DBD Breakout Session 1 Agenda

SAND2016-5351PE

SESSION 1 - WEDNESDAY, JUNE 8, 2016: 08:00 AM – 09:50 AM

Time	Presenter	Topic
08:00 – 08:10	Tim Gunter (DOE)	DBFT Overview and Status
08:20 – 08:30	Geoff Freeze (SNL)	DBD Safety Case Framework
08:30 – 08:45	Dave Sassani (SNL)	DBFT Site Evaluation and Site Selection
08:45 – 09:00	Frank Perry (LANL)	Geologic Framework Model
09:00 – 09:05	Glenn Russell (INL)	Regional Geology Web Map Application
09:05 – 09:20	Emily Stein (SNL)	DBD PA Model
09:20 – 09:30	Kris Kuhlman (SNL)	DBFT Borehole Characterization
09:30 – 09:35	Kurt Nihei (LBNL)	Monitoring and Characterization
09:35 – 09:50	**Group Discussion**	**Siting and Characterization**

DBD Breakout Session 2 Agenda

SESSION 2 - WEDNESDAY, JUNE 8, 2016: 10:10 AM – 12:00 NOON

Time	Presenter	Topic
10:10 – 10:30	Ernie Hardin (SNL)	DBFT Engineering Overview
10:30 – 10:40	Fred Peretz (ORNL)	Surface Handling and Transfer Cask Concept
10:40 – 10:50	John Cochran (SNL)	Emplacement Zone Completion Options
10:50 – 11:10	**Group Discussion**	**Engineering**
11:10 – 11:20	Jonny Rutqvist (LBNL)	DRZ Modeling and Testing
11:20 – 11:30	Pat Dobson (LBNL)	Swedish Deep Borehole R&D
11:30 – 11:40	Florie Caporuscio (LANL)	Laboratory Testing of Sealing Materials
11:45 – 11:50	T.J. Ulrich (LANL)	DRZ and Fracture Detection
11:50 – 11:55	Andrew Delorey (LANL)	Stresses and Breakouts

Used Fuel Disposition Campaign

Deep Borehole Disposal (DBD) Safety Case Framework

Geoff Freeze

Sandia National Laboratories

UFD Working Group Meeting

Las Vegas, NV

June 8, 2016

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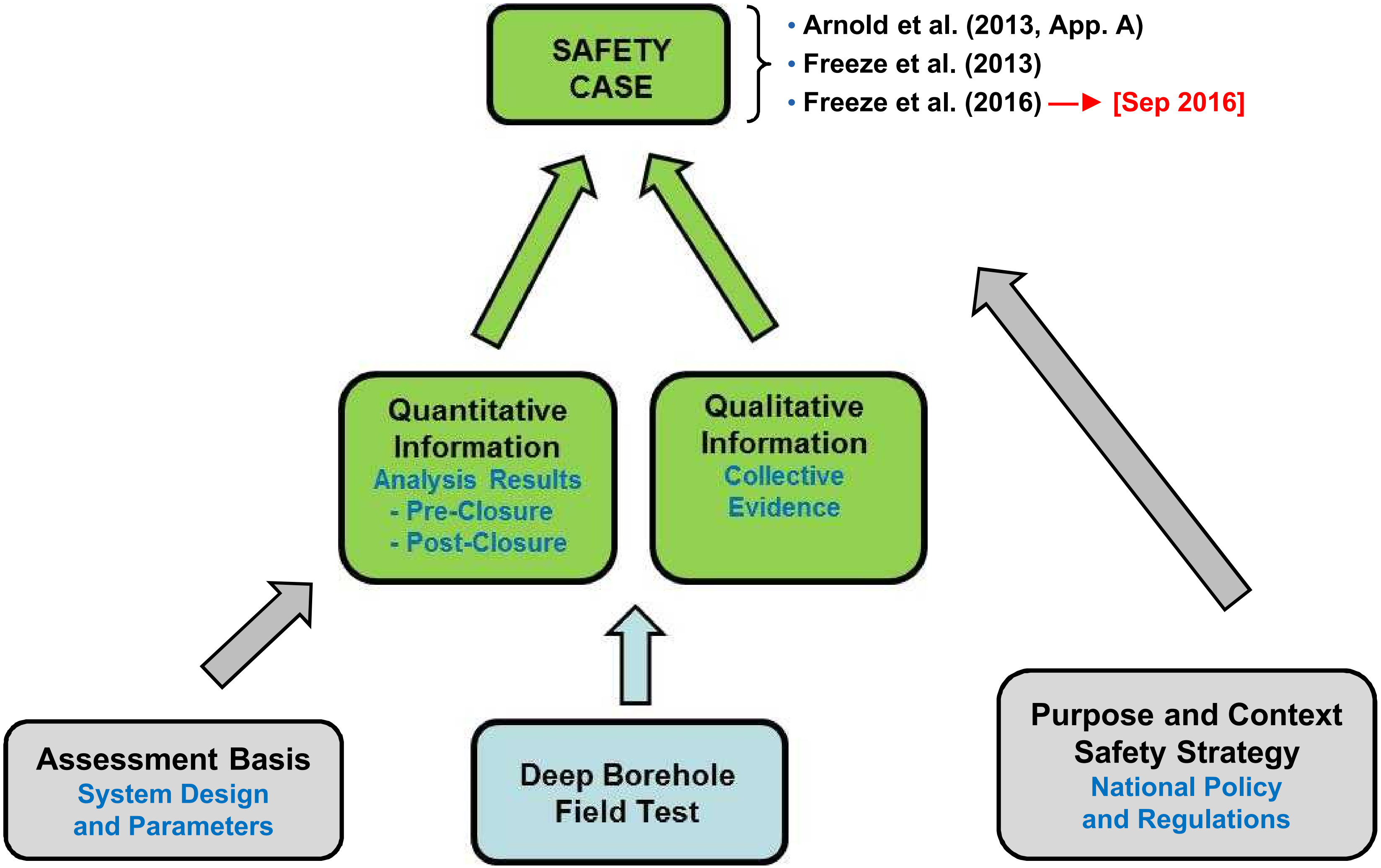
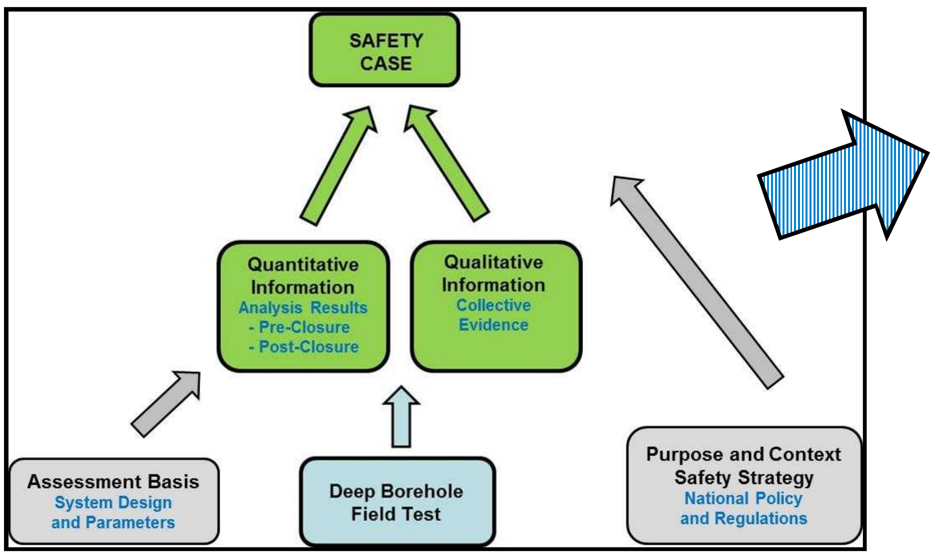
DBD and DBFT Overview

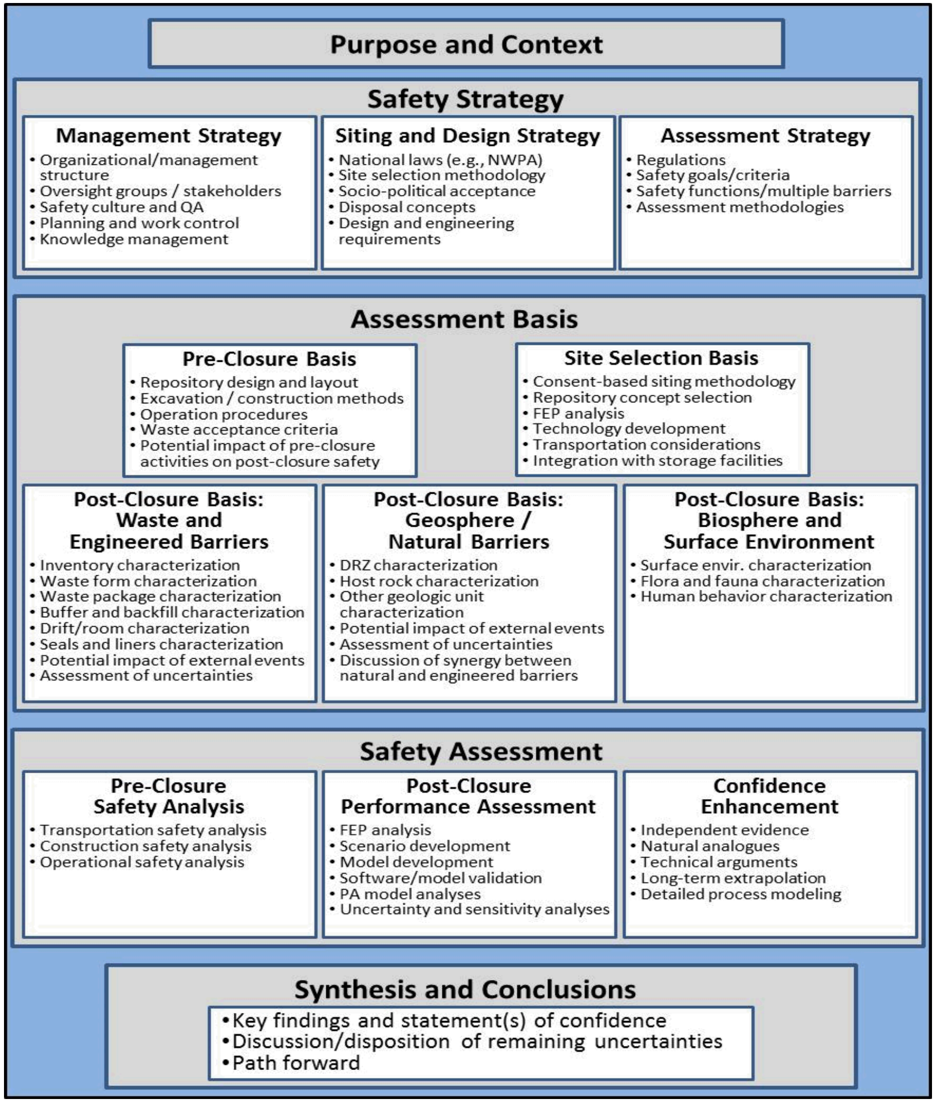
- **UFD Deep Borehole Disposal (DBD) R&D initiated in FY12**
  - Informed by prior studies (e.g., MIT, Sheffield, SNL, SKB) that were focused on SNF disposal
- **DOE-NE Assessment of Disposal Options** [DOE 2014]
  - Recommended consideration of deep borehole disposal of smaller DOE-managed waste forms, such as cesium (Cs) and strontium (Sr) capsules
- **UFD is conducting a Deep Borehole Field Test (DBFT)**
  - To demonstrate and evaluate technologies necessary for determining the safety and feasibility of the DBD concept
    - *Develop a DBD Safety Case*
    - *Identify of areas for further R&D*
  - Without the use or disposal of radioactive waste
    - *Use surrogate "test packages"*
  - Planned 5-year duration, $80M budget

DBD Safety Case Framework



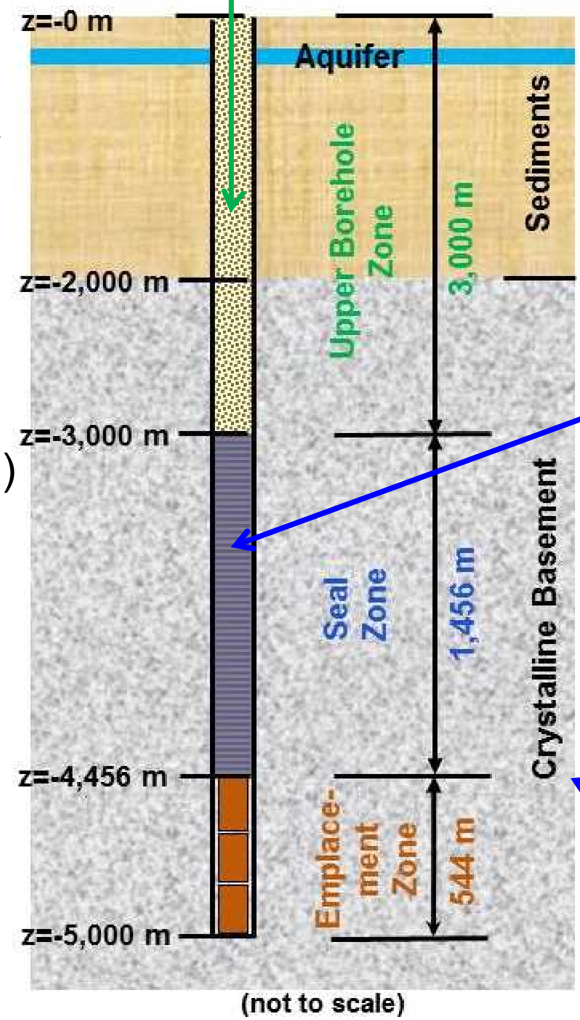
DBD Safety Case Framework





DBD of Cs/Sr Capsules – Design (for this iteration of the Safety Case)

- **All 1936 Cs/Sr capsules fit in a single borehole with a 544-m Emplacement Zone**
  - 108 WPs (4.76 m each)
    - 34 Sr WPs in upper EZ
    - 74 Cs WPs in lower EZ
  - 3 cement plugs (10 m each)
  - Bottom-hole diameter = 31.1 cm (12.25 in)
- **WPs are lowered, one at a time, on wireline inside a removable guidance casing**



Pre-Closure

Waste package emplacement system can be engineered to maintain structural integrity and operational safety during surface handling and downhole emplacement

Post-Closure

Borehole seals (and disturbed rock zone (DRZ)) can be engineered/evolve to maintain a low-permeability barrier over the period of thermally-induced upward flow

Deep crystalline rocks typically have low permeability and lack hydraulic connection to shallow groundwater

DBD Safety Case – Purpose and Safety Strategy

Purpose and Context (for this iteration)

- Evaluation of concept feasibility

Purpose and Context

Safety Strategy

Management Strategy

- Organizational/management structure
- Oversight groups / stakeholders
- Safety culture and QA
- Planning and work control
- Knowledge management

Siting and Design Strategy

- National laws (e.g., NWPA)
- Site selection methodology
- Socio-political acceptance
- Disposal concepts
- Design and engineering requirements

Assessment Strategy

- Regulations
- Safety goals/criteria
- Safety functions/multiple barriers
- Assessment methodologies

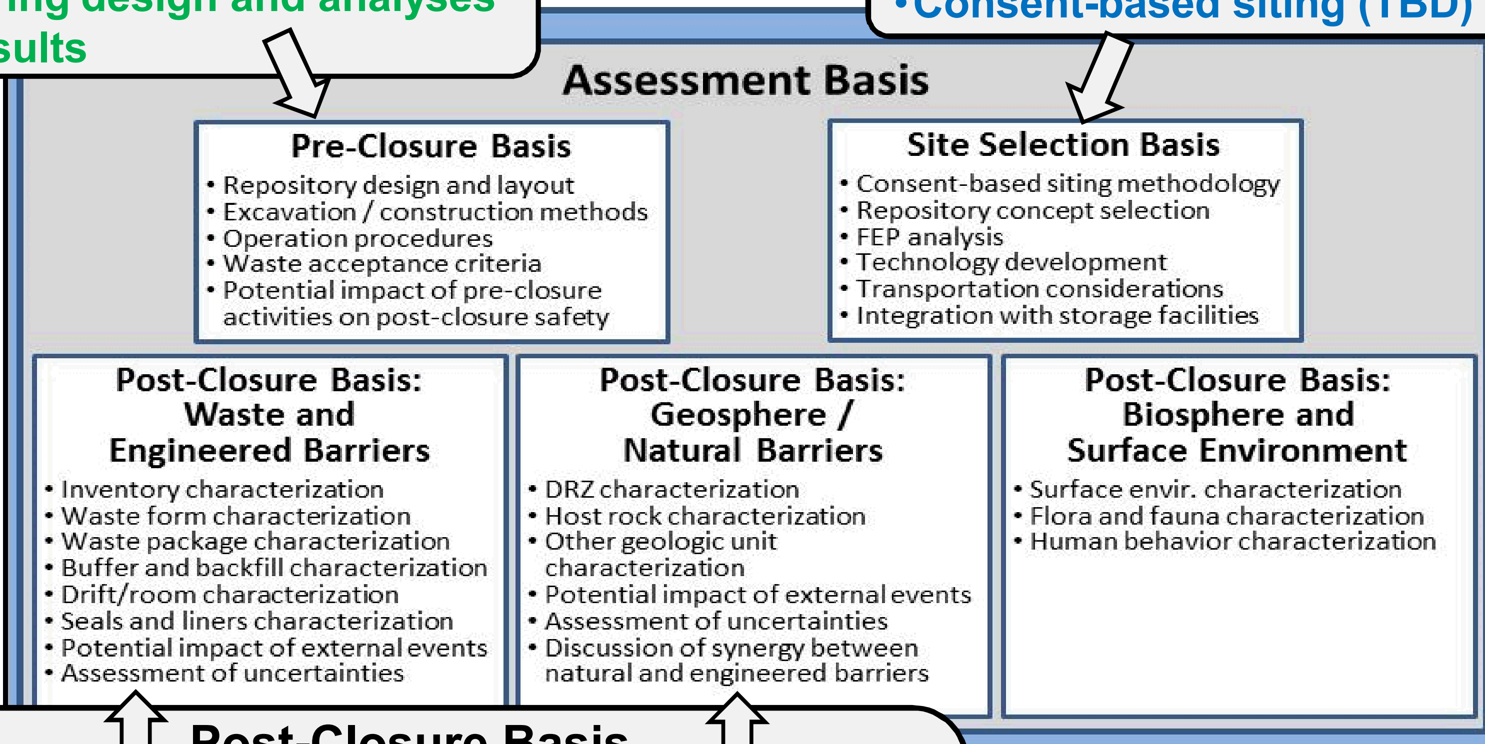
Safety Strategy

- National Laws and Policy (TBD)
- Regulations and Licensing (TBD)

DBD Safety Case – Assessment Basis

Pre-Closure Basis
- Engineering design and analyses
- DBFT results

Site Selection Basis
- Consent-based siting (TBD)



Post-Closure Basis
- Waste form and waste package design
- Emplacement Zone design and properties
- Seal design
- Generic THMC properties of host rock and DRZ
- DBFT results

Used Fuel Disposition

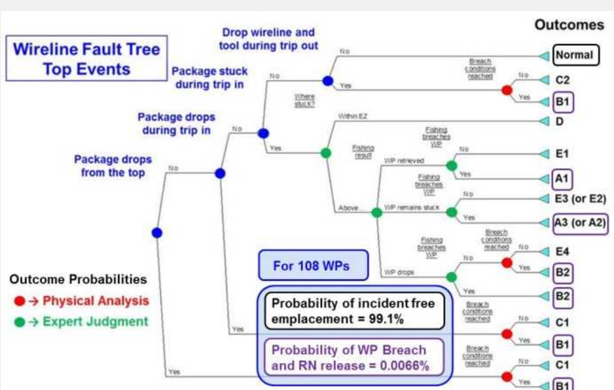
DBD Safety Case – Safety Assessment

Safety Assessment

Pre-Closure Safety Analysis	Post-Closure Performance Assessment	Confidence Enhancement
• Transportation safety analysis • Construction safety analysis • Operational safety analysis	• FEP analysis • Scenario development • Model development • Software/model validation • PA model analyses • Uncertainty and sensitivity analyses	• Independent evidence • Natural analogues • Technical arguments • Long-term extrapolation • Detailed process modeling

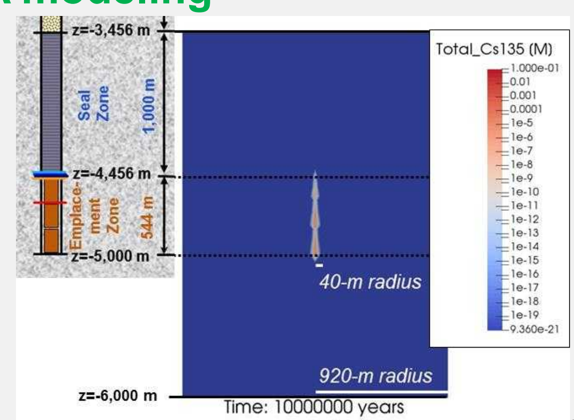
Pre-Closure Safety Analysis

- Wireline emplacement hazards analysis



Post-Closure Performance Assessment

- FEP identification and screening
- Scenarios (undisturbed)
- PA modeling



Confidence Enhancement

- Independent evidence

DBD Safety Case – Synthesis and Conclusions

Synthesis and Conclusions

- Key findings and statement(s) of confidence
- Discussion/disposition of remaining uncertainties
- Path forward

Synthesis and Conclusions

- Evaluation of concept feasibility
- Identification of future R&D
- Inform policy and regulations

DBD Safety Case – Current Status

- **Pre-Closure Safety Case for Deep Borehole Disposal of Cs/Sr:**
  - Drilling and casing a large diameter borehole to 5,000 m depth in crystalline basement rock is achievable with existing drilling technology.
  - Surface handling and emplacement systems can be engineered to provide a high level of assurance that waste packages can be safely emplaced at the desired depth with minimal probability of packages becoming stuck and/or breached.
  - Additional hazard analyses needed for: transportation, worker exposure, surface handling, and external events (e.g., seismic, flooding, sabotage)
- **Post-Closure Safety Case for Deep Borehole Disposal of Cs/Sr:**
  - Waste emplacement is deep; in low-permeability crystalline basement rock with limited interaction with shallower groundwater.
  - Borehole seals can be engineered to maintain their physical integrity, at least over the approximately 100-year time period of thermally-induced upward groundwater flow.
  - Preliminary results from post-closure PA calculations suggest minimal radionuclide releases beyond the disposal zone and zero dose at biosphere.

DBD Safety Case – Current Status

- **The Deep Borehole Field Test (DBFT) objectives and scope specifically address key technologies and data necessary to evaluate the feasibility of the DBD concept, particularly unproven or especially critical components, e.g.,**
  - deep drilling
  - collecting diagnostic geochemical signatures from deep low-permeability crystalline rocks at possibly elevated temperatures
  - package handling and emplacement
- **This is a lesser scope than would be needed to site and fully characterize an actual DBD facility**
  - some activities required for DBD have a high technology readiness level (TRL) and therefore do not require explicit demonstration in the DBFT; these high-TRL activities are not included or in some cases minimally included in the DBFT scope

References

- Arnold, B.W, P. Brady, S. Altman, P. Vaughn, D. Nielson, J. Lee, F,. Gibb, P. Mariner, K. Travis, W. Halsey, J. Beswick, and J. Tillman 2013. *Deep Borehole Disposal Research: Demonstration Site Selection Guidelines, Borehole Seals Design, and RD&D Needs.* SAND2013-9490P, FCRD-USED-2013-000409. U.S. Department of Energy, Office of Used Nuclear Fuel Disposition, Washington, DC.
- DOE (U.S. Department of Energy) 2014. *Assessment of Disposal Options for DOE-Managed High-Level Radioactive Waste and Spent Nuclear Fuel* . October 2014, U.S. Department of Energy, Washington, DC.
- Freeze, G., M. Voegele, P. Vaughn, J. Prouty, W.M. Nutt, E. Hardin, and S.D. Sevougian 2013. *Generic Deep Geologic Disposal Safety Case.* SAND2013-0974P, FCRD-UFD-2012-000146 Rev. 1. Sandia National Laboratories, Albuquerque, NM.
- Freeze, G. et al. 2016. *Deep Borehole Disposal Safety Analysis*. FCRD-UFD-2016-000075. U.S. Department of Energy, Office of Used Nuclear Fuel Disposition, Washington, DC. (to be published Sept. 2016)