UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of:	)	
	)	Docket No. 50-443-LA-2
NEXTERA ENERGY SEABROOK, LLC	)	
	)	November 21, 2019
(Seabrook Station Unit 1)	)	

NEXTERA ENERGY SEABROOK LLC'S PROPOSED FINDINGS OF FACT AND CONCLUSIONS OF LAW

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Pursuant to 10 C.F.R. § 2.1209, and the Atomic Safety and Licensing Board's ("Board") oral instructions at the evidentiary hearing,[1] NextEra Energy Seabrook, LLC ("NextEra") submits its Proposed Findings of Fact and Conclusions of Law ("FOF/COL") regarding C-10 Research and Education Foundation, Inc.'s ("C-10") Contention, as admitted by the Board in LBP-17-7. The FOF/COL are based on the evidentiary record in this proceeding, and are submitted in the form of a proposed Initial Decision by the Board. The FOF/COL are set out in numbered paragraphs beginning in the next section, with corresponding citations to the record of this proceeding.

I. INTRODUCTION AND SUMMARY OF FINDINGS

1. This Initial Decision presents the Board's Findings of Fact and Conclusions of Law on C-10's sole Contention. As admitted by the Board, the Contention is a safety contention asserting that "[t]he large-scale test program [or LSTP], undertaken for NextEra at the [Ferguson Structural Engineering Laboratory or] FSEL, has yielded data that are not 'representative' of the

[1] Official Transcript of Proceedings, Docket No. 50-442-LA-2 at 1181-82 ("Tr."); *see also generally* ASLB Order (Adopting Transcript Corrections, Transcript Redactions, and Final Exhibit List), App. A (Oct. 29, 2019) ("Tr. Corr.").

progression of [Alkali-Silica Reaction or] ASR at Seabrook [Station Unit 1]. As a result, the proposed monitoring, acceptance criteria, and inspection intervals are not adequate."[2] More specifically, C-10 claims that NextEra's License Amendment Request 16-03 ("LAR") is deficient because the LSTP did not replicate certain allegedly-unique aging and environmental exposure-related aspects of Seabrook's concrete; and that "as a result" of this alleged non-representativeness, crack width indexing and extensometer deployment are not sufficient tools for determining the extent and progression of ASR, further core sampling and testing are required to adequately monitor ASR progression, and the expansion monitoring intervals allegedly are too long.[3]

2. As a threshold matter, the Board finds that C-10 has failed to meet its initial burden of moving forward with sufficient evidence on the Contention as pled and admitted. As discussed in further detail below, the "key issue" in the Contention is C-10's claim that the concrete in the LSTP test specimens was not "representative" of the concrete at Seabrook because the plant's concrete had *aged* and been exposed to various *environmental conditions* such as salt water, heat, and radiation. However, C-10's hearing evidence (supported by their current expert witness, Dr. Saouma) materially departs from C-10's original claims (which were supported by historical comment letters from a different expert, Dr. Brown). In summary, C-10's hearing evidence purports to challenge the LAR on numerous *other* grounds—but not the ones pled in the original Contention—and thus is not probative of the Contention as pled and

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2 *NextEra Energy Seabrook LLC* (Seabrook Station Unit 1), LBP-17-7, 86 NRC 59, 90 (2017), *aff'd* CLI-18-4, 87 NRC 89 (2018).

3 *See generally* C-10 Research and Education Foundation, Inc., Petition for Leave to Intervene at 2 (Apr. 10, 2017) (ML17100B013) ("Petition") (contentions A, B, C, D, and H).

admitted, and fails to satisfy the *prima facie* threshold for those original arguments (which its evidence does not address).

3. Nevertheless, even if C-10 had satisfied its initial "burden of going forward" on the Contention, we conclude that NextEra has demonstrated by a preponderance of the evidence that the LSTP yielded data that are "representative" of the progression of ASR at Seabrook, to the extent necessary to provide reasonable assurance regarding NextEra's ability to evaluate the structural adequacy of Seabrook's seismic Category I structures. We further find that the preponderance of the evidence demonstrates that NextEra's proposed monitoring, acceptance criteria, and inspection intervals are adequate to provide reasonable assurance.

4. Overall, we find that a preponderance of the evidence supports the NRC Staff's conclusion that the LAR's plant-specific method of evaluation for seismic Category I reinforced concrete structures affected by ASR at Seabrook is acceptable and provides reasonable assurance that these structures continue to meet the relevant requirements of 10 CFR Part 50, Appendix A, General Design Criteria ("GDC") 1, 2, 4, 16 and 50, and 10 CFR Part 50, Appendix B; and that NextEra has satisfied the requirements of 10 C.F.R. §§ 50.92 and 50.57(a)(3) and (6).

5. Furthermore, for the reasons set forth below, the Board finds that the LAR is based on sound science, the current state of established knowledge of ASR development and progression at Seabrook, and well-established structural engineering principles. It is also fully compliant with the long-established industry codes (which themselves incorporate inherent margins of safety) and Nuclear Regulatory Commission ("NRC") regulations applicable to domestic operating nuclear plants. The Board acknowledges that ASR is a developing field of scientific and engineering research. However, as further explained below, the Board finds the preponderance of the evidence collectively demonstrates that, among other things, the LSTP

yielded data that are appropriate for use in the LAR, the Structures Monitoring Program ("SMP") is adequate for monitoring Seabrook's ASR, and the Structural Evaluation Methodology ("SEM") is adequate for analyzing the structural adequacy of Seabrook's seismic Category I structures, and thus the LAR provides the requisite reasonable assurance for the NRC Staff to issue the requested amendment.

6. Our conclusions are informed by hundreds of pages of written testimony, a transcript of oral testimony that is over a thousand pages, and many thousands of pages of exhibits. Our specific findings and conclusions are detailed in the sections below. However, our decision is guided at least partially by a few high-level observations.

7. First, the LAR uses a classic aging management approach, long endorsed by the NRC to monitor various degradation mechanisms. This approach has been proven to adequately manage degradation mechanisms regardless of extent or rate of degradation because they monitor actual progression rather than attempt to predict it, so long as the monitoring intervals are appropriate.[4] As detailed below, we have determined that NextEra's monitoring intervals are, in fact, appropriate. In practical terms, after more than 30 years of ASR propagation in Seabrook's structures, it has reached only low to moderate levels and has been referred to as "slow."[5] But even if that rate changes, the LAR's aging management approach ensures ASR will be adequately managed.

8. Second, the LAR is firmly rooted in structural engineering concepts that are fully compatible with Seabrook's existing licensing basis and that leverage industry consensus codes

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[4] Testimony of NextEra Witnesses Michael Collins, John Simons, Christopher Bagley, Oguzhan Bayrak, and Edward Carley at A220, A229 (July 24, 2019) ("MPR Testimony") (NER001).

[5] Testimony of NextEra Witnesses Said Bolourchi, Glenn Bell, and Matthew Sherman at A90 (July 24, 2019) ("SGH Testimony") (NER004).

that (1) already have embedded conservatisms to address potential uncertainty and (2) utilize acceptance criteria proven to be conservative and appropriate over many decades of real world structural performance experience. The record indicates that NextEra could have started from scratch with theoretical research, including probabilistic methods that attempt to predict (rather than monitor, in the classic sense) the progression of ASR. However, there are no NRC or broader industry consensus standards for such an approach, and no time-tested acceptance criteria. Furthermore, it is not at all clear how such an approach would be consistent with Seabrook's design and licensing basis or NRC regulations.[6] On balance, we find NextEra's approach eminently reasonable given the current state of ASR knowledge and NextEra's need to analyze the structures at its operating power plant now. Moreover, NextEra is legally obligated to continuously monitor the state of ASR knowledge going forward, and to take appropriate action (subject to NRC oversight and enforcement) if it discovers information that would call into question the approach in the LAR.

9. Accordingly, NextEra has fully met its burden of showing, by a preponderance of the evidence, that the Contention lacks merit. Thus, the Board enters a ruling on the merits in NextEra's favor.

II. HISTORY OF THE PROCEEDING

10. NextEra first identified symptoms of ASR expansion at Seabrook in 2009 in the B Electrical Tunnel.[7] Notably, at that time (and still to this day) there existed no specific NRC guidance, NRC regulations, or accepted nuclear industry standards for addressing ASR.[8]

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6 *See, e.g.*, Tr. at 1130 (Ms. Buford expressing doubt that such an approach could even be licensed by the NRC).

7 MPR Testimony at A76 (NER001).

8 *See* Tr. at 986-98 (discussing lack of guidance on ASR); *see also id*. at 986-87 (Dr. Saouma stating, "[t]here is no guidance as of now for concrete with ASR.").

Various ASR-related research is currently being conducted by various researchers around the globe. But this research remains ongoing, and has not yielded any consensus method for addressing ASR in existing structures. As Dr. Souma and others have noted in various papers (prepared several years after ASR was first discovered at Seabrook), research on multiple proposed probabilistic and chemo-mechanical models is still in its early stages, and has not been reviewed (much less adopted) by any consensus body.[9] And a presentation at the NRC's 2018 Regulatory Information Conference indicated that the National Institute of Standards and Technology is continuing to perform testing to support the NRC's eventual development of guidance on this topic.[10] Thus, when ASR was discovered at Seabrook—an operating nuclear power plant—NextEra was left to develop its own program for managing ASR that was compatible with its existing licensing basis.

11. Seabrook's original legal licensing basis, as described in its Updated Final Safety Analysis Report ("UFSAR"), includes methods for performing structural evaluations on Seabrook's Containment Building ("Containment") and certain other structures (collectively known as "seismic Category I structures") at the plant to ensure that they fulfill their design basis functions following a design basis earthquake.[11] These methods correspond to the structural design codes in Seabrook's UFSAR—more specifically, the ASME Boiler and Pressure Vessel Code Section III, Div. 2, 1975 ("ASME 1975") (NRC050) for the Containment Building, and ACI Standard 318-71 ("ACI 318-71") (NRC049) for all other seismic Category I structures at the plant.[12] These codes, developed by consensus committees of leading structural engineering

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9 MPR Testimony at A195 (NER001).

10 *Id*. at A60.

11 *Id*. at A31.

12 *Id*. at A31, A62.

experts, are NRC-approved, impose mandatory legal requirements on NextEra, and have been proven to contain safe and conservative structural analysis methods and acceptance criteria based on decades of actual experience around the world. Although ASR is not among the prescriptive (*i.e.*, minimum) list of loads that must be considered, the codes permit the analysis and inclusion of additional loads, such as ASR, in the calculations.[13]

12. Thus, NextEra submitted LAR 16-03 on August 1, 2016, seeking NRC approval to revise its UFSAR to incorporate a means of doing so ("Original LAR Package").[14] In addition to its structural engineering-based monitoring approach in the SMP, the LAR methodology also includes an analytical approach in the SEM for evaluating ASR-affected concrete structures using the original licensing basis design codes by accounting for the effects of ASR on design basis loads.[15] In essence, NextEra's approach was to develop an ASR supplement for use in Seabrook's existing codes, and to do so in a way that maintains the required level of structural performance and margin of safety implicit in the original design criteria, codes, and standards.[16]

13. As discussed in relevant detail elsewhere in our decision, NextEra refined and revised the LAR several times during the course of the NRC's review. More specifically, NextEra supplemented its Original LAR Package on September 30, 2016 ("LAR

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13 *Id*. at A31. *See also infra* Part IV.F.(4).

14 *Id*. at A31. NextEra License Amendment Request (LAR) 16-03 - Revise Current Licensing Basis to Adopt a Methodology for the Analysis of Seismic Category I Structures with Concrete Affected by Alkali-Silica Reaction (Aug. 1, 2016). The Original LAR Package included: NextEra's Evaluation of the Proposed Change and Attach. 1 (Markup of UFSAR Pages) (Aug. 1, 2016) ("LAR Evaluation") (INT010 (Proprietary ("P")), NRC089 (P) (non-highlighted proprietary version), INT010 (Non-Proprietary ("NP"))); MPR-4288, Rev. 0, "Seabrook Station: Impact of Alkali-Silica Reaction on Structural Design Evaluations" (July 2016) ("MPR-4288") (INT014 (P), INT012 (NP)); MPR-4273, Rev. 0, "Seabrook Station – Implications of Large Scale Test Program Results on Reinforced Concrete Affected by Alkali-Silica Reaction" (July 2016) (NRC009 (P), NRC008 (NP)); and SG&H Report 160268-R-01, Rev. 0, "Development of ASR Load Factors for Seismic Category I Structures (Including Containment) at Seabrook Station, Seabrook, NH (July 2016) (INT013).

15 MPR Testimony at A31 (NER001); *see also* LAR Evaluation (INT010 (NP), NRC089 (P)).

16 *Id*.

Supplement"),[17] and provided additional details and refinements to the proposed methodology in various responses to NRC requests for additional information ("RAI") between October 2017 and June 2018 (collectively, the "RAI Responses").[18]

14. There are three key aspects of the LAR: the LSTP, the SMP, and the SEM.

15. LSTP: Due to limitations in the published literature directly addressing the effects of ASR on structural adequacy,[19] NextEra commissioned the LSTP in 2011 to supplement the available information[20]. The LSTP included extensive testing of specimens that sufficiently reflected the characteristics of ASR-affected structures at Seabrook.[21] Tests were completed over the course of approximately four years[22] at various levels of ASR development, including levels of ASR beyond that experienced at Seabrook to date, to assess the resulting impacts on structural performance.[23] The LSTP found that, up to the levels of expansion observed in the testing, structural capacity was not degraded in ASR-affected concrete members.[24] In fact, the

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17 Seabrook Station, Supplement to License Amendment Request 16-03 Revise Current Licensing Basis to Adopt a Methodology for the Analysis of Seismic Category I Structures with Concrete Affected by Alkali-Silica Reaction (SBK-L-16153) (Sept. 30, 2016). The LAR Supplement included: NextEra's Supplement to LAR 16-03 (Sept. 30, 2016) (NRC010); SG&H, "Evaluation and Design Confirmation of As-Deformed CEB, 150252-CA-02," Rev. 0 (July 2016) (Seabrook FP#100985) ("Rev. 0 CEB Evaluation") (INT015); and MPR-4153, Rev. 2, "Seabrook Station – Approach for Determining Through-Thickness Expansion form Alkali-Silica Reaction" (July 2017) (this revision was not submitted as an exhibit, but Rev. 3 (Sept. 2017) was (INT020 (P), INT018-R (NP)) ("MPR-4153")).

18 Seabrook Station, Response to Request for Additional information Regarding License Amendment Request 16-03 Related to ASR (SBK-L-17156) (Oct. 3, 2017) ("SBK-L-17156") (NRC013); Seabrook Station, Response to Request for Additional information Regarding License Amendment Request Related to ASR (SBK-L-17204) (Dec. 11, 2017) ("SBK-L-17204") (NRC014); Seabrook Station, Response to Request for Additional information Regarding License Amendment Request 16-03 (SBK-L-18074) (June 7, 2018) ("SBK-L-18074") (NRC015) (collectively, along with their associated attachments, the "RAI Responses").

19 MPR Testimony at A40 (NER001).

20 *Id*. at A99.

21 *See infra* Part IV.D.

22 *Id*. *See also* NRC Safety Evaluation Related to Amendment No. 159 to Facility Operating License No. NPF-86 at § 3.1.2 (Mar. 11, 2019) ("Final SE") (INT024 (NP), INT025(P)).

23 MPR Testimony at A115 (NER001); MPR Testimony, Attach. 2, Proprietary Appendix, tbl.2 (NER003) ("Prop. App'x").

24 MPR Testimony at A91 (NER001).

testing showed that structural capacities were even *greater* than the capacities calculated using the plant's original specified concrete material properties and relevant sections of applicable design codes.[25] This increase in capacity resulted from a phenomenon known as the "chemical prestressing effect."[26] Thus, the LSTP concluded that this approach (*i.e.*, using the plant's *original* specified concrete material properties and relevant sections of applicable design codes) was appropriate (and indeed conservative) for calculating the capacities of ASR-affected structures at Seabrook.[27]

16. SMP: Seabrook's SMP is an existing program used to address aging of structural elements within the scope of the maintenance rule, 10 C.F.R. § 50.65.[28] The LAR methodology included the addition of several specific provisions to Seabrook's SMP to provide for ongoing ASR detection and monitoring.[29] The purpose of these new provisions is two-fold. Purpose (1) is to gather concrete expansion measurements (*e.g.*, from crack width measurements, pin-to-pin mechanical measurements, and extensometer readings from numerous locations in seismic Category I structures) for monitoring against specified acceptance criteria based on the LSTP ("Expansion Monitoring Limits") to ensure ASR-related expansion at Seabrook does not exceed levels achieved in the LSTP (*i.e.*, to ensure the LSTP results remain applicable to Seabrook).[30] And Purpose (2) is to gather crack width and deformation measurements for monitoring against

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25 *See, e.g.*, MPR-4273, Rev. 1, Seabrook Station – Implications of Large-Scale Test Program Results on Reinforced Concrete Affected by Alkali-Silica Reaction at 5-7, fig.5-5 (July 2016) ("MPR-4273") (INT019 (NP), INT021 (P)).

26 *See, e.g.*, *id*. at 5-7

27 MPR Testimony at A91 (NER001).

28 *Id*. at A158.

29 *Id*.

30 *See infra* Part IV.E.

specific criteria established in the individual structural evaluations (performed in accordance with the SEM).[31]

17. SEM: The SEM prescribes the methodology for performing structural evaluations consistent with the design codes and standards in Seabrook's UFSAR, as modified by the LAR.[32] Briefly summarized, the SEM uses Seabrook's *existing* UFSAR provisions on concrete capacities with the original design concrete specifications (*capacity* side of the equation)—*i.e.*, it calls for no departure from the existing licensing basis—provided that the Expansion Monitoring Limits (in the SMP) are not exceeded (*see* Purpose (1) of the SMP).[33] On the *demand* side of the equation, the SEM provides a methodology for calculating the ASR "loads" on a structure, based on in-plane expansion measurements (*i.e.*, crack-width, pin-to-pin mechanical) and structural deformation measurements (*see* Purpose (2) of the SMP).[34] The SEM also provides a three-stage approach for performing the structural evaluations, in which higher stages of the analysis apply more sophisticated methods and use additional field data where refinement is required or desirable.[35]

18. The LAR methodology was developed with assistance from multiple external experts and organizations, and was subject to multiple peer reviews and independent evaluations.[36] First, NextEra retained MPR and SGH—internationally respected global engineering firms with established track records of analyzing nuclear structures—to assist in

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31 *See infra* Part IV.F.(1).

32 *See generally* SBK-L-18074, Encl. 3, Simpson Gumpertz & Heger Document No. 170444-MD-01, Rev. 1, "Methodology for the Analysis of Seismic Category I Structures with Concrete Affected by Alkali-Silica Reaction," for Seabrook Station (May 31, 2018) ("SEM Document") (INT022).

33 *Id*.

34 *Id*.

35 *Id*.

36 MPR Testimony at A86, A88, A223 (NER001); SGH Testimony at A60 (NER004).

developing the LAR. MPR's team included Dr. Oguzhan Bayrak from the University of Texas, who is a well-respected structural engineer with over 13 years of ASR-related research experience.[37] SGH's team included Dr. Said Bolourchi, who is a well-respected structural engineer with over 40 years of experience in evaluating seismically-rated nuclear structures. Collectively, these teams consisted of multiple licensed Professional Engineers (the engineering profession's highest standard of competence),[38] multiple members of well-respected consensus code committees,[39] and personnel with decades of ASR-related structural evaluation, testing, and monitoring experience with published works on this topic.[40] NextEra also used the Electric Power Research Institute ("EPRI") as an independent third party reviewer.[41] Among the personnel involved in EPRI's review was Dr. Yann LePape, a well-respected ASR researcher currently performing ASR-related testing at Oak Ridge National Laboratory.[42] Dr. Bruce Ellingwood of Colorado State University—an internationally-recognized authority on structural load modeling and structural reliability theory—provided a third-party review of the LAR analytical methodology, including its treatment of ASR loads and load factors.[43] Talisman International, LLC ("Talisman") provided an independent third-party review of the LAR.[44] During the early stages of NextEra's efforts to develop a methodology to address ASR, Dr.

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37 Tr. at 266-67; *see also* Dr. Oguzhan Bayrak *Curriculum Vitae* (NER010).

38 *See, e.g.*, Glenn Bell *Curriculum Vitae* (NER032); Matthew Sherman *Curriculum Vitae* (NER033); Dr. Oguzhan Bayrak *Curriculum Vitae* (NER010); Dr. Said Bolourchi *Curriculum Vitae* (NER031).

39 *See, e.g.*, Glenn Bell *Curriculum Vitae* (NER032); Matthew Sherman *Curriculum Vitae* (NER033); Dr. Oguzhan Bayrak *Curriculum Vitae* (NER010); Dr. Said Bolourchi *Curriculum Vitae* (NER031).

40 *See, e.g.*, Matthew Sherman *Curriculum Vitae* (NER033); Dr. Oguzhan Bayrak *Curriculum Vitae* (NER010).

41 MPR Testimony at A86 (NER001).

42 Tr. at 270; *see also* N. Ezell *et al*., "Experimental Collaboration for Thick Concrete Structures with Alkali-Silica Reaction" (2018) (NER047).

43 MPR Testimony at A88 (NER001); SGH Testimony at A60 (NER004).

44 MPR Testimony at A88 (NER001).

Kevin Folliard of the University of Texas—an internationally-recognized authority on ASR—provided insights on ASR from a materials perspective and on application of provisions within the FHWA Guideline (which he co-authored).[45] Furthermore, the LAR was submitted to the NRC—an independent regulatory agency—which extensively reviewed NextEra's approach against the agency's codified regulatory requirements. The NRC also contracted with subject matter experts at Brookhaven National Laboratory to assist its review.[46] And finally, NextEra presented its approach, and the NRC presented its proposed findings, to the Advisory Committee on Reactor Safeguards ("ACRS"), which is an independent body statutorily mandated by the Atomic Energy Act of 1954, and whose distinguished members are drawn from outside organizations, national laboratories, and academic institutions, several of whom have substantial structural engineering and material science experience.[47] Collectively, this cadre of contributors and reviewers includes numerous preeminent authorities, several experts with significant ASR experience, a balanced mix of engineering theoreticians and practitioners, and many decades of experience in structural engineering—which is by and large the most relevant field of expertise for this LAR, which pertains to confirmations of structural adequacy.

19. C-10's Petition, filed on April 10, 2017, originally proposed ten contentions ("A" through "J").[48] These contentions were based primarily on statements from Dr. Paul Brown, and only purported to challenge the LAR as presented in the Original LAR Package (*i.e.*, it did not acknowledge or challenge the LAR Supplement).[49]

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45 *Id*. at A211 (NER001); FHWA Guideline (NER013).

46 MPR Testimony at A88, A89, A223 (NER001); SGH Testimony at A60 (NER004).

47 MPR Testimony at A42 (NER001); Tr. at 268-69.

48 Petition at 2-3.

49 *Id*. at 3-15.

20. On October 7, 2017, in LBP-17-7, the Board found portions of five contentions—A, B, C, D, and H—admissible, but rejected the remaining contentions.[50] The Board reformulated the admissible portions into a single admitted contention, as follows:

> The large-scale test program, undertaken for NextEra at the FSEL, has yielded data that are not "representative" of the progression of ASR at Seabrook. As a result, the proposed monitoring, acceptance criteria, and inspection intervals are not adequate.[51]

21. NextEra appealed the Board's decision to the Commission, which affirmed the Board's ruling. As relevant to the scope of the Contention admitted for adjudication in this proceeding, the Commission held that "[t]he five elements of the reformulated contention relate as follows."

- "In Contention D, C-10 challenges the overall representative nature of the data from the large-scale test program."
- "In Contention A, as admitted, C-10 challenges the effectiveness of crack width indexing and extensometer deployment as tools for determining the presence and extent of ASR in safety-related structures. C-10's concerns regarding these monitoring techniques arise from the question of whether the test program results can adequately predict the effectiveness of crack width indexing and extensometer deployment as monitoring techniques at Seabrook."
- "In Contentions B and C, taken together, C-10 contends that results gathered via the test program do not provide information comparable to that obtainable by core sampling and that, without such information, NextEra cannot understand the progression of ASR at Seabrook."
- "And finally, in Contention H, as admitted, C-10 challenges the frequency of proposed inspection intervals on the ground that the test program results on which the intervals are based are not representative of Seabrook concrete."[52]

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50 *Seabrook*, LBP-17-7, 86 NRC at 68.

51 *Id*. at 127.

52 *NextEra Energy Seabrook LLC* (Seabrook Station, Unit 1) CLI-18-4, 87 NRC 89, 94-95 (2018).

22. As the Board emphasized, "the key issue is Contention D's challenge to the representativeness of the large-scale test program," whereas the remaining portions of the admitted contentions (A, B, C, and H) merely assert "consequences" stemming from this "alleged lack of representativeness."[53] In other words, and as confirmed by the Commission, the Board did **not** admit the Contention as a broad challenge to the adequacy of NextEra's monitoring, acceptance criteria, and inspection intervals on unlimited grounds. Rather, those aspects of the LAR are subject to challenge in this proceeding only to the extent they relate to the "key issue" of LSTP "representativeness," and are within the envelope of bases pled in C-10's original Petition.

23. Notably, the Board rejected a contention seeking to challenge NextEra's monitoring of rebar, reasoning that rebar monitoring is conducted under a separate program (*i.e.*, not part of the LAR) and thus not within the scope of this proceeding.[54] The Board also rejected C-10's demand that NextEra adopt C-10's preferred alternative approach to regulatory compliance and include "a methodology to test materials up to and beyond their point of failure."[55] Such arguments are inadmissible because, in licensing proceedings, the question before the NRC is whether the applicant's approach complies with regulatory requirements, not whether there exists some alternative or arguably better means of doing so.

24. The NRC conducted extensive oversight of NextEra's efforts to address ASR at Seabrook. In summary, from 2010 to 2018, the Staff oversight of NextEra's response to the Seabrook ASR issue involved thousands of direct inspection hours by NRC regional inspectors and headquarters structural experts over the course of 20 inspections specifically on the topic of

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53 *Seabrook*, LBP-17-7, 86 NRC at 127.

54 *Id*. at 133.

55 *Id*. at 134-35.

ASR. This included several inspections and an onsite audit, collectively around five weeks of onsite time, all of which occurred during the time period from 2013 to 2015.[56] These inspections observed, on a sampling basis, the setup of the program and the facilities, fabrication and concrete pour, and testing of the specimens.[57] The Staff also conducted five ASR-related onsite audits at Seabrook, four of which specifically reviewed the Seabrook ASR expansion monitoring program.[58]

25. On October 24, 2018, C-10 advised the parties that Dr. Victor Saouma, not Dr. Brown (whose comment letters C-10 cited as support for the original Petition) would be its witness at the evidentiary hearing.[59]

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56 NRC Staff Testimony of Angela Buford, Bryce Lehman, and George Thomas at A.10 (July 24, 2019) ("NRC Testimony") (NRC001-R).

57 *Id*. *See also* Letter from R. Lorson, NRC, to K. Walsh, "Seabrook Station, Unit No. 1 - Confirmatory Action Letter Follow-up Inspection - NRC Inspection Report 05000443/2012010" (Aug. 9, 2013) (NRC026); Letter from G. Dentel, NRC, to K. Walsh, NextEra, "Seabrook Station, Unit No. 1 - NRC Integrated Inspection Report 05000443/2013005" (Jan. 30, 2014) (NRC027); Letter from G. Dentel, NRC, to K. Walsh, NextEra, "Seabrook Station, Unit No. 1 - NRC Integrated Inspection Report 05000443/2014002" (May 6, 2014) (NRC028); Letter from G. Dentel, NRC, to D. Curtland, NextEra, "Seabrook Station, Unit No. 1 - NRC Integrated Inspection Report 05000443/2014005" (Feb. 6, 2015) (NRC030); and Letter from F. Bower, III, NRC, to D. Curtland, NextEra, "Seabrook Station, Unit No. 1 - NRC Integrated Inspection Report 05000443/2015004 and Independent Spent Fuel Storage Installation Report No. 07200063/2015001" (Feb. 12, 2016) (NRC032).

58 NRC Testimony at A10 (NRC001-R); *see also* Seabrook ASR-Monitoring Program Audit Report (Dec. 17, 2015) (NRC018); Letter from R. Plasse, NRC, to K. Walsh, NextEra, "Aging Management Program Audit Report Regarding the Seabrook Station License Renewal Application (TAC No. ME4028)" (Dec. 23, 2013) (NRC041); Letter from T. Tran, NRC, to E. McCartney, NextEra, "Alkali Silica Reaction Monitoring Aging Management Program Audit Report Regarding the Seabrook Station, Unit 1, License Renewal (CAC No. ME4028)" (Dec. 26, 2016) (NRC042); Letter from J. Poole, NRC, to M. Nazar, NextEra, "Seabrook Station, Unit No. 1 – Site Visit Report Regarding Regulatory Audit for License Amendment Request Re: Alkali-Silica Reaction License Amendment Request and License Renewal Alkali-Silica Reaction Aging Management Program Review (CAC No. MF8260; EPID L-2016-0007)" (July 26, 2017) (NRC043); and Letter from J. Poole, NRC, to M. Nazar, NextEra, "Seabrook Station, Unit No. 1 – Site Visit Report Regarding Alkali-Silica Reaction License Amendment Request and License Renewal Alkali-Silica Reaction Aging Management Program Review (CAC No. MF8260; EPID L-2016-LLA-0007)" (May 21, 2018) (NRC044).

59 Letter from N. Treat to P. Bessette and A. Ghosh, "Monthly Disclosure: Addition of expert Victor E. Saouma and request for access to protected information , Pursuant to 10 C.F.R. § 2.336; NextEra Energy Seabrook, LLC (Seabrook Station Unit 1), Docket No. 50-443-LA-2" (Oct. 24, 2018) (ML18297A149).

26. On December 14, 2018, the ACRS concluded its review of the LAR and issued the following conclusions:

- NextEra License Amendment Request 16-03 establishes a robust analytical methodology, supported by a comprehensive large scale test program, for the treatment and monitoring of alkali-silica reaction-affected seismic Category I structures at Seabrook.

- The NextEra License Renewal Application includes two new Aging Management Programs to monitor alkali-silica reaction and building deformation. These incorporate the test program results and license amendment request methodology and assure that the effects of alkali-silica reaction will be effectively tracked and evaluated through the end of the License Renewal Application period of extended operation.

- The staff safety evaluations of the license amendment request and alkali-silica reaction related Aging Management Programs in the License Renewal Application provide thorough assessments and findings. We agree with the staff's conclusion that NextEra's programs are acceptable.[60]

27. On March 11, 2019, the NRC Staff approved the LAR, and issued the license amendment and the Staff's final safety evaluation ("Final SE"), which concluded as follows:

> the proposed plant-specific method of evaluation for design evaluation of seismic Category I reinforced concrete structures affected by ASR at Seabrook is acceptable and provides reasonable assurance that these structures continue to meet the relevant requirements of 10 CFR Part 50, Appendix A, GDC [General Design Criteria] 1, 2, 4, 16 (Containment only) and 50 (Containment only), and 10 CFR Part 50, Appendix B.[61]

28. As noted above, NextEra revised and refined its LAR through various submissions to the NRC between the time it filed the Original LAR Package and the time the NRC issued the requested license amendment. Notably, C-10 never sought to amend its admitted Contention to challenge the updated methodology in the final version of the LAR, and

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[60] Letter from M. Corradini, Chairman, ACRS, to K. Svinicki, Chairman, NRC, "Seabrook Station Unit 1 License Renewal Application: Review of Licensee Program Addressing Alkali-Silica Reaction," (Dec. 14, 2018) (NRC048).

[61] Final SE (INT024 (NP), INT025 (P)).

never submitted a new contention seeking to challenge any information in the LAR Supplement or any of the RAI Responses.

29. On April 23, 2019, prior to the deadline for submission of written testimony, NextEra filed a motion *in limine* seeking to preemptively exclude testimony and exhibits related to the structure deformation monitoring portion of the LAR ("First MIL").[62] On June 7, 2019, the Board issued an order deferring its ruling on the First MIL until it had reviewed the evidentiary submissions.[63]

30. The parties filed written testimony and exhibits on June 10, 2019 (C-10 initial testimony), July 24, 2019 (NextEra and NRC Staff testimony), and August 24, 2019 (C-10 rebuttal testimony).[64]

31. On September 4, 2019, C-10 filed a motion for leave to submit "Supplemental Rebuttal" testimony.[65] The Board granted that motion on September 16, 2019, and invited NextEra and the NRC Staff to file their own responsive testimony.[66] The NRC Staff did so on September 20, 2019, as did NextEra on September 22, 2019.[67]

32. On September 9, 2019, after the submission of written testimony, NextEra filed a renewed and expanded motion *in limine* seeking to strike or exclude testimony and exhibits on a

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62 NextEra's Motion *in Limine* to Exclude Testimony and Exhibits Regarding Structure Deformation Monitoring (Apr. 23, 2019) (ML19114A076) ("First MIL").

63 ASLB, Order (Ruling on NextEra's Motion in Limine) (June 7, 2019) (unpublished) (ML19158A512) ("Order on First MIL").

64 Pursuant to the Board's invitation, NextEra and C-10 filed additional exhibits prior to the evidentiary hearing.

65 C-10 Research and Education Foundation's Motion for Leave to File Supplemental Rebuttal Testimony (Sept. 4, 2019) (ML19247D593).

66 ASLB Order (Granting C-10's Motion for Leave to File Supplemental Rebuttal Testimony) (Sept. 16, 2019) (ML19259B318).

67 Staff Testimony in Response to Exhibit INT030 (Sept. 20, 2019) (NRC090); Testimony of NextEra Witnesses John Simons, Christopher Bagley, Oguzhan Bayrak, and Edward Carley in Response to Exhibit INT030 (Sept. 22, 2019) (NER076).

range of topics ("Second MIL") that exceeded the scope of the admitted contention.[68] On September 20, 2019, the Board deferred ruling on the Second MIL until after the evidentiary hearing.[69]

33. The evidentiary hearing was held across four days between September 24-27, 2019, in Newburyport, Massachusetts.[70]

34. On September 30, 2019, C-10 filed a post-hearing motion seeking to compel NextEra to produce "mineralogy data" and requesting leave to submit supplemental testimony on that data ("Second Supplemental Testimony").[71] At the Board's request,[72] C-10 submitted a clarification of that request on October 28, 2019.[73] That clarification also included a motion for leave to submit further supplemental testimony on a Seabrook petrography document ("Third Supplemental Testimony").[74]

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68 NextEra's Motion in Limine to Strike or Exclude Portions of C-10's Testimony and Exhibits (Sept. 9, 2019) (ML19252B232) ("Second MIL").

69 ASLB Order (Deferring Ruling on NextEra's Second Motion in Limine) (Sept. 20, 2019) (unpublished) (ML19263E820) ("Order on Second MIL").

70 Tr. at 214-1203.

71 C-10 Research and Education Foundation's Motion to Compel Production of Mineralogy Data and Request for Opportunity to Submit Supplemental Written Testimony Regarding the Data (Sept. 30, 2019) (ML19272B325).

72 ASLB Memorandum (Request for Clarification) (Oct. 16, 2019) (ML19289D761).

73 C-10 Research and Education Foundation's Response to ASLB Memorandum and Motion to Submit Additional Exhibits Regarding Petrographic Observations and Analyses of ASR at Seabrook (Oct. 28, 2019) (Proprietary) (ML19301C924) (re-filed Oct. 30, 2019 as Non-Proprietary) (ML19304B352).

74 [As of the due date for submission of the FOF/COL, the Board had neither ruled on these motions nor closed the evidentiary record.]

III. APPLICABLE LEGAL AND REGULATORY STANDARDS

A. License Amendment Standards

35. Pursuant to 10 C.F.R. §§ 50.92 and 50.57(a)(3) and (6), to grant the LAR, the NRC must find that: (1) there is reasonable assurance that the health and safety of the public will not be endangered by operation of the plant as proposed in the LAR, (2) there is reasonable assurance that such activities will be conducted in compliance with the Commission's regulations, and (3) the issuance of the amendment will not be inimical to the common defense and security or to the health and safety of the public.

36. The LAR implicates GDC 1, 2, 4, 16, and 50, which are codified in 10 C.F.R. Part 50, Appendix A, and impose general criteria for the design of nuclear power plants on topics such as design bases for protection against natural phenomena, and the containment design basis. Also, the activities related to the changes proposed in the LAR are subject to the NRC's Quality Assurance ("QA") regulations in 10 C.F.R. Part 50, Appendix B. Notably, the Contention does not challenge the LAR's compliance with any of these requirements.

B. The Reasonable Assurance Standard

37. Longstanding Commission precedent makes clear that the reasonable assurance standard does not require an applicant to meet an "absolute" or "beyond a reasonable doubt" standard.[75] In other words, "reasonable assurance" is not synonymous with "absolute assurance." Likewise, reasonable assurance "is not susceptible to formalistic quantification (*i.e.*,

[75] *AmerGen Energy Co., LLC*, (Oyster Creek Nuclear Generating Station), CLI-09-7, 69 NRC 235, 262 n.142 (2009); *Commonwealth Edison Co.* (Zion Station, Units 1 & 2), ALAB-616, 12 NRC 419, 421 (1980); *N. Anna Envtl. Coal. v. NRC*, 533 F.2d 655, 667-68 (D.C. Cir. 1976) (rejecting the argument that reasonable assurance requires proof beyond a reasonable doubt and noting that the licensing board equated "reasonable assurance" with "a clear preponderance of the evidence").

95% confidence) or mechanistic application."[76] The NRC historically has interpreted "reasonable assurance" with the understanding that "some risks may be tolerated and something less than absolute protection is required."[77] As particularly relevant here, "[t]he mere casting of doubt" on some aspect of an application is legally insufficient "to defeat a finding of reasonable assurance."[78]

38. In applying the reasonable assurance standard, the Commission takes a case-by-case approach, exercising sound technical judgment and verifying the applicant's compliance with Commission regulations based on all relevant facts and circumstances[79] Importantly, an intervenor's demand for compliance with a standard *beyond* the reasonable assurance standard is legally unsustainable because "a licensing board cannot impose requirements that exceed those in the regulation[s]."[80] Furthermore, if an applicant's supporting analyses are "grounded on reasonable assumptions, data, techniques of analysis and interpretations," a finding of reasonable assurance can be made "even though other data and methods might have been used."[81] In other words, an intervenor's mere presentation of an alternative method of regulatory compliance is not sufficiently probative to demonstrate an alleged lack of reasonable assurance.

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76 *AmerGen Energy Co., LLC* (Oyster Creek Nuclear Generating Station), LBP-07-17, 66 NRC 327, 340 (2007), *aff'd* CLI-09-07, 69 NRC 235 (2009).

77 Memorandum from F. Brown to New Reactor Business Line, "Expectations for New Reactor Reviews" at 4 (Aug. 29, 2018) (ML18240A410).

78 *Private Fuel Storage, L.L.C.* (Indep. Spent Fuel Storage Installation), CLI-00-13, 52 NRC 23, 31 (2000) (citing *La. Energy Servs.* (Claiborne Enrichment Center), CLI-97-15, 46 NRC 297 (1997); *N. Atl. Energy Serv. Corp.* (Seabrook Station, Unit 1), CLI-99-6, 49 NRC 201, 222 (1999)).

79 *See Oyster Creek*, CLI-09-7, 69 NRC at 262-63, 262 n.143; *Entergy Nuclear Generation Co.* (Pilgrim Nuclear Power Station), CLI-10-14, 71 NRC 449, 465-66 (2010).

80 *Entergy Nuclear Operations, Inc.* (Palisades Nuclear Plant), CLI-15-22, 82 NRC 310, 317 (2015).

81 *Long Island Lighting Co.* (Shoreham Nuclear Power Station, Unit 1), LBP-88-13, 27 NRC 509, 548 (1988), *affirmed in part*, *vacated in part*, *remanded by* ALAB-905, 28 NRC 515 (1988). *Cf. Palisades*, CLI-15-22, 82 NRC at 317-18 (noting that there may be alternate or alternative methods by which a licensee can demonstrate reasonable assurance).

C. Burden of Proof

39. At the hearing stage, an intervenor has the initial "burden of going forward"; that is, it must provide sufficient, probative evidence to establish a *prima facie* case for the claims made in the admitted contention.[82] The mere admission of a contention does not satisfy this burden.[83] If (and only if) the intervenor establishes a *prima facie* case on a particular claim, then the burden shifts to the applicant to provide sufficient evidence to rebut the intervenor's contention.[84] To prevail, the applicant's position need only be supported by a preponderance of the evidence.[85]

40. At the admissibility stage, the petitioner has the "ironclad obligation" to examine the available documentation with sufficient care to support the foundation for a contention.[86] This obligation applies with equal, if not greater, force at the hearing stage.[87]

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82 *Oyster Creek*, CLI-09-07, 69 NRC at 269 (quoting *Consumers Power Co.* (Midland Plant, Units 1 & 2), ALAB-123, 6 AEC 331, 345 (1973) ("The ultimate burden of proof on the question of whether the permit or license should be issued is . . . upon the applicant. But where . . . one of the other parties contends that, for a specific reason . . . the permit or license should be denied, that party has the *burden of going forward* with evidence to buttress that contention. Once he has introduced sufficient evidence to establish a *prima facie* case, the burden then shifts to the applicant who, as part of his overall burden of proof, must provide a sufficient rebuttal to satisfy the Board that it should reject the contention as a basis for denial of the permit or license.") (emphasis in original)); *see also Vt. Yankee Nuclear Power Corp. v. Natural Res. Def. Council*, 435 U.S. 519, 554 (1978) (upholding this threshold test for intervenor participation in licensing proceedings); *Phila. Elec. Co.* (Limerick Generating Station, Units 1 & 2), ALAB-262, 1 NRC 163, 191 (1975) (holding that the intervenors had the burden of introducing evidence to demonstrate that the basis for their contention was more than theoretical).

83 *See Oyster Creek*, CLI-09-07, 69 NRC at 268-70.

84 *See, e.g., id*. at 269; *La. Power & Light Co.* (Waterford Steam Electric Station, Unit 3), ALAB-732, 17 NRC 1076, 1093 (1983) (citing *Midland*, ALAB-123, 6 AEC at 345); *see also* 10 C.F.R. § 2.325.

85 *See Pac. Gas & Elec. Co.* (Diablo Canyon Nuclear Power Plant, Units 1 and 2), ALAB-763, 19 NRC 571, 577; *Oyster Creek*, CLI-09-07, 69 NRC at 263.

86 *See Duke Power Co.* (Catawba Nuclear Station, Units 1 & 2), ALAB-687, 16 NRC 460, 468 (1982), *vacated in part on other grounds*, CLI-83-19, 17 NRC 1041 (1983).

87 *See Entergy Nuclear Operations, Inc.* (Indian Point Nuclear Generating Units 2 & 3), LBP-13-13, 78 NRC 246, 301 n.308 (2013) (rejecting an expert's claims based on "some averages" and a "gut feeling," rather than a thorough a review of available documentation).

D. Scope of Contentions and Motions *in Limine*

41. The evidentiary hearing is limited to the admitted Contention. And the "reach of a contention necessarily hinges upon its terms *coupled with* its stated bases."[88] Importantly, "an intervenor 'may not freely change the focus of an admitted contention at will' to add a host of new issues and objections that could have been raised at the outset."[89] Absent a formal amendment of the admitted contention, intervenors may only develop their admitted contentions *within the boundaries* of the bases pled in the original petition. 10 C.F.R. § 2.309(f)(1)(vi) has long been held to require petitioners to specify—at the petition stage—the *specific and identifiable portions* of the application that are being disputed.[90]

42. The Commission has consistently and explicitly held that intervenors may not unilaterally expand the scope of their admitted contentions at the hearing stage to challenge new *portions* of the application or raise new bases *outside* the boundaries of the bases as pled and admitted.[91] 10 C.F.R. § 2.337(a) provides that "[o]nly relevant, material, and reliable evidence which is not unduly repetitious will be admitted,"[92] and 10 C.F.R. § 2.319(e) empowers the Board to "[r]estrict irrelevant, immaterial, unreliable, duplicative or cumulative evidence and/or arguments" from the record. Although boards have considerable discretion in the conduct of

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88 *Entergy Nuclear Generation Co.* (Pilgrim Nuclear Power Station), CLI-10-11, 71 NRC 287, 309 (2010) (emphasis in original) (citing *Pub. Serv. Co. of N.H.* (Seabrook Station, Units 1 & 2), ALAB-899, 28 NRC 93, 97 (1988), *aff'd sub nom*. *Massachusetts v. NRC*, 924 F.2d 311 (D.C. Cir.), *cert. denied*, 502 U.S. 899 (1991).

89 Order on First MIL at 7 (citing *Duke Energy Corp.* (McGuire Nuclear Station, Units 1 & 2; Catawba Nuclear Station, Units 1 & 2), CLI-02-28, 56 NRC 373, 386 (2002)).

90 *Ga. Power Co., et al.* (Vogtle Electric Generating Plant, Units 1 & 2), CLI-93-16, 38 NRC 25, 41 (1993). *See also Yankee Atomic Elec. Co.* (Yankee Nuclear Power Station), CLI-05-15, 61 NRC 365, 381 (2005).

91 *See, e.g.*, *NextEra Energy Seabrook, LLC* (Seabrook Station, Unit 1), CLI-12-5, 75 NRC 301, 310 n.50 ("We remind our boards, however, of the need to specify each basis relied upon for admitting a contention. . . . Contrary to the Board's statement (LBP-11-2, 73 NRC at 56), an admitted contention is defined by its bases.").

92 *See also* 10 C.F.R. § 2.337(a) (providing that "[i]mmaterial or irrelevant parts of an admissible document will be segregated and excluded so far as is practicable").

evidentiary hearings, denials of motions *in limine* that result in hearings beyond the proper scope of the proceeding constitute reversible procedural error.[93]

43. This longstanding principle has been enshrined in numerous Commission adjudicatory decisions. For example, in *Vogtle*, the Commission upheld a Board ruling excluding testimony that strayed beyond the scope of the original contention and bases, as pled and admitted, noting that the limitations in the initial pleadings "defined the scope of the . . . contention."[94] Similarly, in *Pilgrim*, the Commission reiterated this longstanding precedent:

> NRC threshold contention standards require petitioners to review application materials and set forth their contentions "with particularity." *Where any issue arises over the proper scope of a contention, "NRC opinions have long referred back to the bases set forth in support of the contention." . . .* Our contention rules require "'reasonably specific factual and legal' allegations at the outset" to assure that matters admitted for hearing . . . *provide notice to opposing parties of the issues they will need to defend against*.[95]

44. Intervenors certainly are not required to prove their case, or even to provide an exhaustive list of possible bases, at the contention admissibility stage.[96] But, the Commission explicitly prohibits "distinctly new complaints to be added at will as litigation progresses,"[97] including new arguments or challenges by a newly retained expert.

45. For rebuttal testimony, the scope of permissible evidence and arguments is even more limited.[98] In essence, rebuttal evidence is that for which the need was entirely unforeseen.

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93 *See, e.g.*, *Entergy Nuclear Operations, Inc.* (Indian Point Nuclear Generating Units 2 & 3), CLI-15-6, 81 NRC 340, 377 (2015).

94 *S. Nuclear Operating Co.* (Early Site Permit for Vogtle ESP Site), CLI-10-5, 71 NRC 90, 100-02 (2010).

95 *Pilgrim*, CLI-10-11, 71 NRC at 308-09 (2010) (emphasis added and citations omitted).

96 *La. Energy Servs., LP* (National Enrichment Facility), CLI-04-35, 60 NRC 619, 623 (2004).

97 *Pilgrim*, CLI-10-11, 71 NRC at 309 (2010) (citation and internal quotation marks omitted).

98 *See, e.g., La. Energy Servs., L.P.* (National Enrichment Facility), LBP-06-15, 63 NRC 591, 620 (2006) (reciting the Board's action striking portions of prefiled rebuttal testimony "that fell outside the scope of any admitted contention and/or the permissible scope of rebuttal testimony").

Its purpose is simply "to permit a litigant to counter new, unforeseen facts brought out in the other side's case."[99] Thus, rebuttal evidence is admissible only insofar as it address matters which the party objectively *could not* have raised earlier. Fundamental fairness requires that rebuttal may not include arguments or information that reasonably should have been, but were not, raised in the party's case-in-chief.[100] Similarly, parties may not use rebuttal to add cumulative evidence to bolster their original case.[101] "[M]erely revisiting evidence earlier presented," but in "more detailed and comprehensive" fashion is impermissible in rebuttal.[102]

IV. FACTUAL FINDINGS AND LEGAL CONCLUSIONS

46. As briefly summarized below, a preponderance of the evidence explains that the LAR—together with substantial supporting information—demonstrates: reasonable assurance that the health and safety of the public will not be endangered, and authorized activities will be conducted in compliance with the Commission's regulations; issuance of the amendment is not inimical to the common defense and security; and all GDC have been satisfied, as required by 10 C.F.R. §§ 50.92, 50.57(a)(3) and (6), and Appendix A.

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99 *Faigin v. Kelly*, 184 F.3d 67, 85 (1st Cir. 1999).

100 *See, e.g., Progress Energy Fla., Inc.* (Combined License Application for Levy County Nuclear Power Plant, Units 1 and 2), LBP-09-22, 70 NRC 640, 655 (2009) ("Being in the nature of rebuttal, the response, rebuttal testimony, and rebuttal exhibits are not to advance any new affirmative claims or arguments that should have been, but were not, included in the party's previously filed initial written statement"); *see also Amergen Energy Co., LLC* (License Renewal for Oyster Creek Nuclear Generating Station), Licensing Board Order (Prehearing Conference Call Summary, Case Management Directives, and Final Scheduling Order) at 5-6 (Apr. 17, 2007) (ML071070437); *Dominion Nuclear N. Anna, LLC* (Early Site Permit for North Anna ESP Site), Licensing Board Order (Revised Scheduling Order) at 4 (Mar. 1, 2006) (ML060610623); *Rockwell Int'l Corp. Rocketdyne Div.* (Special Material License Number SNM-21), LBP-89-27, 30 NRC 265, 269 (1989) (permitting rebuttal testimony "only with respect to new or surprise material" included in the opposing party's submittals).

101 *See* 10 C.F.R. §§ 2.337(a) ("[o]nly . . . evidence which is not unduly repetitious will be admitted"); 2.319(e) (empowering the Board to "[r]estrict . . . duplicative or cumulative evidence and/or arguments" from the record).

102 *Cates v. Sears, Roebuck & Co.*, 928 F.2d 679, 685 (5th Cir. 1991).

A. Witnesses

(1) NextEra's Expert Witnesses

47. Two of NextEra's witnesses (Michael Collins and Edward Carley) are NextEra employees who work at Seabrook. Mr. Collins is the Director of Engineering for Seabrook and has more than 38 years of professional experience in the nuclear power industry.[103] Mr. Collins is responsible for the engineering management and technical oversight of ASR-related activities at Seabrook, and has extensive first-hand knowledge of the facility, the initial identification of ASR at the plant, the development of the LAR, and the execution of the SMP.

48. Mr. Carley is employed by NextEra as a Nuclear Engineering Supervisor for Seabrook.[104] He has more than 38 years of professional experience in the nuclear power industry. Mr. Carley oversaw NextEra's development and regulatory review of the LAR, including the development of the overall approach to the first-in-the-industry aging management program for ASR in the SMP.[105]

49. Two of NextEra's witnesses (John Simons and Christopher Bagley) work for MPR Associates, Inc. ("MPR"), a contractor to NextEra.[106] Mr. Simons works as General Manager of Projects and has extensive first-hand knowledge of NextEra's multi-year program to evaluate ASR at Seabrook, including the LSTP and the SMP.[107] He has more than 32 years of professional experience in the nuclear power industry, and is an author and contributor on numerous Electric Power Research Institute ("EPRI") reports and NUREG publications on

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103 Michael Collins Biography (NER006); MPR Testimony § I.A (NER001).

104 Edward Carley Resume (NER011); MPR Testimony § I.E (NER001).

105 MPR Testimony at A30 (NER001).

106 *See* John Simons *Curriculum Vitae* (NER008); Christopher Bagley *Curriculum Vitae* (NER009); MPR Testimony §§ I.B-C (NER001).

107 John Simons *Curriculum Vitae* (NER008); MPR Testimony § I.B (NER001).

engineering topics relevant to the nuclear industry, including aging management issues on concrete structures and large-scale testing. Mr. Simons' work included the development and conduct of the LSTP conducted at FSEL and the application of the LSTP results as inputs to NextEra's SMP.[108]

50. Mr. Bagley is a Supervisory Engineer at MPR and also has extensive first-hand knowledge of NextEra's multi-year program to evaluate ASR at Seabrook, including the LSTP and the SMP.[109] He has more than 15 years of professional experience in the nuclear power industry and served as an officer and engineer in the United States Navy's Naval Reactors Program. Mr. Bagley worked on the development and execution of the LSTP, the application of LSTP results to Seabrook, and the methodology for calculating past ASR expansion. Mr. Bagley has prepared reports for EPRI on addressing ASR in concrete at nuclear plants.[110]

51. Dr. Oguzhan Bayrak's professional and educational qualifications are summarized in his *curriculum vitae*.[111] Dr. Bayrak is a Distinguished Teaching Professor in the Civil, Architectural, and Environmental Engineering Department of the University of Texas' Cockrell School of Engineering. Dr. Bayrak was previously the Director of the FSEL at the University of Texas and held that position during the LSTP. He holds a Doctorate ("Ph.D.") in Civil Engineering from the University of Toronto and is a licensed Professional Engineer. Dr. Bayrak has more than 20 years of professional experience in structural engineering and focuses on the behavior, analysis, and design of reinforced and prestressed concrete structures, the evaluation of structures in distress, and earthquake engineering. Dr. Bayrak has over 13 years of

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108 MPR Testimony at A10-A11.

109 Christopher Bagley *Curriculum Vitae* (NER009); MPR Testimony § I.C (NER001).

110 MPR Testimony at A18.

111 Dr. Oguzhan Bayrak *Curriculum Vitae* (NER010); MPR Testimony § I.D (NER001).

experience related to ASR,[112] and has been published or presented over 200 times in technical journals, conference proceedings, books, technical reports, and other publications. He is a Fellow of the American Concrete Institute ("ACI") and serves on several technical committees including the Committee on Reinforced Concrete Columns and the Committee on Shear and Torsion. Dr. Bayrak is also a member of the Precast/Prestressed Concrete Institute ("PCI"). Dr. Bayrak is the chair for the Federation Internationale du Beton's ("*fib,*" also known as the International Federation for Structural Concrete) committee on shear, is the deputy chair for *fib*'s Commission 2, Analysis and Design of Concrete Structures, and serves on the editorial board of *Structural Concrete* (the official technical journal of *fib*). In addition to his work on the LSTP, Dr. Bayrak has supervised four ASR research projects, other than the LSTP; these included field assessments of ASR-affected concrete and fabrication of test specimens that experienced accelerated ASR progression.[113]

52. NextEra's final three witnesses (Dr. Said Bolourchi, Glenn Bell, and Matthew Sherman) are Senior Principals at Simpson Gumpertz & Heger Inc. ("SGH"), a contractor to NextEra, and all are licensed Professional Engineers in multiple states.[114] Dr. Bolourchi is a Senior Principal at SGH, and has extensive first-hand knowledge of the development of the LAR, and in particular the SEM.[115] He is the Principal-in-Charge for all SGH projects associated with the evaluation of seismic Category I structures at Seabrook, including oversight and supervision of the testing and petrography of Seabrook's cores, field measurements for structural evaluations, structural evaluations of Seabrook's structures under the SEM,

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112 Tr. at 267.

113 MPR Testimony at A22 (NER001).

114 SGH Testimony §§ I.A-C (NER004); Dr. Said Bolourchi *Curriculum Vitae* (NER031); Glenn Bell *Curriculum Vitae* (NER032); Matthew Sherman *Curriculum Vitae* (NER033).

115 Dr. Said Bolourchi *Curriculum Vitae* (NER031); SGH Testimony § I.A (NER004).

development of ASR loads and load factors, and development of structural monitoring parameters. He holds a Ph.D. from the Massachusetts Institute of Technology, and has more than 40 years of professional experience in the nuclear power industry. Dr. Bolourchi has extensive experience related to seismic evaluations of nuclear structures and non-linear modeling and analysis of highly-complex structural loading.[116]

53. Mr. Bell is a Senior Principal at SGH and has extensive first-hand knowledge of the development of the SEM. He has more than 44 years of professional experience in the structural engineering industry, and was the CEO of SGH from 1995 through 2016, and Chair of its Board of Directors from 2016 through 2018.[117] Mr. Bell supervised the development of the "ASR load factors" used in the SEM and the structural analysis of the Containment Building at Seabrook. He is also the President-Elect of the Structural Engineering Institute and a Board Trustee of the Institution of Structural Engineers.[118]

54. Mr. Sherman is a Senior Principal at SGH and has extensive first-hand knowledge of the development of the SEM. He has more than 25 years of professional experience in the civil/structural engineering industry with a focus on construction materials, repair/rehabilitation, and testing.[119] In his current position, he oversees the fieldwork, testing, and petrographic studies associated with the structural evaluation of Seabrook structures affected by ASR, including the application of proposed structural monitoring parameters and frequency of monitoring included as inputs to the SMP. Mr. Sherman is a Fellow of the ACI and the International Concrete Repair Institute ("ICRI"), and serves on several ACI committees

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116 Tr. at 363-64, 1105; SGH Testimony at A4-A6 (NER004).

117 Glenn Bell *Curriculum Vitae* (NER032); SGH Testimony §§ I.A-C (NER004).

118 Glenn Bell *Curriculum Vitae* (NER032); SGH Testimony at A10-A11 (NER004).

119 Matthew Sherman *Curriculum Vitae* (NER033); SGH Testimony § I.C (NER004).

including the Committee on Durability of Concrete and Design of Nuclear Structures. Mr. Sherman has worked on ASR-related structural engineering issues throughout his career.[120]

55. Based on the above, we conclude that NextEra's witnesses collectively are qualified through knowledge, skill, directly-relevant experience, training, and education to provide expert witness testimony on the topics of: (1) ASR; (2) structural engineering, testing and analysis; (3) nuclear regulation and licensing; (4) NextEra's LAR (including the LSTP, the SMP, and the SEM); (5) Seabrook's seismic Category I structures; (6) the NRC's oversight of NextEra's ASR-related activities and review of the LAR; and (7) consensus codes for structural evaluation.

(2) NRC Staff's Expert Witnesses

56. Ms. Angela Buford is a structural engineer in the Division of Engineering, Office of Nuclear Reactor Regulation ("NRR") at the NRC.[121] In that role, Ms. Buford is responsible for performing safety evaluations of NRC licensing requests and supporting the NRC's reactor oversight activities, including providing technical and regulatory expertise in the structural engineering area for inspection and enforcement activities. She has been involved in the review of ASR at Seabrook since 2010, including participation in various audits of the LSTP and inspections of Seabrook's seismic Category I structures. Ms. Buford is the primary author of the NRC Staff's safety evaluation report ("SER") for the Seabrook License Renewal Application ("LRA") and peer reviewed its safety evaluation ("SE") for the LAR.[122]

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120 Tr. at 329-30; SGH Testimony at A15-A17.

121 Statement of Professional Qualifications of Angela Buford (NRC002); NRC Testimony at A.1a, A.2a, A.3a (NRC001-R).

122 NRC Testimony at A.3a (NRC001-R).

57. Mr. Bryce Lehman is a structural engineer in the Division of Engineering, Office of NRR, at the NRC.[123] Mr. Lehman is responsible for performing safety evaluations of NRC licensing requests and supporting the NRC's reactor oversight activities, including providing technical and regulatory expertise in the structural engineering area for inspection and enforcement activities, and consensus codes and standards activities. He has been involved in the review of ASR at Seabrook since 2010, including participation in various audits of the LSTP and inspections of Seabrook's seismic Category I structures. Mr. Lehman is a co-author of the NRC Staff's safety evaluation ("SE") for the LAR.[124]

58. Mr. George Thomas is a senior structural engineer in the Division of Engineering, Office of NRR, at the NRC.[125] Mr. Thomas is responsible for performing safety evaluations of NRC licensing requests and supporting the NRC's reactor oversight activities, including providing technical and regulatory expertise in the structural engineering area for inspection and enforcement activities, and consensus codes and standards activities. He has been involved in the review of ASR at Seabrook since 2011, including participation in various audits of the LSTP and inspections of Seabrook's seismic Category I structures. Mr. Thomas is a co-author of the NRC Staff's safety evaluation ("SE") for the LAR.[126]

59. Mr. Jacob Philip is a senior geotechnical (civil) engineer in the Structural, Geotechnical, and Seismic Engineering Branch, Division of Engineering, Office of Nuclear

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123 Statement of Professional Qualifications of Bryce Lehman (NRC003); NRC Testimony at A.1b, A.2b, A.3b (NRC001-R).

124 NRC Testimony at A.3b (NRC001-R).

125 Statement of Professional Qualifications of George Thomas (NRC004); NRC Testimony at A.1c, A.2c, A.3c (NRC001-R).

126 NRC Testimony at A.3c (NRC001-R).

Regulatory Research ("RES"), at the NRC.[127] Mr. Philip is the project manager of the RES research project, "Structural Performance of Nuclear Power Plant (NPP) Concrete Structures Affected by Alkali Silica Reaction (ASR)" being conducted at the National Institute of Standards and Technology (NIST). He served as the primary reviewer for RES's independent review of the LAR, as requested by NRR.[128]

60. Based on the above, we conclude that the NRC Staff's witnesses collectively are qualified through knowledge, skill, directly-relevant experience, training, and education to provide expert witness testimony on the topics of: (1) ASR; (2) structural engineering, testing and analysis; (3) nuclear regulation and licensing; (4) NextEra's LAR (including the LSTP, the SMP, and the SEM); (5) Seabrook's seismic Category I structures; (6) the NRC's oversight of NextEra's ASR-related activities and review of the LAR; and (7) and consensus codes for structural evaluation.

(3) C-10's Expert Witness

61. Dr. Victor Saouma is a Professor of Civil Engineering at the University of Colorado in Boulder, the Managing Partner of consulting firm XElastica, LLC, and a Professeur des Universités in France.[129] He has conducted theoretical, numerical (deterministic/probabilistic, static/dynamic), and experimental (material and structural) research related to ASR, and developed his own predictive model. He has conducted research for various government agencies, and written peer-reviewed articles on various engineering topics, including

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127 Statement of Professional Qualifications of Jacob Philip (NRC006); NRC Staff Testimony of Jacob Philip at A.1-A.3 ("RES Testimony").

128 RES Testimony at A.2-A.3 (NRC005).

129 *Curriculum Vitae*, Dr. Victor E. Saouma (INT003); Pre-Filed Opening Testimony of Victor E. Saouma, Ph.D. Regarding Scientific Evaluation of NextEra's Aging Management Program for Alkali-Silica Reaction at the Seabrook Nuclear Power Plant, Submitted on Behalf of C-10 Research and Education Fund § A.1 ("Saouma Testimony") (INT001-R).

ASR. Dr. Saouma has provided consultation services related to fracture mechanics, and is the chair of a RILEM (also known as International Meeting of Laboratories and Experts of Materials, Construction Systems and Structures) committee on Diagnosis and Prognosis of ASR affected Structures.[130]

62. Based on the above, we conclude that C-10's witness is qualified through knowledge, skill, directly-relevant experience, training, and education to provide expert witness testimony on the topics of: (1) ASR; and (2) structural engineering, testing and analysis, *excluding* anchors and reinforcement anchorage. We find that Dr. Saouma disavowed any expertise related to anchors and reinforcement anchorage,[131] and is unfamiliar with NRC licensing and regulation.[132] We also find that Dr. Saouma has not demonstrated sufficient expertise or factual knowledge regarding Seabrook's seismic Category I structures (including their structural design and applicable codes, standards, and regulations), the LAR and its various components (*i.e.*, the LSTP, SMP, and SEM), or the NRC's oversight of NextEra's ASR-related activities and review of the LAR, because there exists no evidence in the record that he reviewed the majority of the documentation related thereto.[133] We further find that Dr. Saouma is not licensed for the practice of engineering anywhere in the United States (or elsewhere),[134] and therefore is not qualified to provide expert witness testimony on engineering practice.

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130 Saouma Testimony at A.3 (INT001-R).

131 Tr. at 674 (Dr. Saouma: "I confess full ignorance about anchors"); *id*. at 675 (Dr. Saouma noting he is not "in a position" to present any testimony to contradict NextEra's evidence regarding the LSTP anchor testing); *id*. at 435 (Dr. Bayrak noting that Dr. Saouma confirmed reinforcement anchorage was "outside his area of expertise"); *id*. at 266 & Tr. Corr. at 4 (Dr. Saouma: "I don't claim expertise on anchorage").

132 Tr. at 365-66 (C-10's counsel interrupting the evidentiary hearing to advise the Board that Dr. Saouma is unfamiliar with common NRC terminology, concepts, and acronyms).

133 Saouma Testimony § A.5 (INT001-R); Rebuttal Testimony of Victor E. Saouma, Ph.D Regarding Scientific Evaluation of NextEra's Aging Management Program for Alkali-Silica Reaction at the Seabrook Nuclear Power Plant § A.7 (Aug. 23, 2019) ("Saouma Rebuttal") (INT028).

134 Saouma Rebuttal § A.3 (INT028) ("I am not a licensed P[rofessional]E[ngineer]").

B. Technical Background on ASR and Structural Adequacy

63. The UFSAR for a nuclear power plant includes references to certain structural criteria, including industry consensus codes and standards, that specify means for determining and confirming the structural adequacy of structures for both existing structures[135] and the design of new structures. These codes, developed by consensus committees of leading structural engineering experts (*e.g.*, the ACI and ASME), are NRC-reviewed and endorsed, impose mandatory legal requirements on NextEra, contain inherent margins of conservatism, and have been proven to contain safe and conservative structural analysis methods and acceptance criteria based on decades of actual experience around the world.

64. Evaluations of structural adequacy under these codes and standards determine whether the "demands" (*i.e.*, load effects) on a structure exceed the "capacities" (*e.g.*, strength or stress limits) of the structure.[136] Methods of determining appropriate demands and capacities are likewise prescribed by the specific criteria, standards, and codes; and these methods typically include consideration of material properties.[137] There are many types of loads that may be specified in UFSARs for use in structural adequacy calculations. Examples are dead loads (the fixed weight of the structure), live loads (such as the time-varying weight of contents, *e.g.*, temporary storage of materials), wind, earthquake effects, and temperature effects.[138] However, these codes do not purport to include a prescriptive list of all loads that must be evaluated.[139]

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135 MPR Testimony at A31 (NER001); SGH Testimony at A36 (NER004); NRC Staff Testimony at A12 (NRC001-R).

136 SGH Testimony at A37 (NER004).

137 *Id*. At Seabrook, these methods are described in its UFSAR at Section 3.8.

138 *Id*. at A51.

139 Tr. at 577-79; 1004-05.

Rather, they anticipate that any additional loads (*i.e.*, those not explicitly enumerated in the minimum list of loads in the code equation) will be added as necessary.[140]

65. ASR is a chemical reaction that manifests over the course of many years (or decades) and occurs in concrete when particular silica-containing constituents of aggregate react with hydroxyl ions and alkali ions (*e.g.*, sodium, potassium) from the cement or another source (*e.g.*, salt).[141] The reaction produces an alkali-silicate gel that expands as it absorbs moisture, exerting tensile stress on the surrounding concrete and resulting in cracking.[142] The initial indication of ASR is usually the presence of pattern cracking on the concrete surface of the affected structure that prompts further evaluation.[143] In the case of ASR, this cracking is usually a network of very fine cracks that may appear to form a pattern or look like a map – hence the terms "pattern cracking" and "map cracking" as typical ASR symptoms.[144]

66. Because ASR produces cracking in concrete, it eventually causes degradation of its material properties when these properties are tested in typical small, unrestrained laboratory specimens or extracted cores.[145] However, in actual, larger, *reinforced* concrete, like that used at Seabrook, the embedded reinforcing bars resist ASR-caused expansion, which results in a "chemical prestressing effect."[146] This "chemical prestressing effect" produces a benefit to the

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140 *Id.*; Am. Concrete Inst. (ACI) Standard 318-71, Building Code Requirements for Reinforced Concrete §§ 8.21, 9.3.2, 9.3.7 (1970) ("ACI 318-71") (NRC049).

141 MPR Testimony at A65, A73 (NER001); NRC Testimony at A5, A8 (NRC001-R).

142 MPR Testimony A65 (NER001); *see also* MPR-4273 § 1.2.1 (July 2016) (INT019 (NP), INT021 (P)).

143 MPR Testimony at A72 (NER001); *see also* Inst. of Structural Engr's, Structural Effects of Alkali-Silica Reaction, § 6 at p. 19 (July 1992) ("ISE Guideline") (NER012) and U.S. Federal Highway Admin., Report on the Diagnosis, Prognosis, and Mitigation of Alkali-Silica Reaction (ASR) in Transportation Structures, FHWA-HIF-09-004, § 1 at p.1 (Jan. 2010) ("FHWA Guideline") (NER013).

144 MPR Testimony at A72 (NER001); ISE Guideline § 6 at p. 19 (NER012); FHWA Guideline § 1 at p. 1 (NER013).

145 MPR Testimony at A68 (NER001).

146 MPR Testimony at A68 (NER001); SGH Testimony at A54 (NER004).

structural performance of concrete in some limit states (*e.g.*, shear) and results in no degradation to others (*e.g.*, flexure, reinforcement anchorage)—until the concrete reaches an excessive level of ASR-related expansion.[147] In other words, the "chemical prestressing effect" causes the *structural performance* of ASR-affected reinforced concrete to be better than what one might expect if merely using the *material properties* of unrestrained ASR-affected concrete in calculations prescribed in existing consensus codes and standards.[148]

67. Furthermore, ASR-related expansion of restrained concrete can produce new demands (*i.e.*, "loads") on the structure.[149] Absent internal or external restraint, ASR expansion will cause concrete to expand freely, and no loads are developed. However, if the concrete is restrained internally (such as by reinforcing steel), the restraint will create *compressive* load in the concrete and *tension* in the reinforcement.[150] Likewise, when ASR-affected concrete is restrained externally (*e.g.*, by bedrock), compressive load will be generated in the ASR-expanded concrete and in the external restraining element.[151]

C. Motions *in Limine*

68. On September 9, 2019, pursuant to 10 C.F.R. §§ 2.1204, 2.319, 2.323, 2.337, and in accordance with the Board's Initial Scheduling Order,[152] NextEra filed the Second MIL, which timely moved to strike or exclude from the record portions of the testimony and exhibits

147 MPR Testimony at A68 (NER001).

148 *Id*.

149 MPR Testimony at A67 (NER001); SGH Testimony at A53 (NER004).

150 MPR Testimony at A68 (NER001); SGH Testimony at A54 (NER004).

151 SGH Testimony at A53 (NER004).

152 ASLB, Initial Scheduling Order (Nov. 29, 2017) (unpublished) (ML17333A981) ("ISO"). *See also* ASLB, Memorandum and Order (Revised Scheduling Order) at 2 n.9 (Feb. 15, 2018) (unpublished) (ML18046A985) (revising certain milestone dates but stating "[t]he remainder of the Initial Scheduling Order continues to be in effect").

offered by C-10 that are irrelevant, immaterial, unduly cumulative, beyond the scope of the Contention admitted by the Board in LBP-17-7, or beyond the permissible scope of rebuttal testimony.[153] NextEra also filed the First MIL on April 23, 2019.[154] The Board initially deferred ruling on both motions.[155] The Second MIL essentially expands upon, incorporates by reference, and supersedes arguments raised in the First MIL. Thus, the Board's ruling pertains to NextEra's Second MIL.

69. As explained further below, portions of C-10's Testimony and exhibits fail to present probative evidence relevant or material to the limited Contention being adjudicated in this proceeding. Thus, the Board grants NextEra's Second MIL and strikes from the evidentiary record those portions of the Testimony and exhibits listed below.

(1) Previously-Rejected Arguments and Extraneous Topics

70. Steel Corrosion: In proposed contention F, C-10 alleged that "elevated levels of salt . . . [have] likely created the conditions for corrosion of reinforcing steel."[156] In LBP-17-7, the Board rejected that argument and denied proposed contention F as outside the scope of the LAR because the corrosion degradation mechanism is covered by an entirely separate monitoring program at the plant.[157] However, C-10 has submitted testimony from Dr. Saouma which attempts to advance arguments regarding this excluded topic.[158] Because these statements

153 Second MIL.

154 First MIL.

155 Order on First MIL; Order on Second MIL.

156 Petition at 12.

157 *Seabrook*, LBP-17-7, 86 NRC at 132-33. *See also* Seabrook Structures Monitoring Program Manual, Rev. 7 at ch. 6 § 1.3 ("SMPM") (NER007).

158 Saouma Testimony at 21 (INT001-R); Rebuttal Testimony at 36 (INT028) (arguing NextEra should test for chloride concentration to monitor rebar corrosion).

simply reiterate the argument previously rejected by the Board, they are stricken from the record.[159]

71. "Point of Failure" and Alternative Means of Regulatory Compliance: In proposed contention G, C-10 argued that the LAR was deficient because it did not include "a methodology to test materials up to and beyond their point of failure."[160] But as the Commission has long recognized, a finding of reasonable assurance can be made "even though other data and methods might have been used."[161] Thus, the mere presentation of an alternative method of regulatory compliance is irrelevant to the question of whether the method presented by the *applicant* satisfies regulatory requirements. In LBP-17-7, the Board rejected C-10's impermissible "attempt to require the use of a specific methodology," and denied the proposed contention as immaterial to the findings the Staff must make to issue the amendment.[162] Nevertheless, C-10 presented testimony and exhibits for the purpose of arguing that NextEra should have used specific alternative methodologies, including the use of "accelerated testing" and predictive methodologies capable of identifying the "point of failure."[163] But these arguments already have been excluded from this proceeding, and therefore are irrelevant and

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159 Saouma Testimony at 21, last sentence, beginning "Because of the proximity . . ."; Rebuttal Testimony § D.8.3.

160 *Seabrook*, LBP-17-7, 86 NRC at 134 (citing Petition at 15).

161 *Shoreham*, LBP-88-13, 27 NRC at 548, *affirmed in part*, *vacated in part*, *remanded by* ALAB-905, 28 NRC 515 (1988). *Cf. Palisades*, CLI-15-22, 82 NRC at 317-18 (noting that there may be alternate or alternative methods by which a licensee can demonstrate reasonable assurance).

162 *Seabrook*, LBP-17-7, 86 NRC at 133-35.

163 *See, e.g.*, Saouma Testimony at 7 (INT001-R) (arguing that the LAR's analysis methodology is deficient because it does not "capture . . . the failure load" of ASR); *id*. at 29-30 (advocating the use of specific alternative methodologies, *e.g.*, abandoning code-based analysis in favor of probabilistic analysis, that purportedly could accomplish these Board-excluded objectives); *id*. at 31-35 (advocating alternative "steps" for addressing ASR at Seabrook in Section C.6); Tr. at 378-79 (Dr. Saouma arguing NextEra should use accelerated testing and predictive models to find the "ultimate expansion") ; V. Saouma, Review of Selected Documents Pertaining to the Structural Evaluation of Seabrook Nuclear Power Plant at 1, 9-19 (Feb. 12, 2019) ("EP Report") (INT031 (NP), INT007 (P)) (advocating alternative methods of analyses).

immaterial for the same reasons articulated by the Board in LBP-17-7, and are hereby stricken from the evidentiary record.[164]

72. License Renewal: C-10 presented evidence purporting to challenge the sufficiency of NextEra's LRA for Seabrook.[165] However, the Seabrook LRA is not at issue in this proceeding. Indeed, as the Commission noted in its recent decision rejecting C-10's Emergency Petition, C-10 already had a full and fair opportunity to raise ASR-related contentions in the license renewal proceeding but did not do so.[166] The Commission noted that, in order to offer new challenges regarding license renewal, C-10 would need to "submit a motion to reopen that proceeding,"[167] something C-10 also had a full and fair opportunity to, but did not, do. As a practical matter, C-10's concerns in this regard are addressed by the Commission's acknowledgement that "any changes resulting from the review of the LAR will be reflected in the license renewal aging management programs."[168] But as a matter of law, C-10's license renewal-related arguments cannot be addressed in this proceeding. Accordingly, that evidence is stricken from the record as irrelevant and immaterial.[169]

73. Emergency Petition: C-10 also presented arguments and documents from its Emergency Petition, which was rejected by the Commission. Notably, the Commission explicitly stated that the Emergency Petition "raises issues . . . that are beyond [the] scope [of

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164 Saouma Testimony §§ B.3, C.3.4.1.1, C.5, C.6, C.7, and C.8; Rebuttal Testimony at 9 (beginning with the first full sentence, "NextEra effectively . . ." through the end of the first full paragraph, ". . . used by NextEra") and §§ A.10, A.11, and A.14; EP Report at 1, sixth para. (beginning, "Of equal . . .") and §§ 5.2 and 6.

165 Saouma Testimony at 36 (INT001-R).

166 *NextEra Energy Seabrook, LLC* (Seabrook Station, Unit 1), CLI-19-7, 90 NRC __, __ (July 25, 2019) (slip op. at 2, 7) (ML19206A427).

167 *Id*. at __ (slip op. at 10-11).

168 *Id*. at __ (slip op. at 14) (citing Safety Evaluation Report Related to the License Renewal of Seabrook Station § 3.0.3.3.6 at 3-228 (Sept. 28, 2018) ("SER") (ML18362A370)).

169 Saouma Testimony at 9, second full para. (beginning "It is important . . .") and § C.10.

this LAR proceeding]."[170] Nevertheless, C-10 submitted as exhibits the full set of documents prepared by Dr. Saouma in support of the Emergency Petition, including his declaration (INT006), Emergency Petition Report ("EP Report") (INT007)(P) and non-proprietary EP Report summary (INT008), and reply declaration (INT009). But there is no discernable basis to import C-10's rejected arguments from the Emergency Petition into this proceeding. Moreover, the content of the EP Report is largely duplicative of Dr. Saouma's Testimony.[171] Thus, in addition to being irrelevant and immaterial, this information also is unduly repetitious, duplicative, and cumulative,[172] and is stricken from the record.[173]

74. Peer Review: In its testimony, C-10 raised an argument alleging NextEra failed to conduct an adequate "peer review."[174] But this is an entirely new[175] argument that could have been, but was not, raised at the outset of this proceeding.[176] This distinctly new argument—which is unrelated to the "representativeness" of the LSTP—was not included in the Contention, as pled and admitted, and therefore is stricken from the evidentiary record.[177]

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170 *Seabrook*, CLI-19-7, 90 NRC at __ (slip op. at 6-7).

171 *Compare* EP Report § 5.3 (INT007)(P) *with* Saouma Testimony § C.3.4.1 (INT001-R) (both containing nearly identical arguments purporting to challenge Rev. 0 of the structural evaluation for the Containment Enclosure Building ("Rev. 0 CEB Evaluation")).

172 *See* 10 C.F.R. §§ 2.337(a), 2.319(e).

173 Saouma Testimony § C.1 (INT001-R); Declaration of Dr. Victor E. Saouma, Ph.D (Feb. 12, 2019) (INT006), EP Report (INT008 (NP), INT007 (P)); Reply Declaration of Victor E. Saouma, Ph.D (Mar. 1, 2019) (INT009).

174 Saouma Testimony § C.9 (INT001-R).

175 Proposed contention E challenged NextEra's use of proprietary information, arguing it purportedly prevented an "independent assessment of the test results" and was "not good science" because "peer review" allows for scientific consensus. Petition at 11. Dr. Saouma's assertion is materially different, and therefore new. Nevertheless, even if the two arguments somehow could be viewed as related, Dr. Saouma's argument would be inadmissible because the Board rejected Proposed contention E altogether. *Seabrook*, LBP-17-7, 86 NRC at 131-32.

176 Moreover, if C-10 *had* raised this issue at the outset, it would have been rejected as immaterial (because there is no requirement for "peer review" in 10 C.F.R. Part 50) and as demonstrably unsupported given the evidence of various independent sources of input and review (*see supra* ¶ 18).

177 Saouma Testimony at 9, first para. (beginning, "I also have . . .") and § C.9; Rebuttal Testimony, § B.6.

(2) New Challenges to the LSTP

75. Expanded Bases Regarding LSTP Representativeness: In LBP-17-7, the Board found admissible a portion of Contention D challenging the "representativeness" of the concrete specimens tested in the LSTP as compared to the condition of Seabrook's concrete on the basis that Seabrook structures have existed for a long duration of time and have been subjected to environmental and operational conditions not replicated in the LSTP. More specifically, C-10 alleged non-representativeness due to the following characteristics: age; length of time ASR has propagated; exposure to fresh water at various levels; exposure to salt in the water at different levels and concentrations; the effects of heat; and the effects of radiation.[178] In simplified terms, the basis for the contention was the alleged contrast between an *older exposed structure* versus *newer test specimens*.

76. As noted above, C-10 proffered comment letters from Dr. Brown to support its original bases. At the hearing stage, C-10 instead relied on Dr. Saouma, whose testimony did not address the above list of age- and exposure-related characteristics. Instead, Dr. Saouma newly argued that the LSTP specimens were not representative of Seabrook due to alleged differences in (1) the LSTP's concrete mixture design, and (2) the LSTP's specimen scale and reinforcement design. In fact, C-10 originally recognized NextEra's "great effort" to obtain the appropriate "concrete mix," but noted that its concern was focused on something else altogether—the alleged lack of "clear definition for the level of 'representativeness'" to be obtained in the LSTP regarding its list of age- and exposure-related characteristics.[179]

178 *Seabrook*, CLI-18-4, 87 NRC at 104 (citing Petition at 11).

179 Petition at 9.

77. Although Dr. Saouma's new arguments are broadly related to the Contention's key subject of "representativeness," the Board is required by law to interpret contentions as being enveloped by their original bases.[180] The Commission has long held that intervenors may add additional bases *within* the envelope of the original bases as the proceeding progresses.[181] Thus, it would have been permissible for C-10 to proffer additional age- and exposure-related arguments, beyond the list in the original Petition. However, we find no evidence that Dr. Saouma's new arguments on aggregate selection and specimen scale (including reinforcement design) are related to the original basis for the contention—the allegedly unique *in situ* aging and exposure characteristics at Seabrook. Thus, the Board strikes these arguments[182] from the evidentiary record.[183]

78. New Challenges to LSTP Experimental Design: Likewise, Dr. Saouma raises a host of new issues and challenges related to the *design and execution* of the LSTP that could have been, but were not, raised at the outset of this proceeding. For example, he challenges the boundary conditions used in the LSTP, the lack of in-plane shear testing in the experimental design, and the alleged lack of discussion of cracking and load displacement in the test reports.[184] But the Board finds no evidence that these arguments on the experimental design of the testing program are related to the original basis for the contention—the allegedly unique *in situ* aging

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180 *Entergy Nuclear Generation Co.* (Pilgrim Nuclear Power Station), CLI-10-11, 71 NRC 287, 309 (2010) (citing *Seabrook*, ALAB-899, 28 NRC at 97 (1988), *aff'd sub nom*. *Massachusetts v. NRC*, 924 F.2d 311 (D.C. Cir.), *cert. denied*, 502 U.S. 899 (1991)).

181 *La. Energy Servs., LP* (National Enrichment Facility), CLI-04-35, 60 NRC 619, 623 (2004); *Duke Energy Corp.* CLI-02-28, 56 NRC at 379 (citations omitted).

182 Saouma Testimony §§ C.2.1, C.2.2 (INT001-R).

183 *Accord Fla. Power & Light Co.* (Turkey Point Units 6 & 7), Memorandum and Order (Ruling on Motions to Strike or Exclude) (Mar. 15, 2017) (ML17074A581) (striking new bases generally related to the admitted contention but outside the envelope of the original bases).

184 Notably, Dr. Saouma later withdrew his challenge regarding cracking and load displacement, noting he simply "missed" the appropriate information in the testing documentation. Tr. at 314.

and exposure characteristics at Seabrook. Thus, the Board strikes these arguments[185] from the evidentiary record.[186]

(3) New Challenges Regarding Seabrook Structural Evaluations

79. As explained in greater detail below in Section IV.F., the evidence shows that Seabrook's UFSAR specifies the method NextEra must use to evaluate the structural adequacy of seismic Category I structures at Seabrook (the "Structural Evaluations"). A Structural Evaluation compares the *demands* (*i.e.*, load effects) on a structure to the *capacities* (*e.g.*, strength or stress limits) of the structure to ensure the structure complies with the plant's licensing basis (*i.e.*, can continue to perform its intended safety function).[187] The LAR included a methodology for performing these Structural Evaluations on Seabrook's structures (*i.e.*, the SEM). The SEM employs Seabrook's existing codes (*i.e.*, no change from the existing UFSAR), and existing capacity values (*i.e.*, no change from the existing UFSAR), but uses demand values that consider new ASR loads and load factors calculated from field data at Seabrook (*i.e.*, a change to the existing UFSAR).[188] Notably, the evidence shows that no values from the LSTP are inputs to the Structural Evaluations.[189]

80. Dr. Saouma's original testimony challenged NextEra's treatment of ASR as a "load" on the structure, and its process for calculating those loads and load factors.[190] But the

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185 Saouma Testimony §§ C.2.2, C.2.3.1, C.2.3.2 (INT001-R).

186 *Accord Fla. Power & Light Co.* (Turkey Point Units 6 & 7), Memorandum and Order (Ruling on Motions to Strike or Exclude) (Mar. 15, 2017) (ML17074A581) (striking new bases generally related to the admitted contention but outside the envelope of the original bases).

187 MPR Testimony at A37 (NER001).

188 SGH Testimony at A57 (NER004).

189 *Id*. at A40.

190 Notably, Dr. Saouma later withdrew his challenge regarding the ASR loads and load factors, ultimately "salut[ing]" NextEra's development of this approach in conjunction with Dr. Ellingwood. Tr. at 440-41; Saouma Rebuttal § A.12 (INT028).

evidence demonstrates that SGH developed the approach of calculating ASR loads and load factors independent of the LSTP.[191] Thus, the loads and load factors would not be impacted either way by any alleged non-representativeness of the LSTP. As such, these arguments are irrelevant and immaterial to the admitted Contention. Accordingly, we strike these arguments as beyond the scope of the Contention.

81. The Board finds the evidence also shows that NextEra's decision to continue using original capacity values in the Structural Evaluations was at least partly driven by a conclusion from the LSTP that this approach was valid. Accordingly, we decline to strike C-10's challenge to the SEM's use of original capacity values, but *only* to the extent that challenge relates to the "representativeness" of the LSTP. C-10 presents *no evidence* that its broader theoretical challenge to NextEra's use of original capacity values—*i.e.*, arguing that this approach improperly conflates material properties and structural properties—somehow is related to the "representativeness" of the LSTP.[192] Accordingly, we strike those portions of C-10's challenge.

82. We also find that Dr. Saouma's criticisms of one specific Structural Evaluation—namely, the Rev. 0 CEB Evaluation[193]—are outside the scope of this proceeding. NextEra did not request approval of (and the NRC did not approve) any individual Structural Evaluations as part of the LAR. Thus, as a general matter, Dr. Saouma's criticisms are beyond the scope of the LAR and this proceeding. Furthermore, the Rev. 0 CEB Evaluation was subsequently updated by NextEra. Thus, C-10's challenges pertain to an outdated document, and C-10 presented no

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191 SGH Testimony at A40 (NER004).

192 The plain language of the Contention, by its own terms, makes clear that challenges to the LAR must purport to be the "result" of the alleged non-representativeness of the LSTP.

193 *See* Saouma Testimony § C.3.4.1 (INT001-R) (discussing Rev. 0 CEB Evaluation (INT015)).

evidence to demonstrate that its criticisms of the outdated document would be material to this proceeding *even if* the individual Structural Evaluations could be challenged here. Thus, these challenges also must be rejected as immaterial. And finally, Dr. Saouma's various criticisms of the Rev. 0 CEB Evaluation go well beyond the "representativeness" of the LSTP. For example, Dr. Saouma criticizes SGH's use of "shell elements," "thermal expansion" to simulate ASR expansion, and "section cuts" in the finite element model ("FEM") software, and the method of seismic evaluation (*i.e.*, "stick model") that is already specified in Seabrook's existing license.[194] But these aspects of the SEM are entirely unrelated to the "representativeness" of the LSTP. Thus, we strike Dr. Saouma's challenges to the Rev. 0 CEB Evaluation for this third reason.

(4) Impermissible Rebuttal

83. C-10's rebuttal testimony addressed numerous issues that could have been, but were not, raised in C-10's case-in-chief, or that otherwise expand on earlier arguments without purporting to "rebut" any evidence by NextEra or the NRC Staff. But parties may not unilaterally use rebuttal to add cumulative evidence to bolster their original case because the scope of proper rebuttal is narrow, and limited to actually "rebutting" new and unforeseeable arguments presented by the other parties.

84. More specifically, C-10's rebuttal supplied new information in rebuttal to bolster its initial testimony regarding Dr. Saouma's professional qualifications, relative humidity, and structural cracking, and a new "cancer" analogy.[195] The record shows that none of these arguments even purport to rebut NextEra's or NRC Staff's testimony. Thus, they are beyond the scope of permissible rebuttal and are stricken from the record.

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194 *Id*.

195 Saouma Rebuttal at §§ A.2, A.9, D.6, and D.7 (INT028).

85. Other portions of C-10's rebuttal purport to rebut certain quotes or statements in NextEra's or NRC Staff's testimony. But the record evidence in this proceeding demonstrates that those quotes and statements do not qualify as "unforeseen" arguments. Rather, they are simple summaries or restatements—sometimes verbatim—of information in the LAR or the NRC Staff's Safety Evaluation ("SE"), which have been available to C-10 for many months or years. C-10 offers no explanation why it could not have challenged the various features of the LAR, and conclusions in the SE, at that time. C-10's untimely challenges to these features and conclusions pertain to: Use of ACI 318-71 (Section B.4); Interim Assessment (Section D.1.1); Probabilistic Features in LAR (Section D.1.2); Load Testing (Section D.3.2); Seismic Response and Flexural Stiffness (Section D.4.2); Validation of Strain with Field Measurements (Section D.8.2); Corroboration Study and Empirical Correlation (Section D.9.1 and "Supplemental Rebuttal" (INT030); ASR Load Inputs (Section D.9.2); Design Basis Concrete Properties (Section D.9.3); and Seismic Uncertainty (Section D.9.4). We find that each of these arguments by C-10 could have been raised based on information available prior to its deadline for filing initial testimony, and that none of these arguments respond to an "unforeseeable" argument advanced by NextEra or NRC Staff in their testimony.[196] Accordingly, they are beyond the scope of permissible rebuttal and stricken from the proceeding.

D. <u>The LSTP</u>

86. NextEra deliberately designed the LSTP to provide test data on structural performance of large-scale test specimens that were more representative of concrete from

[196] A detailed chart correlating C-10's untimely rebuttal arguments to specific portions of the LAR or SE available to C-10 prior to its initial testimony deadline is found in the Second MIL at 29-31. We incorporate that chart here by reference.

Seabrook than data that were publicly available in the literature.[197] The LSTP specifically addressed selected limit states through testing programs for: (1) one-way shear (*i.e.*, beam shear), (2) reinforcement anchorage, and (3) anchor capacity.[198] Because monitoring through-thickness expansion was deemed necessary for long-term aging management of ASR-affected reinforced concrete at Seabrook, and no consensus technique for accomplishing through-thickness monitoring was available in industry guidance, a fourth testing program for evaluating and selecting instrumentation was added to the LSTP.[199]

87. The LSTP was performed at the FSEL of The University of Texas at Austin over a period of approximately four years.[200] The LSTP itself was performed due to the absence of large-scale test data related to the impact of ASR on highly reinforced concrete members. FSEL was selected because of its long history of world-class research using large-scale test specimens, its experience with concrete and degradation by ASR, and its experience with fabrication of concrete test specimens that develop ASR in an accelerated manner necessary for testing.[201] The development, execution, and review of the LSTP were supplemented by multiple non-NextEra personnel and organizations, as noted in paragraph 15, above.

88. MPR prepared test reports and documentation regarding the Commercial Grade Dedication efforts ("CGD," *i.e.*, the formal process based on NRC regulatory requirements for ensuring quality of services obtained from commercial suppliers for application at a nuclear

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197 MPR Testimony at A97 (NER001) (citing MPR-4273 §§. 1.2.2 & 2.3.4 (INT019-R (NP), INT021 (P)).

198 *Id*.

199 *Id*. Specific and extensive details regarding the four structural testing programs are provided in the record *id*. at A137-A142 (Shear Test Program); A143-A149 (Reinforcement Anchorage Test Program); A150-A155 (Anchor Test Program); A156-A157 (Instrumentation Test Program).

200 *Id*. at A98. *See also* Final SE at §3.1.2 (INT024 (NP), INT025 (P)).

201 MPR Testimony at A98 (NER001).

plant)[202] throughout the course of the LSTP.[203] Table 1 below summarizes these various reports, the total page count of which is approximately 24,000 pages.[204] To distill this information into a format that was more readily usable, MPR prepared MPR-4273 (INT019 (NP), INT021(P)) and MPR-4288 (INT012 (NP), INT014(P)), which summarize the LSTP, its conclusions, and the implications for Seabrook.

Table 1. Summary of MPR Reports for LSTP

<table>
<tr><th>Test Program</th><th>Test Reports</th><th>CGD Reports</th></tr>
<tr><td>Anchor</td><td>MPR-3722</td><td>MPR-3726
MPR-4247
MPR-4286</td></tr>
<tr><td>Shear</td><td rowspan="2">MPR-4262</td><td rowspan="3">MPR-4259
MPR-4286</td></tr>
<tr><td>Reinforcement Anchorage</td></tr>
<tr><td>Instrumentation</td><td>MPR-4231</td></tr>
</table>

89. The various test programs in the LSTP were designed—from the outset—with representativeness to Seabrook concrete in mind. The LSTP explicitly endeavored to, and did, satisfy representativeness objectives including:

- Large specimen size to represent the scale of structures at Seabrook;[205]
- Experimental design that is accepted by the concrete industry in, and as the basis for, published Codes and consistent with the design basis of Seabrook;[206]

202 *Id*. at A100.

203 *Id*. at A99.

204 *Id*.

205 *Id*. at A102-A105; Tr. at 635-36.

206 MPR Testimony at A106-A108 (NER001).

- Specimen design that uses a reinforcement configuration and concrete mixture design that sufficiently reflects reinforced concrete structures at Seabrook;[207] and

- Presence of ASR to an extent that is consistent with levels currently observed at Seabrook and at levels that could be observed in the future.[208]

90. Each of the four test programs were governed by a written and approved Test Specification that included provisions to ensure the objectives described above were achieved.[209] And critical characteristics of the test specimens and setup necessary to ensure satisfaction of the representativeness objectives were evaluated as part of CGD activities.[210]

91. The test reports[211] provide technical justifications for representativeness of the specimens; and critical characteristics were included in the commercial grade acceptance plans for the test programs.[212] As documented therein, all parameters met the acceptance criteria, which supported the ultimate conclusion that the test specimens were sufficiently representative of Seabrook in order to meet the established purposes of the LSTP.[213]

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207 *Id*. at A109-A114; Tr. at 635.

208 MPR Testimony at A115-125 (NER001).

209 *Id*. at A101. The test specifications are included as appendices in the respective test reports: *See* MPR-3722, Rev. 2, "Strength Testing of Anchors in Concrete Affected by Alkali-Silica Reaction" (Jan. 2016) (FP100718, Rev. 1) ("MPR-3722") (NER023); MPR-4262, "Shear and Reinforcement Anchorage Testing of Concreted Affected by Alkali-Silica Reaction," Vol. I, Rev. 1 (July 2016) & Vol. II, Rev. 0 (Jan. 2016) (FP100994) ("MPR-4262") (NER022-R); and MPR-4231, Rev. 0, "Instrumentation for Measuring Expansion in Concrete Affected by Alkali-Silica Reaction" (Oct. 2015) (FP100972) ("MPR-4231") (NER021).

210 MPR Testimony at A99, A100, A101 (NER001).

211 MPR-3722 (NER023); MPR-4262 (NER022-R); MPR-4231 (NER021).

212 MPR-4259, Commercial Grade Dedication Report of Seabrook ASR Shear, Reinforcement Anchorage and Instrumentation Testing" App. B (Jan. 2016) ("MPR-4259") (NER025-R); MPR-4247, Rev. 0, "Commercial Grade Dedication Report for Seabrook ASR Anchor Testing (Block Series and Girder Series Phase 2)" App. B (Dec. 2015) (FP100986) ("MPR-4247") (NER024); MPR-4286, Rev. 0, "Supplemental Commercial Grade Dedication Report for Seabrook ASR Test Programs" (Mar. 2016) App. B (FP101003) ("MPR-4286") (NER045).

213 *Id*.

92. Multiple methods were used to characterize ASR development in the test specimens including:

- expansion monitoring by physical measurements of the specimens (*e.g.*, crack width summation, embedded rods);
- material property testing of cores removed from the specimens; and
- petrographic examinations of cores removed from the test specimens.[214]

93. Ultimately, NextEra identified expansion monitoring as the appropriate parameter for correlating the LSTP results to Seabrook, consistent with the approach advocated by industry guidance, as discussed in MPR-3848.[215] Expansion monitoring, as used in the LAR methodology, entails collection of measurements for in-plane expansion (*e.g.*, crack-width measurements) and through-thickness expansion (*i.e.*, extensometer measurements) for monitoring against acceptance criteria for in-plane, through-thickness, and volumetric expansion. This approach is objectively reasonable because expansion is the parameter of interest for the aging effect in question—structural performance of ASR-affected structures.[216] Expansion monitoring is also a practical solution for implementation in a nuclear power plant, given the number, variety and large dimensions of the affected or potentially-affected concrete structures.[217] Furthermore, as indicated by the LSTP, crack width indexing and extensometers provide reliable and accurate measures of in-plane and through-thickness expansion; and the combination of these values provide a reliable and accurate measure of volumetric expansion.[218]

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214 MPR Testimony at A126; *see also* MPR-4273 § 4.1 (INT019 (NP), INT021 (P)).

215 MPR Testimony at A126 (NER001); *see also* MPR-3848 § 2.2.2. (NER015).

216 MPR Testimony at A126 (NER001).

217 *Id*.

218 *Id*. at A130, A170, A177, A217, A222 (NER001).

94. The LSTP demonstrated that the specified material properties of concrete from the original design calculations may be used to calculate the capacity of selected limit states (*i.e.*, flexural and shear capacities and anchorage of reinforcing bars) of ASR-affected structures using the existing design codes specified in the UFSAR, provided that observed and monitored expansion at Seabrook is below the levels of expansion witnessed during the LSTP (*i.e.*, the Expansion Monitoring Limits). NextEra monitors Seabrook's structures against these Expansion Monitoring Limits through implementation of a comprehensive and robust SMP.[219]

95. We find that a preponderance of the evidence demonstrates that the LSTP yielded data that are appropriate for use to represent the structural performance of the ASR-affected concrete structures at Seabrook, and that reasonable assurance exists for the NRC Staff to grant the LAR. Furthermore, as explained below, we find that C-10's criticisms of the LSTP do not defeat a finding of reasonable assurance.

96. Notably, C-10 only presented probative evidence purporting to challenge one of the four testing programs performed as part of the LSTP: namely, the "shear" (aka one-way shear or beam shear) program. C-10's expert explicitly acknowledged that he was not qualified to testify in the areas of reinforcement anchorage and anchor capacity.[220] And C-10's expert was not aware of the existence of the instrumentation testing program,[221] and therefore did not provide any testimony purporting to counter NextEra's evidence regarding the sufficiency of that

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219 *Id*. at A138.

220 Tr. at 674 (Dr. Saouma: "I confess full ignorance about anchors"); *id*. at 675 (Dr. Saouma noting he is not "in a position" to present any testimony to contradict NextEra's evidence regarding the LSTP anchor testing); *id*. at 435 (Dr. Bayrak noting that Dr. Saouma confirmed reinforcement anchorage was "outside his area of expertise"); *id*. at 266 & Tr. Corr. at 4 (Dr. Saouma: "I don't claim expertise on anchorage").

221 Tr. at 1042 (Dr. Saouma suggesting extensometers had been "deployed in the field" at Seabrook without first having been "tested and validated in the laboratory"); *id*. at 1043 (Mr. Simons describing the instrumentation testing program and confirming Judge Trikouros's statement that "extensometers were verified in the test program"); MPR-4231 (NER021).

program. Thus, the preponderance of—and indeed only—probative record evidence demonstrates that the other three testing programs (*i.e.*, reinforcement anchorage, anchor capacity, and instrumentation) yielded data that are appropriate for use to represent ASR-affected concrete at Seabrook, and that reasonable assurance exists as to these program elements.

97. Additionally, C-10 did not purport to challenge the appropriateness of NextEra's representativeness objectives detailed above, or the LSTP's satisfaction thereof under a formal nuclear QA program.[222] Indeed, C-10's expert acknowledged that a reasonable reviewer *could* view the LSTP as being representative of Seabrook based on NextEra's approach.[223] However, C-10's expert also acknowledged that he is particularly "finicky," and that his subjective standard for representativeness is at the far "end of the spectrum."[224] Thus, to satisfy his personal standard, C-10's expert argued that NextEra should have selected and satisfied *additional* representativeness parameters.[225] But C-10 presented no evidence to reconcile its expert's admittedly "finicky" standard with the legal standard applicable to the LAR in this proceeding—the reasonable assurance standard. As noted above, the reasonable assurance standard does not require an applicant to meet an "absolute" or "beyond a reasonable doubt" standard,[226] and has long been interpreted to acknowledge that "some risks may be tolerated and something less than absolute protection is required."[227]

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222 *See generally* MPR Testimony at A197 (NER001).

223 Tr. at 979-80 (Dr. Saouma agreeing that these parameters of representativeness in the LSTP were "fine").

224 *Id*. at 989.

225 *Id*. at 979-80 (Dr. Saouma agreeing that these parameters of representativeness in the LSTP were "fine").

226 *Oyster Creek*, CLI-09-7, 69 NRC at 262 n.142; *Zion Station*, ALAB-616, 12 NRC at 421; *N. Anna Envtl. Coal.*, 533 F.2d at 667-68 (rejecting the argument that reasonable assurance requires proof beyond a reasonable doubt and noting that the licensing board equated "reasonable assurance" with "a clear preponderance of the evidence").

227 Memorandum from F. Brown to New Reactor Business Line, "Expectations for New Reactor Reviews" at 4 (Aug. 29, 2018) (ML18240A410).

98. In LBP-17-7, the Board found admissible a portion of Contention D challenging the representativeness of data from the LSTP because it allegedly fails to account for the condition of Seabrook concrete due to the following aging and environmental factors:

- age;
- length of time ASR has been propagated;
- exposure to fresh water at various levels;
- exposure to salt in the water at different levels and concentrations;
- the effects of heat; and
- the effects of radiation.[228]

Although C-10 presented evidence purporting to challenge the representativeness of the LSTP data on *other* grounds, it presented no record evidence regarding these specific aging and environmental factors. Thus, we conclude that C-10 failed to satisfy its burden of going forward on the Contention, as defined by its original bases. In fact, the only evidence presented in this proceeding regarding the original bases for the Contention is that of NextEra.[229] Thus, even if C-10 had met its burden of going forward, NextEra's position is supported by the preponderance of—and indeed the only—evidence on these issues.

(1) Concrete Mixture Design

99. As noted above, the Board has concluded that the LSTP concrete mixture design was not one of the aging and environmental parameters challenged in the original Contention, and thus C-10's arguments on this topic are outside the scope of this proceeding. Nevertheless, even if those arguments were within scope, a preponderance of the evidence demonstrates that NextEra's approach to LSTP concrete mixture design provides reasonable assurance that the LSTP yielded data appropriate for use in the LAR.

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228 *Seabrook*, CLI-18-4, 87 NRC at 104 (citing LBP-17-7, 86 NRC at 113 (Petition at 11)).

229 MPR Testimony at A224-A235 (NER001).

100. NextEra's evidence shows that the critical characteristics identified in the LSTP for the concrete mixture design to establish representativeness to the plant were compressive strength, cement type, constituent proportions (*e.g.*, ratio of water to cement, aggregate proportions), coarse aggregate size, coarse aggregate surface roughness, and ratio of coarse aggregate to fine aggregate.[230] As explained further below, C-10 contends that NextEra's concrete mixture design is not representative because (a) NextEra also should have considered aggregate chemical mineralogy a critical characteristic, and (b) NextEra's acceptance criteria for LSTP specimen compressive strength were flawed.

101. In Section C.2.1 of his testimony, Dr. Saouma claims that the LSTP specimens were not representative of Seabrook because it was not established that "the aggregate used in the tests were identical to what was used at Seabrook."[231] As a practical matter, the Board notes that the use of "identical" aggregate was not possible because the quarry from which the aggregate was obtained for Seabrook is no longer operating.[232] As the evidence further demonstrates, even if the quarry were still open, the rock layers that are available today would likely have a different composition than what was accessible several decades ago.[233] More importantly, Dr. Saouma did not reference any industry or consensus standards—or any other evidence—requiring such replication.

102. At the evidentiary hearing, Dr. Saouma explained that his specific concern pertained to the "mineralogy" of the aggregate, which he broke into two subparts: physical and

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230 *See* MPR-4262 at 4-7 tbl.4-3 (NER022-R); MPR-4259, app. B at B-9 to B-13 (NER025-R).

231 Saouma Testimony § C.2.1 (INT001-R).

232 MPR Testimony at A119, A198 (NER001).

233 *Id*.

chemical.[234] By the end of the evidentiary hearing, Dr. Saouma agreed with NextEra that the physical aspects of the LSTP coarse aggregates (*e.g.*, size, roughness, ratio) were representative of Seabrook—remarking that there was a "very strong similarity" among the aggregates.[235] Thus, we find that the evidence demonstrates that the physical properties of the LSTP aggregates are appropriately representative of Seabrook.

103. NextEra explained that chemical mineralogy was not a critical representativeness parameter for the LSTP.[236] Consistent with available industry guidance and academic literature (which does not differentiate ASR on the basis of gel chemistry),[237] NextEra neither relies on nor credits in its methodology any alleged representativeness of ASR gel chemistry. And even if it were possible to exactly replicate Seabrook's concrete mixture design, meaningful expansion would not occur in a useful timeframe. Thus, NextEra explicitly designed the LSTP specimens to have aggregate that is *more* reactive than Seabrook to ensure they would expand reasonably quickly (*i.e.* faster than Seabrook) and thus experience a bounding level of expansion.[238] As part of planning for the LSTP, FSEL conducted trial batching and reactivity testing of a variety of concrete mixture designs.[239] These tests demonstrated that, regardless of the reactivity of the coarse aggregate, use of nonreactive fine aggregate (like the concrete at Seabrook) would not produce substantial ASR expansion in a reasonable timeframe and therefore would not be useful

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234 *See, e.g.*, Tr. at 1082-83 (explaining that he reviewed the physical mineralogy information (e.g., "gradation") in NextEra's exhibits and was satisfied with that information, but that he further wanted to review chemical mineralogy information to understand the "type of gel").

235 Tr. at 1074.

236 MPR Testimony at A117-A118 (NER001); Tr. at 642 (Dr. Bayrak: "we're not aiming to model the chemical reaction. This was never an intent").

237 *See, e.g.*, MPR Testimony at A118 (NER001) (noting that "published technical reports on structural testing of ASR-affected concrete typically relate structural performance to expansion level, rather than a particular chemical constituent of the ASR gel").

238 Tr. at 644.

239 MPR-4262 § 4.3 (NER022-R).

for the LSTP.[240] Blending highly reactive coarse aggregate and slow reacting coarse aggregate with highly reactive fine aggregate (aka "sand") was necessary to have a representative (with respect to structural performance) concrete mixture that would develop large ASR expansions in a timely fashion. C-10 did not challenge NextEra's evidence in this regard.[241]

104. Dr. Saouma, however, contends that NextEra should have deemed chemical mineralogy to be a critical representativeness characteristic for the LSTP. Dr. Saouma's argument is that chemical mineralogy influences ASR gel type, which in turn affects the cracking pattern. According to Dr. Saouma, the crack pattern is different if ASR expansion is driven by the sand (which he asserted was the case in the LSTP) versus the coarse aggregate (which he asserted was the case at Seabrook), because expansion driven by sand produces smaller cracks which could be undetectable.[242] But when questioned at the evidentiary hearing regarding his basis for asserting that the expansion driver was different between the LSTP and Seabrook (and therefore not representative), Dr. Saouma admitted that it was nothing more than "speculation."[243] But the Board does not find unsupported speculation persuasive.

105. Furthermore, even if Dr. Saouma is correct that the LSTP specimens experienced smaller cracks (because expansion in the LSTP specimens was driven more by the sand than the coarse aggregate), we see no reason this would render the LSTP results inadequate. It would simply mean that Seabrook's coarse-aggregate-driven[244] cracks will be larger (and more easily

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240 MPR Testimony at A198 (NER001).

241 Dr. Saouma did not review MPR-4262 (NER022-R). *See* Saouma Testimony § A.5 (INT001-R) (listing the materials Dr. Saouma reviewed for the hearing, but excluding MPR-4262).

242 Tr. at 604, 1001-02.

243 Tr. at 605 (Judge Spritzer: "What is the basis for your saying that the aggregate is more important than the sand at Seabrook?" Dr. Saouma: "That's a speculation.")

244 Tr. at 604 (Dr. Saouma: "I believe that, at Seabrook, it's mostly the aggregate and not the sand which is the primary driving force").

detectible), and that the LSTP results were conservative because, for the same measured crack width index, there could be more degradation in the LSTP specimens (due to allegedly-unobserved small cracks) than in concrete measured in the field at Seabrook.

106. Dr. Saouma also provided contradictory testimony as to whether chemical mineralogy (*i.e.*, ASR gel type) truly is a "critical" parameter for representativeness. More specifically, Dr. Saouma testified that it is entirely acceptable, appropriate, and commonplace to *alter* ASR gel chemistry to accelerate expansion.[245] In other words, Dr. Saouma acknowledges that ASR gel chemistry representativeness can be "ignore[d]" if the purpose of the alteration is to accelerate expansion.[246] Indeed, Dr. Saouma has done so in his own research.[247]

107. Furthermore, matching the LSTP ASR gel chemistry exactly with the reference location at Seabrook would have rendered the concrete mixture as slow reacting as Seabrook concrete. This result would be incompatible with NextEra's need to obtain timely and useful test data to develop an ASR program at a currently-operating nuclear power plant. Ultimately, expansions resulting from ASR (and cracking due to those expansions) are the primary concern with respect to structural performance. To that end, we find that the LSTP specimens are appropriately representative.

108. The Board finds that a preponderance of the evidence demonstrates that chemical mineralogy is not a "critical" parameter for representativeness, and that the use of a faster-reacting concrete mix (which purposefully does not yield a representative *rate* of expansion) is

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245 Tr. at 1008.

246 *Id.*

247 Saouma, V. "Experimental and Numerical Investigation of Alkali Silica Reaction in Nuclear Reactors" at 6 (Dec. 2017) (INT005) ("…to enhance the reaction, cement with a high natural alkalinity was selected and then the alkalinity was further raised by adding sodium hydroxide").

common and necessary for accelerated ASR testing, and neither compromises the applicability of the LSTP data to Seabrook nor defeats a finding of reasonable assurance.

109. As to compressive strength, NextEra's evidence demonstrates that the 28-day compressive strength of the reference location (*i.e.*, the B Electrical Tunnel) was approximately 5,500 psi.[248] To promote representativeness, the LSTP established compressive strength acceptance criteria for the test specimens in the range of 3,000 to 7,000 psi, which is consistent with the industry definition for "normal strength" concrete.[249] NextEra's evidence shows that this range was chosen based on both the target compressive strength of the reference location, and also on important overarching *behavioral* differences in concrete above and below these particular thresholds. Below 3,000 psi, concrete is not considered "structural" concrete, but is more akin to "sidewalk" concrete.[250] And above 7,000 psi, concrete would be considered "high-strength" concrete, which can present different (and non-representative) failure modes than "normal strength" concrete.[251] The compressive strength acceptance range for the LSTP provides margin at either end to ensure behavior is consistent with "normal strength" concrete.[252]

110. Dr. Saouma's criticism is that the acceptance range of 3,000 to 7,000 psi is a "huge" range of compressive strengths, which creates a potential "source[] of error" in the LSTP results.[253] But Dr. Saouma's criticism that the acceptance range is too broad is inconsistent with the intended purpose of this criterion, which is discussed above and in MPR-3757. Further, as a

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248 *See* MPR-3757, Rev. 4, "Shear and Reinforcement Anchorage Test Specimen Technical Evaluation" at 3-2 tbl.3-1 (May 2014) (FP100760) ("MPR-3757") (NER026) (NER026).

249 MPR Testimony at A115 (NER001).

250 Tr. at 598; MPR Testimony at A115 (NER001).

251 Tr. at 597-98; MPR Testimony at A115 (NER001).

252 MPR-3757, Section 3.2.1 (NER026).

253 Tr. at 515.

practical matter, the evidence shows that the compressive strengths of the LSTP shear specimens were between approximately 4,100 and 4,800 psi, and Seabrook's structures are between approximately 4,200 and 6,000 psi—in other words, in the middle of the acceptance range.[254] Therefore, the range of actual compressive strengths was significantly narrower than the acceptance range, and none of the specimens or structures are remotely close to either extreme end of the acceptance range. Furthermore, the test results were normalized by compressive strength *to account for the differences* in compressive strength between the specimens.[255]

111. NextEra's evidence also shows that the purpose of the LSTP's shear testing was to evaluate the code expression for concrete contribution to shear strength; and that the applicability of the code expression itself, is *not sensitive to differences* in compressive strengths in the LSTP's acceptance range.[256] Specifically, Dr. Bayrak testified that the industry-accepted code expression widely used for calculating shear strength is applicable for a range of compressive strengths even "broader" than the LSTP's range of 3,000 to 7,000 psi.[257] Dr. Saouma did not challenge NextEra's conclusion in this regard.[258] Thus, the preponderance of the evidence shows that compressive strengths within the LSTP's range do not introduce a "source of error" into the calculation of the shear strength using the relevant Code expression.

112. Dr. Saouma argues that, if concrete of a specific numerical strength exists at Seabrook, and concrete of an *identical* numerical strength was not tested in the LSTP, then the testing is "not representative in the full sense of the term."[259] But we find that replication for its

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254 *Id*. at 596-99.

255 MPR-4273 §§ 5.1.2, 5.2.2 (INT019-R (NP), (INT021)(P)).

256 Tr. at 599.

257 *Id*. at 599-600.

258 *Id*. at 600 ("one can argue that it doesn't affect the shear strength. That's open for debate.")

259 *Id*.

own sake (*i.e.*, "in the full sense of the term") is not a requirement in any accepted code, standard or regulation to demonstrate reasonable assurance.

(2) Specimen Scale and Reinforcement Configuration

113. As noted above, the Board has concluded that LSTP specimen scaling was not one of the aging and environmental parameters challenged in the original Contention, and thus C-10's arguments on this topic are outside the scope of this proceeding. Nevertheless, even if those arguments were within scope, a preponderance of the evidence demonstrates that NextEra's approach to LSTP specimen scaling provides reasonable assurance that the LSTP yielded data appropriate for use in the LAR.

114. In Section C.2.2.1 of his testimony, Dr. Saouma claims that "a significant problem with the FSEL testing is the failure to ensure that the relative dimensions of the concrete beam that was tested were scaled to the prototype."[260] However, NextEra purposefully developed the LSTP with specimen scale in mind.[261] Indeed, that was one of the primary reasons the LSTP was undertaken—because data in existing literature was based on specimens too small to be considered representative of Seabrook's structures.[262]

115. NextEra presented evidence that the appropriate scaling parameters for shear testing are thickness, shear-span-to-depth ratio (*i.e.*, the distance between a concentrated load and the support divided by the beam depth), reinforcing bar size, reinforcing bar spacing, and

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260 Saouma Testimony § C.2.2.1 (INT001-R).

261 MPR Testimony at A85 (NER001) ("shear is known to scale poorly from laboratory-scale specimens to actual large structures, as discussed in Dr. Bayrak's report "Structural Implications of ASR; State of the Art" at 10 (Feb. 2, 2012) ("State of the Art") (NER019)") (also citing Chana and Korobokis, "Structural Performance of Reinforced Concrete Affected by Alkali Silica Reaction: Phase 1" § 7.2 (Oct. 1990) (NER054)).

262 MPR Testimony at A200 (NER001).

concrete cover over reinforcing bars.[263] Dr. Saouma "fully agree[s]" that the LSTP considered the appropriate range of scaling parameters.[264] Thus, we find that a preponderance of the evidence demonstrates that the LSTP considered the appropriate range of scaling parameters.

116. NextEra presented evidence that the physical dimensions of the LSTP specimens were "similar or identical to the reference location at the plant—*i.e.*, the B Electrical Tunnel at Seabrook."[265] In other words, the ratio between the LSTP and the Seabrook reference location was 1:1.[266] Dr. Saouma's criticism, however, is that the 1:1 scaling ratio is based only on a single location at the plant and therefore is inapplicable to other locations.[267] But NextEra's evidence demonstrates that the other walls and structures of interest at Seabrook are of similar size and scale. NextEra also explained that precise replication of all structures throughout the plant was not only impractical, but unnecessary and inconsistent with the technical basis for the Seabrook design codes, ACI 318 and the ASME Code.[268]

117. Importantly, NextEra's detailed consideration of specimen size and scaling is presented in MPR-3757 (NER026). But the record contains no evidence that Dr. Saouma reviewed this document or disputed its content.[269] In contrast, the record does include evidence supporting NextEra's claim that any variance in scaling between the Seabrook reference location

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263 MPR Testimony at A200 (NER001). *See also* Tr. at 428 (Dr. Bayrak explaining that thickness is the parameter of interest, and "the other two dimensions are not germane").

264 Tr. at 613. *See also id* (Dr. Saouma acknowledging "length" of a specimen is "immaterial" to shear testing).

265 MPR Testimony at A200 (NER001).

266 MPR Testimony at A103, A110, A115, A200 (NER001). The parameters of interest come from the testing that informed the original code equations, which have been in use in structural engineering for many decades. Tr. at 428.

267 Tr. at 613.

268 MPR Testimony at A107, A200 (NER001).

269 Dr. Saouma did not include MPR-3757 in the list of materials that he reviewed in preparation for his testimony. *See* Saouma Testimony § A.5 (INT001-R).

and other locations at Seabrook is *de minimis* and was explicitly contemplated and accounted for in the development of the LSTP. More specifically, the record shows that the use of large-scale specimens means that the scaling factor between the test specimens and other areas of the plant is close to 1:1 for *any* location.[270] Furthermore, the purpose of the LSTP was to evaluate the impact of ASR on shear strength (if any) such that the code expression could be applied uniformly to Seabrook structures *regardless* of thickness.[271] On balance, we find that C-10 presented insufficient evidence to support its claim that the representativeness of the LSTP is challenged by the lack of testing of specimens with thicknesses other than that of the reference location, and that a preponderance of the evidence demonstrates that C-10's criticism regarding specimen dimensions does not defeat a finding of reasonable assurance that the LSTP yielded data appropriate for use in the LAR.

118. Dr. Saouma also claimed that the LSTP was not representative because the test specimens had different reinforcement ratios and were not scaled consistent with the structures at the plant.[272] But the preponderance of the evidence demonstrates that, with one exception addressed in the paragraph below, no scaling of the test specimen reinforcement configuration was required because the reinforcing bar size, reinforcing bar spacing, and concrete cover over reinforcing bars were similar or identical to the reference location at the plant.[273] In other words, the reinforcement ratio scale between the LSTP and Seabrook is 1.0.[274]

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270 MPR Testimony at A200 (NER001); *see also* MPR-3757 (NER026).

271 Tr. at 428, 612-13.

272 Saouma Testimony § C.2.2.1 (INT001-R); *see also* Saouma Rebuttal § D.3.1 (INT028).

273 MPR Testimony at A200 (NER001).

274 *Id*.

119. There was one exception to the LSTP's replication of Seabrook's reinforcement spacing. More specifically, as is done in essentially all shear testing, the LSTP shear specimens used additional rebar (*i.e.*, a higher ratio than at Seabrook) in the longitudinal direction because a fundamental basis for the Codes used to design the Seabrook structures is to cause other modes (*e.g.* flexure) to control over shear; thus, the reinforcement within the test specimens had to be altered to allow shear to control the performance of the specimens.[275] This was a purposeful decision in the testing approach, designed to ensure that the specimens would fail in the mode of interest (*i.e.*, shear) rather than some other mode (*e.g.*, flexure).[276] Dr. Saouma's criticism appears to be that this approach unnecessarily renders the test specimen less representative of the reference location.[277] But Dr. Saouma, too, was concerned regarding the possibility of an "erroneous failure mechanism," which he acknowledged would make the failure load non-representative.[278] However, that is why NextEra evaluated this potential phenomenon in the planning phase of the testing programs.[279] NextEra concluded that use of additional longitudinal reinforcing bars in the shear test specimens provided additional flexural capacity, and therefore ensured that failure during load testing would be in shear rather than flexure.[280] And at the conclusion of the testing, NextEra confirmed these design efforts were, in fact, successful by confirming that the test specimens failed by the appropriate mode.[281]

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275 *Id*.

276 *Id*.

277 Saouma Rebuttal § D.3.1 (INT028); *id*. (quoting MPR-3848 noting that, under this approach, "using the in plane CCI to translate between test results and structures at Seabrook Station will be conservative").

278 Saouma Testimony § C.2.2.1 (INT001-R).

279 MPR Testimony at A200 (NER001); MPR-3757 §§ 2, 3 (NER026).

280 *See* MPR-3757 § 3.2.3 (NER026).

281 *See, e.g.*, MPR-4262 at 6-10 to 6-11, figs.6-9 & 6-10 (NER022-R).

120. Dr. Saouma acknowledges that specimens need only be "scaled properly as much as possible."[282] C-10 presented no evidence to show that it was "possible" (or necessary, for purposes of representativeness) to perform shear testing using some other reinforcement configuration that would preclude erroneous failure mechanism—which C-10 agreed was an important consideration.[283] NextEra's rationale in selecting reinforcement for the LSTP specimens is presented in MPR-3757 (NER026), and its confirmatory review is documented in MPR-4262 (NER025-R). Again, the record contains no evidence that Dr. Saouma reviewed these documents or disputed their contents.[284] On balance, we find that C-10 presented insufficient evidence to support its claim that the representativeness of the LSTP is challenged by NextEra's use of additional rebar in the longitudinal direction in the LSTP shear specimens. Thus, a preponderance of the evidence demonstrates that C-10's criticism regarding reinforcement ratio does not defeat a finding of reasonable assurance that the LSTP yielded data appropriate for use in the LAR.

(3) Experimental Design

121. As noted above, the Board has concluded that C-10's various criticisms of the execution of the LSTP were not among the aging and environmental parameters challenged in the original Contention, and thus C-10's arguments on this topic are outside the scope of this proceeding. Nevertheless, even if those arguments were within scope, a preponderance of the evidence demonstrates that none of C-10's criticisms regarding the execution of the LSTP defeat a finding of reasonable assurance that the LSTP yielded data appropriate for use in the LAR.

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282 Tr. at 275.

283 Saouma Testimony § C.2.2.1 (INT001-R).

284 Dr. Saouma did not include MPR-3757 (the Shear Test technical evaluation) or MPR-4262 (the Shear Test results) in the list of materials that he reviewed in preparation for his testimony. *See* Saouma Testimony § A.5 (INT001-R).

122. NextEra testified that, consistent with long-standing industry-standard tests for studying shear behavior, as documented in MPR-3848 (NER015), the LSTP test setups were not aimed at replicating *in situ* boundary conditions at Seabrook (*i.e.*, external influences on the structural elements such as interactions with adjacent structural components).[285] NextEra concluded that it was essential that the specimens from the LSTP represent what was previously tested by many research groups around the world to obtain data to serve as the basis for the shear design expressions in the codes.[286] The relevant code expressions are designed for applicability to a variety of structural elements (*e.g.*, walls, slabs, beams, columns), consider inherent variations in boundary conditions, and are based on the most severe boundary conditions to obtain the most conservative results.[287] NextEra further concluded that replicating boundary conditions for every specific location at Seabrook impacted or potentially impacted by ASR would be impractical, excessively complex, and ultimately would not meaningfully inform a comprehensive engineering evaluation of the mechanisms of interest.[288] Thus, consistent with the codes, the LSTP used the *most severe* loading and boundary conditions for the limit states of interest, which ultimately produced failure in the target region by the desired failure mode.[289] Dr. Bayrak testified that this approach allowed the LSTP to yield conservative results—"in many examples, greatly so."[290]

123. C-10 argues that axial forces from *in situ* boundary conditions can "negate" the pre-stressing effect observed in ASR-affected reinforced concrete—more specifically, that the

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285 MPR Testimony at A107 (NER001); MPR-3848 § 4.3 (NER015).

286 *Id*. at A106.

287 *Id*. at A62, A108.

288 *Id*. at A108.

289 *Id*.

290 Tr. at 283; *see also* MPR Testimony at A203 (NER001).

pre-stressing effect may be "dwarfed" by axial loads from gravity, and therefore cannot be relied upon.[291] Thus, according to C-10, NextEra's failure to replicate these axial load conditions caused the LSTP data to be unrepresentative of Seabrook.[292] But this claim overlooks the fact that the LSTP was designed as a separate effects test, so the structural loading mode naturally focused on the limit state in question.[293] As relevant here, independent effects of the other axial loads described by Dr. Saouma are, in fact, addressed on a structure-specific basis through NextEra's Structural Evaluations.[294] Thus, it would have been inappropriate to include axial compression forces in *both* the LSTP and the Structural Evaluations.[295] C-10 did not rebut this assertion. NextEra's experts also testified that restraint provided by the *in situ* boundary conditions would in fact *benefit* shear strength—thus, the LSTP approach is more representative.[296] C-10 also did not rebut this assertion either.

124. On balance, we find that C-10 presented insufficient evidence to support its assertion that the representativeness of the LSTP is challenged by the lack of replicating Seabrook's *in situ* boundary load conditions, and that NextEra presented sufficient evidence to provide a technical justification for its separate-effects testing approach.

125. C-10 also criticizes the LSTP for modeling "only the out of plane shear and not the in-plane."[297] NextEra explained that, in the context of Seabrook, out-of-plane shear is not

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291 Saouma Testimony § C.2.2.2 (INT001-R).

292 *Id*.

293 MPR Testimony at A203 (NER001).

294 MPR-4288 (INT012 (NP), INT014 (P)); SEM Document (INT022).

295 MPR Testimony at A203 (NER001).

296 *Id*.

297 Saouma Testimony § C.2.2.2 (INT001-R).

resisted by reinforcement, whereas in-plane shear is.[298] As discussed in MPR-3727, NextEra reviewed published literature and confirmed that the one-way shear strength of test specimens with a minimum quantity of transverse reinforcement was not affected by ASR. Accordingly, the in-plane shear strength of walls (reinforced with more than a "minimum quantity of reinforcement") was not a concern for Seabrook due to the beneficial effects of chemical prestressing or confinement provided by reinforcing bars.[299] Thus, based on this existing body of published research, NextEra concluded there was no need to evaluate in-plane shear as part of the LSTP.[300]

126. C-10 presented no evidence to contradict the published literature on this point.[301] Dr. Saouma merely commented that in-plane shear presents a "potential for debonding of the rebar between the wall and the base."[302] However, Dr. Saouma stated that he *did not know* whether this was accounted for in the LSTP.[303] Whereas, Dr. Bayrak noted that this was "explicitly addressed in our reinforcing bar anchorage testing programs."[304] As noted above, the reinforcement anchorage test program was neither reviewed nor challenged by Dr. Saouma, who

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298 MPR Testimony at A202 (NER001).

299 *Id*. *See also* MPR-3727, Rev. 1, "Seabrook Station: Impact of Alkali-Silica Reaction on Concrete Structures and Attachments" (Jan. 2014) and NextEra Supplements I-V Thereto (FP100716, Rev. 4) tbl.6-4 ("MPR-3727") (NER018). *See also* State of the Art, tbl.4 (NER019); D. Deschenes, et al., "ASR/DEF-Damaged Bent Caps: Shear Tests and Field Implications," Technical Report No. 12-8XXIA006 summarizing work conducted for the Texas Dep't of Trans. at Ferguson Structural Eng'g Lab., The Univ. of Texas at Austin § 7.2.2 (Aug. 2009) (NRC075).

300 MPR Testimony at A202 (NER001); MPR-3727 (NER018).

301 Dr. Saouma did not include MPR-3727 in the list of materials that he reviewed in preparation of his testimony. *See* Saouma Testimony § A.5 (INT001-R).

302 Tr. at 914.

303 *Id*.

304 *Id*. at 915.

confirmed his lack of expertise on this topic at the evidentiary hearing.[305] On balance, we find that NextEra's evidence supports its assertion that the representativeness of the LSTP is not challenged by the lack of in-plane shear testing.

127. In his initial written testimony, Dr. Saouma alleged that NextEra had failed to address load-displacement and cracking pattern in the LSTP, and raised several criticisms on those topics.[306] In its responsive testimony, NextEra explained that those items had in fact been addressed in the LSTP and rebutted each of Dr. Saouma's criticisms.[307] For example, Dr. Saouma questioned whether the load testing of shear specimens actually produced a shear failure, and criticized the LSTP reports for lack of pictures showing the shear cracks.[308] NextEra's experts testified, with citation to record evidence, that these claims were directly refuted by extensive documentation (including photographs) from the LSTP.[309] At the evidentiary hearing, Dr. Saouma withdrew those arguments and noted that he had simply "missed" the relevant information.[310] Thus, we find that NextEra's evidence that the LSTP's treatment of load-displacement and cracking supports a finding of reasonable assurance that the LSTP yielded data appropriate for use in the LAR.

E. The SMP

128. As explained in LBP-17-7, the sole basis in the admitted Contention for C-10's challenge to the LAR's monitoring, acceptance criteria, and inspection intervals was the alleged

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305 *See* Saouma Testimony § A.5 (MPR-3722 (anchorage test report) not listed among documents reviewed); Tr. at 266 (Dr. Saouma: "I don't claim expertise on anchorage").

306 Saouma Testimony § C.2.3 (INT001-R).

307 MPR Testimony at A204-208 (NER001).

308 Saouma Testimony § 2.3.1 (INT001-R).

309 MPR Testimony at A204 (NER001) (citing, *e.g.*, MPR-4259, app. G at G-14, G18-G19 (NER025-R).

310 Tr. at 314.

non-representativeness of the LSTP. As noted above, the Board has concluded that a preponderance of the evidence shows the LSTP data are, in fact, representative and appropriate for use in the LAR. As a result, the Contention must be resolved in NextEra's favor, and the Board need not consider C-10's further arguments regarding the LAR's monitoring, acceptance criteria, and inspection intervals.

129. Nevertheless, as explained below, the Board has evaluated the SMP's monitoring, acceptance criteria, and inspection intervals, and concludes that a preponderance of the evidence demonstrates that NextEra's SMP is adequate to support a finding that reasonable assurance exists for the NRC Staff to grant the LAR. Furthermore, as explained below, we find that C-10's criticisms of the SMP do not defeat a finding of reasonable assurance.

130. Seabrook's SMP (which is a typical program at nuclear power plants used to address the aging of structural elements within the scope of the maintenance rule, 10 C.F.R. § 50.65) includes specific provisions for ongoing ASR monitoring—*i.e.*, the ASR Monitoring Program. Under this aspect of the SMP, NextEra performs an overall assessment and screening of concrete throughout the plant. In particular, NextEra uses crack width indexing as part of its SMP to evaluate ASR throughout the plant, consistent with published literature (*e.g.*, FHWA Guideline, ISE Guideline), to determine in-plane expansion, which is used as a screening tool to determine whether an extensometer should be installed at that location. For areas with in-plane expansion above 0.05%, NextEra also uses pin-to-pin measurements to corroborate crack width index measurements.[311] To date, they continue to track together.[312] As a general matter, the LSTP confirmed that crack width indexing does, in fact, represent the overall in-plane expansion

311 MPR Testimony at A127, A163 (NER001); *see also* SMPM ch. 3 § 1.3.1 (NER007).

312 Tr. at 501.

of a concrete surface.[313] And the LSTP compared crack width indexing measurements (obtained using a documented procedure under a nuclear QA program) against mechanical gauge expansion measurements and found that the two are consistent in trend and magnitude.[314]

131. If in-plane expansion exceeds 0.1% (1 mm/m), NextEra installs an extensometer to commence through-thickness expansion monitoring. As NextEra demonstrated, this threshold is approximately the point of divergence of the ASR strains in all three directions, regardless of the presence of reinforcement.[315] NextEra then monitors in-plane, through-thickness, and volumetric expansion (*i.e.*, the total of the measured expansion in each of the three directions) to ensure that these parameters remain below the levels achieved at the LSTP (*i.e.*, that they meet the corresponding acceptance criteria in the SMP, aka the Expansion Monitoring Limits). We find that these monitoring methods are entirely reasonable and appropriate for application at Seabrook in order to ensure seismic Category I structures comply with the plant's licensing basis and can continue to perform their intended safety functions.[316]

132. NextEra's testimony describes the acceptance criteria for determining when an extensometer is needed, and for each of the monitoring parameters (*i.e.*, in-plane, through-thickness, and volumetric),[317] and describes the SMP's graded monitoring approach, which includes monitoring on an interval that reflects the observed condition of Seabrook structures.[318]

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313 Tr. at 320.

314 Tr. at 323, 471-72. The LSTP did identify a "small lag" between the two at the early stages of the comparison, representing the period before cracks form and become large enough to be observed and included in the crack width index data set. MPR Testimony at A166; Tr. 471. But the two agree closely starting at relatively low levels of expansion. Prop. App'x, fig.4 (NER003).

315 MPR Testimony at A180 (NER001); *see* MPR-4273 § 6.1.1 (INT019-R (NP), (INT021)(P)).

316 MPR Testimony at A163-A167 (in-plane expansion); A168-A176 (through-thickness expansion); A177-A178 (volumetric expansion) (NER001).

317 *Id*. at A179, A181, A183, A185.

318 *Id*. at A187.

NextEra's evidence provides a technical justification for each acceptance criterion,[319] and for the monitoring frequencies.[320]

133. Further, the approved amendment includes a license condition requiring NextEra to perform periodic expansion assessments, which includes evaluation of the *rate* of ASR progression ("Periodic Expansion Assessment"). If data suggest that the monitoring intervals (or any other aspect of the SMP) at Seabrook are insufficient, the plant will evaluate the need for potential changes.[321]

134. We conclude that the preponderance of the evidence demonstrates that the monitoring techniques, acceptance criteria, and inspection intervals in NextEra's SMP are adequate to provide reasonable assurance.

(1) SMP ASR Expansion Monitoring Techniques

135. As the Commission explained, "In Contention A, as admitted, C-10 challenges the effectiveness of crack width indexing and extensometer deployment as tools for determining the presence and extent of ASR in safety-related structures. C-10's concerns regarding these monitoring techniques arise from the question of whether the test program results can adequately predict the effectiveness of crack width indexing and extensometer deployment as monitoring techniques at Seabrook."[322]

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319 *Id*. at A180, A182, A184, A186.

320 *Id*. at A188-A193.

321 *Id*. at A193.

322 *Seabrook*, CLI-18-4, 87 NRC at 94.

a. In-Plane Expansion

136. As a preliminary matter, we note that the crack width indexing technique was not developed by NextEra.[323] It is a well-established technique, endorsed by various respected industry guidelines.[324] Dr. Saouma acknowledges that crack width indexing is an appropriate "first step" in monitoring ASR.[325] But he argues that, once ASR becomes "more serious," monitoring programs must "go beyond that."[326] But the evidence demonstrates that NextEra's SMP does precisely that. Once in-plane expansion exceeds 0.05%, NextEra's SMP goes "beyond" crack width indexing to also include performing pin-to-pin measurements for in-plane expansion. And "beyond" that, once in-plane expansion exceeds 0.1%, NextEra then installs extensometers, examines and tests material properties of cores, and performs structural evaluations (if not already performed). As detailed below, we find that C-10 presented no evidence to suggest that 0.1% is the incorrect threshold to commence through-thickness and volumetric monitoring, and no evidence to challenge NextEra's use of crack width indexing beyond 0.05% in conjunction with other monitoring techniques.

137. First, Dr. Saouma claims that crack width indexing can only be used in conjunction with advanced petrography.[327] As support for his assertion, Dr. Saouma points to the FHWA Guideline, which recommends a combination of crack width indexing and petrography for the *preliminary investigation* stage of an ASR assessment program.[328] NextEra

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323 MPR Testimony at A217 (NER001); *see also* Tr. at 323 (Dr. Bayrak stating that he and NextEra did not develop and "cannot take credit for" crack width indexing).

324 *See, e.g.*, FHWA Guideline (NER013); ISE Guideline (NER012); *see also* Tr. at 323-24.

325 Tr. at 494-95.

326 Tr. at 495.

327 Saouma Testimony § C.3.1.2. (INT001-R).

328 *Id*. (citing FHWA Guideline § 2.2 (NER013)).

did perform crack width indexing and petrography during its preliminary investigation.[329] But the FHWA Guideline also explicitly endorses crack width indexing during the later *detailed study* stage of an ASR assessment program "to generate a quantitative assessment of the extent (severity) of deterioration."[330] The record otherwise contains no evidence indicating that crack width indexing is an invalid monitoring technique absent companion petrography.[331] Thus, C-10's assertion in this regard does not defeat a finding of reasonable assurance.

138. C-10 also argues that crack width indexing is not an appropriate monitoring technique because the surface of Seabrook's concrete has "dried." C-10 asserts that ASR cannot propagate if the relative humidity is less than 80%. Thus, according to C-10, surface ASR will not cause Seabrook's surface concrete to expand or crack. Meanwhile, per Dr. Saouma's theory, internal expansion and cracking could go undetected, and "hidden" internal delamination could occur.[332] Thus, Dr. Saouma claims, NextEra also must monitor relative humidity at the surface of the concrete and deeper within the concrete in order to predict whether ASR may occur.

139. NextEra's evidence, however, demonstrates that surface cracking will indicate the potential presence of internal expansion due to ASR even if ASR is not present (or is not propagating) at the concrete surface.[333] In other words, NextEra's experts testified that there simultaneously could be internal ASR expansion along with zero ASR at the surface, and the

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329 SGH Testimony at A65 (NER004) (citing SG&H Report 110594-RPT-02, Rev. 1, "Damage Rating Index and ASR Rating" (Feb. 10, 2012) (FP100702) ("SG&H Report") (NER028)).

330 FHWA Guideline §§ 5.2.1 & 5.2.2. (NER013).

331 Moreover, to the extent C-10 asserts that ASR gel chemistry or crack pattern somehow impact the efficacy of crack width indexing, Dr. Saouma acknowledges any such connection is attenuated. Tr. at 425-26.

332 Dr. Saouma also claimed that an LSTP specimen experienced delamination. However, we find that NextEra sufficiently demonstrated that it was an "edge effect crack," not an internal delamination. *See* MPR Testimony at A208 (NER001); MPR-4273, § 4.2.3 (INT019-R (NP), (INT021)(P)); MPR-4262 § 5.2.3 (NER022). Accord Tr. at 1138 (NRC Staff stating they were present and observed first-hand that it was an "edge effect crack").

333 *See, e.g.,* SGH Testimony at A65 (NER004).

internal ASR expansion still would manifest itself through surface cracking. As NextEra's experts further explained, this is because surface cracking can be caused by many things *in addition to* ASR, including shrinkage (which would occur if the surface concrete has "dried"), and differential movement wherein the expansion of the interior concrete would create forces and movements that would crack the relatively thin zone of drier near-surface concrete as it was forced to move along with the expanding interior concrete (*e.g.*, where the inside is expanding but the surface is not).[334] [Placeholder for discussion of INT049-R and INT050, if admitted by the Board, and any responsive testimony and exhibits permitted by the Board.[335]]

140. NextEra's technical justification is supported by the FHWA Guideline (NER013), which states:

> cracking at the surface of a concrete member reflects differential deformations (expansion or contraction) between the surface and the inner concrete due to various mechanisms such as ASR, sulphate attack, freezing/thawing, and shrinkage.[336]

Conservatively, NextEra's SMP initially presumes that all cracking is caused by ASR.[337]

141. C-10 provides no evidentiary support, other than Dr. Saouma's opinion, for its assertion that internal ASR cracking so severe that it causes *delamination* somehow could occur without *any* indication on the surface.

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334 *See, e.g.*, Tr. at 497 (Mr. Sherman analogizing surface concrete without ASR expansion to a dry lake bed, and noting that cracking will still occur due to surface shrinkage or subsurface expansion/deformation that "drags all those top pieces along"); *id*. at 499 (Mr. Sherman explaining that, "[v]ery specifically, since th[e] surface is not expanding [due to ASR], [crack indexing is] actually catching more of the inner expansion that's happening").

335 [As of the due date for submission of the FOF/COL, the Board had neither ruled on C-10's pending motions to submit additional testimony and exhibits nor closed the evidentiary record.]

336 FHWA Guideline at 30 (NER013) (emphasis added).

337 MPR Testimony at A214 (NER001).

142. Dr. Saouma's written testimony included photographs of unknown structures (described as "surface reinforced concrete retaining walls") with visible cracks (which Dr. Saouma characterized as "delamination").[338] However, the cause of the readily visible cracking shown in the photographs is unknown because they were not accompanied by a source document with further technical details and factual observations. At the evidentiary hearing, Dr. Saouma stated that these photographs came from a German-language document, but C-10 subsequently indicated that it would not file the German document as an exhibit. Instead C-10 stated it would rely on an existing exhibit—the ISE Guideline (NER012)—which it viewed as "sufficient" on this point.[339] More specifically, Dr. Saouma pointed to the ISE Guideline for its discussion of microcracks.[340] However, we see no support in that discussion of "microcracks" for Dr. Saouma's assertion that large "hidden" delamination, without any other signs of cracking or structural deformation, is plausible.[341] Further, the photographs, whatever their source, show readily visible surface cracking, not hidden delamination, and do not show any condition (cracked or not) of the perpendicular face on which the purported delamination would or would not be visible.

143. NextEra provided further evidence demonstrating that the SMP requires a core to be removed and an extensometer installed if in-plane expansion exceeds 0.1%, and that all of those cores (and the corresponding boreholes) be visually inspected.[342] To date, in over 200

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338 Saouma Rebuttal at 33 fig.16 (INT028).

339 Tr. at 959-60.

340 Tr. at 889-91.

341 *See also* Tr. at 891-92 (Mr. Lehman observing that the ISE Guideline itself makes clear that "'microcracking' is not delamination"); *id*. at 892 (Dr. Saouma agreeing that microcracks would become macrocracks *prior* to delamination).

342 MPR Testimony at A133 (NER001); Tr. at 680.

cores that have been evaluated, NextEra has never observed internal delamination or mid-plane cracking.[343] Thus, Dr. Saouma's speculation regarding the current state of Seabrook's concrete is contradicted by direct physical evidence from Seabrook. Moreover, Dr. Saouma's concern that possible future internal cracking or internal delamination could go undetected is refuted by NextEra's SMP, which provides a specific and mandatory requirement to inspect cores for such internal cracking or delamination on a going-forward basis,[344] and Seabrook's license, which contains a condition requiring NextEra to review cores for mid-plane cracking as part of the Periodic Expansion Assessments.[345]

144. To the extent Dr. Saouma speculates that internal cracking or delamination (severe enough to compromise the structure's ability to perform its intended safety function) could occur in the future before a core is removed and inspected (*i.e.*, where in-plane expansion is less than 0.1%), he provides no evidence to support his assertion.

145. We conclude that the preponderance of the evidence demonstrates that the SMP's acceptance criteria limit for in-plane expansion, the use of crack width indexing to monitor in-plane expansion up to 0.1%, and the use of crack width indexing plus pin-to-pin measurements to monitor in-plane expansion from 0.05% to the acceptance criteria limit are adequate to provide reasonable assurance.

b. *Through-Thickness Expansion*

146. NextEra's SMP measures through-thickness expansion against established acceptance criteria. However, because Seabrook was not originally constructed with embedded

343 MPR Testimony at A208 (NER001); MPR-0326-062-88 Rev. 2 at 4 (NER020); Tr. at 456, 572, 705, 1097.

344 SMPM, ch. 3 at 3-1.5 (NER007) ("The cores that are taken will be subjected to visual examination to confirm the absence of mid-plane cracks").

345 MPR Testimony at A94 (NER001).

instruments to measure through-thickness expansion due to ASR, NextEra uses a two-part process to calculate through-thickness expansion.[346] Previous (*i.e.*, historical) through-thickness expansion is calculated via an empirical correlation using elastic modulus.[347] And additional (*i.e.*, going forward) expansion is measured with an extensometer. Combining the two values provides the total through-thickness expansion, which is measured against acceptance criteria in the SMP.

147. C-10 does not offer any specific challenge to or criticism of the use of extensometers to measure through-thickness expansion going forward. Dr. Saouma's initial testimony commented that extensometers "should be placed *at least* at mid-distance between the [two sides of a wall]."[348] But Seabrook's procedures specify that the deep anchor for each extensometer be installed *well beyond* the midpoint of the wall thickness.[349] Thus, Dr. Saouma's remark is entirely consistent with—and identifies no deficiency in—the SMP. At the evidentiary hearing, Dr. Saouma noted that he no longer has any concerns regarding NextEra's use of extensometers in the SMP.[350] NextEra's evidence also shows that the LSTP examined various instruments for measuring through-thickness expansion and determined that the snap-ring borehole extensometer was the best instrument.[351] C-10 did not challenge these conclusions.[352] Thus, we conclude that the preponderance of the evidence demonstrates that NextEra's use of

346 MPR Testimony at A168 (NER001).

347 *Id*.

348 Saouma Testimony § C.3.2. (INT001-R) (emphasis added).

349 MPR Testimony at A213 (NER001) (citing Seabrook Mechanical Maintenance Procedure MS0517.51, Installation of Geokon Snap-Ring Borehole Extensometers" Rev. 0, figs.1-7 (Feb. 2016) (NER046)).

350 Tr. at 458 ("I have corrected myself . . . so I'm perfectly fine with it").

351 MPR Testimony at A156-57 (NER001); MPR-4273 §§ 5.4.2 & 5.4.3 (INT019-R (NP), (INT021)(P)).

352 *See supra* note 222 (C-10's expert was unaware of the instrument testing program).

extensometers as a monitoring technique for ongoing through-thickness expansion is adequate to provide reasonable assurance.

148. However, in rebuttal, Dr. Saouma raised—for the first time in the proceeding—an argument regarding NextEra's method for estimating previous through-thickness expansion (aka the "Modulus Correlation" described in the next paragraph).[353] As noted above, the Board has concluded that C-10's new rebuttal arguments (including this one) are impermissible and thus are stricken from the record. Thus, all of the evidence in this proceeding supports the adequacy of NextEra's Modulus Correlation. Nevertheless, even if those arguments were permissible, a preponderance of the evidence demonstrates that none of C-10's criticisms defeats a finding of reasonable assurance.

149. C-10 does, however, challenge NextEra's Modulus Correlation (*i.e.*, its technique for estimating previous through-thickness expansion which involves:

- Determining the current elastic modulus of the concrete by material property testing of cores removed from the structure.
- Calculating the reduction in elastic modulus by taking the ratio of the test result from the ASR-affected area to the original elastic modulus (*i.e.*, the "normalized elastic modulus").
- Quantifying through-thickness expansion using a correlation developed as part of the LSTP, which relates reduction in elastic modulus with measured expansion from beam specimens used during the LSTP.[354]

150. Dr. Saouma stated at the evidentiary hearing that this technique is an approximation, and has a "margin of error" that he claims has not been "accounted for."[355] However, NextEra explicitly addressed uncertainty in this technique in MPR-4153. Indeed, that

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353 Saouma Rebuttal § D.9.1 (NER028).

354 MPR Testimony at A171 (NER001). *See also* MPR-4153 at iv (INT018-R (NP), INT020 (P)).

355 Tr. at 515.

document contains an entire section devoted to "Uncertainty Considerations," which analyzes and evaluates the potential sources of uncertainty and their related impacts.[356]

151. The evidence shows that NextEra took various affirmative steps to address potential uncertainty in the Modulus Correlation. First, the current elastic modulus for an entire concrete member will be determined based on the area with the greatest symptoms of ASR-related expansion, thus conservatively characterizing the elastic modulus of the member.[357] Second, NextEra applies a "reduction factor" to the normalized elastic modulus to add conservatism to the calculated through-thickness values (the reduction factor artificially increases the estimated through-thickness expansion and reduces the margin to the acceptance criteria), thereby addressing potential uncertainty associated with the original modulus.[358] Third, NextEra validated the Modulus Correlation against published literature data, and presented the assessment in MPR-4153.[359] C-10 challenged none of the published literature or NextEra's assessment. Finally, NextEra will conduct a "Corroboration Study" in 2025, and again ten years later, to obtain in-plant data to corroborate the approach for using the Modulus Correlation.[360] In essence, NextEra will take new cores adjacent to a sampling of the 20% of existing extensometer locations to calculate expansion using the Modulus Correlation technique, and then compare the results to the actual measurements obtained from the extensometers.[361] This is an explicit legally-enforceable condition of NextEra's operating license.[362]

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356 MPR-4153 § 4.2 (INT018-R (NP), INT020 (P)).

357 *Id*.

358 *Id*.

359 MPR Testimony at A175 (NER001); MPR-4153 (INT018-R (NP), INT020(P)).

360 MPR Testimony at A95 (NER001).

361 *Id*.

362 *Id*. at A93, A96 (NER001).

152. C-10 did not challenge NextEra's approach of selecting the "worst case" location for determining the elastic modulus. However, it did challenge the value of the reduction factor, because, in its view, there is "a lot of uncertainty" in the Modulus Correlation.[363] NextEra's evidence demonstrates that the value of the reduction factor was confirmed based on an analysis of the normalized elastic modulus and through-thickness expansion of 21 sets of cores removed from LSTP specimens where that reduction factor yielded a result that bounded or closely approximated 20 of the 21 sets of cores.[364] Dr. Bayrak testified that this was akin to a "5 percent fractal approach" that "leaves 95% of the data on the safe side," and that this is a commonly-used technique (in lieu of "error bars") among structural engineering practitioners in the ACI and the International Concrete Federation.[365] C-10 did not offer an alternative reduction factor, and acknowledged that the value used by NextEra may, in fact, be appropriate.[366] C-10 also did not dispute Dr. Bayrak's testimony regarding the industry standard "5 percent fractal approach."

153. Even if there is some uncertainty regarding the reduction factor, NextEra will conduct a Corroboration Study in 2025 to compare expansion estimated using the Modulus Correlation against *actual* expansion measurements at the plant. This process was added to the LAR methodology to assess any potential unconservativeness in the Modulus Correlation.

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363 Tr. at 535. *See also* Saouma Rebuttal § D.9.1 (INT028) (listing areas of alleged uncertainty and claiming the Modulus Correlation is "sensitive"); Rebuttal Testimony of Victor E. Saouma, Ph.D Regarding Scientific Evaluation of NextEra's Aging Management Program for Alkali-Silica Reaction at the Seabrook Nuclear Power Plant (Revised) ("Saouma Supplemental Rebuttal") (INT030-R) (claiming the Modulus Correlation fails to account for the increase in compressive strength of concrete over time due to cement hydration). *But see* NextEra Response to Supplemental Rebuttal (NER076) (explaining that the Modulus Correlation does, in fact, account for this curing effect, and that its sensitivity at higher expansion levels is immaterial to the overall methodology). Notably, at the evidentiary hearing, Dr. Saouma did not rebut NextEra's evidence in this regard.

364 Tr. at 545; MPR-4153 fig.4-1 (INT020).

365 Tr. at 780-81.

366 Tr. at 535 (Dr. Saouma suggesting he does not know if the value is correct, or if it should be higher or lower).

Successful corroboration would show comparable results between the two methods.[367] In other words, the results will reveal whether uncertainty adversely impacts the Modulus Correlation. If the results are not comparable, NextEra must take action to establish the pre-instrumentation expansion, reassess total through-thickness (and volumetric) expansion against the acceptance criteria established from the LSTP, and "determine whether the structures [a]re operable and whether their licensing basis need[s] to be changed to address it."[368]

154. However, we also must consider the period of time between now and 2025, when the Corroboration Study is completed. In this regard, the record provides the following data points: (1) the highest observed through-thickness expansion in any seismic Category I structure at Seabrook is 0.56%; (2) the current through-thickness expansion rate is 0.02% per year;[369] and (3) the expansion rate has been steady since monitoring began.[370] Based on these three triangulation points, one can reasonably expect the expansion at the location of highest observed through-thickness expansion to be 0.68% in 2025. In other words, it *still* would have decades of margin before reaching the proprietary through-thickness Expansion Monitoring Limit. Likewise, this area (like all Tier 3 locations) will continue to be monitored on a six-month interval (which provides reasonable assurance, as discussed below in Section IV.E.(3). And should NextEra's trending of expansion measurements indicate a significant rate change, it would be required to act accordingly, again, as discussed in Section IV.E.(3).

155. Based on a preponderance of the evidence, the Board finds that the Modulus Correlation approach includes sufficient conservatism to provide reasonable assurance—for the

367 MPR Testimony at A176 (NER001).

368 Tr. at 742 (Ms. Buford speaking).

369 Tr. at 1136.

370 Tr. at 399.

short period of time between now and 2025—that previous through-thickness expansion can be sufficiently estimated for purposes of the SMP. The Board further finds that the license condition requiring a Corroboration Study in 2025, and again in 2035, provides reasonable assurance that the Modulus Correlation approach either will be corroborated, or appropriate action will be taken by NextEra (subject to regulatory oversight) for the periods of time after 2025 and 2035, respectively.

156. We conclude that the preponderance of the evidence demonstrates that the monitoring techniques and acceptance criteria for through-thickness expansion are adequate to provide reasonable assurance.

c. *Volumetric Expansion*

157. The evidence explains that the SMP calculates volumetric expansion by adding the measured expansion in all three directions. The purpose of evaluating volumetric expansion is that it provides an overall characterization of expansion, regardless of any preference in expansion direction.[371] This value is then compared to the proprietary volumetric expansion acceptance criterion in the SMP. C-10 does not challenge NextEra's technique for evaluating or calculating volumetric expansion. Thus, the preponderance of—and indeed the only—evidence regarding the technique for volumetric expansion demonstrates that they are adequate to provide reasonable assurance.

d. *Other Monitoring Techniques*

158. As noted above, the Board has concluded that C-10's arguments that advocate alternative means of regulatory compliance are outside the scope of this proceeding. Nevertheless, even if those arguments were within scope, a preponderance of the evidence

[371] MPR Testimony at A177-78 (NER001); *see also* MPR-4273, app. B, § 4.3 (INT019-R (NP), INT021 (P)).

demonstrates that none of the alternative monitoring methods advocated by C-10 are essential to a finding of reasonable assurance.

159. C-10 argues that NextEra should monitor the free chloride concentration in Seabrook's concrete.[372] However, NextEra notes that chloride is not an alkali metal and does not participate in the ASR chemical reaction, and thus it need not be addressed as part of the ASR monitoring provisions in the SMP.[373] Although chloride can cause corrosion of rebar, that degradation mechanism is covered by a separate part of the SMP,[374] which is the reason the Board rejected similar arguments in C-10's original Petition as outside the scope of this proceeding. Regardless, a preponderance of the evidence demonstrates that C-10's arguments regarding chloride and rebar monitoring do not defeat a finding of reasonable assurance.

160. C-10 advocates that NextEra should monitor the temperature and humidity for ASR affected locations at Seabrook.[375] According to C-10, such information could be useful in interpreting ASR data, understanding whether ASR is likely to occur in a given location, or predicting potential future expansion.[376] However, the SMP—consistent with other NRC-approved aging management programs—is a monitoring mechanism, not a prediction model. And NextEra conservatively assumes that ASR exists in all plant structures and that all cracks are from ASR, so the Board sees no practical use for such information in the context of NextEra's SMP. Ultimately, a preponderance of the evidence demonstrates that C-10's

372 Saouma Testimony § C.3.2 (NER001).

373 MPR Testimony at A215 (NER001).

374 SMPM, ch. 6 § 1.3 (NER007).

375 Saouma Testimony § C.3.2 (NER001).

376 Saouma Rebuttal § A.11 (INT028).

arguments regarding temperature and humidity monitoring do not defeat a finding of reasonable assurance.

161. Contentions B and C argued that the LAR should have included additional core sampling.[377] More specifically, in Contention B, the Board found admissible a narrow part of the contention asserting that "[t]he LAR misconstrues expansion occurring within a reinforced concrete structure due to [ASR] because any mitigation of lost structural capacity, due to reinforcement [*i.e.*, the "chemical prestressing effect"], is temporary and unpredictable."[378] Furthermore, the Board found Contention C admissible as a challenge to "NextEra's primary rationale for not undertaking petrographic analysis: that once ASR-affected cores are removed, the behavior of those cores no longer reflects that of the confined structure."[379]

162. C-10's evidence does not address the original bases pled for contentions B and C, and thus these arguments have been abandoned. However, C-10 does advocate the collective use of accelerated expansion tests, DRI, and detailed petrographic studies.[380] Dr. Saouma stated that using these methods collectively would be a "different way to do the job," and one that he personally considers a "better way."[381] But Dr. Saouma's suggestion is in the context of recommending a different ASR evaluation approach altogether. Most directly, he recommends the approach used by Hydro-Quebec (a post-tensioned facility[382] unlike Seabrook Station, which is conventionally reinforced), which was a chemo-mechanical approach (at a facility that, also

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377 *Seabrook*, CLI-18-4, 87 NRC at 94.

378 *Seabrook*, LBP-17-7, 86 NRC at 107.

379 *Id*. at 108 (citing Petition at 6-7).

380 Saouma Rebuttal § B.1 (INT028); *see also* Saouma Testimony §§ C.8, C.4 (item 3) (INT001-R).

381 Saouma Rebuttal § B.1 (INT028).

382 Tr. at 438; EPRI Report 3002013190, "Modeling Concrete Structures Affected by Alkali Silica Reaction: Hydro-Quebec Approach for Hydraulic and Nuclear Power Plants" (Oct. 15, 2018) (NER029).

unlike Seabrook,[383] had extensive expansion monitoring instrumentation imbedded in its structures from its inception[384]) intended to predict the ultimate ASR growth (*i.e.*, extreme levels well beyond the Expansion Monitoring Limits established in the SMP). But this suggestion for an alternative approach does not identify any specific deficiency in NextEra's approach.

163. Moreover, as noted above, petrography is not needed to confirm the *presence* of ASR, because the SMP *presumes* that all cracking at Seabrook is caused by ASR.[385] And to the extent C-10 argues that DRI could provide an alternative semi-quantitative method for monitoring ASR progression along the "sigmoid curve," the evidence shows that the "sigmoid curve" advocated by Dr. Saouma is a *qualitative* measure, not a quantitative one.[386] The Board also finds—and all parties agree—that there is no consensus standard for performing DRI, and such a method presents significant challenges (*e.g.*, subjectivity and repeatability).[387] Thus, it is not obviously superior to the quantitative methods in NextEra's SMP. Thus, a preponderance of the evidence demonstrates that C-10's arguments regarding additional petrography and DRI do not defeat a finding of reasonable assurance.

(2) SMP ASR Expansion Acceptance Criteria

164. As noted above, C-10 challenges NextEra's monitoring techniques for in-plane expansion. But C-10 offers no specific challenge to either of the acceptance criteria values for

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383 Tr. at 486.

384 *See, e.g.*, EPRI Report 3002013190 at 2-9 (NER029) ("The envelope of the reactor building of G2 is well instrumented with 139 extensometers installed during the *construction* of the plant") (emphasis added).

385 MPR Testimony at A229 (NER001); SGH Testimony at A71 (NER004).

386 *See also infra* Part IV.E.(3) (further discussing the "sigmoid curve" and accelerated expansion testing).

387 *See, e.g.*, Saouma Testimony § C.4 (INT001-R) ("I would caution that this is a delicate test that should only be performed by a very qualified petrographer, and should be performed repeatedly by the same one"); MPR Testimony at A210 (NER001) (quoting FWHA Guideline § 5.3.2 (NER013)) ("the results are very much related to the experience of the petrographer and since there is currently no standard test procedure available, the method is fairly subjective and the results can be quite variable from one operator to another").

in-plane expansion. The SMP's threshold of 0.1% in-plane expansion triggers the installation of an extensometer and a Structural Evaluation.[388] This value was established based on guidelines from published literature.[389] The LSTP corroborated that this value was appropriate for Seabrook, based on observations that expansion is approximately consistent in all three directions up to a certain point (when expansion reorients primarily to the through-thickness direction).[390] C-10 also offers no specific challenge to the SMP's separate proprietary limit for in-plane expansion.[391] This value was established from the conclusions of the LSTP anchor testing program.[392] Indeed, C-10's witness acknowledged he was unqualified to testify regarding the anchor testing program.[393] Thus, the preponderance of—and indeed the only—evidence regarding the acceptance criteria values for in-plane expansion demonstrates that they are adequate to provide reasonable assurance.

165. As noted above, C-10 challenges NextEra's technique for estimating previous through-thickness expansion. But C-10 offers no specific challenge to the through-thickness or volumetric proprietary expansion limit values, themselves.[394] These values were established from the conclusions of the LSTP.[395] Thus, the preponderance of—and indeed the only—evidence regarding the acceptance criteria values for through-thickness and volumetric expansion demonstrates that they are adequate to provide reasonable assurance.

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388 SMPM, ch. 3 at 3-1.13, tbl.3-1-1 (NER007).

389 MPR Testimony at A159 (NER001).

390 *Id*. at A159, A180.

391 SMPM, ch. 3 at 3-1.14 (NER007); Prop. App'x, tbl.3 (NER003).

392 MPR Testimony at A159 (NER001); Prop. App'x, tbl.3 (NER003).

393 Tr. at 674 (Dr. Saouma: "I confess full ignorance about anchors").

394 SMPM, ch. 3 at 3-1.14 (NER007); Prop. App'x, tbl.3 (NER003).

395 MPR Testimony at A159 (NER001); Prop. App'x, tbl.3 (NER003).

(3) SMP ASR Expansion Inspection Intervals

166. As the Commission explained, "in Contention H, as admitted, C-10 challenges the frequency of proposed inspection intervals on the ground that the test program results on which the intervals are based are not representative of Seabrook concrete."[396] However, the undisputed evidence demonstrates that the SMP's intervals are *not* based on the LSTP.[397] Thus, the underlying premise of the contention is incorrect; and the intervals in the SMP are entirely detached from any alleged lack of representativeness in the LSTP. Thus, C-10's unsupported assertions regarding any alleged connection between the monitoring intervals and the "representativeness" of the LSTP do not defeat a finding of reasonable assurance.

167. Furthermore, in LBP-17-7, the Board explained that the core of Contention H was C-10's "challenge[to] the monitoring intervals in Table 5" of the LAR Evaluation.[398] But Dr. Saouma's initial testimony explicitly stated that this information "will be ignored by [him]."[399] Thus, because C-10 chose not to review this aspect of the admitted Contention, it failed to carry its burden of going forward.

168. However, in rebuttal, Dr. Saouma raised an argument related to the monitoring intervals for the first time.[400] As noted above, the Board has concluded that C-10's new rebuttal arguments (including this one) are impermissible and thus are stricken from the record. Thus, all of the evidence in this proceeding supports the adequacy of NextEra's monitoring frequencies.[401]

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396 *Seabrook*, CLI-18-4, 87 NRC at 94-95.

397 MPR Testimony at A188 (NER001) ("None of these monitoring frequencies are based on the LSTP conclusions. Because the LSTP used accelerated aging, the LSTP conclusions are not useful for determining a time-based monitoring frequency").

398 *Seabrook*, LBP-17-7, 86 NRC at 123.

399 Saouma Testimony § C.3.4 (INT001-R).

400 Saouma Rebuttal § D.8.1 (INT028).

401 *See, e.g.*, MPR Testimony A187-A193 (NER001).

Nevertheless, even if those arguments were permissible, a preponderance of the evidence demonstrates that none of C-10's criticisms of the SMP monitoring intervals defeats a finding of reasonable assurance.

169. The evidence shows that NextEra's SMP uses a graded monitoring approach that includes monitoring on an interval that reflects actual observed conditions.[402] For locations with no symptoms of ASR (*i.e.*, no indications of pattern cracking or water ingress), general walkdowns are performed every 5 years (for locations in harsh environments or 10 years (for locations in mild environments).[403] These intervals are based on ACI 349.3R-02, "Evaluation of Existing Nuclear Safety-Related Concrete Structures" (NRC055). For locations with observed ASR symptoms and in-plane expansion values below 0.1%, in-plane expansion monitoring occurs every 30 months. And for locations with in-plane expansion values of 0.1% or greater, the monitoring interval for in-plane expansion, through-thickness expansion, and volumetric expansion is every 6 months. The technical basis for the 6-month monitoring frequency was addressed in NextEra's response to NRC RAI-M2.[404] In summary, the evidence shows this interval is consistent with the most conservative ASR inspection interval found in industry guidance, and is supported by *actual data from Seabrook* (see discussion above at paragraph 152 and explained further below), including trending of in-plane and through-thickness expansion measurements at dozens of locations at the plant since monitoring started in 2011.[405]

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402 LAR Evaluation § 3.5.1, tbl.5 (INT010 (NP), NRC089 (P)); *see also* SMPM, ch. 2 § 1.3.1 & ch. 3 at 3-1.13, tbl.3-1-1 (NER007).

403 "Harsh Environment is an area routinely subjected to one or more of the following conditions: outside ambient conditions, high moisture, humidity, very high ambient temperatures or frequent large cycling of temperatures (including freezing/thawing), frequent exposure to caustic materials, or extremely high radiation levels." SMPM at 1-1.5 (NER007). In other words, this covers the areas most susceptible to ASR.

404 SBK-L-17156, Encl. 1 (NRC013); *see also* Final SE at 24-26 (discussing NRC Staff's review of NextEra's response to RAI-M2).

405 MPR Testimony at A188 (NER001).

170. C-10 argues that the monitoring intervals in NextEra's SMP are potentially flawed. More specifically, Dr. Saouma asserts that the SMP is "based on a concept of linear growth in ASR," and is invalid because ASR progress along a "sigmoid curve."[406] According to Dr. Saouma, it is essential that NextEra establish where each of Seabrook's structures are on that sigmoid curve in order to identify the appropriate inspection interval.

171. As an initial matter, the sigmoid curve referenced by Dr. Saouma is illustrative only, and provides no values on either the x or y axis and thus does not represent any actual conditions at Seabrook or elsewhere. Further, C-10 provides no evidence to support its claim that the SMP inspection intervals necessarily hinge on assumptions of linear growth of ASR. NextEra measures, trends, and analyzes actual expansions.[407] This approach is consistent with the classic aging management approach endorsed by the NRC, which monitors degradation parameters against established thresholds (rather than attempting to model and predict degradation beyond the inspection intervals).[408] The Board notes that the notion of "trending" implicitly acknowledges that the slope of a data set may *change* over time. And if, at any time, NextEra found that the trended expansion rates suggested a deficiency in the inspection intervals, NextEra would be required to evaluate and address this condition.[409]

172. Nevertheless, the *actual data from Seabrook*, including trending of in-plane and through-thickness expansion measurements at dozens of locations at the plant, shows a relatively linear trend.[410] This provides a significant data point indicating that Seabrook's Tier 3 locations

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406 Saouma Rebuttal § D.8.1 (INT028).

407 MPR Testimony at A199 (NER001).

408 *Id*. at A220.

409 Tr. at 1135-37 (discussing the NUREG-0737 Operating Experience program and specific docketed commitments made to the NRC).

410 *Id*. at 399.

(*i.e.*, the most severe) are on the central, linear part of the "sigmoid curve," *i.e.*, after initiation.[411] And it is consistent with the petrography and elastic modulus measurements from Seabrook's structures, which also show locations in the "active" phase of ASR growth.[412] But as NextEra has explained—and we agree—the information of interest for evaluations of structural adequacy (the topic of the LAR) pertains to cracking, expansion, and structural performance (which may be different than chemical progression of ASR, *per se*). Importantly, NextEra does have real-world information regarding these parameters at Seabrook.

173. At the evidentiary hearing, Dr. Saouma initially claimed that a structure's location on the sigmoid curve, and therefore informed selection of inspection intervals, "can be *only* provided by an accelerated expansion test."[413] However, Dr. Saouma later corrected himself and acknowledged that other data (such as the elastic modulus measurements performed by NextEra, mentioned above) can provide this information.[414] Otherwise, we find that Dr. Saouma's calls for "accelerated expansion testing" (which were stricken by the Board as outside the scope of this proceeding)[415] identify no deficiency in the SMP. As Dr. Saouma himself acknowledged, the primary purpose of such tests is to quantify the "potential for future expansion."[416] But NextEra's SMP does not require the knowledge of any maximum bound on potential expansion.[417] Instead, the SMP relies on confirming that the structures remain within the Expansion Monitoring Limits (and any additional limits imposed by the individual Structural

411 *Id*. at 685.

412 *Id*. at 421-22.

413 *Id*. at 386 (emphasis added).

414 *Id*. at 414.

415 *See supra* Part IV.C.(1).

416 Tr. at 772.

417 MPR Testimony at A199 (NER001).

Evaluations). Further, C-10 cited no regulatory basis or aging management precedent that requires or even suggests that testing for ultimate expansion is necessary given the ongoing in situ monitoring. Accordingly, we find that the evidence does not demonstrate any practical use for accelerated expansion testing in the context of NextEra's SMP (which monitors, rather than predicts, future expansion).

174. The evidence also demonstrates that, for the highest expansion levels observed at Seabrook, and the current rates of expansion at the Tier 3 (*i.e.*, most severe) locations, there exists "decades of margin" before those locations would reach a corresponding acceptance criterion.[418] Those locations are monitored on a six-month frequency. As one of NextEra's witnesses put it, "[i]f that rate were to increase 1,000 percent in that six months, we still would be well below the limit."[419]

175. The Board invited Dr. Saouma to provide testimony, or cite to evidence, that could demonstrate that NextEra's six-month inspection frequency somehow could be insufficient.[420] But he failed to do so.[421] Ultimately, the record contains no evidence—from Seabrook, the LSTP, academic literature, or otherwise—that indicates that NextEra's inspection intervals are too long, or that ASR (unaided by chemical accelerants used in testing programs) could ever expand at a rate that would challenge these frequencies.

176. NextEra also is subject to a requirement (through a formal license condition) to perform Periodic Expansion Assessments.[422] Among other things, these Periodic Expansion

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418 Tr. at 415-16.

419 *Id*. at 1136.

420 *Id*. at 418, 419.

421 *Id*.

422 MPR Testimony at A93 (NER001).

Assessments must review both the margin for future expansion and the *rate* at which expansion trends are approaching the acceptance criteria.[423] An initial assessment was completed in 2018, with no adverse findings.[424] And another assessment will be completed by 2025, and repeated every 10 years thereafter.[425] Furthermore, as noted above, NextEra is subject to an *ongoing* obligation to evaluate the trend data regarding actual expansion rates at Seabrook and to take action *independent* of the Periodic Expansion Assessment if it identifies information that would challenge the appropriateness of the SMP's inspection intervals.[426]

177. Based on a preponderance of the evidence, the Board finds that the SMP's inspection intervals provide reasonable assurance—for the period of time between now and 2025—to ensure that potential unacceptable expansion is identified prior to reaching the acceptance criteria limits. The Board further finds that the license condition requiring Periodic Expansion Assessment in 2025, and again in 2035 and 2045, provide reasonable assurance that the inspection intervals either will be confirmed, or appropriate action will be taken by NextEra (subject to regulatory oversight) for the periods of time after 2025, 2035 and 2045, respectively.

F. The SEM

178. As noted above, the Board has concluded that C-10's various criticisms of the SEM were not included in the original Contention, and thus C-10's arguments on this topic are outside the scope of this proceeding. Nevertheless, even if those arguments were within scope, a preponderance of the evidence demonstrates that none of C-10's criticisms regarding the SEM defeat a finding that the SEM is appropriate for evaluating the structural adequacy of seismic

423 *Id*. at A94.

424 *Id*.

425 *Id*.

426 Tr. at 1135-37 (discussing the NUREG-0737 Operating Experience program and specific docketed commitments made to the NRC).

Category I structures at Seabrook and provides reasonable assurance for the NRC Staff to approve the LAR.

179. By way of background, Seabrook's UFSAR specifies the method NextEra must use to evaluate the structural adequacy of seismic Category I structures at Seabrook (the "Structural Evaluations"). A Structural Evaluation compares the *demands* (*i.e.*, load effects) on a structure to the *capacities* (*e.g.*, strength or stress limits) of the structure to ensure the structure complies with the plant's licensing basis (*i.e.*, can continue to perform its intended safety function).[427]

180. However, Seabrook's UFSAR did not include a method to account for ASR in Structural Evaluations. Thus, the purpose of the SEM is to provide a methodology for analyzing and evaluating seismic Category I structures with concrete affected by ASR to evaluate whether a given structure affected by ASR meets the intent of the original design codes of record and achieves the structural safety reliability indices consistent with the original design.[428] NextEra considered other theoretical methods of ASR analysis, but concluded that in the absence of NRC regulations or guidance or accepted industry standards on addressing ASR in seismically-rated concrete structures, the most direct, meaningful, and reliable approach to analyzing ASR-affected structures was to firmly root the SEM in the original design basis codes.[429]

181. The *capacities* of Seabrook's concrete structures are derived from the plant's original design material properties and the applicable code expressions supporting the UFSAR. The LSTP concluded that these originally-specified capacities can continue to be used in Structural Evaluations, so long as the Acceptance Criteria from the SMP (which provide

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427 SGH Testimony at A37 (NER004).

428 *Id*. at A33, A34.

429 *Id*. at A84-A97.

reasonable assurance, per our finding above) are not exceeded. Thus, the LAR requested *no changes* to the capacity side of the Structural Evaluation calculations in Seabrook's license.

182. As to the *demand* side, Seabrook's original design basis documents and UFSAR also specify the various loads and load factors that must be considered in Structural Evaluations. Examples of loads include dead loads (the fixed weight of the structure), live loads (such as the time-varying weight of contents, *e.g.*, temporary storage of materials), wind, earthquake effects, and temperature effects.[430] Load factors are essentially multipliers applied to each load, for purposes of conservatism, to achieve a target margin of safety and reliability. The LAR requested no changes to Seabrook's *existing* loads and load factors. However, the LAR requested a modification of the UFSAR to incorporate an *additional* load (and corresponding load factor) that accounts for ASR. As explained further below in Section IV.F.(4), the codes contemplate a process such as this in which a new load is added to the minimum set of loads that are prescriptively enumerated in the code itself.

183. The SEM provides a method for calculating that ASR load, and specifies the ASR load factor, to be used in Structural Evaluations.[431] In summary, ASR loads specific to each structure are calculated from actual field data and ASR expansion measurements collected at Seabrook.[432] Notably, the LSTP is unrelated to, and provides no input for, this method of calculating ASR loads or ASR load factors. The calculated ASR load and its corresponding load factor then are incorporated into the Structural Evaluations, along with the other design loads and load factors specified in the UFSAR.[433]

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430 *Id*. at A51.

431 *Id*. at A42-A44, A51-A60.

432 *Id*. at A61-A71.

433 *Id*. at A43.

184. The SEM employs a three-stage approach for Structural Evaluations.[434] Each ascending stage applies more sophisticated methods and uses additional field measurement data of ASR expansion to improve the rigor of the analysis.[435] For example, certain evaluations use FEM, which is a computer analysis method used by engineers to perform more complex Structural Evaluations.[436]

185. Notably, the SEM also requires that Stage Three Structural Evaluations be validated against field observations and measurements (*e.g.*, plumbness or levelness measurements) to confirm that models actually represent the in-situ conditions. For example, FEM results are correlated with the deformations, strains, and distressed areas (if any) observed at Seabrook. Thus, the *simulated* deformations from the Structural Evaluations are compared to the *field-measured* deformed shape of the structure to validate and confirm its ability to represent the current structural deformed and distressed condition.

186. The Board concludes that the preponderance of the evidence demonstrates that the SEM is appropriate for evaluating the structural adequacy of seismic Category I structures at Seabrook and provides reasonable assurance for the NRC Staff to approve the LAR.

(1) Individual Structural Evaluations

187. As a preliminary matter, the Board notes that the individual Structural Evaluations performed under the SEM for the various structures at Seabrook are not, themselves, part of the LAR. NextEra's LAR only sought approval of the *methodology* for performing those evaluations (*i.e.*, the SEM).[437]

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434 *Id*. at A47, A78-A83.

435 *Id*.

436 *Id*. at A72-A77.

437 *Id*. at A78.

188. C-10's expert provided testimony purporting to challenge one of the individual Structural Evaluations—namely, the Rev. 0 CEB Evaluation (a superseded version of the Structural Evaluation for the CEB).[438] But as discussed above, the Rev. 0 CEB Evaluation was originally submitted to the NRC as an *example* of the proposed method for performing Structural Evaluations. However, the method was refined and its analysis approach was altered during the course of the NRC's review. To formalize the analysis approach used by NextEra and to provide repeatability of the analysis by a knowledgeable licensed Professional Engineer for future evaluations a methodology document was developed (*i.e.*, the SEM Document), which served as the docketed basis for the NRC's review (and approval) of the SEM aspect of the LAR. Likewise, the Structural Evaluation for the CEB was updated (*i.e.*, Rev. 1) to reflect the revised and updated methodology, but was not submitted on the docket because an *example* was no longer needed, given the docketing of the SEM Document, and because the LAR did not request approval of the individual evaluations.

189. Accordingly, we struck these challenges from the record as out of scope, moot, irrelevant, and immaterial, as noted in Paragraph 84 above. Nevertheless, we consider and reject each of those challenges in the sections below.[439]

190. One of the key outputs of a Structural Evaluation is a customized, structure-specific Deformation Monitoring plan.[440] Each plan includes unique monitoring parameters, acceptance thresholds, and monitoring intervals specific to the structure. These are separate and

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438 Saouma Testimony § C.3.4.1 (INT001-R) (discussing Rev. 0 CEB Evaluation (INT015)).

439 Furthermore, even if C-10's challenges to the Rev. 0 CEB Evaluation were within the scope of this proceeding, and not mooted by the issuance of a superseded analysis, we find that the preponderance of the evidence demonstrates that Dr. Saouma's criticisms in Section 3.4.1 of his testimony (INT001-R) are meritless and do not defeat a finding of reasonable assurance, as discussed *infra* at Section IV.F.(5).

440 *See* SGH Testimony at A83 (NER004).

distinct from the SMP Expansion Monitoring techniques, acceptance criteria, and inspection intervals discussed above. More specifically, the Structural Evaluation outputs a "Threshold Factor" for each structure, which is the amount the ASR load can increase and still meet the applicable limits of the code (*i.e.*, to remain in the linear-elastic range).[441] In other words, the Threshold Factor is the margin to the limit. Future expansion of the structure is then monitored against that Threshold Factor, which is insensitive to the *rate* of ASR growth—because it is merely an acceptance value.[442] The Threshold Factor also informs the definition of other required monitoring and observation parameters (*e.g.*, width of seismic isolation gaps, or distances between adjacent structures), and their corresponding limits.[443] The LAR defines presumptive monitoring frequencies for these Deformation Monitoring plans, but the frequency can be adjusted on a case-by-case basis as conditions dictate.[444]

191. We conclude that, because the individual Structural Evaluations are not part of the LAR, the Deformation Monitoring plans that are the outputs of the individual Structural Evaluations—and their corresponding monitoring parameters, acceptance thresholds, and monitoring intervals—also are not subject to challenge in this proceeding.[445] Moreover, C-10 presented no evidence seeking to challenge any structure-specific Deformation Monitoring plan.[446]

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441 *See id*. at A81.

442 Tr. at 937-38.

443 *See* SGH Testimony at A83 (NER004).

444 *See id*.

445 In our decision admitting the Contention, we explicitly noted that the Contention "does not challenge" these frequencies. LBP-17-7, 86 NRC at 127.

446 Dr. Saouma's initial testimony misconstrued the "Threshold Factor" as being an *assumed limit* of future expansion. *See* Saouma Testimony at 24-25 (INT001-R). However, NextEra explained (and the evidence shows) that it is actually a building-specific *calculated* value representing remaining margin to the allowable limits of the code expressions. SGH Testimony at A102 (NER004).

(2) Original Design Capacities

192. As noted above, because ASR produces cracking in concrete, it eventually causes degradation of its material properties.[447] However, as all the parties agree,[448] in reinforced concrete the "chemical prestressing effect" causes a scenario in which this change in material properties does not correspond to a degradation of stiffness or structural capacity (and in some cases actually *increases* structural capacity) up to a certain level of ASR-related expansion.[449]

193. The design codes used for Seabrook seismic Category I structures include methodologies to calculate structural capacities for the various limit states and loading conditions.[450] Material properties are inputs to these calculations. However, as expected, laboratory testing of Seabrook's cores has shown decreases in the concrete material properties of ASR-affected structures.[451] NextEra observed that calculating structural capacities using the *degraded* material properties for ASR-affected reinforced concrete structures would yield values that do not accurately portray the *actual* in situ structural capacities that exist as a result of the "chemical prestressing effect."

194. One of the key conclusions from the research performed as part of the LSTP is that Seabrook's *original* concrete material properties remain valid for purposes of calculating structural capacities for ASR-affected structures subject to one caveat—that the SMP Acceptance Criteria (*i.e.*, the limits derived from the LSTP) are not exceeded.[452] SGH

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447 MPR Testimony at A67 (NER001); *see also* ISE Guideline § 4.4 at pp. 13-14 (NER012); FHWA Guidelines § 5.3.3 at p. 25 (NER013).

448 *See, e.g.*, Saouma Testimony § C.2.4.1 (INT001-R).

449 MPR Testimony at A68 (NER001).

450 *See* LAR Evaluation § 3.2.3 (INT010 (NP), NRC089 (P)).

451 MPR Testimony at A209 (NER001).

452 *See* MPR-4288 (INT012 (NP), INT014 (P)).

independently verified this conclusion in their development of the SEM.[453] Accordingly, the SEM provides that Seabrook's original material properties will be used in performing capacity calculations for the Structural Evaluations (subject to the structure meeting the SMP Acceptance Criteria).[454]

195. Because the Board concluded that the LSTP yielded data appropriate for use to represent Seabrook, C-10's challenge to the use of original concrete material properties on the basis of alleged LSTP non-representativeness also fails.

196. However, C-10 disputes this approach on other grounds as well. More specifically, Dr. Saouma generally asserts that this approach erroneously conflates material properties and structural properties.[455] He further claims that it is improper to use the original material properties as inputs to FEMs, given that those material properties now are degraded due to ASR. But C-10 presents *no evidence* that this broader theoretical challenge to NextEra approach somehow is related to the "representativeness" of the LSTP.[456] Accordingly, as noted in Paragraph 83 above, we struck these arguments from the record. Nevertheless, we considered these arguments and find that they also fail on the merits.

197. The Board notes that C-10 does *not* dispute the overarching principle that structural capacity is not degraded by ASR. In fact, Dr. Saouma admits that "[m]any tests have shown an increase in structural shear strength in reinforced concrete beams (through the so-called prestressing effect) because of ASR."[457] And Dr. Saouma appears to agree that the reason

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453 SBK-L-018074, Encl. 5 (NRC015) (NextEra's response to NRC RAI-D10).

454 SEM Document at 4 (INT022).

455 Saouma Testimony § C.2.4 (INT001-R).

456 The plain language of the Contention, by its own terms, makes clear that challenges to the LAR must purport to be the "result" of the alleged non-representativeness of the LSTP.

457 Saouma Testimony § B.1 (INT001-R).

NextEra can calculate capacities "without accounting for the deterioration due to ASR" is because of the LSTP results showing that "there was no deterioration in the she[a]r strength."[458] Dr. Saouma notes that "without conducting the LSTP" NextEra would "not be able to use" the original material properties.[459] But the fact remains that NextEra *did* conduct the LSTP; and the conclusions of that research demonstrate, across tens of thousands of pages of technical justification, that NextEra *is* able to use the original material properties (provided that the expansions remain within the Expansion Monitoring Limits).

198. C-10 presents no evidence to suggest that the LSTP's overarching conclusion—that structural capacity is not degraded due to ASR expansion, up to the limits of the testing—is flawed or incorrect. And Dr. Saouma identified no published literature or independent research or analysis to contradict NextEra's approach. In contrast, NextEra's approach is based on scientific research in the LSTP, as confirmed by sound structural engineering principles, which are extensively documented in the record and independently verified by SGH's confirmatory analysis. Thus, the preponderance of the evidence demonstrates that the use of Seabrook's original material properties in performing capacity calculations for the Structural Evaluations (subject to the structure meeting the SMP Acceptance Criteria) is adequate to provide reasonable assurance.

(3) ASR Loads and Load Factors

199. As noted above, the SEM provides a method for calculating ASR load, and specifies the ASR load factor, to be used in Structural Evaluations.[460] The ASR loads (specific to each structure) are calculated from Seabrook field measurements, which is entirely separate

458 Tr. at 973.

459 *Id*.

460 SGH Testimony at A42-A44, A51-A60 (NER004).

and disconnected from the LSTP.[461] Thus, even assuming some portion of the SEM was within the scope of this proceeding, this portion (related to ASR loads and load Factors) clearly would not be because it is unrelated to the Contention admitted for adjudication in this proceeding, which pertains solely to the "representativeness" of the LSTP.

200. Dr. Saouma initially challenged this aspect of the SEM, claiming that "[t]he assumption that ASR can be considered a load is fundamentally wrong."[462] However, he later rescinded that remark and acknowledged there is no controversy on this point.[463] Dr. Saouma also suggested that the use of crack width indexing (*i.e.*, the Seabrook field measurements) to calculate ASR loads and load factors rendered this aspect of the SEM "unreliable."[464] As we concluded above, crack width indexing is adequate to provide reasonable assurance. And after further reviewing the technical basis, Dr. Saouma stated that he "salute[s]" NextEra's effort in developing the ASR loads and load factors.[465] Dr. Saouma noted "for the record" that he "do[es] not disagree" with this aspect of NextEra's methodology, but rather contests "the manner in which it was applied" (*i.e.*, in a code-based analysis).[466]

201. Ultimately, C-10 presents no evidence to contradict NextEra's code-based approach to ASR loads and load factors. Thus, the preponderance of the evidence demonstrates that the SEM approach to ASR loads and load factors is adequate to provide reasonable assurance.

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461 *Id*. at A61-A71.

462 Saouma Testimony § C.2.4.2 (INT001-R).

463 Tr. at 440.

464 Saouma Testimony § C.11 (INT001-R).

465 Tr. at 440-41. (Dr. Saouma observing that this aspect of the LAR was independently reviewed by Dr. Ellingwood, who concluded that the approach was sound, and noting that he respects and defers to Dr. Ellingwood's expert opinion.)

466 Saouma Rebuttal § A.12 (INT028).

(4) Code-Based Structural Evaluation Approach

202. As noted above, NRC regulations at 10 C.F.R. § 50.92(a) state that, in determining whether to approve a license amendment request, "[t]he Commission will be guided by the considerations which govern the issuance of [the] initial license[] . . . to the extent applicable and appropriate."

203. As the NRC Staff explained, Seabrook's LAR approach of using the Structural Evaluation methods in ACI 318-71 and ASME 1975 were deemed "applicable" because they are part of Seabrook's existing licensing basis code of record for performing Structural Evaluations on seismic Category I structures.[467] C-10 also agrees that these codes are "applicable."[468]

204. As the NRC Staff explained, Seabrook's LAR approach of using the Structural Evaluation methods in ACI 318-71 and ASME 1975 were deemed "appropriate" because NextEra provided a robust technical basis, supported by the LSTP, demonstrating that the existing codes could continue to be used for Structural Evaluations of ASR-affected structures.[469] C-10, however, disagrees.[470] Its expert suggests that codes, in general, cannot be used to analyze structures affected by ASR,[471] and that only probabilistic and constitutive modeling (*i.e.*, beyond code) methods would qualify as appropriate.[472] However, as noted above, the Board has stricken C-10's arguments regarding alternative means of regulatory compliance. Nevertheless, the Board has considered the appropriateness of ACI 318-71 and ASME 1975, as explained below.

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467 Tr. at 336.

468 *Id*. at 337.

469 *Id*. at 336.

470 *Id*. at 337.

471 Saouma Rebuttal § B.1 (INT028) (suggesting that code-based approaches can only "scratch at the problem"); Tr. at 1065 (Dr. Saouma: "code code code" [speaking derisively regarding the use of consensus engineering codes]).

472 *See, e.g.*, Saouma Testimony §§ C.5 to C.8 (INT001-R).

205. Neither ACI 318-71 or ASME 1975 contain a prescriptive method of accounting for ASR in Structural Evaluations. But this is not dispositive of the "appropriate[ness]" of these codes. In fact, it is not uncommon that a new load or a new phenomenon, not otherwise explicitly addressed in the four corners of a code, must be evaluated.[473] And the codes permit—and indeed anticipate—that new loads will be evaluated.[474] For example, ACI 318-71 indicates that the prescribed loads specified in the code are the *minimum* set of loads that must be evaluated in Structural Evaluations, as opposed to an exhaustive list.[475] Indeed, consistent with NUREG-0800 § 3.8.4, Seabrook's licensing basis (UFSAR Table 3.8-16 (NRC007)) requires NextEra to use ACI 318-71 to evaluate *other* loads and phenomena not specifically enumerated in ACI 318-71, such as operational piping loads (R_O) and accident pressure (P_a).[476] Ultimately, we find that the absence of explicit ASR provisions in ACI 318-71 and ASME 1975 has no bearing on whether they are appropriate for use in the LAR.

206. Dr. Saouma criticizes the use of ACI 318-71 and ASME 1975 as inappropriate primarily because they employ linear-elastic analysis.[477] By way of background, linear-elastic structural behavior refers to the general load-deformation behavior of a reinforced concrete structure in which, as the load increases, the structure deforms proportionately (*i.e.*, linearly), and when the load decreases, the structure recovers to the point of zero deformation in the same linear fashion (*i.e.*, elastic behavior).[478] If a structure is loaded beyond the limits of linear-elastic behavior, its deformation increases faster than the load increases, which is called non-linear (*i.e.*,

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473 Tr. at 1105.

474 *Id*. at 1004

475 *Id*. at 577-79; ACI 318-71 §§ 8.21, 9.3.2, 9.3.7 (NRC049).

476 *See also* Tr. at 578.

477 Saouma Testimony § B.7 (INT001-R).

478 SGH Testimony at A93 (NER004).

plastic) behavior.[479] Dr. Saouma asserts that ASR could ultimately cause non-linear structural behavior, and that only a non-linear analysis method can evaluate non-linear behavior.[480]

207. One of the key differences between code-based linear and nonlinear analysis methods is that linear analyses use conservative code limits in order to streamline and simplify the analysis, whereas nonlinear analyses apply more granular methods and use additional input parameters where refinement is necessary to demonstrate compliance with the codes.[481] For example, if a structure is predicted to experience highly nonlinear behavior, it may not be able to demonstrate satisfaction of conservative code limits via linear analysis; thus, a nonlinear analysis may be appropriate. The question is thus, what is the appropriate tool for the job? We find that a preponderance of the evidence supports NextEra's conclusion that linear-elastic analysis remains the appropriate tool for evaluating structural adequacy in Seabrook's seismic Category I structures.

208. Under normal operating conditions, Seabrook's license requires, as a matter of law, that plant structures "*shall be maintained within elastic limits*."[482] For Seabrook's seismic Category I structures other than the Containment Building, ACI 318-71 provides a means to evaluate low levels of localized nonlinearity and still demonstrate compliance with the limits of elastic structural behavior.[483] Thus, to the extent C-10 claims NextEra's analysis method cannot account for low levels of localized nonlinearity, it is factually mistaken. And to the extent C-10 argues Seabrook's structures will experience high levels of, or non-localized, nonlinearity, it

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479 *Id*.

480 Saouma Testimony § B.3 (INT001-R).

481 Tr. at 304, 585-86.

482 Final SE at 48 (INT024 (NP), INT025 (P)) (quoting Seabrook UFSAR §§ 3.8.4.3, 3.8.4.5, 3.8.3.3, 3.8.3.5).

483 Tr. at 865, 869. We reject Dr. Saouma's claim that a single localized point of low-level nonlinearity will cause the structure to go "[c]aput." *Id*. at 870.

provides no evidentiary support—and its claim is contradicted by NextEra's evidence. More specifically, NextEra submitted a detailed analysis in response to an NRC RAI which demonstrated that, under realistic normal operating conditions, with an operating basis earthquake—*i.e.*, "a very high level conservative earthquake"[484]—Seabrook's seismic Category I structures *still* would remain within the elastic range.[485] Given this clear and legally-enforceable requirement that Seabrook's structures can only incur loading (including loading from ASR) up to the limits of linear-elastic structural behavior, and the fact that NextEra routinely monitors the margin of ASR expansion remaining to these limits (*i.e.*, the Threshold Factor), we find the record presents no basis to conclude that the linear-elastic analysis methods in ACI 318-71 in ASME 1975 would be inappropriate.

209. At the evidentiary hearing, Dr. Saouma further criticized NextEra regarding the "appropriateness" of using Seabrook's existing codes of record, suggesting that NextEra "blindly accept[ed] the code."[486] But Mr. Bell's testimony provided a succinct summary of the evidence that rebuts this assertion:

> There has been an enormous amount of work that has gone in through the testing program and our analysis to validate the approach that we have taken. It's not blind at all. It is carefully considered. The validity of the code equations were amply demonstrated by the very extensive testing of the large scale testing program.[487]

210. In contrast to the "extensive testing of the large scale testing program," C-10 provides no evidence, other than Dr. Saouma's opinion, that ACI 318-71 and ASME 1975 are not "appropriate" for use in the LAR. On balance, we find that NextEra has provided the

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484 Tr. at 860.

485 SBK-L-17204, Encl. 1 (NRC014) (response to NRC RAI-D8).

486 Tr. at 581.

487 *Id*. at 582.

preponderance of the evidence on this point, and conclude that Seabrook's codes of record are applicable and appropriate, as required by 10 C.F.R. § 50.92.

(5) Criticisms Specific to the Rev. 0 CEB Evaluation

211. As noted above, even if C-10's challenges to the Rev. 0 CEB Evaluation were within the scope of this proceeding, and even if they were not mooted by the issuance of a superseded analysis, we find that the preponderance of the evidence demonstrates that Dr. Saouma's criticisms in Section 3.4.1 of his testimony (INT001-R) are meritless. As a general matter, these criticisms are far afield from the Contention's "key issue" of LSTP "representativeness." Moreover, they are based in large part on Dr. Saouma's misunderstandings of the LAR—and indeed, the differences between various Seabrook structures[488]—that are either clearly contradicted by the record evidence in this proceeding, or that C-10's rebuttal testimony abandoned (after NextEra's testimony highlighted and corrected Dr. Saouma's error). As further discussed below, these meritless arguments do not defeat a finding of reasonable assurance.

a. Thermal Expansion & Shell Elements

212. C-10 criticizes the use of "thermal expansion" and "shell elements" in the Rev. 0 CEB Evaluation FEM.[489] More specifically, Dr. Saouma asserts that shell elements "cannot capture the through thickness expansion," and that the use of thermal expansion "will fail to capture the anisotropic nature of the expansion."[490] In essence, Dr. Saouma's criticisms are two-fold. First, Dr. Saouma claims that the FEM uses *isotropic* thermal expansion (*i.e.*, the same

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488 Dr. Saouma repeatedly conflated the CEB with the Containment Building in his written and oral testimony. *See, e.g.*, Tr. at 614-15, 858-59. These are two different structures, with different intended safety functions and licensing bases, the structural evaluations of which are governed by entirely separate code provisions. SGH Testimony at A36, A59 (NER004) (noting the CEB reference code is ACI 318-71, whereas the Containment Building is governed by ASME 1975). Dr. Saouma's confusion informs the weight we give to his testimony in this area.

489 Saouma Testimony at 26 (INT001-R).

490 *Id*.

value for each direction of expansion), whereas it should be using elements with *orthotropic* expansions capable of defining unique expansion values for each direction in the model. And second, Dr. Saouma's concern is that the FEM is only modeling expansion in the two in-plane directions, whereas ASR also may cause through-thickness expansion. As a preliminary matter, we note that neither of these criticisms stem from the alleged non-representativeness of the LSTP and were never discussed or mentioned in C-10's original proposed contention, and thus are beyond the scope of the Contention. Further, as noted above in Section IV.C., the Rev. 0 CEB Evaluation (and structure-specific evaluations generally) are not within the scope of the challenged license amendment. Nevertheless, as explained below, we consider and reject these criticisms.

213. First, the evidence shows that the Rev. 0 CEB Evaluation, in fact, used unique input values for each direction in the FEM, entirely disproving Dr. Saouma's contrary assertion.[491] By way of background, FEM codes do not include direct input fields for ASR expansion, but thermal expansion can be used as a proxy in the software.[492] Thus, in the Rev. 0 CEB Evaluation, "ASR expansion is simulated by applying a thermal expansion to the elements representing the CEB concrete."[493] More specifically, "[s]imulated ASR expansion of the CEB is based on Crack Index (CI) strain measurements performed in the regions of the structure defined in Table 13."[494] Dr. Saouma's criticism appears to conflate the concept of Crack Index ("CI") values, which are unidirectional, and Combined Crack Index ("CCI") values, which

491 Tr. at 1183 (Dr. Saouma curtly stating that "It's not there."); *see also id*. at 1171-73.

492 SGH Testimony at A76 (NER004).

493 Rev. 0 CEB Evaluation at 40 (INT015).

494 *Id*. at 79.

represent a *combination* of the vertical and horizontal CI measurements.[495] In other words, the two CI values (horizontal and vertical measurements) are *not* combined for use in the FEM. And Table 13 of the Rev. 0 CEB Evaluation further confirms that unique expansion values were used for each direction.[496] Thus, Dr. Saouma's criticism is not supported by the evidence.

214. Second, NextEra explained that the purpose of the FEM is to capture the *load effects* of ASR expansion, not to predict the dimensional level of expansion.[497] C-10 did not dispute this assertion. Accordingly, NextEra's experts testified that, if the in-plane inputs are bounding the load effects captured in the FEM will be appropriately conservative.[498] Notably, the below-grade portions of the CEB have tri-axial reinforcement[499]—so ASR will *not* expand preferentially in the through-thickness direction in those areas. And even in the upper portions of the CEB without tri-axial reinforcement, the evidence show that through-thickness deformation is "very small" compared to in-plane.[500] And this observation is no surprise, given that the CEB shell is a thin-shell structure (thickness ranges from 15-36") whereas the in-plane dimensions of that shell are many orders of magnitude greater.[501] C-10 did not dispute NextEra's assertion that the in-plane inputs are bounding.

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495 SEM Document at 6 (NER022) ("The Combined Cracking Index (CCI) is the weighted average of the CI in the two measured in-plane directions. A typical ASR-monitoring location produces two CI values (in-plane perpendicular directions) and one CCI value").

496 Rev. 0 CEB Evaluation at 93, tbl.13 (INT015) (showing the separate "hoop" (i.e., horizontal) and "meridional" (i.e., vertical) CI measurements used in the FEM); *id*. tbl.12 (providing the separate hoop and meridional values for each monitoring location). *See also* SEM Document § 3.1 (NER022) (confirming that the SEM specifies the use of CI, not CCI).

497 SGH Testimony at A73, A110 (NER004).

498 *Id*.

499 *Id* at A107.

500 *Id*.

501 *Id*.

215. Third, NextEra's evidence demonstrates that solid elements (*i.e.*, three-dimensional elements recommended by Dr. Saouma in lieu of shell elements) *are* used in the FEM for the portions of the CEB in which through-thickness expansion is relevant and material.[502] For example, the Rev. 0 CEB Evaluation uses solid (3-D) elements to capture the CEB's ring-shaped foundation, which is a thick member.[503] C-10 did not comment on this distinction.

216. On balance, we find that NextEra's selection of shell elements and solid elements for different portions of the CEB was appropriate in the context of the FEM's purpose (to capture load effects), and that the FEM appropriately used unique thermal expansion input values for each direction.

b. *Bubble Expansion*

217. Dr. Saouma also claimed that the Rev. 0 CEB Evaluation failed to account for "bubble" expansion that will occur on the CEB base mat.[504] The record contains no evidence that this criticism stems from the alleged non-representativeness of the LSTP, and again this issue was not described or mentioned in the original proposed contention. Thus, it is beyond the scope of the Contention. Nevertheless, we consider and reject this criticism because NextEra's evidence clearly shows—and we agree—that the CEB foundation is a ring, not a mat, and thus Dr. Saouma's assertion regarding alleged bubble expansion of a non-existent base mat is not applicable to the CEB.[505]

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502 *Id*.

503 *Id*.

504 *See* Saouma Testimony at 26, 27-28, and fig.16a (INT001-R).

505 SGH Testimony at A108 & fig.12 (NER004).

c. Steel Membrane Elements

218. C-10 criticizes the Rev. 0 CEB Evaluation because "steel membrane elements" were included "only for the ASR study and not for the other load cases," and suggests this is somehow improper.[506] The record contains no evidence that this criticism stems from the alleged non-representativeness of the LSTP and was not raised in the original contention. Thus, it is beyond the scope of the Contention. Nevertheless, we consider and reject this criticism.

219. NextEra's responsive testimony showed that C-10's claim that steel membrane elements were used *only* for the evaluation of ASR loads was factually inaccurate.[507] Steel membrane elements *also* were included in modeling concrete swelling strains.[508] NextEra's responsive testimony also explained that this distinction was necessary and appropriate because the concrete and reinforcing steel strain *differently* in the assessment of ASR loads and swelling strains (compared to modeling for other loads), and thus should be modeled separately, consistent with ACI 318-71.[509] C-10 did not contest, and offered no rebuttal to, this assertion. Thus, we find that a preponderance of the evidence shows NextEra's use of "steel membrane elements" was reasonable and appropriate.

d. Swelling

220. C-10 criticizes the Rev. 0 CEB Evaluation because it used moisture-related swelling values that Dr. Saouma called "arbitrary" and "without scientific basis."[510] Again, the record contains no evidence that this criticism stems from the alleged non-representativeness of

506 *See* Saouma Testimony at 26 (INT001-R).

507 SGH Testimony at A111 (NER004).

508 *Id*.

509 *Id*. (citing ACI 318-71 ¶ 8.5.3.1 (NRC049)).

510 Saouma Testimony at 26-27 (INT001-R).

the LSTP or mentioned in the original contention, and therefore is beyond the scope of the Contention. Nevertheless, we consider and reject this criticism. NextEra cited several sources of scientific research that provided the technical justification for the swelling values it used.[511] C-10 offered no rebuttal to the accuracy or appropriateness of this information. Thus, we find that a preponderance of the evidence shows the swelling values used in the Rev. 0 CEB were reasonable and appropriate.

e. *Seismic Analysis*

221. C-10 criticized the Rev. 0 CEB Evaluation for performing a seismic response spectra analysis using the "stick method."[512] Dr. Saouma criticized this method as a "model of the past" that is "overly simplistic."[513] Dr. Saouma also criticizes the analysis for allegedly confusing in-plane and out-of-plane shear, and improperly assuming that cracking can only occur in the direction of seismic excitation.[514] But the record contains no evidence that the criticisms are in any way related to the alleged non-representativeness of the LSTP nor were they mentioned in the original contention. Thus, they are beyond the scope of the Contention. Notwithstanding, we consider and reject these criticisms.

222. As a preliminary matter, the evidence shows the Rev. 0 CEB Evaluation uses the "multi-step method," not merely the "stick method."[515] Indeed, contrary to Dr. Saouma's impression that such methods are outdated, that's what Seabrook's existing licensing basis

511 SGH Testimony at A113 (NER004).

512 *See* Saouma Testimony at 27 (INT001-R).

513 *See id*.

514 *See id*. at 28.

515 SGH Testimony at A114 (NER004) (The multi-step method applies seismic accelerations calculated from the lumped-mass stick model, Step 1, to a more detailed model, Step 2, for calculating structural forces for evaluation).

explicitly requires.[516] Accordingly, we find no merit in Dr. Saouma's assertion that either the "stick method" or the "multi-step method" are outdated and therefore inappropriate. In practical terms, both methods continue to be endorsed in the NRC's Standard Review Plan, which was updated in 2013, and in ASCE 4-16, which was published in 2016.[517] In fact, the "stick method" was recently approved by the NRC for use in two new nuclear power units.[518]

223. Furthermore, as to Dr. Saouma's assertion that the seismic analysis conflates in-plane and out-of-plane shear, NextEra's experts testified that Dr. Saouma's arguments appear to conflate the LSTP testing with the Rev. 0 CEB Evaluation.[519] The evidence shows that the Rev. 0 CEB Evaluation did not conflate the in-plane and out-of-plane shear because they were evaluated separately in the detailed FEM at both the element level and the section cut level.[520] C-10 failed to rebut, either in Dr. Saouma's Rebuttal Testimony or at the evidentiary hearing, NextEra's responses on this topic; C-10 also failed to rebut NextEra's responses to Dr. Saouma's other minor criticisms related to the Rev. 0 CEB Evaluation seismic analysis).[521]

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516 SGH Testimony at A114 (NER004).

517 SRP § 3.7.2 at 11 (Rev. 4, Sept. 2013) (NER043); ASCE 4-16 § 3.1.2 (NER036).

518 SGH Testimony at A114 (NER004) (discussing the combined operating license for South Texas Project, Units 3 & 4).

519 *Id*. at A120.

520 *Id*. at A121. As a practical matter, NextEra's evidence also provides a technical analysis showing that in-plane cracking is "unlikely" due to low seismic motion at Seabrook. SGH Testimony at A122 (NER004). C-10 also did not rebut this assertion.

521 *Compare* Saouma Testimony at 27 (INT001-R) (asserting the method did not account for "seismic contact between the wall and the adjacent soil") *with* SGH Testimony at A114 (NER004) (explaining the dynamic soil pressure is explicitly considered in the analysis, based on the pressure profiles is described in Seabrook's UFSAR § 3.7(B).2). *Compare* Saouma Testimony at 29 & fig.17 (INT001-R) (challenging NextEra's use of fixed-base analysis and arguing ASCE 4-16 requires soil structure interaction ("SSI") analysis) *with* SGH Testimony at A115 (NER004) (explaining that Seabrook structures are founded on hard rock with shear wave velocity of 8,000 to 10,000 ft/sec, *see* UFSAR Section 2.5.2.5 (NER044), and that ASCE 4-16 and the SRP specify that fixed base analysis is appropriate (and no SSI analysis is necessary) when the shear wave velocity is greater than 8,000 ft/sec, *see* ACI 4-16 § 5.1.1(a)(3) (NER036); SRP § 3.7.2 (NER043)).

224. In contrast, Dr. Bolourchi, a structural engineer and seismic expert who has performed seismic analyses for many nuclear power plants in the United States across his four decades of experience in this area, provided testimony that NextEra's method is entirely acceptable and appropriate.[522] Based on the evidentiary record, the Board finds that Dr. Saouma's claims are unsupported, and that a preponderance of the evidence supports the appropriateness of NextEra's method of seismic analysis.

f. Section Cut Approach

225. C-10 criticizes the "section cut approach" used in the Rev. 0 CEB Evaluation. More specifically, in his initial testimony, Dr. Saouma claimed this approach reduces the assessment to a "series of parallel column[s] with no interaction among them."[523] In essence, Dr. Saouma asserts that the inputs to NextEra's FEM are not granular enough to capture structural behavior. But the record contains no evidence that this criticism was raised in the original Contention or is in any way related to the alleged non-representativeness of the LSTP. Thus, it is beyond the scope of the Contention. Notwithstanding, we consider and reject this criticism.

226. In its testimony, NextEra demonstrated that the "section cut approach" (as used in the Rev. 0 CEB Evaluation) actually uses the *results* from the FEM, with all of its connectivity, properties, loading, and boundary conditions.[524] More specifically, the output from a series of consecutive elements is aggregated to a load over a length (so called "section cut") and compared to the capacity across the length of the section cut.[525] NextEra pointed to information in the Rev. 0 CEB Evaluation itself showing that the section cuts are simply selections from the

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522 *See, e.g.*, SGH Testimony at A114-15, A120-22 (NER004).

523 *See* Saouma Testimony at 28 (INT001-R).

524 SGH Testimony at A116 (NER004).

525 *Id*.

finite element model (not a series of isolated clusters of elements) designed to capture the *peak demand* in a particular portion of the structure.[526] NextEra's experts testified that the section cut approach captures the actual structural response,[527] and that this approach is fully consistent with the ACI code.[528]

227. C-10 failed to rebut, either in Dr. Saouma's Rebuttal Testimony or at the evidentiary hearing, NextEra's explanation. Accordingly, we find C-10's claims unpersuasive, and we find that a preponderance of the evidence supports the appropriateness of NextEra's use of the section cut approach.

V. SUMMARY FINDINGS OF FACT AND CONCLUSIONS OF LAW

228. Based upon a review of the entire record of this proceeding and the proposed findings of fact and conclusions of law submitted by the parties, and based upon the findings set forth above, which are supported by reliable, probative, and substantive evidence in the record, the Board has decided all matters in controversy as to the admitted Contention and the reaches the following conclusions.

229. The Board concludes that NextEra's Second MIL should be granted for the reasons articulated above in Section IV.C.

230. The Board finds that C-10 has not satisfied its initial "burden of going forward" on the Contention because it has failed to provide sufficient probative evidence to establish a *prima facie* case for any of the Commission-summarized "elements" of the Contention presented

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526 *Id*. & fig. 13 (consolidating figures from Rev. 0 CEB Evaluation, App. N figs. N-2, N-7, & N-11 (INT015)).

527 *Id*.

528 *Id*. at A117, A118 (NER004).

by C-10 at the outset of this proceeding. Thus, the Board concludes that the Contention is resolved in favor of NextEra.

231. We find that, even if C-10 had satisfied its initial "burden of going forward" on the Contention, NextEra has demonstrated, by a preponderance of the evidence, through the MPR Testimony, the SGH Testimony, and corresponding exhibits, that its program for addressing Seabrook's "slow-growing" version of ASR (which, "after more than thirty years, has reached only low to moderate levels")[529] is robust, conservative, technically justified, and satisfies the reasonable assurance standard. Importantly, the NRC's reasonable assurance standard does not require that the LAR satisfy an "absolute" or "beyond a reasonable doubt" standard.[530] And as noted above, "[t]he mere casting of doubt" on some aspect of an application is legally insufficient "to defeat a finding of reasonable assurance."[531] Thus, even assuming C-10 had submitted sufficient probative evidence to move forward on the Contention—which it has not—that evidence is wholly insufficient to overcome the evidence submitted by NextEra, or to defeat the NRC's finding of reasonable assurance.

232. More specifically, the Board finds that a preponderance of the evidence demonstrates that: (1) the LSTP yielded representative data that are appropriate for use to represent ASR-affected concrete at Seabrook, (2) the SMP is adequate to monitor the progression of ASR at Seabrook, (3) the SEM is appropriate for evaluating the structural adequacy of seismic

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529 *Id*. at A90 (NER004).

530 *Oyster Creek*, CLI-09-7, 69 NRC at 262 n.142; *Zion Station*, ALAB-616, 12 NRC at 421; *N. Anna Envtl. Coal.*, 533 F.2d at 667-68 (rejecting the argument that reasonable assurance requires proof beyond a reasonable doubt and noting that the licensing board equated "reasonable assurance" with "a clear preponderance of the evidence").

531 *PFS*, CLI-00-13, 52 NRC at 31 (citing *LES*, CLI-97-15, 46 NRC 297 (1997); *Seabrook*, CLI-99-6, 49 NRC at 222).

Category I structures at Seabrook, (4) reasonable assurance exists for the NRC Staff to grant the LAR, and (5) C-10's criticisms of the LAR do not defeat a finding of reasonable assurance.

233. In Contention D, C-10 challenged the representativeness of the data from the LSTP. In Contentions A, B, and C, C-10 challenged the effectiveness of monitoring techniques at Seabrook based on the alleged non-representativeness of the LSTP. And in Contention H, C-10 challenged the frequency of the proposed monitoring intervals at Seabrook based on the alleged non-representativeness of the LSTP. Because the Board finds that the LSTP yielded representative data that are appropriate for use to represent ASR-affected concrete at Seabrook, we conclude that each of these contentions, and the reformulated Contention, are resolved in favor of NextEra.

234. Overall, we find that a preponderance of the evidence supports the NRC Staff's conclusion that the LAR's plant-specific method of evaluation for seismic Category I reinforced concrete structures affected by ASR at Seabrook is acceptable and provides reasonable assurance that these structures continue to meet the relevant requirements of 10 CFR Part 50, Appendix A, General Design Criteria ("GDC") 1, 2, 4, 16 and 50, and 10 CFR Part 50, Appendix B; and that NextEra has satisfied the requirements of 10 C.F.R. §§ 50.92 and 50.57(a)(3) and (6).

VI. ORDER

WHEREFORE, IT IS ORDERED, pursuant to 10 C.F.R. §§ 2.1210, that the Contention is resolved on the merits in favor of NextEra.

IT IS FURTHER ORDERED, this Initial Decision will constitute a final decision of the Commission forty (40) days from the date of issuance (or the first agency business day following that date if it is a Saturday, Sunday, or federal holiday, *see* 10 C.F.R. § 2.306(a)), unless a petition for review is filed in accordance with 10 C.F.R. § 2.1212, or the Commission directs otherwise.

IT IS FURTHER ORDERED that any party wishing to file a petition for review on the grounds specified in 10 C.F.R. § 2.341(b)(4) must do so within twenty-five (25) days after service of this Initial Decision. The filing of a petition for review is mandatory for a party to have exhausted its administrative remedies before seeking judicial review. Within twenty-five (25) days after service of a petition for review, parties to the proceeding may file an answer supporting or opposing Commission review. Any petition for review and any answer shall conform to the requirements of 10 C.F.R. § 2.341(b)(2)-(3).

Respectfully submitted,

Executed in Accord with 10 C.F.R. § 2.304(d)

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Dated in Washington, DC
this 21st day of November 2019

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of:	)	
NEXTERA ENERGY SEABROOK, LLC	)	Docket No. 50-443-LA-2
(Seabrook Station Unit 1)	)	November 21, 2019

CERTIFICATE OF SERVICE

Pursuant to 10 C.F.R. § 2.305, I certify that, on this date, the foregoing "NextEra Energy Seabrook LLC's Proposed Findings of Fact and Conclusions of Law" was served upon the Electronic Information Exchange (the NRC's E-Filing System), in the above-captioned proceeding.

Signed (electronically) by Ryan K. Lighty

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