Department of Energy
Washington, DC 20585

September 28, 2022

Dr. Jean M. Bahr
Chair
Nuclear Waste Technical Review Board
2300 Clarendon Boulevard
Suite 1300
Arlington, Virginia 22201-3367

Dear Dr. Bahr:

The U.S. Department of Energy's (DOE) Office of Nuclear Energy appreciates your letter of January 7, 2022, which summarized the Nuclear Waste Technical Review Board's Fall 2021 Meeting. In that virtual meeting, held on November 3–4, 2021, information was presented by DOE and national laboratory participants on DOE's research and development (R&D) activities related to the Geologic Disposal Safety Assessment (GDSA) Framework.

DOE also provided the Board with an update on current efforts to implement a consent-based approach for siting a federal interim storage facility for spent nuclear fuel (SNF), and on the work DOE has been conducting to prepare for an integrated waste management system.

The Board's letter provided observations, findings, and recommendations on DOE's GDSA R&D activities, and included comments related to DOE's consent-based siting efforts.

The enclosure provides DOE's responses to the Board's specific observations, findings, and recommendations on the GDSA R&D activities. DOE would also like to thank you for the attention to and comments on DOE's consent-based siting efforts. We will be considering these comments as DOE moves forward with the consent-based siting process.

DOE appreciates the Board's input to our program and looks forward to future insight from the Board on DOE's activities related to the management and disposal of SNF and high-level radioactive waste.

If you have any questions, please feel free to contact Timothy Gunter, Disposal R&D Team, Office of Spent Fuel and Waste Science & Technology, Office of Nuclear Energy, at Timothy.Gunter@nuclear.energy.gov.

Sincerely,

Kathryn Huff

Dr. Kathryn Huff
Assistant Secretary
for Nuclear Energy

Enclosure

U.S. Department of Energy (DOE) Response to the Nuclear Waste Technical Review Board (NWTRB) Report on the DOE's Research & Development Activities Related to the Geologic Disposal Safety Assessment (GDSA) Framework

Board findings, observations, and recommendations, and DOE responses:

1. The Board finds that DOE has a technically valid approach to developing its geologic disposal safety assessment capability that will enable it to evaluate the post-closure performance of potential SNF and HLW repositories in different host rocks and with different disposal options. DOE is competently carrying out the development of the GDSA Framework and is making great progress in this effort while recognizing some of the challenges.

The Board encourages DOE to continue its GDSA Framework development efforts.

DOE Response:

The DOE continues to work to ensure the geologic disposal safety assessment (GDSA) capability is applicable to disposal in a variety of host rocks and includes the features, events, and processes most relevant to the generic research and development program. GDSA Framework development leverages high-performance computing to enable process model integration, simulation of 3-D geometries, and probabilistic uncertainty and sensitivity analyses. Ongoing development will continue to implement new capabilities, address challenges, and respond to advances in understanding and methods.

2. The Board finds that DOE needs to more clearly define and articulate the near-term goals and applications of the GDSA Framework in order to better prioritize what needs to be incorporated into the software framework at different stages of the repository program.

The Board recommends that DOE define a clear strategy and intended outcome for the use of the GDSA Framework in the near term and systematically apply it to a broad suite of reference cases.

DOE Response:

The DOE SFWST Campaign endeavors continuously to improve the transparency and clarity regarding the goals for the GDSA Framework as applied to advancing the GDSA capabilities defined in detail (Mariner et al., 2021) and at higher level (Sassani et al., 2021). The SFWST Campaign is centered on developing the technical bases for, and the GDSA capabilities to represent, multiple generic repository concepts in various geologic systems. The primary focus is on expanding the process capabilities relevant to each of the generic concepts. The implementation into GDSA of added model complexity is managed in the GDSA Framework (Mariner et al., 2021 Section 3.1), as is the development of the Next Generation Workflow (Mariner et al., 2021 Section 3.2) that is

used to construct and execute the application of GDSA to reference cases and allows workflow automation and management of the GDSA analyses (i.e., Reference Cases). Such capabilities development is essential for all potential generic repository concepts and is a higher priority focus because of that broad applicability. Drawing conclusions about the relative performance of generic disposal concepts at this point is premature given the nature of such generic reference cases in this conceptual stage, which is focused on demonstrating the GDSA capabilities. The program has been, and plans to continue, using the GDSA Framework for developing Reference Cases for generic disposal concepts with a range of source inventories, and included features, events, and processes.

References:

Mariner et al., 2021, GDSA Framework Development and Process Model Integration FY2021, M2SF-21SN010304053, SAND2021-12626 R, Sandia National Laboratories, Albuquerque, NM.

Sassani et al., 2021, SFWST Disposal Research R&D 5-Year Plan – FY2021 Update, M2SF-21SN010304054, SAND2021-12491 R, Sandia National Laboratories, Albuquerque, NM.

3. The Board finds that the GDSA Framework currently does not have an adequate capability to assess the performance of engineered barriers, which may be necessary for evaluating engineered barrier capability and different disposal options.

The Board recommends that DOE expedite the development of the GDSA Framework such that it has sufficient capability to assess the performance of different engineered barriers. This capability is needed to assess different disposal options and to apply the GDSA Framework systematically to a broad suite of reference cases. The Board notes that in developing this capability, DOE also needs to take account of near-field processes that could affect the performance of engineered barriers.

DOE Response:

As presented by Sassani in the NWTRB Fall 2020 Board Virtual Meeting (December 2, 2020), the SFWST Campaign is in the very early stages of a generic repository program, that potentially may transition to another program (if appropriate congressional actions occur) that includes siting processes. Until that program exists, the focus of the current program is on developing technical bases and capabilities that apply to generic repository concepts, without assessing site-specific constraints for any of these. This broad approach creates planning and prioritization challenges associated with addressing process-level constraints and system-level analytical capabilities for multiple disparate geologic systems, as well as the variety of generic engineered barriers for each of those.

Given the extensive list of potential materials, processes, and generic repository configuration combinations, the SFWST Campaign leverages the work being conducted in international programs for their specific sites to inform the technical bases (data sets, process models, parameter values) for the primary identified engineered barrier system

(EBS) materials and potential configurations. This information is being used to identify and integrate the most relevant barriers into our generic repository concepts in our Reference Cases. However, additional process level R&D is also focused on developing capabilities to model/analyze the barriers at conditions potentially relevant only to the US program (e.g., higher temperatures) and to incorporate such aspects appropriately into the GDSA Reference Case (e.g., see section 3.1.3 of Mariner et al., 2021).

The SFWST work prioritizes the engineered barriers that are most common in multiple generic repository concepts, such as bentonite backfill. For example, there are process-level studies that incorporate data from international URL testing to develop models for evolution of bentonite that address a range of thermal conditions and near-field chemical evolution in both argillite and crystalline systems. These would be used to modify GDSA models of bentonite buffer behavior as appropriate for barrier capability evolution in future updates of those reference cases. In the international programs, specific engineered barrier designs for outer barriers of waste packages are developed and evaluated relative to their site-specific conditions and that data set provides clear starting points for engineered barriers for SFWST generic repository concepts.

Evaluation of design details of waste containers was included in the Roadmap Prioritization activity (DOE, 2012) and provided that "…specific design concepts and site environments are ultimately needed to evaluate waste container performance within the context of a fully coupled engineered barrier system." As such, the SFWST campaign priority (Sevougian et al., 2019) is to mine the literature data/models to constrain degradation rates, degradation products, and corrosion processes for container materials identified from prior studies to inform GDSA representation of failure processes/rates for waste packages (e.g., Sec. 3.1.3, Mariner et al., 2021). Further R&D on detailed engineered barrier design/evaluation/selection would likely occur within a program in the site-selection stage, so the SFWST focus is on incorporating important barrier capabilities into the GDSA Framework (e.g., variable timing for waste package failures) such that appropriate analyses are possible in such a future program.

References:

Mariner et al., 2021, GDSA Framework Development and Process Model Integration FY2021, M2SF-21SN010304053, SAND2021-12626 R, Sandia National Laboratories, Albuquerque, NM.

DOE, 2012, "Used Fuel Disposition Campaign Disposal Research and Development Roadmap", U.S. Department of Energy Used Fuel Disposition Campaign, FCR&D-USED-2011-000065 REV 1.

Sevougian, S. D., P. E. Mariner, L. A. Connolly, R. J. MacKinnon, R. D. Rogers, D. C. Dobson, and J. L. Prouty (2019). "DOE SFWST Campaign R&D Roadmap Update", Rev. 1. SAND2019-9033 R, July 22, 2019. Sandia National Laboratories, Albuquerque, New Mexico.

Sassani et al., 2021, SFWST Disposal Research R&D 5-Year Plan – FY2021 Update, M2SF-21SN010304054, SAND2021-12491 R, Sandia National Laboratories, Albuquerque, NM.

4. The Board finds that the development of the GDSA Framework can be improved by peer reviews by a broader spectrum of stakeholders.

The Board recommends that DOE solicit input on the development of the GDSA Framework from a broader spectrum of stakeholders, including the public and the regulator.

DOE Response:

The DOE agrees that peer review is important to development and credibility of the complex set of tools required for probabilistic performance assessment. The DOE's objective is to make the capabilities of GDSA Framework transparent and accessible to facilitate use by, and feedback from, external sources. To this end DOE has chosen open-source software as the building blocks of its framework and offers a variety of avenues for peer and public interaction with key components of GDSA Framework. GDSA team members publish and present at national and international public venues, lead and participate in international collaborations, and offer PFLOTRAN short courses frequently.

Since 2017, DOE has offered 8 PFLOTRAN short courses; audiences have included the academic community, the national lab community, and the international repository science community. DOE (with the national laboratories) maintains public-facing documentation of GDSA Framework and its components (pa.sandia.gov) and publishes multiple publicly available reports each year. Currently, the generic research and development program is not connected to a process that includes site selection (during which community outreach and dialogue would be beneficial) nor to any site characterization process (during which the Nuclear Regulatory Commission (NRC) may be more active/engaged). Therefore, stakeholder engagement currently reflects the limited specificity of this disposal R&D program. The DOE does intend to continue to publish, present, and share its safety assessment capabilities and tools, and to develop GDSA Framework in such a way that these can be readily migrated to a future program that includes site selection and beyond. Additionally, DOE will offer to engage on this topic with the NRC, however this will be dependent upon the NRC's current interest and priorities.

5. The Board observes that, although DOE has applied its own quality assurance (QA) program, the GDSA Framework, PFLOTRAN, and DAKOTA codes have not been developed under a Nuclear Quality Assurance (NQA-1)[1] or equivalent QA program. Yet this will be an important requirement for any future submission of a license to the NRC for repository construction. The Board believes that qualifying the computer codes using

[1] ASME NQA-1-2019, "Quality Assurance Requirements for Nuclear Facility Applications," American Society of Mechanical Engineers, New York, NY.

an acceptable QA program will be more costly, challenging, and time consuming the longer the implementation of the QA program is delayed.

The Board notes that it would be appropriate for DOE to start an assessment of what needs to be done to have all the components of the GDSA Framework NQA-1 qualified (or equivalent). Moreover, it appears to the Board that the capabilities of the DAKOTA code are not being utilized in model calibration to determine the values and associated uncertainties of parameters that appear in various models.

DOE Response:

The DOE recognizes that quality assurance is an important component of model and software development. Currently the Spent Fuel and Waste Science and Technology (SFWST) Campaign works to the requirements of DOE Order 414.1. PFLOTRAN development is carried out using change and version control, rigorous review of new code, automated regression and unit testing, publication of an online users' manual and theory guide, and software verification testing. The DOE intends to expand software quality assurance activities in the near-term to include a more complete suite of documentation compatible with potential future programs within an NQA-1 quality assurance environment. Such expansion includes additional documentation of software requirements and verification testing.

Currently, the development/documentation effort focuses on PFLOTRAN, the code in which the bulk of GDSA capability development occurs. As other purpose-built software matures, more complete documentation can be developed. Ultimately, any software quality assurance plan will be tied to facilitate potential transition for use in potential future, possibly externally regulated, programs.