SAND2019-0302PE

2019 SFWST Roadmap Update – Workshop Methodology and Breakout Group Assignments

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2019 SFWST (UFD) R&D Roadmap Update Workshop

UNLV – SEB

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Workshop (and Future) Goals

Consensus of Project experts regarding:

1. **What we *have accomplished* on generic repository R&D**
   - ← documentation (deliverables since 2012 R&D Roadmap) mapped to R&D Issues (FEPs) and R&D Activities
   - ← There are currently 796 DR deliverables since 2010 (M2s, M3s, and M4s; 379 were M2s & M3s)!! – does not include S&T deliverables
2. **What we still *need to accomplish* on generic repository R&D**
   - → updated R&D Roadmap or Plan (via the new R&D Activities spreadsheet)

Primary focus of the next three days will be the second goal (which is clearly based on the first goal), as I will explain….

Key Points to Keep in Mind

1. **This Workshop is not the be-all and end-all:**

   ← it is an important "snapshot" *consensus* of Campaign experts regarding what R&D has been completed and what is still needed at this point in time – the 2012 Roadmap was stated to be a "living" document

2. **We may re-package and re-map after the Workshop to make this info more easily accessible to stakeholders, e.g.,**

   ← map the Activities and Deliverables to a Safety Case Document structure (see MacKinnon, Sevougian, and Freeze, June 19, 2013)

3. **One of our Campaign goals should be to have an initial safety case ready at the time siting begins – regardless of the host rock**

4. **After we process the outcomes of this Workshop, a follow-on may be desirable next FY**

5. **Initial spreadsheet entries are only to facilitate discussion!!!**

   ← Thanks Ralph and Dave!!

Workshop Guidelines

- **Respect each participant:**
  - Don't take part in side conversations
  - Listen and ask clarifying questions
- **Everyone's input is equally valued**
- **It will take everyone's effort to make this succeed**
  - We will all have to come to some common and collegial "calibration":
    - *Good example: the Apollo moon program*
    - *Bad example: the Wall*
- **Use the "parking lot" for off-track topics or issues that need to be resolved**
- **No idea is bad idea, but try to stick to the methodology**
- **Respect differences**
- **Silence cell phones, etc.!!!**

Prioritization Is Needed

- **Constraints on R&D activities:**

  1. **Time**
  2. **Resources**

  } ⇒ **prioritization of R&D is required**

- **General R&D Prioritization Methodology**

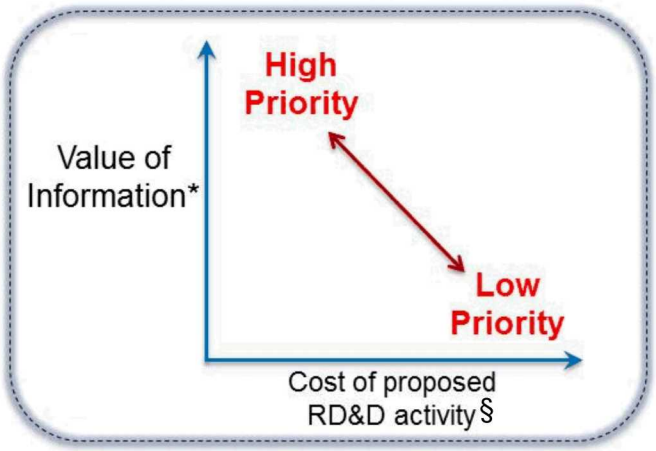
  → **Qualitative with a quantitative (or systematic) basis:**

  - Qualitative: Resources (personnel and funds) apportioned to broad work-package areas based on expert/management judgment (e.g., PICS-NE)
  - Qualitative – Quantitative: Resources further divided based on importance of individual R&D "quanta" (issues or activities), with the "importance" having an "expert-quantified" basis from a decision analysis workshop(s), such this one.

First workshop(s) for prioritizing generic repository R&D were conducted in 2012 and the resultant UFD R&D Roadmap was generated. It was stated to be a "living" document to be updated when appropriate. *This workshop represents that decision analysis update…*

Formal Prioritization Process

- **Prioritization process can be formalized (as in 2012 UFD Roadmap)**
  1. Identify a set of items (or "quanta") to be evaluated (e.g., activities, issues, or options, …)
  2. Identify criteria and associated metrics for assessing the set of items:
     - *Importance* to the safety case and PA (e.g., to safety assessment, technical bases, confidence-building)
     - Potential to reduce key *uncertainties*, i.e., to change the SAL (or TRL)
     - Other factors, e.g., *cost*, redundancies and/or synergies among the items, stakeholder objectives, etc.
  3. Evaluate each item (R&D Activity) against the metrics
  4. Define a "utility function" (or ranking function) to combine the metric values and produce an overall ranking or score for each R&D Activity
  5. Compare rankings of the R&D Activities



* = ***Func*** {sensitivity of performance to the information obtained; uncertainty reduction potential (TRL)}

§ Cost not formally considered in this update workshop.

Phases of a Repository Project
(and maturation of safety case)

2012 – UFD Roadmap

2019 – SFWST Roadmap Update

20??

2010 – YMP LA

Concept Evaluation

Evaluate Disposal Concepts; FEPs; Develop and Demonstrate Technologies; Preliminary RD&D

Site Selection/Characterization

Development of Siting Criteria

Identification of Potential Sites

Progressive Site Down-Selection

Repository Development

Detailed Site Characterization & Repository Design → License Submittal

Construction & Monitoring

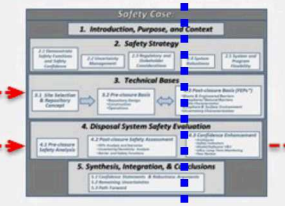
Operations & Monitoring

Closure

Maturation & Iteration of the Safety Case

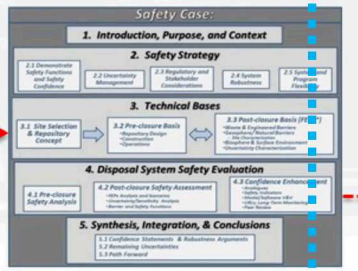
Construction → Operations → Closure

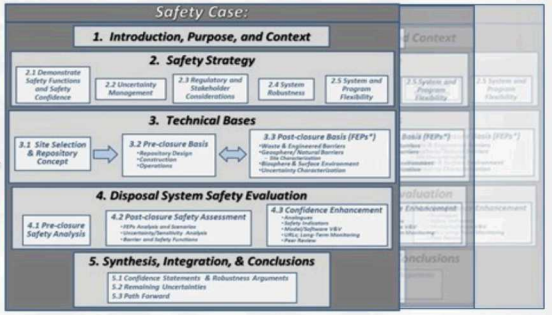
Generic



Siting

Licensing





2012 UFD R&D Roadmap

- **To help prioritize generic R&D for a deep geologic repository in one of three potential host-rock environments: argillite, crystalline, and bedded salt – deep borehole also considered**
- **Two expert workshops conducted**
- **Generic R&D to be prioritized in the workshops was *quantized* as a set of ~ 354 *R&D Issues*:**
  - → **simply a *standard FEPs* list* used on all repository programs (tailored to the U.S. program)**
  - → **Three basic metrics used to for prioritization:**
    1. Importance to the safety case (safety assessment, design/construction/operations, and confidence building)
    2. Current state-of-the-art knowledge about the Issue
    3. Importance of Issue at various "decision points" in the repository timeline

UFD FEP Number	FEP Description	Associated Processes
2.0.00.00	2. DISPOSAL SYSTEM FACTORS	
2.1.00.00	1. WASTES AND ENGINEERED FEATURES	
2.1.03.00	1.03. WASTE CONTAINER	
2.1.03.02	**General Corrosion of Waste Packages**	Dry-air oxidation in anoxic condition Humid-air corrosion in anoxic condition Aqueous phase corrosion in anoxic condition Passive film formation and stability Chemistry of brine contacting WP Salt deliquescence
2.1.03.03	**Stress Corrosion Cracking (SCC) of Waste Packages**	Residual stress distribution in WP from fabrication Stress development and distribution in contact with salt undergoing creep deformation Crack initiation, growth and propagation
2.1.03.04	**Localized Corrosion of Waste Packages**	Pitting Crevice corrosion
2.1.03.05	**Hydride Cracking of Waste Packages**	Hydrogen diffusion through metal matrix Crack initiation and growth in metal hydride phases
2.1.09.00	1.09. CHEMICAL PROCESSES - CHEMISTRY	
2.1.09.05	**Chemical Interaction of Water with Corrosion Products - In Waste Packages**	Corrosion product formation and composition (waste form, waste package internals, waste package) Evolution of water chemistry in waste packages, in backfill, and in tunnels
2.1.09.11	**Electrochemical Effects in EBS**	Enhanced metal corrosion
2.1.11.00	1.11. THERMAL PROCESSES	
2.1.11.13	**Thermal Effects on Chemistry and Microbial Activity in EBS**	

Potential R&D "Issues" used in 2012 Roadmap (based on 208 original FEPs)

* Features, Events, and Processes

Example Output* – 2012 Roadmap

Process (Issue)			Importance of Issue/Process to Safety Case				State of the Art Relative to Issue/Process	
UFD FEP ID	UFD FEP Title	Discussion	Performance (Safety Analysis)	Design, Construction, Operations	Overall Confidence	Discussion *	Status	Discussion
2.1.03.00	1.03. WASTE CONTAINER							
2.1.03.01	Early Failure of Waste Packages	Also Material Specific. Need design/materials defined to conduct further R&D Generic R&D on closure and NDE methods.	High	High	High	Early waste container failure may be of high importance for performance (magnitude of risk and timing) Manner in which waste containers are closed could be of high importance to design and operations. Early waste package failure of high importance for overall confidence in the safety case	Fundamental Gaps in Method, Fundamental Data Needs	Depends on material/design. Some more advanced than others. U.S. program has evaluated manufacturing defects for the TAD and large waste package concept considered at Yucca Mountain. Other programs have also investigated closure techniques for different materials.
2.1.03.02	General Corrosion of Waste Packages	Also media specific Specific to EBS materials and concept design Applies to waste container and any other "isolation" barriers that could be included in a design. Focus on material performance under various conditions	High	Medium	High	May be of high importance for performance in certain environments. In addition, the waste container is a key part of a multiple-barrier disposal system concept and must be included in the safety analysis. More Important from a gas generation standpoint in salt and perhaps clay. More Important to granite from a hyrdologic barrier capability standpoint. Not very important to deep borehole for either gas generation or barrier capability. At least Medium importance for design - could effect container / overpack design. Could impact handling / operation (constraints) High importance for overall confidence - primary isolation barrier. Medium importance for for overall confidence in specific EBS design concepts and repository environments	Fundamental Gaps in Method, Fundamental Data Needs	Considerable studies in the corrosion of a variety of metallic materials both in the U.S. and abroad that can be leveraged. Some knowledge gaps exist regarding degradation modes for various alloys under various conditions. Little/no information available regarding new/novel materials Uncertainty in extrapolating short-term laboratory tests to long-time periods and spatially variable conditions. Interest in gas generation resulting from corrosion in some programs (Europe) Potential for novel alloys with increased resistance to corrosion - little information known.

UFD FEP ID No., Title, and Media	Overall Priority Score
2.2.01.01 - Evolution of EDZ - Clay/Shale	8.00
2.2.08.01 - Flow Through the Host Rock - Salt	7.73
2.2.08.02 - Flow Through the Other Geologic Units - Confining units - Aquifers - Salt	7.73
2.2.08.06 - Flow Through EDZ - Salt	7.73
2.2.08.04 - Effects of Repository Excavation on Flow Through the Host Rock - Salt	7.10
2.2.08.07 - Mineralogic Dehydration - Salt	6.49
2.2.01.01 - Evolution of EDZ - Deep Boreholes	6.13

* Eight columns deleted regarding "importance to decision points

Granularity of R&D "Quanta"

In 2019 Update, use R&D Activities/Tasks:

- **Generally, we don't think in terms of FEPs; they are more or less used for a completeness check.**
  - ← They are too "fine-grained" and "discretized" for a high-level "grasp" of how to assign resources and schedule
- **We think more broadly (at a higher grouping level) when designing models and experiments**
  - → i.e., we do our work at the *activity* or task level, each of which usually encompasses several FEPs
  - → PICS-NE scope descriptions are generally too broad – more on this later….
- **So, this Update Workshop over the following three days will prioritize *R&D Activities* – i.e., the rows in the spreadsheet**
- **Although there is no "right" or "wrong" way to quantize R&D, we are asking for Activities to be quantized somewhere *between the fine level of FEPs and the broad level of PICS***

Examples of Activity Quantization

Reasonable:

C-1	Discrete Fracture Network (DFN) Model	• Generation and representation of realistic fracture networks • Fluid flow& transport in fracture networks • Mapping tools (dfnWorks to PFLOTRAN) • Dual continuum; matrix diffusion

Too broad (no LDRD proposals!):

C-13	Reactive transport modeling of groundwater chemistry evolution and radionuclide transport	This task will focus on the following improvements to the existing reactive transport modeling capability: • Incorporation of interfacial reactions (e.g., surface complexation), microbially mediated reactions, colloid-facilitated transport, and radionuclide decay and ingrowth; • Improved representation of spatial heterogeneity of chemical and transport properties • Coupling of radionuclide transport with evolving water chemistry along a transport pathway (e.g. alkaline plumes) • Robustness of numerical algorithms for coupling chemical reactions with solute transport • Explicit consideration of structural complexity of the media in the solute transport (e.g. the fracture-matrix system in DRZ or the micro, macro-pores system for host clay rock).

Generic R&D "Completion" State

Two criteria for "ending" or transitioning to next phase:

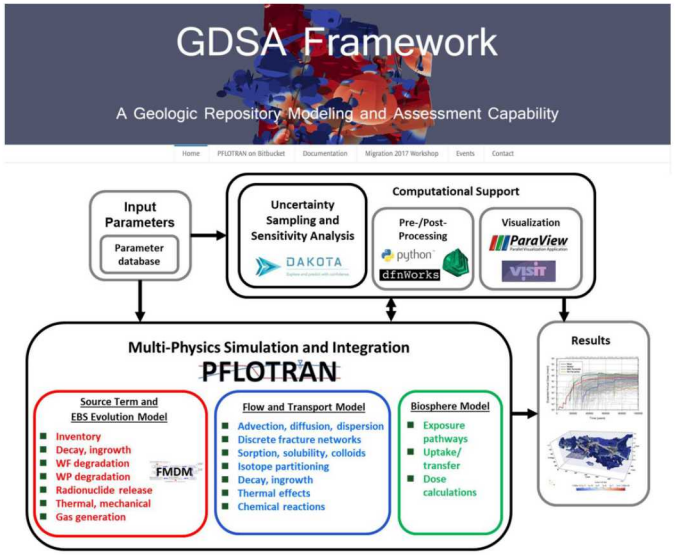
1. Change in State-of-the-Art Level (or Knowledge)

- → R&D necessary to move the state-of-the-art to the next level (defined later in SAL table) for the given R&D "quanta" (i.e., activity) – analogous to a change in TRL*
- → See Column N in R&D Activities spreadsheet

* Sevougian and MacKinnon 2017. "Technology Readiness Assessment Process Adapted to Geologic Disposal of HLW/SNF" IHLRWM 2017, Charlotte, NC.

2. Time constraint:

- → PA "baseline" capability: Process models and their implementation in *GDSA Framework* will have a certain "fidelity" that allows for a full PA calculation, i.e., a PA simulation that addresses important post-closure FEPs
- → Safety case confidence: Fidelity of (generic) safety case reaches a certain level
- → Achieved by a specified date on the repository timeline (2022 for this workshop)
- → Year-by-year work scopes and activities should support the baseline PA capability

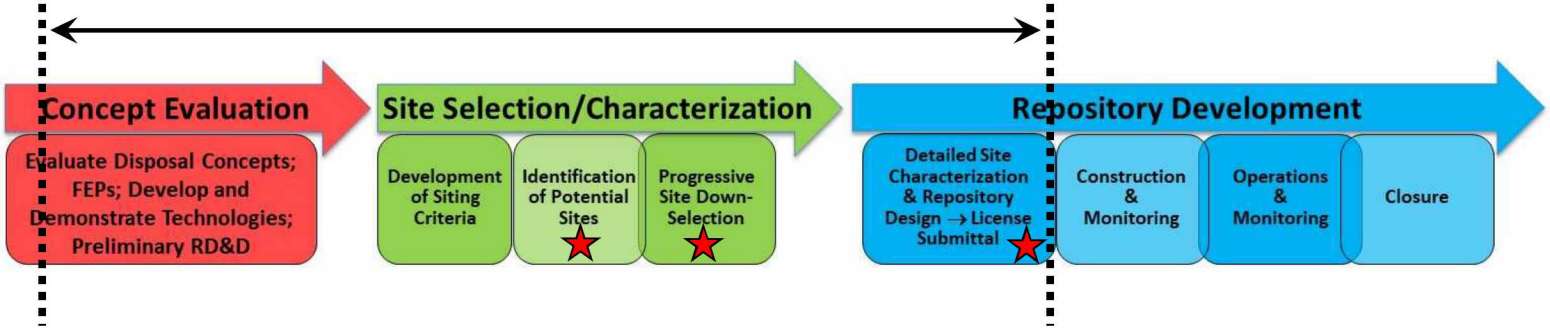


R&D "Completion" State for Site Evaluation

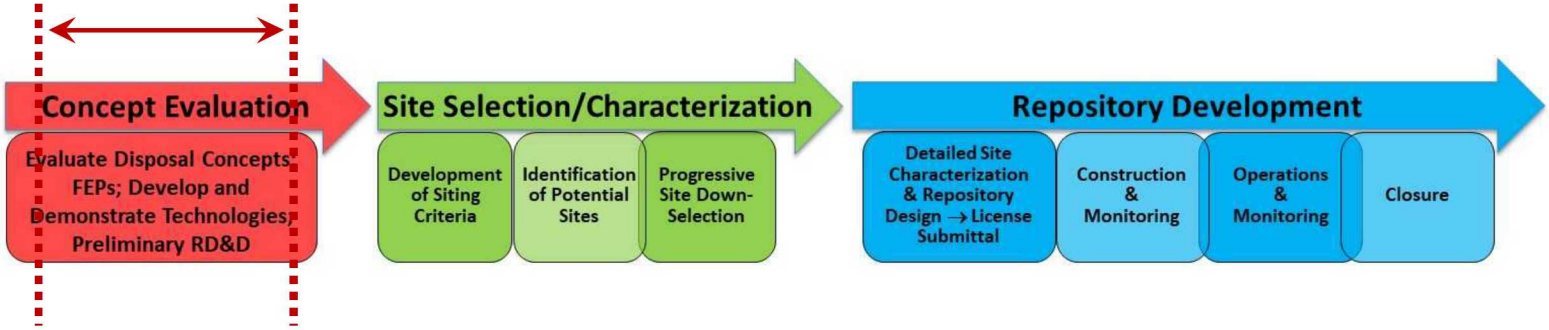
- At the time of site evaluation and/or selection, the PA and process models must be "run ready," and a good safety case framework already started
- Models and tools must already be "in hand" to initiate a siting stage in any potential host rock
- Good repository designs for any potential host rock must have already been developed (designs suitable for the U.S. waste packaging, i.e., DPCs)
- Data needed at the beginning of site evaluation process versus that needed after a final site is selected must be documented
- Generic site-characterization plans for each potential host rock

Simplified Prioritization Methodology for 2019

- 2012 UFD Roadmap considered "siting decision points (★)" in its utility (or "scoring") function for R&D Issues:



- 2019 Roadmap Update will take a simpler view of generic R&D prioritization, by concentrating more definitely on the generic R&D phase ("Concept Evaluation" phase) that is currently applicable to our program—thereby creating a simpler and more "reproducible" utility function:

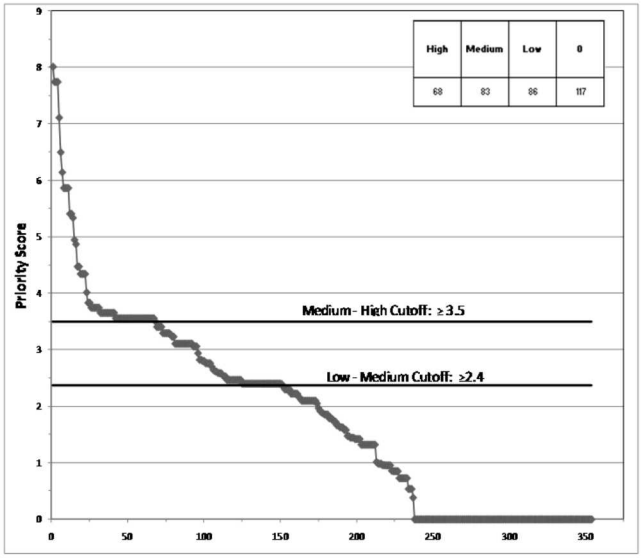


R&D Issue and/or Activity Rankings: 2019 vs. 2012

- **2012 UFD Roadmap rankings – used both numerical ordering and broad categories (H, M, L):**

FEPs or "R&D Issues": **"priority score"** **Quantitative → qualitative score"**

UFD FEP ID No., Title, and Media	Overall Priority Score
2.2.01.01 - Evolution of EDZ - Clay/Shale	8.00
2.2.08.01 - Flow Through the Host Rock - Salt	7.73
2.2.08.02 - Flow Through the Other Geologic Units - Confining units - Aquifers - Salt	7.73
2.2.08.06 - Flow Through EDZ - Salt	7.73
2.2.08.04 - Effects of Repository Excavation on Flow Through the Host Rock - Salt	7.10
2.2.08.07 - Mineralogic Dehydration - Salt	6.49
2.2.01.01 - Evolution of EDZ - Deep Boreholes	6.13
2.2.09.01 - Chemical Characteristics of Groundwater in Host Rock - Deep Boreholes	5.86
2.2.09.02 - Chemical Characteristics of Groundwater in Other Geologic Units (Non-Host-Rock) - Confining units - Aquifers - Deep Boreholes	5.86
2.2.09.05 - Radionuclide Speciation and Solubility in Host Rock - Deep Boreholes	5.86
2.2.09.06 - Radionuclide Speciation and Solubility in Other Geologic Units (Non-Host-Rock) - Deep Boreholes	5.86
2.2.09.03 - Chemical Interactions and Evolution of Groundwater in Host Rock - Deep Boreholes	5.40
2.2.09.04 - Chemical Interactions and Evolution of Groundwater in Other Geologic Units (Non-Host-Rock) - Confining units - Aquifers - Deep Boreholes	5.40
1.2.03.01 - Seismic Activity Impacts EBS and/or EBS Components -	4.94
2.1.09.13 - Radionuclide Speciation and Solubility in EBS - In Waste Form - In Waste Package - In Backfill - In Tunnel -	4.86



- **2019 SFWST Roadmap Update rankings – broad categories only:**
  - → High (H), Medium (M), or Low (L) categories for the priority scores
  - → Priority score or ranking to be derived from the convolution of *two metrics*: State-of-the-Art Level (SAL) and Importance to the Safety Case (ISC)

Prioritization Metrics: SAL and ISC

- **State-of-the-Art Level (SAL):**
  - → five SAL or knowledge levels, based fairly closely on the state-of-the-art categories used in the original 2012 Roadmap, but simplified and clarified (we hope!) so as to be easier to assign/evaluate – see later slide

SAL Numerical Value	SAL Descriptive Value
5	*Fundamental Gaps in Method or Fundamental Data Needs, or Both*
4	*Improved Representation*
3	*Improved Defensibility*
2	*Improved Confidence*
1	*Well Understood*

- **Importance to the Safety Case (ISC):**

ISC Numerical Value	ISC Descriptive Value
5	***High*** *Importance to SC*
3	***Medium*** *Importance to SC*
1	***Low*** *Importance to SC*

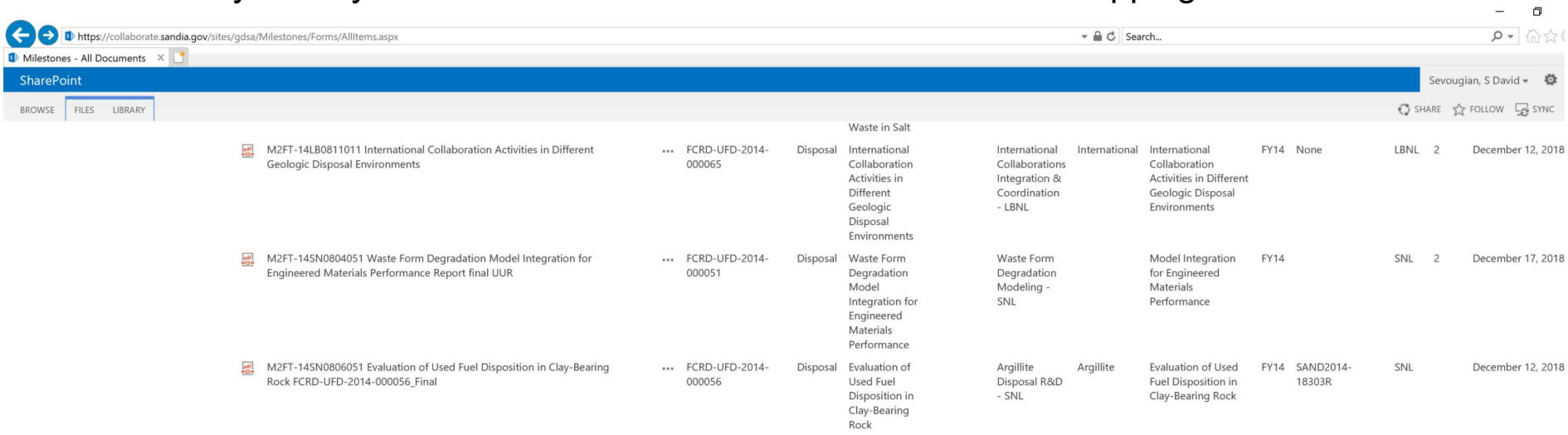
- **In 2019 we are evaluating R&D Activities, rather than FEPs or Issues:**
  - → however, we generally can compare the 2019 priority score of an R&D Activity to the 2012 priority score of the highest ranking "associated FEP" (i.e., from the set of FEPs that this Activity is designed to address)
- **The breakout group leads and the R&D group leads have taken a first cut at providing the ISC and SAL values and rationales**
  - → Their's is an initial cut only – to facilitate discussion; feel free to change – that's the whole point!!!!
- **We did something similar at the May 2018 SFWST Annual Meeting**

Goal 1: What Has Been Accomplished

- **Goal 1 to be documented in two GDSA deliverables this FY:**

Deliverable #	GDSA Deliverable Title	Due Date	Description (Workshop related items)
M2SF-19SN010304042	GDSA Model Integration and R&D Roadmap	04/30/19	• Document Workshop process; • Workshop-revised R&D Activities spreadsheet; • Repository for UFD/SFWST 2010-19 deliverables; • FEPs – Activities mapping……(see new spreadsheet)
M2SF-19SN010304041	GDSA Framework Development and Process Model Integration	09/16/19	• FEPs – Activities – 2012-19 Deliverable mapping • Finalized R&D Activities spreadsheet

- **New SharePoint site for Project deliverables (in process):**
  - → May or may not be used for FEPs-Activities-Deliverable mapping



Goal 2: What Needs to be Accomplished

- **This is the major focus of this workshop (informed by Goal 1)**
- **Use R&D Activities spreadsheet to document this Goal**
  - → Seven major groupings of R&D Activities: Argillite, Crystalline, Salt, DPC, EBS, International, Other, and PA

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R&D Task #	R&D Task (or Activity) Name	Brief Task Description	Type of Activity L = Literature Review PM = Process Model PA = PA Model or submodel LT = Lab Test FT = Field Test or URL EA = Experimental Data Analysis MA = Model Output Analysis	Code (if applicable)	Related Safety Case Element(s) (from the provided figure)	Related FEPs Associated 2012 UFD Roadmap FEP(s)/ Issue(s), and corresponding UFD Roadmap priority scores* *(especially include the highest scoring related FEP in App. B of 2012 UFD Roadmap)	2012 Roadmap "State of the Art" ** **(from App. A of 2012 Roadmap for the highest scoring related FEP)	2019 "State of the Art" Level (SAL) *Descriptive* Value for this Task** **(see current SAL table definitions)	2019 SAL *Numerical* Value** **(see current SAL table definitions)
DPC R&D Tasks									
D-B.1	Probabilistic post-closure DPC criticality consequence analyses Task 1 - Scoping Phase Task 2 - Preliminary Analysis Phase Task 3 - Development Phase	• Develop technical and regulatory strategy for low consequence analyses. Identify an appropriate set of criticality FEPs. Define key parameters and metrics.	LT, PM	PFLOTRAN, other codes and scripts as applicable	SC element 4.2b	• 2.1.14.01 Criticality in Package; (score based on TAD canisters in LA = 0.96)	Fundamental Data Needs	Fundamental Gaps in Method or Fundamental Data Needs, or Both	5
International R&D Tasks									
I-11	Microbial Processes Affecting Hydrogen Generation and Uptake: FEBEX-DP and Mont Terri Studies	• Gas Transport: Hydrogen generation can result in long-term damage to bentonite and clay host rock • Microbial activity can lead to hydrogen uptake and reduced risk of damage; however, the transient activity of microbes in heated and pressurized bentonite/rock is not well understood	FT, PM	TBD	4.3 Confidence	• Primary FEP is 2.2.11.04, with score of 3.74 for clay/shale; 2.2.11.04 - Score 2.4 for granite and salt; 2.2.11.04 - Score 3.55;	Fundamental Gaps in Method, Fundamental Data Needs	Fundamental Gaps in Method or Fundamental Data Needs, or Both	5
EBS R&D Tasks									
E-2	SNF Degradation testing activities (GAP ?) (Other SNF Types ?)	• Degradation testing and integration of testing results into mixed potential model of spent fuel matrix degradation	M, T	PFLOTRAN et al.	SC element 3.3.1b	• Primary FEP is 2.1.02.01; score = 4.01 • Other related FEPs (2.1.02.06, 2.1.07.06, 2.1.11.02) have lower scores		Fundamental Gaps in Method or Fundamental Data Needs, or Both	5
Other Cross-cutting R&D Tasks									
O-2	GDSA Geologic Modeling	• geologic and hydrologic conceptual framework for GDSA reference cases • data feeds to GDSA models (hydrologic parameters, stratigraphy, fractures) • Confidence in demonstrating understanding of the geologic environment • GIS analysis of site selection options	L, PA	Rockworks, JewelSuite, ArcGIS	SC element 3.3.2	• Primary FEP is 2.2.02.01; Score = 3.74. • Other FEP 2.2.05.01; Fractures; Score = 3.65	Fundamental Gaps in Method	Improved Representation	4
Argillite R&D Tasks									
A-1	Two-Part Hooke's Model (saturated)	• Clay deformation, constitutive model development for EDZ evolution in Argillite and Chrystalline rock.	PM	TPHM-FLAC3D	SC elements 3.3 & 4.2	• Primary FEP is 2.2.01.01 (granite); score = 2.58 FEP 2.2.07.01 Mechanical Effects on Host Rock - Clay/Shale - Score = 3.83 FEP 2.2.08.06 Flow Through EDZ - Clay/Shale - Score = 3.65 FEP 2.1.04.01 Evolution and Degradation of Backfill/Buffer - Score = 3.50 FEP 2.1.08.04 Flow Through Seals - Score = 2.80 FEP 2.1.08.03 Flow Through Backfill - Score = 2.76	Fundamental Data Needs	Fundamental Gaps in Method or Fundamental Data Needs, or Both	5

Goal 2: What Needs to be Accomplished

- **R&D Activities spreadsheet**
  - → To be actively revised during each breakout group session
- **Demo of spreadsheet:**

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R&D Task #	R&D Task (or Activity) Name	Brief Task Description	Type of Activity L = Literature Review PM = Process Model PA = PA Model or submodel LT = Lab Test FT = Field Test or URL EA = Experimental Data Analysis MA = Model Output Analysis	Code (if applicable)	Related Safety Case Element(s) (from the provided figure)	Related FEPs Associated 2012 UFD Roadmap FEP(s)/ Issue(s), and corresponding UFD Roadmap priority scores* *(especially include the highest scoring related FEP in App. B of 2012 UFD Roadmap)	2012 Roadmap "State of the Art" ** **(from App. A of 2012 Roadmap for the highest scoring related FEP)	2019 "State of the Art" Level (SAL) *Descriptive* Value for this Task** **(see current SAL table definitions)	2019 SAL *Numerical* Value** **(see current SAL table definitions)
DPC R&D Tasks									
D-B.1	Probabilistic post-closure DPC criticality consequence analyses Task 1 - Scoping Phase Task 2 - Preliminary Analysis Phase Task 3 - Development Phase	• Develop technical and regulatory strategy for low consequence analyses. Develop source term representing effects from criticality events, using coupled process modeling input. Identify appropriate criticality FEPs. Define key parameters and metrics.	**LT, PM**	PFLOTRAN, other codes and scripts as applicable	SC element 4.2b	• 2.1.14.01 Criticality in Package; (score based on TAD canisters in LA = 0.96)	Fundamental Data Needs	Fundamental Gaps in Method or Fundamental Data Needs, or Both	5
D-B.4	Maintain and populate DPC as-loaded database	• Maintain UNF-ST&DARDS database; ; analyze baseline post-closure criticality responses	**L,M**	Database; SCALE; etc.	NA	NA	NA	Improved Confidence	2
D-C.1	DPC filler and neutron absorber degradation testing	• Identify potential filler compositions, and test relevant behavior (injectability, radiolysis, material interactions, leachability). Follow the FY18 workplan (SFWD-SFWST-2018-000481) with appropriate modifications to focus on promising fillers. Test Boral and other absorber materials to check boron loss, and threshold humidity/temperature corrosion for filler interaction studies.	**L, LT**	NA	SC element 3.3.1b	NA	Fundamental Data Needs	Fundamental Gaps in Method or Fundamental Data Needs, or Both	5
D-D.1	Coupled multi-physics simulation of DPC postclosure (neutronic, thermal-hydraulic & mechanical)	• Analyze conditions inside and outside waste packages subjected to criticality events. Implement coupling between neutronics and thermal-hydraulics, and between corrosive/mechanical degradation and thermal-hydraulics and neutronics. Incorporate conditions external to waste packages (saturated and unsaturated repositories). Evaluate how more processes (e.g., chemical, radiolysis, aqueous transport), and disruptive events (seismic) can be incorporated in the modeling framework.	**LT, PA**	Existing software (e.g., TOUGH-FLAC, FLAC3D-3DEC-PFC-TOUGH3, ORNL neutronics and CFD codes, others as applicable	SC element 4.2e	• 2.1.14.01 Criticality in Package; (score based on TAD canisters in LA = 0.96) • FEP 2.1.11.01 Heat Generation in EBS - Score = 2.59	Fundamental Data Needs	Fundamental Gaps in Method or Fundamental Data Needs, or Both	5
D-D.2	Technical integration of DPC direct disposal	Technical integration of DPC direct disposal solutions, considering concepts of operations, overpack concepts, engineering feasibility, cost analysis, and preclosure safety. Conduct periodic independent peer reviews.	???	NA	???	• 2.1.14.01 Criticality in Package; (score based on TAD canisters in LA = 0.96)	NA	Improved Confidence	2

Day 1 Breakout Group Tasks

- **See Agenda, and associated handouts, for more detail!!**

DAY 1, TUESDAY, 1/15/2019		
10:15 a.m.	**Host-Rock Breakout Groups:*** **[Argillite (Rm 1243); Crystalline (Rm 1242); Salt (Rm 1240)]** 1) Review and revise existing R&D Activity names/descriptions, as warranted (Columns B and C – and D, E, F, as needed) 2) Decide upon SAL rating and rationale (Columns K, L, M), and determine generic R&D still needed to decrease SAL (Column N) 3) Brainstorm and add "Gap" Activities, as appropriate (add new rows) *(**PLEASE** follow the detailed breakout group assignments given on p. 4)* *(consider EBS, DPC, and International Activities, as assigned – complete one-half of the host rock R&D Activities first; then switch to cross-cutting EBS, DPC, and Intl. – see p. 5 for list of assigned Activities)*	Rooms 1240, 1242, 1243

- ***NOTES:**
  1. When considering how much R&D is still needed, keep in mind and identify the type of coupling with GDSA Framework that is appropriate at the "baseline capability" point (2022)
  2. When considering potential "gap" activities, identify how much R&D needs to be performed "in-house" vs. how much can be leveraged internationally
  3. *If time grows short, concentrate more on the SAL evaluation than on the ISC evaluation*

Day 2 Breakout Group Tasks

DAY 2, WEDNESDAY, 1/16/2019		
8:30 a.m.	**Host-Rock Breakout Groups (continued):*** **[Argillite (Rm 1243); Crystalline (Rm 1242); Salt (Rm 1240)]** 1) Complete Day 1 tasks (if incomplete) 2) Decide upon ISC rating and justification (Columns O, P, Q) 3) Discuss and document ongoing and "unresolved" integration issues, particularly with PA-GDSA (Column T) **PLEASE* follow the detailed breakout group assignments given on p. 4)*	Rooms 1240, 1242, 1243
1:00 p.m.	**Host-Rock Breakout Groups (continued),** • Complete morning tasks (ISC ratings)	Rooms 1240, 1242, 1243
	Cross-cutting Breakout Groups Reporting Prep (begin) • Three Cross-cutting Breakout Groups Summary Development [EBS (Rm 2151); DPC (Rm 1245); International (Rm 2212)]	Rooms 1245, 2151, and 2212
3:00 p.m.	**Preparation for Thursday Reporting – Reporting Preparation** • Three Host-Rock Groups Summary Development (begin) • Three Cross-cutting Breakout Groups Summary Development (continued)	Rooms 1240, 1242, 1243, 1245, 2151, and 2212

Day 2 Breakout Group Tasks (continued)

Summary Reporting Tasks (at 1:00 pm for Cross-cutting and 3:00 pm for Host-Rock Groups):

Each breakout group chairman/rapporteur summarizes (with the help of the R&D Activities spreadsheet, if appropriate):

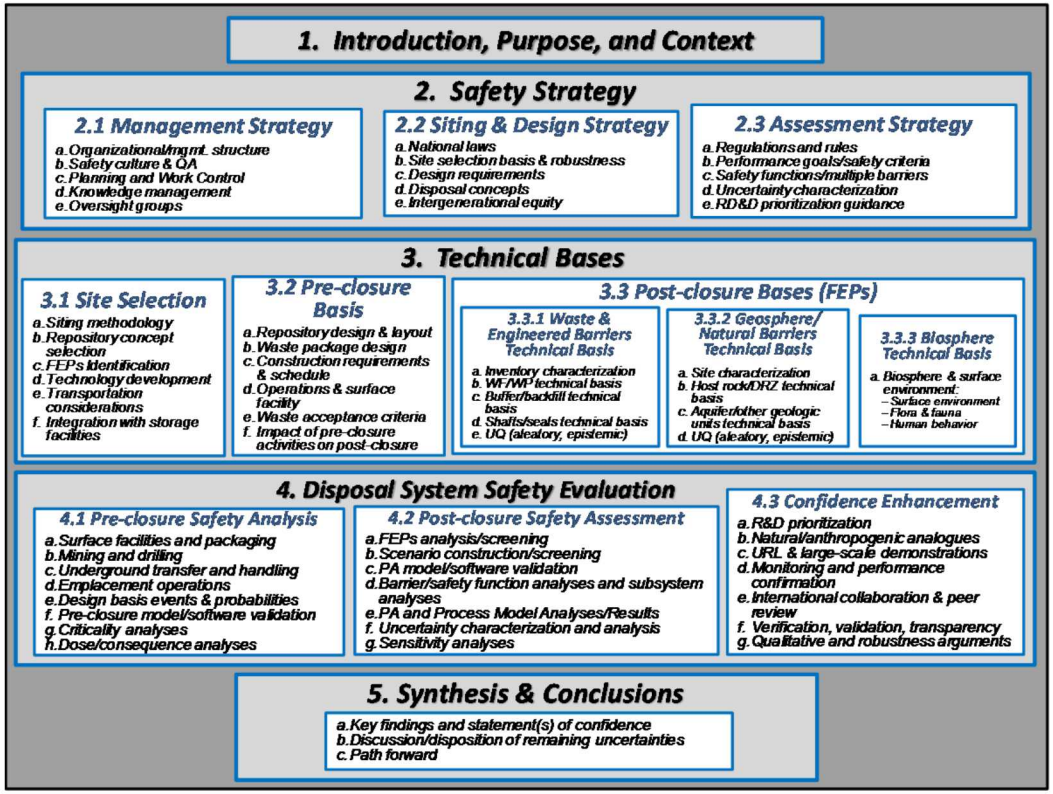
1) Unresolved integration issues (e.g., with GDSA)
2) Key R&D priorities (generic R&D needed) going forward, along with SAL and ISC ratings for these, and justifications
3) Major gap activities or needs identified, if any—especially those for H and M FEPs not currently being worked on
4) If time allows, key points of progress since 2012: e.g., changes to SAL values since 2012, which would be a comparison between the highest scoring 2012 FEP for an R&D Activity with the new SAL for the Activity itself

SAL Metric Table

SAL Numerical Value	SAL Descriptive Value	SAL Definition	Questions to be answered for: (1) Rationale for current SAL (Column M) (2) R&D to move to next SAL (Column N)
5	*Fundamental Gaps in Method or Fundamental Data Needs, or Both*	The representation of an issue (conceptual and/or mathematical, experimental) is under development, and/or the data or parameters in the representation of an issue (process) is being gathered	Rationale for being at Level 5: • What is under development and what data is being gathered? • What are the fundamental gaps? R&D necessary to get to Level 4?
4	*Improved Representation*	Methods and data exist, and the representation may be reasonable but there is not widely-agreed upon confidence in the representation (scientific community and other stakeholders).	Rationale for being at Level 4: • What methods and data currently exist? • Why is the representation reasonable? • Why is there not widely agreed upon confidence? R&D necessary to get to Level 3? • e.g., what is needed to build agreement and confidence in the representation? and what additional data need to be gathered?
3	*Improved Defensibility*	Focuses on improving the technical basis and defensibility of how an issue (process) is represented by data and/or models	Rationale for being at Level 3: • Why and what needs to be (and can be) improved for defensibility for a generic repository? R&D necessary to get to Level 2? • e.g., What level of effort on data and models would lead to the issue being technically defensible
2	*Improved Confidence*	The representation of an issue is technically defensible, but improved confidence would be beneficial (i.e., lead to more realistic representation).	Rationale for being at Level 2: • Why is it technically defensible? R&D necessary to get to Level 1? • e.g., What R&D would lead to improved confidence?
1	*Well Understood*	The representation of an issue (process) is well developed, has a strong technical basis, and is defensible. Additional R&D would add little to the current understanding	

ISC Metric Table

ISC Numerical Value	ISC Descriptive Value	ISC Definition (see Safety Case Elements figure)
5	***High*** *Importance to Safety Case*	Knowledge gained by proposed R&D strongly affects one of the three elements of "Disposal System Safety Evaluation" in the Safety Case (pre-closure safety analysis, post-closure safety assessment, confidence enhancement)
3	***Medium*** *Importance to Safety Case*	Knowledge gained strongly affects one of the Technical Bases elements of the Safety Case but the Technical Basis element itself only weakly or moderately influences a safety assessment metric
1	***Low*** *Importance to Safety Case*	Knowledge gained is only of a supporting nature and does not strongly affect the associated process model or model inputs



Some Practical Points

1) You must address not only your own existing host-rock Activities, but also those other cross-cutting Activities assigned to your group, i.e., the relevant EBS, International, and DPC Activities – do one-half of the host-rock Activities first; then move to the Cross-Cutting
2) It is important to finish all existing R&D Activities, but please recognize that much more time will generally be spent on the first few Activities, in order for the group to "calibrate" itself; this is normal!
3) To repeat: make sure you finish the SAL ratings, rationale, and generic R&D needed; ISC is less important but would be nice to finish, so we don't have to convene a subsequent workshop
4) The breakout group chairman (and rapporteur) must ensure that you get through all of your R&D Activities in the time allotted in the Agenda

Some Practical Points (continued)

5) Spend less time on UZ (alluvium or other), since it was not part of the original Roadmap; this could change next FY

6) There may be an over-generous assignment of FEPs to R&D Activities (Column H) – we may have address after Workshop but at least check accuracy of highest-scoring 2012 FEP

7) If you want to add "closed" (i.e., prior-year) Activities that have been completed, please do so or put them in the Parking Lot file – may have to address after Workshop

8) If you feel there is a person-session assignment out of order, see me, so we can discuss re-assignment

9) Cross-cutting group members need to be able to take the message from the host-rock groups to the cross-cutting groups on Wednesday afternoon

Some Practical Points (continued)

Breakout Groups please follow your assignments on pp. 4-5 of the Agenda…..

Agenda – Day 1

DAY 1, TUESDAY,1/15/2019		
8:00 a.m.	**Sign in and obtain name tag**	SEB foyer
8:30 a.m.	**Opening Remarks,** *DOE (Gunter, Tynan); SNL (Swift)*	Room 1242
9:00 a.m.	**Workshop Methodology & Breakout Group Instructions,** *Dave Sevougian*	Room 1242
10:00 a.m.	*Break*	Room 1242
10:15 a.m.	**Host-Rock Breakout Groups:*** **[Argillite (Rm 1243); Crystalline (Rm 1242); Salt (Rm 1240)]** 1) Review and revise existing R&D Activity names/descriptions, as warranted (Columns B and C – and D, E, F, as needed) 2) Decide upon SAL rating and rationale (Columns K, L, M), and determine generic R&D still needed to decrease SAL (Column N) 3) Brainstorm and add "Gap" Activities, as appropriate (add new rows) ***(PLEASE** *follow the detailed breakout group assignments given on p. 4)* *(consider EBS, DPC, and International Activities, as assigned – complete one-half of the host rock R&D Activities first; then switch to cross-cutting EBS, DPC, and Intl. – see p. 5 for list of assigned Activities)*	Rooms 1240, 1242, 1243
11:45 a.m.	*Lunch (on your own, but at the UNLV cafeteria—to save time)*	
1:00 p.m.	**Host-Rock Breakout Groups (continued),** *All* • Continue with the Day 1 tasks listed above	Rooms 1240, 1242, 1243
5:00 p.m.	*Adjourn for the day*	

Agenda – Day 2

DAY 2, WEDNESDAY, 1/16/2019		
8:30 a.m.	**Host-Rock Breakout Groups (continued):*** **[Argillite (Rm 1243); Crystalline (Rm 1242); Salt (Rm 1240)]** 1) Complete Day 1 tasks (if incomplete) 2) Decide upon ISC rating and justification (Columns O, P, Q) 3) Discuss and document ongoing and "unresolved" integration issues, particularly with PA-GDSA (Column T) **(PLEASE follow the detailed breakout group assignments given on p. 4)*	Rooms 1240, 1242, 1243
11:45 a.m.	*Lunch (on your own, but at the UNLV cafeteria—to save time)*	
1:00 p.m.	**Host-Rock Breakout Groups (continued),** • Complete morning tasks (ISC ratings)	Rooms 1240, 1242, 1243
	Cross-cutting Breakout Groups Reporting Prep (begin) • Three Cross-cutting Breakout Groups Summary Development [EBS (Rm 2151); DPC (Rm 1245); International (Rm 2212)]	Rooms 1245, 2151, and 2212
2:45 p.m.	*Break*	
3:00 p.m.	**Preparation for Thursday Reporting – Reporting Preparation** • Three Host-Rock Groups Summary Development (begin) • Three Cross-cutting Breakout Groups Summary Development (continued)	Rooms 1240, 1242, 1243, 1245, 2151, and 2212
5:30 p.m.	*Adjourn for the day*	
7:00 p.m.	***Group Dinner ("Dutch Treat") – Sassani is organizing***	

Agenda – Day 3

DAY 3, THURSDAY, 1/17/2019		
8:30 a.m.	**Summary Reports and Integration (30 minutes per breakout),** *Everyone* 1) Host-Rock Groups Summary Reporting (order: Salt, Argillite, Crystalline) 2) Cross-cutting Breakout Groups Summary Reporting (order: International, DPC, EBS)—be sure to point out commonalities and/or differences in host-rock breakout group findings 3) "Other" R&D Tasks (O-1 to O-4): Discuss briefly (lead for each task – Sassani, Perry, Zavrin)	Room 1242
11:45 a.m.	*Lunch (on your own, but at the UNLV cafeteria—to save time)*	
1:00 p.m.	**Report/Integrate – Full Group (continued)** 1) Complete morning assignments listed above, *All* 2) Summary of new Activity and/or FEP R&D priorities, *Sevougian/Dobson* 3) Discuss future integration/updating still needed, e.g., a follow-up workshop, etc.	Room 1242
2:30 p.m.	*Adjourn*	

Back-Up Slides

1. Introduction, Purpose, and Context

2. Safety Strategy

2.1 Management Strategy

a. Organizational/mgmt. structure
b. Safety culture & QA
c. Planning and Work Control
d. Knowledge management
e. Oversight groups

2.2 Siting & Design Strategy

a. National laws
b. Site selection basis & robustness
c. Design requirements
d. Disposal concepts
e. Intergenerational equity

2.3 Assessment Strategy

a. Regulations and rules
b. Performance goals/safety criteria
c. Safety functions/multiple barriers
d. Uncertainty characterization
e. RD&D prioritization guidance

3. Technical Bases

3.1 Site Selection

a. Siting methodology
b. Repository concept selection
c. FEPs Identification
d. Technology development
e. Transportation considerations
f. Integration with storage facilities

3.2 Pre-closure Basis

a. Repository design & layout
b. Waste package design
c. Construction requirements & schedule
d. Operations & surface facility
e. Waste acceptance criteria
f. Impact of pre-closure activities on post-closure

3.3 Post-closure Bases (FEPs)

3.3.1 Waste & Engineered Barriers Technical Basis

a. Inventory characterization
b. WF/WP technical basis
c. Buffer/backfill technical basis
d. Shafts/seals technical basis
e. UQ (aleatory, epistemic)

3.3.2 Geosphere/ Natural Barriers Technical Basis

a. Site characterization
b. Host rock/DRZ technical basis
c. Aquifer/other geologic units technical basis
d. UQ (aleatory, epistemic)

3.3.3 Biosphere Technical Basis

a. Biosphere & surface environment:
   - Surface environment
   - Flora & fauna
   - Human behavior

4. Disposal System Safety Evaluation

4.1 Pre-closure Safety Analysis

a. Surface facilities and packaging
b. Mining and drilling
c. Underground transfer and handling
d. Emplacement operations
e. Design basis events & probabilities
f. Pre-closure model/software validation
g. Criticality analyses
h. Dose/consequence analyses

4.2 Post-closure Safety Assessment

a. FEPs analysis/screening
b. Scenario construction/screening
c. PA model/software validation
d. Barrier/safety function analyses and subsystem analyses
e. PA and Process Model Analyses/Results
f. Uncertainty characterization and analysis
g. Sensitivity analyses

4.3 Confidence Enhancement

a. R&D prioritization
b. Natural/anthropogenic analogues
c. URL & large-scale demonstrations
d. Monitoring and performance confirmation
e. International collaboration & peer review
f. Verification, validation, transparency
g. Qualitative and robustness arguments

5. Synthesis & Conclusions

a. Key findings and statement(s) of confidence
b. Discussion/disposition of remaining uncertainties
c. Path forward

R&D Activity Priority Score (using ISC × SAL product)

ISC (importance to safety case) value:

ISC Numerical Value	ISC Descriptive Value	ISC Definition (see Safety Case Elements figure)
5	***High*** *Importance to SC*	Knowledge gained by proposed R&D strongly affects one of the three elements of "Disposal System Safety Evaluation" in the Safety Case (pre-closure safety analysis, post-closure safety assessment, confidence enhancement)
3	***Medium*** *Importance to SC*	Knowledge gained strongly affects one of the Technical Bases elements of the Safety Case but the Technical Basis element itself only weakly or moderately influences a safety assessment metric
1	***Low*** *Importance to SC*	Knowledge gained is only of a supporting nature and does not strongly affect the associated process model or model inputs

SAL (state of the art) value

SAL Numerical Value	SAL Descriptive Value	SAL Definition
5	*Fundamental Gaps in Method or Fundamental Data Needs, or Both*	The representation of an issue (conceptual and/or mathematical, experimental) is under development, and/or the data or parameters in the representation of an issue (process) is being gathered
4	*Improved Representation*	Methods and data exist, and the representation may be reasonable but there is not widely-agreed upon confidence in the representation (scientific community and other stakeholders).
3	*Improved Defensibility*	Focuses on improving the technical basis and defensibility of how an issue (process) is represented by data and/or models
2	*Improved Confidence*	The representation of an issue is technically defensible, but improved confidence would be beneficial (i.e., lead to more realistic representation).
1	*Well Understood*	The representation of an issue (process) is well developed, has a strong technical basis, and is defensible. Additional R&D would add little to the current understanding

SAL: / ISC:	1	2	3	4	5
5	L	M	M	M	**H**
3	L	M	M	M	M
1	L	L	L	L	L

Final R&D Priority Score for an Activity