TERRAPOWER, LLC - AUDIT SUMMARY REPORT, TOPICAL REPORT "NATRIUM HUMAN FACTORS ENGINEERING PROGRAM PLAN AND METHODOLOGIES," REVISION 0

Applicant: TerraPower, LLC

Applicant Address: 15800 Northup Way, Bellevue, WA 98008

Plant Name: Natrium

Project No.: 99902100

1.0 BACKGROUND

By letter dated April 26, 2023, TerraPower, LLC (TerraPower) submitted topical report (TR) NAT-2965, "Natrium Human Factors Engineering Program Plan and Methodologies" Revision 0 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML23116A225), to the U.S. Nuclear Regulatory Commission (NRC) staff. The TR describes the Natrium Human Factors Engineering (HFE) Program Plan (HFEPP), including related methodologies, and requests that the NRC staff review and approve to support referencing of the report in future licensing submittals. By email dated June 21, 2023, the NRC staff informed TerraPower that the TR provided sufficient information for the NRC staff to conduct a detailed technical review (ML23167A476).

TerraPower's overall licensing approach for the Natrium reactor design follows the Licensing Modernization Project (LMP) methodology described in Nuclear Energy Institute (NEI) 18-04, Revision 1, "Risk-Informed Performance-Based Technology Inclusive Guidance for Non-Light Water Reactor Licensing Basis Development" (ML19241A472). Regulatory Guide (RG) 1.233, "Guidance for a Technology-Inclusive, Risk-Informed, and Performance-Based Methodology to Inform the Licensing Basis and Content of Applications for Licenses, Certifications, and Approvals for Non-Light Water Reactors," Revision 0 (ML20091L698) endorses the LMP methodology described in NEI 18-04.

The NRC staff provided its audit plan for the subject TR to TerraPower dated on May 28, 2024 (ML24137A289). The audit was conducted virtually from June 13, 2024, through August 6, 2024, using TerraPower's electronic reading room (ERR). The NRC staff held an audit exit meeting with TerraPower on August 6, 2024. By letter dated September 17, 2024, TerraPower submitted a revision to the subject TR, NAT-2965, "Natrium Human Factors Engineering Program Plan and Methodologies," Revision 1 (ML24261B926), which is a result of the audit discussions between the NRC staff and TerraPower, as summarized below.

2.0 AUDIT REGULATORY BASES

The basis for the NRC staff audit includes the following key regulations, guidance, and standards (which are also referenced by TerraPower in the TR):

- Title 10 of the *Code of Federal Regulations (*10 CFR) 50.34(f)(2)(ii), which states, in part, "establish a program, to begin during construction and follow into operation, for integrating and expanding current efforts to improve plant procedures. The scope of the

program shall include emergency procedures, reliability analyses, [HFE], crisis management, operator training…"

- 10 CFR 50.34(f)(2)(iii), which states, in part, "provide, for Commission review, a control room design that reflects state-of-the-art human factor principles prior to committing to fabrication or revision of fabricated control room panels and layouts."
- NUREG-0700, "Human-System Interface Design Review Guidelines," Revision 3 (ML20162A214)
- NUREG-0711, "[HFE] Program Review Model," Revision 3 (ML12324A013)
- NUREG-1764, "Guidance for the Review of Changes to Human Actions," Revision 1 (ML072640413)

3.0 AUDIT PURPOSE AND OBJECTIVES

The purpose of the audit was for the NRC staff to gain a more detailed understanding of the Natrium HFEPP and how the HFEPP will support or demonstrate compliance with NRC regulations as discussed below. In section 2.0 of the TR, "Requirements and Technical Basis," TerraPower states that the HFEPP creates an HFE program that is compliant with the requirements of 10 CFR 50.34(f)(2)ii and 50.34(f)(2)iii. TerraPower states in the TR that the HFEPP considers relevant practices provided in NUREG-0711. A secondary purpose of the audit was to identify any information that will require docketing to support the NRC staff's safety evaluation (SE).

4.0 SCOPE OF THE AUDIT AND AUDIT ACTIVITIES

The audit followed the guidance in the Office of Nuclear Reactor Regulation's Office Instruction LIC-111, "Regulatory Audits," Revision 1 (ML19226A274). Audit activities included virtual meetings to discuss questions and review of files in the ERR.

Members of the audit team included the NRC staff Jesse Seymour (Senior Reactor Engineer (Examiner), Audit Lead) and Stephanie Devlin-Gill (Senior Project Manager, Audit Manager).

The participants from TerraPower for this audit were Patrick Alexander, Patrick Donnelly, Timothy Enfinger, Stephanie Foerester, Jamie Getchius, Jeffrey Grogan, Kenny Grover, Nick Kellenberg, Daniel Laughman, Gabrielle Schreier, and Mark Verbeck.

On August 6, 2024, the NRC staff held an audit exit meeting with TerraPower and summarized the audit purpose, activities, and high-level results, including the NRC staff's plan to include limitations and conditions (L&C) in the NRC staff's SE regarding various topics discussed during the audit. The NRC staff did not acquire any documents during the audit. The NRC staff reviewed the following document during the audit using TerraPower's ERR:

- ADI-RMD-102, "Procedure Writer's Manual" (Revision 1), dated June 13, 2024

5.0 SUMMARY OF OBSERVATIONS

As indicated in the NRC staff's audit plan, the audit was focused on specific inquiries pertaining to the content of the TR. The NRC staff reviewed information through the TerraPower ERR and held discussions with TerraPower to understand and resolve questions. The table below replicates the transmitted audit questions and summarizes the resolution of the questions.

Number	Question	Resolution of Question
1	TR section 1, “Introduction” a. Criterion 2.4.1(2): The design assumptions and constraints of the HFE program (i.e., aspects of the design that are inputs to the HFE program) are not described. The NRC staff request that TerraPower identify these design assumptions and constraints. b. Criterion 2.4.1(3): The duration of the HFE program is not described. The NRC staff request that TerraPower clarify whether the HFE program will be in effect from the start of the design cycle through completion of the initial plant startup test program. c. Criterion 2.4.1(4): The Energy Island (EI) is not addressed within the programmatic scope discussion (i.e., only a Nuclear Island (NI) control room is discussed). The NRC staff request that TerraPower clarify whether a separate control room will exist for the EI and whether it will be included within the scope of the HFEPP.	1.a: TerraPower clarified that staffing assumptions were included in the "Natrium “Human Factors Engineering Concept of Operations” white paper (WP) (ML23125A328) and that the staffing is both assumed to meet the requirements of 10 CFR 50.54(m) and expected to align with what will be included in the Operating License Application (OLA). Additionally, TerraPower confirmed that no other assumptions or constraints have been identified that apply to the general HFE program. TerraPower agreed to address this item via changes incorporated into a revision of the TR. 1.b: TerraPower agreed to address this item via changes incorporated into a revision of the TR. 1.c: TerraPower agreed to address this item via changes incorporated into a revision of the TR.
2	Criterion 2.4.1(6): section 5.4, “Staffing,” of the TR describes that a staffing analysis process systematically determines the minimum staff complement. However, the TR does not include discussion of the Shift Technical Advisor (STA) role. The NRC staff request that TerraPower clarify whether the HFEPP is intended to be utilized in conjunction with a future justification for omission of the STA from the staffing model.	TerraPower clarified that they will request an exemption in conjunction with the OLA to omit the STA, with HFE program activities under the HFEPP serving to provide support for the justification of this requested exemption. The NRC staff have identified this area as being the subject of a potential L&C for the TR in the NRC staff’s SE.
3	Criterion 2.4.2(2): section 4.0, “Human Factors Engineering Organization,” of the TR provides a description of the HFE organization. However, details related to the organizational relationships, reporting relationships, and lines of communication associated with this team are unclear. The NRC staff requests that TerraPower clarify how the HFE team will have the authority and appropriate organizational placement to	TerraPower clarified that their organization will use established processes and procedures to identify, understand, and resolve issues relating to the HFE scope. TerraPower described that GE Hitachi Nuclear Energy (GE Hitachi) staffs the core HFE team, to include the HFE Technical Lead role. This HFE Technical Lead coordinates design activities with the TerraPower HFE Program Owner who, in turn, provides

Number	Question	Resolution of Question
	assure that its areas of responsibility can be completed, to identify problems in establishing the overall HFE plan, and to control further processing, delivery, installation, or use of HFE products until any nonconformances, deficiencies, or unsatisfactory conditions have been adequately resolved.	oversight. The TerraPower HFE Program Owner is described as having responsibility for ensuring the communication, reporting, and processing of HFE concerns is advocated and resolved through the TerraPower design organization. The TerraPower HFE Program Owner reports to the Manager, Plant Maintenance and Operational Design Integration who, in turn, reports to the Senior Manager, Integrated Pant and Structure. The Senior Manager, Integrated Plant and Structure, serves as the technical design authority and senior-level advocate for HFE and reports to the Vice President of Plant Delivery. TerraPower agreed to address this item via changes incorporated into a revision of the TR.
4	Criterion 2.4.2(3): section 4.1.1, "Roles," of the TR describes the roles and qualifications of the HFE team and states that this definition of roles is based on NUREG-0711. However, the description provided in the HFEPP does not fully conform to the guidance of NUREG-0711 in this area and clarification is needed regarding how the HFEPP addresses the following aspects of team roles and qualifications from the NUREG-0711 appendix, "Composition of the HFE Design Team": ○ The typical contribution of Nuclear Engineering to "provide knowledge of the processes involved in controlling reactivity and generating power." ○ The minimum qualifications of Instrumentation and Control (I&C) Engineering to have "familiarity with the theory and practice of software quality assurance and control," and the typical contribution to "provide input to software quality assurance programs."	TerraPower provided the following clarifications: • TerraPower considered "that knowledge of the processes involved in controlling reactivity and generating power" would be part of the aggregate knowledge of plant operations provided in the HF Operations/Maintenance role included in section 4.1.1, sub-bullet C, "HF Operations/Maintenance," of the TR. TerraPower agreed to address this item via changes incorporated into a revision of the TR. • TerraPower did not include statements around software quality assurance and control because, though the importance is recognized, it is not a point of collaboration with the core HFE team for the HFE program. • TerraPower did not specify qualification requirements for the extended team, such as Architect Engineering, because TerraPower considered to be beyond the purview of the HFE program. It was further discussed that the qualification process is expected to be defined and implemented through the applicable performer's

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	○ The minimum qualification of Architect Engineering to have "4 years of experience in the design of power plant control rooms." ○ The minimum qualifications of Computer System Engineering, including degree and experience requirements. ○ The minimum qualifications of Plant Procedure Development to have "4 years of experience in developing procedures for nuclear power plants," and the expected typical contributions of the position. ○ The minimum qualifications of Personnel Training to have "4 years of experience in developing personnel training programs for power plants" and "experience in applying the systems approach to training," in addition to the expected typical contributions to "develop content and format of personnel training programs for licensed and non-licensed plant personnel" and to "coordinate training issues arising from activities."	quality programs. TerraPower agreed to address this item via changes incorporated into a revision of the TR. • TerraPower clarified that it does not have a separate Computer System Engineering team, as the capabilities are included with I&C Engineering. TerraPower further clarified that they did not specify qualification requirements for the extended team as those qualification processes are defined and implemented through the applicable performer's quality programs. TerraPower agreed to address this item via changes incorporated into a revision of the TR. • TerraPower clarified that plant procedures are not being developed by the core HFE team or by engineering, so the related qualifications and contributions were not included. Instead, TerraPower stated that plant procedure development will be performed by the US SFR Owner, LLC (USO) in accordance with the administrative procedures described in the Construction Permit Application for the Natrium Reactor Plant, Kemmerer Power Station (Kemmerer), Unit 1, Preliminary Safety Analysis Report (PSAR) section 11.1.4, "Operating Organization and Technical Support" (ML24088A065). TerraPower agreed to address this item via changes incorporated into a revision of the TR. • Personnel training is not being developed by the core HFE team or by engineering, so the related qualifications and contributions were not included. Personnel training as discussed in PSAR section 11.1.5.2, "Training of Personnel," will be developed and implemented by the USO in accordance with

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		the administrative procedures described in PSAR section 11.1.4. TerraPower agreed to address this item via changes incorporated into a revision of the TR.
5	TR section 4.1.2, "Responsibilities" a. Criterion 2.4.2(4): The NRC staff requests TerraPower further describe assignments of tasks to personnel, such as assignments of individual core team members and extended team members for various tasks and within HFE program elements. b. Criterion 2.4.3(1): The NRC staff requests TerraPower also identify the process through which the team will execute its responsibilities, including procedures for the following: o assigning HFE activities to individual team members o governing the internal management of the team o making decisions on managing the HFE program o making HFE design decisions o controlling changes in design of equipment o reviewing of HFE products	5.a: TerraPower clarified that their organization will use established processes and procedures to identify, understand, and resolve issues relating to the HFE scope. TerraPower described that GE Hitachi staffs the core HFE team, to include the HFE Technical Lead role. This HFE Technical Lead coordinates design activities with the TerraPower HFE Program Owner who, in turn, provides oversight. The TerraPower HFE Program Owner is described as having responsibility for ensuring the communication, reporting, and processing of HFE concerns is advocated and resolved through the TerraPower design organization. The TerraPower HFE Program Owner reports to the Manager, Plant Maintenance and Operational Design Integration who, in turn, reports to the Senior Manager, Integrated Plant and Structure. The Senior Manager, Integrated Pant and Structure, serves as the technical design authority and senior-level advocate for HFE and reports to the Vice President of Plant Delivery. 5.b: TerraPower clarified that they will generate the procedures for execution of the Natrium design for Kemmerer Unit 1. These procedures will include the process for design and project decisions, inclusive of HFE. The procedures also address the design change control process and acceptance of engineering products from suppliers. These procedures are governed by TP-QA-PD-0001, Revision 14-A, "TerraPower [Quality Assurance] Program Description" (ML23213A199). TerraPower further clarified that companies supporting Natrium HFE work under their

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		respective programs, plans, and procedures. For the core HFE team, this includes procedures for workforce planning, scheduling, and project management. TerraPower also stated that there are procedures addressing personnel qualification, technical training, and proficiency, that support making resource assignments. For HFE work performed by GE Hitachi, these procedures are governed by NEDO-11209A, "GE Hitachi Nuclear Energy Quality Assurance Program Description" (ML21348A339 and ML22278A214). TerraPower stated that technical reviews are conducted per the performer's specific procedures for design and review for engineering products and for HFE work performed by GE Hitachi, these procedures are also governed by NEDO-11209A. TerraPower agreed to address this item via changes incorporated into a revision of the TR.
6	Criterion 2.4.3(5): The TR describes HFE Implementation Plans that will be used to subsequently develop Results Summary Reports (RSRs). However, procedures for the retention of HFE documentation items (such as RSRs and their supporting materials) and for making them available to the NRC staff for review are not described within the TR. The NRC staff request that TerraPower make these procedures (or a summary of their scope and content) available.	TerraPower clarified that the retention of engineering documentation for HFE is completed as required by the performer's plans and procedures and that for HFE work performed by GE Hitachi, these procedures are governed by NEDO-11209A. TerraPower plans to develop RSRs addressing at least the minimum information stipulated in NUREG-0711. The RSRs and supporting documentation will be retained as required by the performer's quality assurance program. TerraPower will provide the RSRs for NRC staff review. TerraPower agreed to address this item via changes incorporated into a revision of the TR.
7	Criterion 2.4.3(6): The TR does not discuss the how the Natrium HFE program will be applied to contractors and subcontractors that are engaged in HFE-related work. The NRC staff requests TerraPower clarify how HFE requirements will be included in contracts and subcontracts that contribute to the HFE program, how	TerraPower clarified that contractors and subcontractors doing HFE-related work are tied into the Natrium HFE program through several different means. TerraPower stated that first the project uses a requirements-based approach to inform design, with those requirements being flowed down though the

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	contractor and subcontractor compliance with HFE requirements will be verified, and what milestones and the methods will be used for this verification.	procurement process and NI-related contracts reference either NUREG-0700 or specific requirements from the Natrium requirements database that originate from NUREG-0700. TerraPower stated that these are work activities to allow the HFE team to be part of the feedback process for HFE-related work done through the contractors or subcontractors. In some circumstances, such as the digital control system which houses the majority of human-system interfaces (HSIs), TerraPower stated that the HFE team will provide the vendor with system-specific design specifications developed through HFE task analysis. Finally, TerraPower stated that an HSI style specification is being developed to implement many of the HFE requirements into a relevant format and that the HSI style specification will be used by the different vendors as applicable to maintain a consistent look/feel for the HSIs. TerraPower stated that through a combination of factory acceptance testing and through the HFE Verification and Validation (V&V) process, compliance with the HFE requirements will be ensured, with the equipment and interfaces provided by contractors and subcontractors being part of the sampling population to perform HFE V&V and potentially Integrated System Validation (ISV). TerraPower stated HFE V&V will be an ongoing activity that will be performed independently and will start with the receipt of the first deliverable from the digital control system vendor. TerraPower agreed to address this item via changes incorporated into a revision of the TR.
8	Criterion 2.4.4(2): In section 8.2, “Criteria for Prioritizing Human Factors Engineering Issues and Human Engineering Discrepancies,” of the TR, TerraPower discusses the methodology for prioritizing HFE issues and Human Engineering Discrepancies (HEDs).	TerraPower agreed to address this item via changes incorporated into a revision of the TR.

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	However, the TR does not appear to specify that those HEDs categorized at Priority 1 (i.e., highest) and Priority 2 (high) must be resolved, as well as when such HEDs must be resolved by during the design lifecycle and licensing process. The NRC staff request that TerraPower clarify how the resolution of Priority 1 and 2 HEDs will be ensured by the HFE program.	
9	section 5.1, "Operating Experience Review" a. Criterion 3.4.1(2): The TR does not appear to address the consideration of relevant HFE issues from NUREG/CR-6400, "[HFE] Insights for Advanced Reactors Based Upon Operating Experience," (ML063480112) (e.g., generic safety issues, Three Mile Island (TMI) issues, NRC generic letters and information notices, etc.) within the Operating Experience Review (OER) process scope. The NRC staff requests TerraPower clarify how the information in NUREG/CR-6400, where appropriate, is considered within the OER process. b. Criterion 3.4.2(1): The TR does not discuss the administrative procedures for evaluating operating, design, and construction experience, and for ensuring that applicable important industry experiences will be provided in a timely manner to those designing and constructing the plant. The NRC staff request that TerraPower provide details regarding how the OER process will account for evaluation of operating experience. c. Criterion 3.4.2(4): The TR does not describe how operating experience issues determined to be relevant to the design, but not yet addressed, will be documented within an issue-tracking system. The NRC staff requests TerraPower describe the mechanism by which this tracking will be accomplished.	9.a: TerraPower clarified that they will conduct a review of NUREG/CR-6400 with consideration of the Natrium design and will identify any operating experience that needs to be addressed. TerraPower also indicated that they will add to section 5.1 of the TR that NUREG/CR-6400 will be addressed in the OER and will evaluate removing this information from Kemmerer Unit 1 PSAR section 11.2.2.2.4 "Recognized Industry Issues," to avoid duplication. 9.b: TerraPower indicated that the operating experience that has been gathered to support the Natrium HFE design was collected over many years of new nuclear design efforts and will also be updated with new sodium reactor operating experience at the start of HFE design activities. TerraPower further stated that they will develop a separate report which will detail how the HFE operating experience was collected and evaluated (i.e., the OER RSR). 9.c: TerraPower clarified that, as of the time of this audit discussion, operating experience issues with relevance to the HFE design which remain to be addressed are not yet being formally tracked. However, TerraPower confirmed that they will establish formal tracking of such issues within the Human Factors Engineering Issue Tracking System and that this will be added to section 5.1 of the TR.

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10	Criterion 4.4(2): TR section 5.3, "Allocation of Function," and appendix A, "[HFE] Allocation of Function and Task Grading Methodology," describe the Allocation of Function (AOF) process. However, the TR does not appear to discuss whether the function allocation will be performed iteratively to keep it current throughout the facility lifecycle. The NRC staff request that TerraPower clarify how the AOF process will maintain the function allocation current.	TerraPower clarified that section 5.3 of the TR describes that the AOF is iterated upon as necessary as the design progresses. TR section A.2.2, "Allocation of Function Evaluation," and figure A.2-2 "Allocation of Function Evaluation Process," also include a **[[** **]].** TerraPower also confirmed that, once the plant is turned over to the licensee, any evaluations or changes in the AOF would be implemented using the administrative procedures described in PSAR section 11.1.4.
11	Criterion 5.4(1): In section B.1.2, "Scope," of TR appendix B, "[HFE] Task Analysis and [HSI] Design Methodology," TerraPower states that the task analysis (TA) process addresses human interactions with NI plant systems. However, it is not clear whether the TA and HSI design HFE elements will be applied within the scope of EI functions as well. The NRC staff request that TerraPower clarify whether the TR addresses any EI tasks that may be important to plant safety during maintenance, tests, inspections, and surveillances, in addition to those EI tasks with potential concerns for personnel safety.	TerraPower agreed to address this item via changes incorporated into a revision of the TR.
12	Criterion 6.4(2): TR section 5.4, "Staffing," and appendix C, "[HFE] Staffing Analysis Plan," describe the staffing analysis process. However, the TR does not address the regulatory requirements of 10 CFR 50.54(k), 50.54(l),	TerraPower clarified that the requirements of 10 CFR 50.54(k) through (m) will be addressed by the OLA and, furthermore, that TerraPower will seek an exemption via the OLA for the omission of the STA role. The NRC

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	and 50.54(m) for licensed operator staffing. Additionally, the TR does not describe how it is intended to address the STA role. The NRC staff request that TerraPower clarify both how 50.54(k) through (m) and the STA role will be addressed by the TR.	staff have identified this area as being the subject of a potential L&C for the TR in the NRC staff's SE.
13	Criteria 8.4.3(1)-(5): The TR references the development and application of an HFE style guide. However, this style guide was not included in conjunction with the TR. The NRC staff request that TerraPower make the HFE style guide available for the NRC staff review in TerraPower's ERR.	TerraPower agreed to address this item via changes incorporated into a revision of the TR.
14	Criterion 8.4.4.1(7): The TR does not address the change process that is expected to be used for HSIs in the operating plant. The NRC staff request that TerraPower describe how, in the operating plant, HSIs will be modified and updated, temporary HSI changes will be made, and personnel-defined HSIs will be created.	TerraPower clarified that, once the plant is turned over to the licensee, any modification or updates to the HSIs will be in accordance with the administrative procedures described in the PSAR.
15	Criteria 8.4.4.2(1-3), (5-7), and (10–11): The TR does not appear to address the post-TMI HSI inventory requirements of 10 CFR 50.34(f)(2)(iv), (v), (xi), (xvii), (xviii), (xix), (xxvi), and (xxvii). The NRC staff request that TerraPower describe how the HSI design process of the HFEPP will ensure that the technologically relevant aspects of, at a minimum, the requirements summarized below are incorporated into the design: ○ 50.34(f)(2)(iv) - Safety parameters display system ○ 50.34(f)(2)(v) - Status of safety systems ○ 50.34(f)(2)(xi) - Relief and safety valve indication ○ 50.34(f)(2)(xvii) - Containment related indications ○ 50.34(f)(2)(xviii) - Core cooling indications ○ 50.34(f)(2)(xix) - Instrumentation to monitor post-accident plant conditions ○ 50.34(f)(2)(xxvi) - Leakage control and detection ○ 50.34(f)(2)(xxvii) - Radiation monitoring	TerraPower agreed to address this item via changes incorporated into a revision of the TR.
16	TR section 5.7, "Human-System Interface Design," and appendix B describe the HSI design process.	16.a: TerraPower agreed to address this item via changes incorporated into a revision of the TR.

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	a. Criterion 8.4.4.2(12): The TR does not appear to address how the HSI design process will account for the manual initiation of protective actions. The NRC staff request that TerraPower describe how it will be ensured that the HSI design will support the manual initiation of protective actions at the system level for those safety systems otherwise initiated automatically. b. Criterion 8.4.4.2(13): The TR does not appear to cover how the HSI design process will address the manual initiation of systems associated with critical safety functions. The NRC staff request that TerraPower describe how the HSI design process will provide displays and controls in the control room for the manual actuation of critical safety function related systems, as well as for monitoring those parameters that support them. Additionally, the NRC staff request that TerraPower describe how these displays and controls will be independent of, and different from, the normal instrumentation and controls otherwise used. c. Criterion 8.4.4.5(2): The TR does not discuss how consistency will be achieved between those HSIs which are in the control room and those located outside of it. The NRC staff request that TerraPower discuss how it will be ensured that the HSIs of the Remote Shutdown Facility are consistent with those in the main control room (MCR). d. Criterion 8.4.4.6(2): The TR also does not appear to address how consistency will be achieved between the design of HSIs for local control stations and those in the control room. The NRC staff requests TerraPower describe how HFE will be incorporated into the HSIs for local control stations to ensure both that they are consistent with those in the MCR and	TerraPower also clarified that PSAR section 4.2, "Defense-in-Depth," includes the defense-in-depth (DID) process description. 16.b: TerraPower agreed to address this item via changes incorporated into a revision of the TR. TerraPower also clarified that DID functions are classified as either safety-related (SR), non-safety-related with special treatment (NSRST), or non-safety-related no special treatment (NST) using the safety classification process described in PSAR section 5.1, "Safety Classification of SSCs." TerraPower indicated that there are currently no SR manual actions and that none are expected and that the NSRST and NST manual actions will be performed using diverse, independent HSI as described in PSAR section 7.6.2.4, "Operator Interface," and the I&C architecture is illustrated in figure 5-1, "Overall I&C Architecture Diagram," of NAT-4950, "[I&C] Architecture and Design Basis [TR]," Revision 1 (ML24068A186). 16.c: TerraPower agreed to address this item via changes incorporated into a revision of the TR. TerraPower also clarified that consistency between the HSIs of the Remote Shutdown Complex (formerly the Remote Shutdown Facility) and like HSIs in the MCR will be ensured through the use of the same style specification for the HSIs. 16.d: TerraPower agreed to address this item via changes incorporated into a revision of the TR. TerraPower also clarified that consistency between HSIs for local control stations and the MCR is facilitated by developing a style specification and providing it to the various vendors. Where there are commercial-off-

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	that personnel can easily understand and use the HSIs. e. Criteria 8.4.5(1 – 4): The NRC staff note that an HSI design process should address considerations related to the following as they relate to HSI failures and degradations: o the effects of HSI failures and degradations, o the alarms and indications needed for timely detection, o back-up systems to ensure that important personnel tasks can be completed, and o compensatory actions (as well as supporting procedures) to ensure that personnel effectively manage degradations and transitions to back-up systems. While the TR addresses HSI failures during ISV activities (with identified issues generally being expected to be addressed via the iterative HFE process), the NRC staff also note that ISV only samples a subset of the possible I&C and HSI degradations that can impact personnel task performance. The NRC staff request that TerraPower clarify how the HFEPP processes for HSI design, TA, procedures, and HFE V&V will, in aggregate, adequately address the impact of automation failures, I&C degradations, and HSI degradations on personal task performance.	the-shelf considerations for applied HSI designs and compliance with the style specification, HFE evaluates and collaborates with the designer to develop a solution, or a justification of acceptability as provided within TR section 5.7.5 “Detailed [HSI] Design.” 16.e: TerraPower agreed to address this item via changes incorporated into a revision of the TR. TerraPower also clarified that PSAR section 4.2 includes the DID process description.
17	TR section 5.8, “Procedure Development” a. Criterion 9.4(1): The TR does not describe the development of Generic Technical Guidelines (GTG) within the Procedure Development Plan. The NRC staff request that TerraPower clarify whether GTGs will be included in the procedure development program.	17.a: TerraPower clarified that they are currently in the process of obtaining vendor support for the development of the emergency operating procedures (EOPs) and that technical guidelines will be produced for the EOPs. However, TerraPower indicated that a decision has not yet been made regarding whether site-specific or GTGs will be developed for the EOPs and that this decision is not expected to be made until

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	b. Criterion 9.4(4): The NRC staff request that TerraPower make the procedure writer's guide available for review so that the adequacy of its content can be verified. Specifically, confirmation is needed that procedures developed using this guide will contain the following elements, as applicable: o title and identifying information o statement of applicability and purpose o prerequisites o precautions o important human actions o limitations and actions o acceptance criteria o check off lists, and o reference material c. Criterion 9.4(8): The TR does not specifically address the plan for maintaining procedures and controlling updates. Clarification is needed regarding how the procedure plan will address both maintaining procedures and controlling procedure updates. d. Criterion 9.4(9): The TR does not appear to describe the physical means by which personnel will access and use procedures, particularly during operational events. However, the NRC staff noted that the "TerraPower [HFE] Concept of Operations White Paper" (ML23125A328), section 3.5 "Procedures," describes that the HSIs in the nuclear control room are designed to support use of computer-based procedures and, furthermore, that storage space is provided in the nuclear control room and remote shutdown facilities for hardcopy sets of operating procedures to support required operation. The NRC staff request that equivalent information to what is described in the WP regarding procedure	approximately one year from the present time. The NRC staff have identified this area as being the subject of a potential L&C for the TR in the NRC staff's SE. 17b: During the audit, a copy of ADI-RMD-102, "Procedure Writer's Manual" (Revision 1). was available in the ERR for the NRC staff to audit. **]]** **]].** 17.c: TerraPower confirmed that they will conform to the requirements in NQA-1-2015, "Quality Assurance Requirements for Nuclear Facility Applications," and ANSI/ANS-3.2-2012, "Managerial, Administrative, and Quality Assurance Controls for the Operational Phase of Nuclear Power Plants," (with the exception that the 2015 version of NQA-1 will be used instead of the 2008 version referenced in ANSI/ANS-3.2-2012) for procedure maintenance and development. TerraPower also clarified its commitment to conform to the requirements of NQA-1-2015 is contained in section 5 "Instructions, Procedures and Drawings," of TP-QA-PD-0001, Revision 14-A. A description of the USO Operating Organization conformance to ANSI/ANS-3.2-2012 is contained in section 11.1.4 of the PSAR. If additional detail on conformance to NQA-1-2015 and

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	accessibility also be included within the TR or otherwise docketed.	ANSI/ANS-3.2-2012 is needed, TerraPower will provide this as part of the PSAR. 17.d: TerraPower agreed to address this item via changes incorporated into a revision of the TR.
18	TR section 5.9, "Training and Qualification Program Development" a. Criterion 10.4.1(2): section 5.9 does not specify whether the categories of personnel covered by 10 CFR 50.120, "Training and qualification of nuclear power plant personnel," are within the scope of the Systems Approach to Training (SAT)-based training program. The NRC staff request that TerraPower clarify what specific categories of personnel that will be trained under the training program. b. Criterion 10.4.2(1): The NRC staff note that the TR does not define organizational roles related to training program development. The NRC staff requests TerraPower describe the organizational roles for developing training requirements, training information sources, and training materials, as well as for implementing the training program. c. Criterion 10.4.2(3): The TR does not appear to describe the facilities and resources that will be needed to satisfy the requirements of the training program. The NRC staff request that TerraPower define these necessary facilities and resources (e.g., a plant-referenced, full-scope simulator). d. Criterion 10.4.4(2): The TR does not specify whether the simulation facility will conform to NRC RG 1.149, "Nuclear Power Plant Simulation Facilities for use in Operator Training, License Examinations, and Applicant Experience Requirements," nor does the TR provide a description of either the simulator facility or the	18.a: TerraPower clarified that compliance with 10 CFR 50.120, "Training and qualification of nuclear power plant personnel," will be addressed in the PSAR. The NRC staff have identified this area as being the subject of a potential L&C for the TR in the NRC staff's SE. 18.b: TerraPower clarified that they intend to obtain accreditation of their training program through the Institute of Nuclear Power Operations. Additionally, TerraPower indicated that they plan to achieve training program accreditation within 18 months of initial fuel load. The NRC staff have identified this area as being the subject of a potential L&C for the TR in the NRC staff's SE. 18.c: TerraPower confirmed that they plan to establish a full-scope, plant-referenced simulator. The NRC staff have identified this area as being the subject of a potential L&C for the TR in the NRC staff's SE. 18.d: TerraPower clarified their intention for the simulator facility to model the MCR design initially and, later, the as-built MCR. TerraPower also described their plans for simulator training to include demonstrations, training scenarios, job performance measures (JPMs), and evaluated scenarios. TerraPower planned training and evaluation to encompass normal, abnormal, and emergency scenarios, with the design and development of simulator training being conducted using a SAT-based process. TerraPower anticipates that the

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	program for simulator training. The NRC staff requests TerraPower clarify whether the simulation facility will conform to RG 1.149 (including revision number), provide the details of the program for simulator training (including length of time), and describe the simulation facility as required by 10 CFR 55.45(b), "Implementation--Administration," and 10 CFR 55.46, "Simulation facilities."	simulator portion of licensed operator training will take approximately 10 months, with the duration being modified based upon the finalized design, as well as upon programmatic evaluation and experience. TerraPower intends for the operating test to be accomplished per 55.45(b)(2) using a plant walkthrough and in a plant-referenced simulator. Based upon construction status, TerraPower stated that the alternatives or additions to the plant walkthrough portion, including models or mockups, may be desired to provide enough JPMs for the operating exam. TerraPower stated it intends for the training simulator to comply with the requirements of 55.46 as they relate to plant-referenced simulators and continued assurance of simulator fidelity. Furthermore, TerraPower indicated that they will review their system design and ability to conform to RG 1.149 Revision 4. TerraPower stated that they plan to engage with the NRC on potential exceptions to this RG or on the possible use of newer standards at an appropriate point in the design and that they understand the benefit of prioritizing this engagement. The NRC staff have identified this area as being the subject of a potential L&C for the TR in the NRC staff's SE.
19	Criterion 11.4.3.5.1(4): TR section D.6.7.5, "Situation Awareness," discusses how situational awareness (SA) is assessed during V&V activities. This section proposes to use traditional three-level SA measures in which, in part, participants answer SA questions during freezes in scenarios. The NRC staff note that this type of SA measure was originally developed for measuring SA during tasks that demand quick reactions and predictions in rapidly changing aviation situations. The NRC staff request that TerraPower clarify the basis for the selected methodology and whether other SA	TerraPower agreed to address this item via changes incorporated into a revision of the TR.

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	measurement approaches were considered. Additionally, while section D.6.7.5 discusses the use of Situation Awareness Global Assessment Technique, it is unclear whether this method will only be used during early validation work, or if it will also be applied during ISV. If other methodologies (e.g., Situation Awareness Rating Technique) will be utilized as well, then that should also be clarified.	
20	Criterion 11.4.3.5.1(5): TR section D.6.7.6, "Workload," states that cognitive workload will be measured during ISV using the National Aeronautics and Space Administration's Task Load Index. Please explain how cognitive workload will be assessed. Clarification is needed both regarding whether other cognitive workload measurement approaches were considered and the rationale for the selected assessment methodology.	TerraPower agreed to address this item via changes incorporated into a revision of the TR.
21	TR section 5.12, "Human Performance Monitoring" a. Criterion 13.4(1): TR section 5.12 does not address how the human performance monitoring program will address future plant changes/modifications and their potential effects on human performance. The scope of the performance monitoring program should provide assurance that personnel can use the design effectively, changes/modifications do not adversely affect human performance, important human actions can be accomplished within the criteria for time and performance, and that an acceptable level of performance is maintained. The NRC staff requests TerraPower describe how the human performance monitoring program will ensure that plant changes do not adversely affect human performance. b. Criterion 13.4(2): It is unclear whether the human performance monitoring program will be in effect beginning at the initial loading of plant fuel. A	TerraPower clarified that the aspects of the Human Performance Monitoring element that are covered by these criteria are outside of the scope of TR and that a future report will be provided in conjunction with OLA that addresses these items. The NRC staff have identified this area as being the subject of a potential L&C for the TR in the NRC staff's SE.

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	human performance monitoring program should, in part, begin at initial loading of the plant's fuel and trend human performance after the plant is operational. The NRC staff request that TerraPower clarify at what point the human performance monitoring program will commence. c. Criterion 13.4(3): TR section 5.12 does not address whether the human performance monitoring program will be informed, in part, by deterministic safety insights or whether the plan will ensure that degradations and corrective actions are promptly addressed. A human performance monitoring program should be, in part, structured such that the monitoring of human actions is commensurate with their safety importance, while facilitating the detection and correction of degradations in performance before they compromise plant safety. Clarification is needed regrading whether the human performance plan will be informed by deterministic safety insights in conjunction with risk insights, as well as whether the plan will ensure that degradations and corrective actions are addressed in a timely manner. d. Criterion 13.4(4): TR section 5.12 does not discuss the potential use performance data approximations for circumstances in which plant or personnel performance under actual design basis conditions might not be readily measurable. Such approximations of performance data should be used when the performance of the plant or personnel under actual design basis conditions may not be readily measurable. The NRC staff request that TerraPower clarify whether it is intended to use approximations of performance data within such contexts.	

6.0 REQUESTS FOR ADDITIONAL INFORMATION RESULTING FROM AUDIT

As a result of the audit, the NRC staff did not identify any requests for additional information related to this TR.

7.0 OPEN ITEMS AND PROPOSED CLOSURE PATHS

There are no open items resulting from this audit.