areas:
  - Activity concentrations and half-lives, volume and activity, and other waste characteristics (e.g., heat output, gas generation, or criticality)
  - Past and present disposal site characteristics and waste isolating capabilities of natural barriers
  - Proposed disposal facility and its engineered barriers

Waste Characteristics: Example – Activity Concentrations and Radionuclide Half-Lives



GTCC LLRW

1) Activated metals not from West Valley
1a. Conc. at year 2019
1b. Conc. at year 2119
1c. Short-lived radionuclides only at 2019
1d. Long-lived radionuclides only at 2019

2) Activated metals from West Valley
2a. Conc. at year 2019

3) Smaller sealed sources
3a. Conc. at year 2019
3b. Long-lived radionuclides only

4) Sealed sources Cs-137 irradiators
4a. Conc. at year 2019
4b. Conc. at year 2119

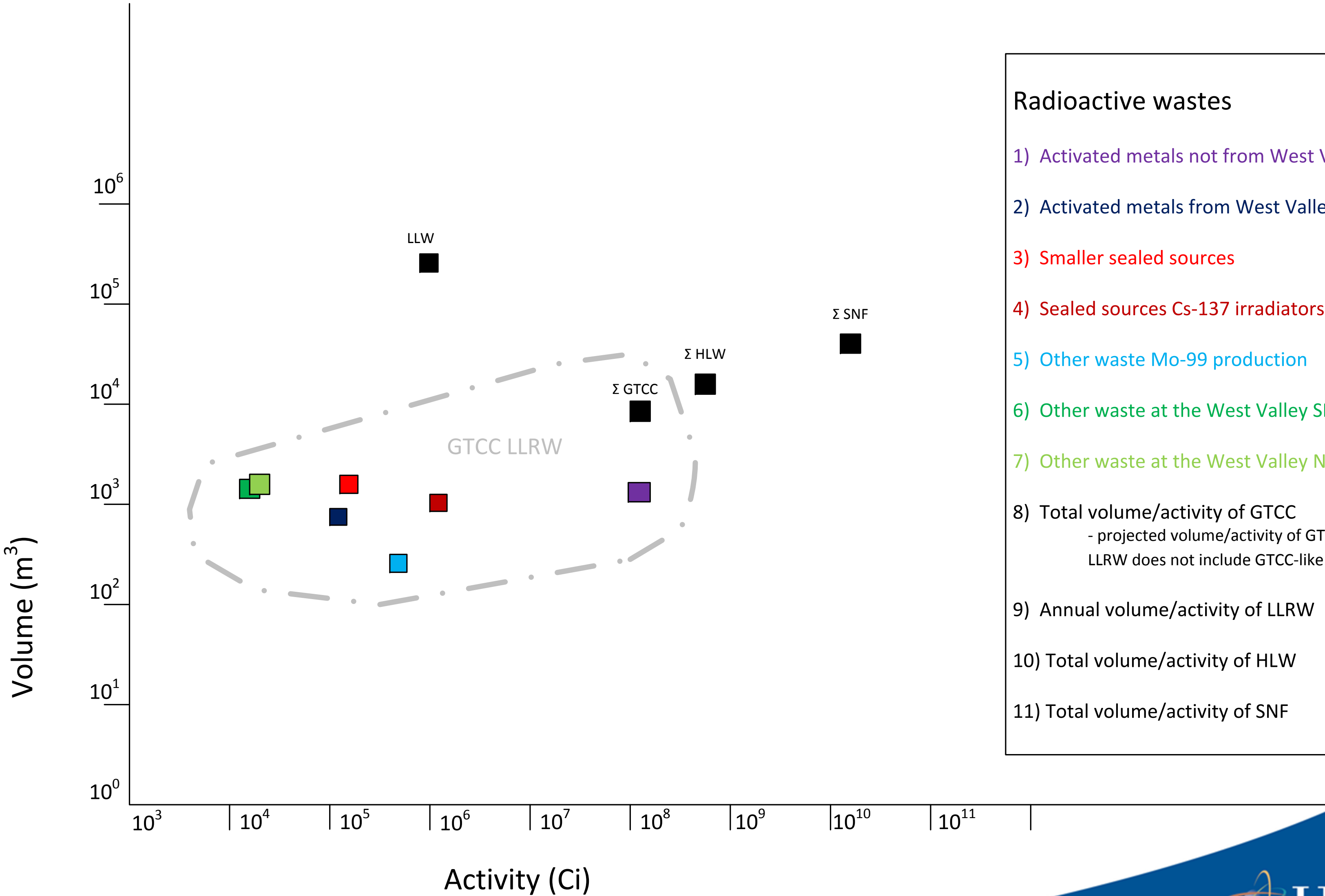
5) Other waste Mo-99 production
5a. Conc. at year 2019
5b. Conc. at year 2119

6) Other waste at the West Valley SDA
6a. Conc. at year 2019
6b. Conc. at year 2119

7) Other waste at the West Valley NDA
7a. Conc. at year 2019

10^0 or 1 Ci = 3.7×10^{10} Bq
1 Bq = 2.7×10^{-11} Ci

Waste Characteristics: Example – Volume and Activity



Radioactive wastes

1) Activated metals not from West Valley
2) Activated metals from West Valley
3) Smaller sealed sources
4) Sealed sources Cs-137 irradiators
5) Other waste Mo-99 production
6) Other waste at the West Valley SDA
7) Other waste at the West Valley NDA
8) Total volume/activity of GTCC
   - projected volume/activity of GTCC LLRW does not include GTCC-like waste
9) Annual volume/activity of LLRW
10) Total volume/activity of HLW
11) Total volume/activity of SNF

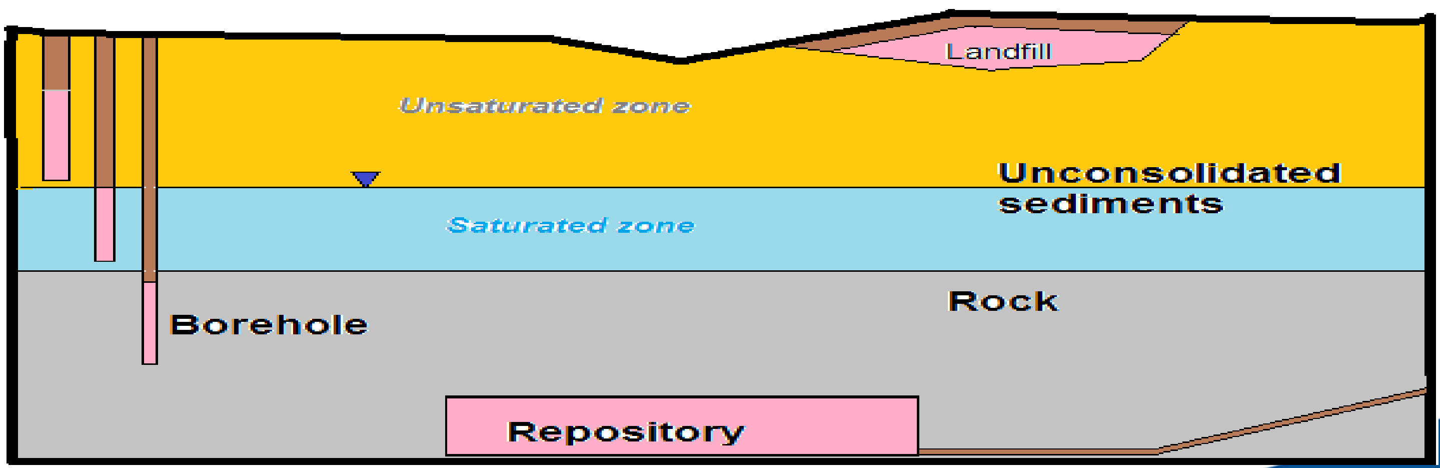
1 Ci = 3.7×10^{10} Bq
1 Bq = 2.7×10^{-11} Ci

Disposal Site Characteristics and Past Environments

- Meteorological features and processes
- Hydrogeological and geochemical features and processes
- Disruptive plausible future events

Disposal Environment

- Geologic/Geomorphic features and processes



Potential Disposal Methods

- Borehole
- Trench (near surface)
- Concrete Structure or Vault (usually near surface)
- Variations and Combinations of Disposal Methods and Depths

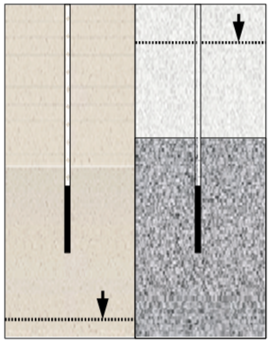
Exposure Scenarios

Onsite inadvertent intruder receptor
(acute exposure from radioactive drill cuttings)

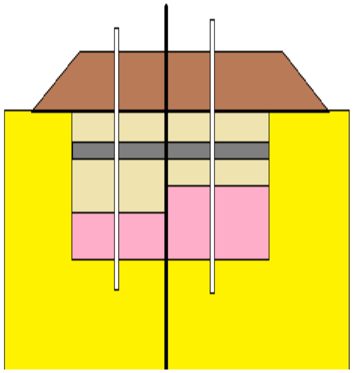
Offsite receptor
(chronic exposure from radioactive groundwater)

Technical Considerations and Insights

- Using Borehole Disposal Method at an Intermediate Depth
  - Semiarid and arid environments as well as humid environments possible
  - For the intruder-drilling receptor scenario, the plausibility of the small area of a borehole disposal site being chosen as the drill site by inadvertent intruder would need to be evaluated



- Using Trench or Vault Disposal Method at the Near Surface
  - For the intruder-drilling receptor scenario, area concentration limits may be possible to keep dose to an intruder below a limit



- Bottom line: technical bases and assumptions concerning the wasteforms, infiltration rates, chloride content, corrosion rates, and degradation of concrete intrude barriers and stabilizing grouts will influence the peak dose
  - For example, corrosion by pitting of stainless steel found in sealed source canisters and activated metals is dependent on the chloride content of the surrounding waters
  - The integrity of the wasteform would influence the radionuclide release rate and the likelihood of drilling through activated metals or a canister

Insights from DOE's Final GTCC EIS

- Within 10,000 years, radionuclides from activated metals contribute to offsite peak dose in semiarid to arid environments
- In contrast, contribution to peak dose from sealed sources can be minimal, but can be significant after 10,000 years as well as for humid sites in general due to corrosion
- Much of the GTCC Other Waste is soluble and therefore radionuclides can readily leach out into the groundwater before 10,000 years and be a key contributor to dose for humid sites
- The result is that not all GTCC waste types may produce a peak in dose at the same time

Conclusions

- Due to the way LLRW is defined in the US, there is a category of LLRW (i.e., GTCC waste) that was categorized in the 1980's and is similar to ILW and not generally acceptable for near-surface disposal
- Three decades later, it cannot be excluded that future NRC analyses may find some GTCC waste type suitable for near-surface disposal, and a proposed rule may be developed for licensing the disposal of such waste
- Current regulations only allow individual proposals for GTCC LLRW disposal to be evaluated on a case-by-case basis to determine the acceptability of land disposal other than in a geologic repository
- Based on current regulations, the variability and diversity of FEPs associated with such safety cases is theoretically large:
  - The range of activity concentrations, half-lives, and volumes of GTCC waste types is large
  - The range of physical forms is large: metal pieces to soils and sludges
  - The range of potential disposal methods is large: trench, vault, landfill, shaft, borehole
  - The range of potential disposal environments is large: arid vs. humid, unsaturated vs. saturated, sediment vs. rock, near-surface to intermediate
  - The stability and past natural history of a specific disposal site must also be adequately known

Conclusions

- Examples of potential site-specific cases designed to demonstrate the acceptability of GTCC LLRW land disposal other than deep geologic:
  - Proposals for disposal could entail concepts that have been relatively well assessed by NRC staff in the past; e.g., trench disposal of a moderate volume of GTCC Other Waste in an arid, unsaturated, near-surface environment
  - Proposals for disposal could also entail concepts that have been less frequently assessed; e.g., borehole disposal of higher activity sealed sources in a humid, saturated, intermediate depth environment
- However, if one potential site and design was under consideration, the variability and diversity of FEPs associated with that site-specific disposal facility (vs. a generic facility) would be smaller
- In summary, the level of time and effort for NRC staff to complete such evaluations would correspond with complexity and details of the proposals

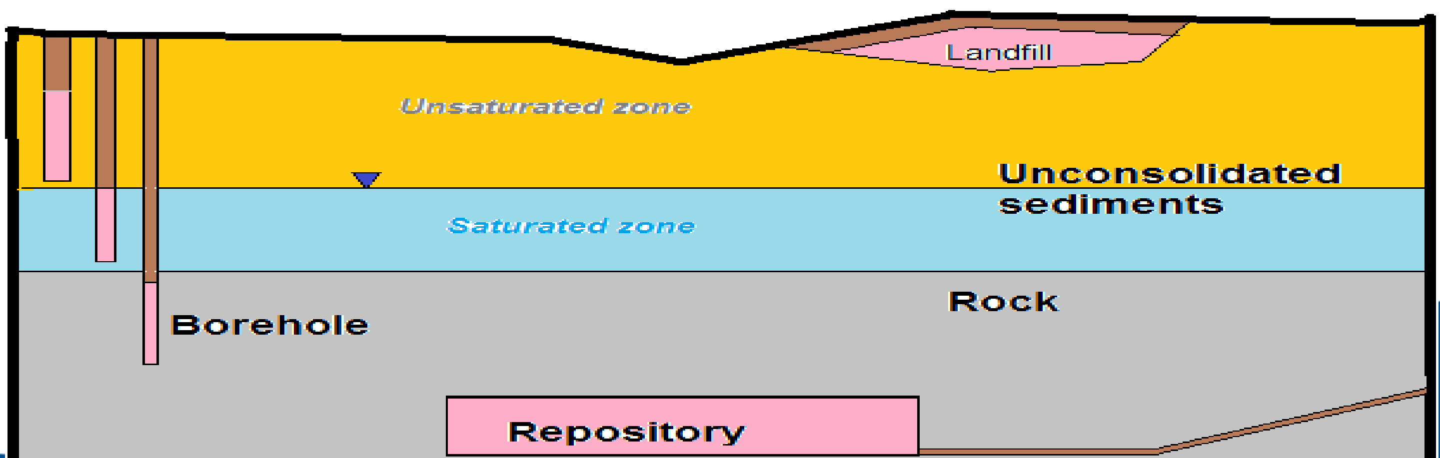
Backup Slides

Disposal Site Characteristics and Past Environments

- Meteorological features and processes
  - Present and past regional climate and its associated properties such as precipitation
  - **Arid/dry** versus **humid/wet** and everything in-between
- Hydrogeological features and geochemical processes
  - Preferred flow within a system
  - Advective-dispersive mechanisms that act to redistribute radionuclides from the waste through the surrounding environment
  - Physical-chemical interactions between liquid, solid, and gas phases within the disposal site and surrounding environment
- Disruptive plausible future events
  - Tectonic, igneous, floods, and other events and processes from the past that may significantly impact performance in the future

Disposal Environment

- Geologic/Geomorphic Features and Processes
  - Topography and associated site stability concerns such as erosion and weathering
  - Level of consolidation of surrounding host material
    - Consolidated (rock) or unconsolidated (loose sediment or soil)
  - Depth of disposal
    - Near surface: 30 m below the local topographic low point (as defined in NRC regulations)
    - Intermediate depth: order of tens of meters to a few hundred meters (this qualitative examination was considering intermediate depths between 30 and 150 m)
    - Deep geologic: several hundred meters or more below the surface (this qualitative examination was considering repositories deeper than 100-150 m)

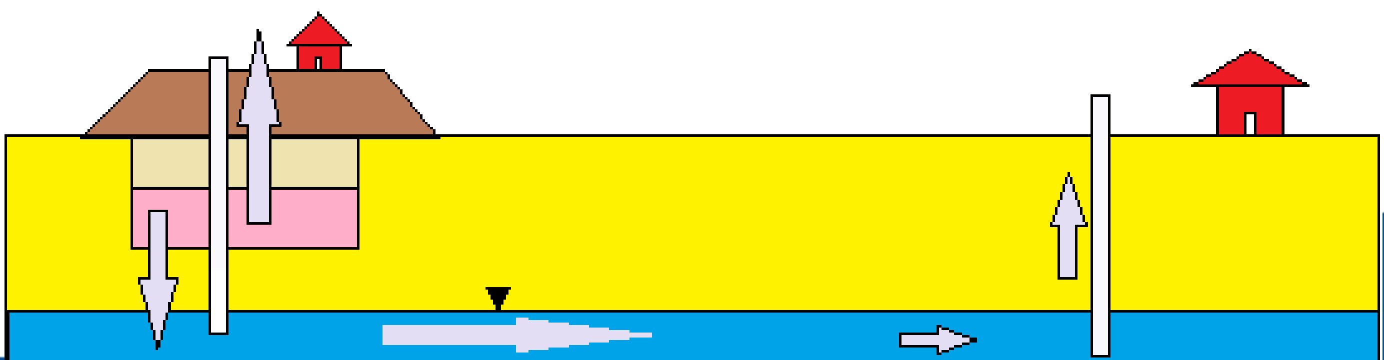


Disposal Methods at Disposal Facility

- Deep Geologic Repository
  - May take the form of a tunnel, a chamber, or a silo
  - Granite, salt, clay, tuff and others as host rock/material
- Borehole
  - Depth may be shallow, intermediate, or deep
  - Unsaturated or saturated disposal
- Trench (near surface)
  - Vertical to semi-vertical side walls; compacted material on bottom; backfill around the waste containers; reinforced concrete layer on top
- Concrete Structure or Vault (usually near surface)
  - Enclosed, engineered concrete structure; backfill and surface cover on top
- Variations and Combinations of Disposal Methods and Depths
  - For example, mine-like shafts near surface or intermediate depths
  - Landfills may be deeper than 30 m and include multiple engineered barriers around all sides

Exposure Scenarios

- Onsite inadvertent intruder receptor scenarios are often correlated with activity concentration, while offsite receptor doses from contaminated groundwater plumes are often correlated with total repository activity
- This qualitative examination assumed no disposal less than 5 m deep
- Therefore, no intruder exposed during construction excavation
- Intruder could be exposed by waste bought up during drilling
  - Intruder-Drilling Receptor Scenario
    - **Acute** exposure while drilling through the waste to install a well
    - Volume of radioactive material exhumed is limited to the dimensions of the borehole
- Offsite exposure scenario assumes receptor drinks and uses well water contaminated from disposal site groundwater plume (**chronic** exposure)



Technical Considerations Associated with GTCC Waste Disposal

- Using Deep Geologic Repository Disposal Method
  - Semiarid and arid environments as well as humid environments possible
    - Humid environment repository would need to contend with moisture or find deep sites keeping moisture out, e.g., salt deposits, very compact clay layers, dry bedrock
  - Plausibility of an inadvertent intruder driller exposure scenario would depend on the characteristics of the facility and the site
  - If intrusion at such depths were plausible, technical bases and assumptions concerning the degradation of the stabilizing agent (e.g., grout) and the corrosion rate of metals would be important
  - For exposure scenarios involving groundwater transport offsite, performance assessment results for GTCC LLRW disposal in a repository in New Mexico indicate that although there is radionuclide release from activated metals and other waste streams, no significant dose could be expected from the low activity involved