UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

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

NRC STAFF PROPOSED FINDINGS OF FACT AND CONCLUSIONS OF LAW FOR THE ADMITTED CONTENTION

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(Representativeness of the Large-Scale Test Program Data to the Progression of Alkali-Silica Reaction at Seabrook)

I. INTRODUCTION

1.1 The Atomic Safety and Licensing Board's initial decision rules on all outstanding issues associated with the NextEra Energy Seabrook, LLC, license amendment request (LAR) to adopt a methodology to account for the impacts of alkali-silica reaction (ASR) (also known as alkali-aggregate reaction (AAR)) on seismic Category I[1] reinforced concrete structures at Seabrook Station, Unit No. 1.[2] Specifically, the Board's initial decision rules on whether the

[1] Seismic Category I structures, systems, and components include those necessary to control the release of radioactive material or otherwise mitigate the consequences of an accident. *See* Exhibit NRC088-00-BD01, Regulatory Guide (RG) 1.29, Seismic Design Classification for Nuclear Power Plants at 5 (July 2016) (ML19205A444).

[2] Exhibit INT010-00-BD01/Exhibit NRC089-00-BD01, 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 (Aug. 1, 2016) (ML19161A381 (nonproprietary) and ML19205A478 (proprietary), respectively) (Original LAR) (The Staff does not cite Exhibit INT011-00-BD01 because it includes highlighting that is not a part of the original document).

NextEra supplemented the Original LAR on September 30, 2016, October 17, 2017, December 11, 2017, and June 7, 2018. Exhibit NRC010-00-BD01, Letter from Ralph A. Dodds III, NextEra, to NRC, "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" (Sept. 30, 2016) (ML19205A356) (Sept. 2016 LAR Supplement); Exhibit NRC013-00-BD01, Letter from Eric McCartney, NextEra, to NRC, "Seabrook Station, Response to Request for

large-scale test program (LSTP), undertaken for NextEra at the Ferguson Structural Engineering Laboratory (FSEL), has yielded data that are representative of the progression of ASR at Seabrook and that, as a result, the proposed monitoring, acceptance criteria, and inspection intervals of the ASR expansion monitoring program proposed in the LAR are adequate. ASR is a chemical reaction in concrete that occurs in the presence of moisture where alkalis, usually from the cement, react with certain reactive types of silica in the aggregate, which produces an alkali-silica gel that can absorb water and expand to cause micro-cracking of the concrete.[3] Excessive expansion of the gel can lead to significant cracking that may degrade the material properties of the concrete.[4] The purpose of the LSTP was to determine whether the structural properties of the Seabrook reinforced concrete structures could still be conservatively estimated by the existing Seabrook design basis codes, even

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Additional Information Regarding License Amendment Request 16-03 Related to Alkali-Silica Reaction" (Oct. 3, 2017) (ML19205A358) (Oct. 2017 LAR Supplement); Exhibit NRC014-00-BD01, Letter from Eric McCartney, NextEra, to NRC, "Seabrook Station, Response to Request for Additional Information Regarding License Amendment Request Related to Alkali-Silica Reaction" (Dec. 11, 2017) (ML19205A359) (Dec. 2017 LAR Supplement); Exhibit NRC015-00-BD01, Letter from Christopher Domingos, NextEra, to NRC, "Seabrook Station, Response to Request for Additional Information Regarding License Amendment Request 16-03" (June 7, 2018) (ML19205A360) (June 2018 LAR Supplement) (enclosure 3 of this submittal is Exhibit INT023-00-BD01 and enclosure 4 is Exhibit INT024-00-BD01). Separately, on May 18, 2018, in updating its license renewal application for Seabrook, NextEra provided revised versions of MPR Associates (MPR) reports previously submitted as LAR supplements. Exhibit NRC016-00-BD01, Letter from Eric McCartney, NextEra, to NRC, "Seabrook Station Revised Structures Monitoring Aging Management Program" (May 18, 2018) (ML19205A361) (May 2018 MPR Reports Update) (enclosure 2 of this letter is INT017-00-BD01; enclosure 4, MPR-4153, Rev. 3 (nonproprietary) is INT018-R-00-BD01; enclosure 5, MPR-4273, Rev. 1 (non-proprietary) is INT019-R-00-BD01; enclosure 6, MPR-4153, Rev. 3 (proprietary) is INT020-00-BD01; Enclosure 7, MPR-4273, Rev. 1 (proprietary) is INT020-00-BD01).

Collectively, the Original LAR, all LAR supplements, and the May 18, 2018 MPR report revisions, including all enclosures and attachments, constitute the "LAR."

[3] Exhibit NRC001-R-00-BD01, Staff Testimony at 6–8 (ML19261A762); Exhibit INT024-00-BD01/Exhibit INT025-00-BD01, Safety Evaluation by the Office of Nuclear Reactor Regulation Related to Amendment No. 159 to Facility Operating License No. NPF-86, encl. 2 at 5 (Mar. 11, 2019) (ML19161A392 (nonproprietary) and ML19162A020 (proprietary), respectively) (Safety Evaluation (SE)); Exhibit NRC060-00-BD01, NRC Information Notice 2011-20: Concrete Degradation by Alkali-Silica Reaction, at 2 (Nov. 18, 2011) (ML19205A432) (IN-2011-20).

[4] Exhibit NRC001-R-00-BD01, Staff Testimony at 6–8. The material properties of concrete include compressive strength, elastic modulus, tensile strength, shear strength, and flexural strength. *Id.* at 7.

though the material properties of the Seabrook concrete affected by ASR may be degraded.[5] In general, the LSTP data demonstrated that as long as ASR expansion within Seabrook structures remains below the limits established from the LSTP, the structural properties will be unaffected. Therefore, the structural performance of the structures can still be conservatively estimated by the design basis codes, regardless of degradations in concrete material properties due to ASR.[6]

1.2 This ruling is in response to a request for a hearing on the LAR filed by the C-10 Research and Education Foundation (C-10) on April 10, 2017.[7] The request included ten proposed contentions.[8] In LBP-17-7, the Board ruled that C-10 had demonstrated standing and had pled five admissible contentions, which the Board reformulated into the following single contention:

> 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.[9]

From September 24–27, 2019, the Board held an evidentiary hearing on the reformulated contention at the Newburyport City Hall Auditorium.

1.3 C-10's position in this proceeding is that the LSTP was not representative of the concrete structures at Seabrook and that, therefore, NextEra has not met its burden of demonstrating by a preponderance of the evidence that its proposed monitoring based on the

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[5] Exhibit NRC001-R-00-BD01, Staff Testimony at 58.

[6] *Id*. at 8–9, 58.

[7] C-10 Research and Education Foundation, Inc. Petition for Leave to Intervene: Nuclear Regulatory Commission Docket No. 50-443 at 2–3 (Apr. 10, 2017) (ML17100B013).

[8] *Id*.

[9] *NextEra Energy Seabrook, LLC* (Seabrook Station, Unit 1), LBP-17-7, 86 NRC 59, 114 (2017).

data from the LSTP is adequate to assess the progression of ASR at Seabrook.[10] Among other things, C-10 argued that NextEra's approach of using the LSTP data to demonstrate the continuing applicability of Seabrook's design basis codes to its concrete structures, despite the presence of ASR, fails to address the complexities of ASR.[11] C-10's position is supported by the testimony of its expert witness Victor E. Saouma.[12]

1.4 NextEra's position in this proceeding is that the preponderance of the evidence demonstrates that NextEra's approach of using the existing design basis codes within the limits of the LSTP is based on sound science and well-established principles of practical structural engineering, is fully compliant with all applicable codes and regulations, and is based on the long-established licensing and design basis for Seabrook.[13] NextEra's position is supported by the testimony of its expert witnesses from MPR Associates, Inc. (MPR): Michael Collins, John Simons, Christopher Bagley, Oguzhan Bayrak, and Edward Carley.[14] NextEra's position is also supported by the testimony of its expert witnesses from Simpson Gumpertz & Heger Inc. (SGH): Said Bolourchi, Glenn Bell, and Matthew Sherman.[15]

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[10] Memorandum (Distributing Redacted Transcript) at 235–36 (Sept. 24–27, 2019) (ML19312B609) (Tr.).

[11] *Id*. at 236.

[12] *See* C-10 Research and Education Foundation, Inc. In[i]tial Statement of Position on C-10's Contentions Regarding NextEra's Program for Managing ASR at Seabrook Station Nuclear Power Plant at 1 (Jun. 10, 2019) (ML19161A371); Exhibit INT001-R, Pre-filed Testimony of Victor E. Saouma, Ph.D Regarding Scientific Evaluation of NextEra's Aging Management Program for ASR at the Seabrook Nuclear Power Plant – Corrected June 20, 2019 at 1–5 (ML19171A403) (Non-publicly available).

[13] Tr. at 238–39.

[14] NextEra Energy Seabrook LLC's Statement of Position at 1 (Jul. 24, 2019) (ML19205A488); Exhibit NER001-00-BD01, Testimony of NextEra Witnesses Michael Collins, John Simons, Christopher Bagley, Oguzhan Bayrak, and Edward Carley ("MPR Testimony") at 1–13 (ML19205A489).

[15] *See* NextEra Energy Seabrook LLC's Statement of Position at 1; Exhibit NER004-00-BD01, Testimony of NextEra Witnesses Said Bolourchi, Glenn Bell, and Matthew Sherman ("SGH Testimony") at 1–78 (ML19205A501).

1.5 The Staff's position in this proceeding is (1) that the discovery of ASR at Seabrook challenged the plant's licensing basis, (2) that NextEra developed a method to address this challenge, (3) that the Staff properly determined that NextEra's method provides reasonable assurance of adequate protection of public health and safety, and (4) that C-10's arguments do not demonstrate that NextEra's method is unsafe.[16] The Staff also noted that the LAR is made up of two, separate monitoring programs: the Seabrook ASR expansion monitoring program and the Seabrook structure deformation monitoring program.[17] Since the admitted contention only addressed the ASR expansion monitoring program, the Staff's position is that C-10's arguments based upon the separate structure deformation monitoring program are outside the scope of this proceeding.[18] The Staff's position is supported by the testimony of its expert witnesses: Angela Buford, Bryce Lehman, George Thomas, and Jacob Philip.[19]

1.6 Based on its review of the evidentiary record in this proceeding and after full consideration of C-10's arguments, the Board finds that:

1. NextEra has demonstrated by a preponderance of the evidence that the LSTP yielded data that are representative of the progression of ASR at Seabrook.

2. NextEra has demonstrated by a preponderance of the evidence that the Seabrook ASR expansion monitoring program's monitoring, acceptance criteria, and inspection intervals derived from the LSTP are adequate.

3. The implementation of the Seabrook structure deformation monitoring program is not based on data generated by the LSTP and, therefore, the structure deformation monitoring program is not within the scope of this proceeding.

4. NextEra has demonstrated by a preponderance of the evidence that, even if the Seabrook structure deformation monitoring program were within the scope of this proceeding, its monitoring, acceptance criteria, and inspection intervals are adequate.

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[16] Tr. at 249–50.

[17] *Id*. at 255–56.

[18] *Id*.

[19] *See* NRC Staff Initial Written Statement of Position at 1–2 (Jul. 24, 2019) (ML19205A341); Exhibit NRC001-R-00-BD01, Staff Testimony at 1–6; Exhibit NRC005-00-BD01, Exhibit NRC005-00-BD01, Jacob Philip Testimony at 2 (ML19205A348).

1.7 Based on these findings of fact and conclusions of law, the Board concludes that NextEra has carried its burden of providing, by a preponderance of the evidence, reasonable assurance that, with the approval of the LAR, Seabrook will continue to meet the applicable NRC requirements and will not endanger the health and safety of the public.

II. FINDINGS OF FACT

A. The Discovery of ASR at Seabrook and NextEra's Development of the Seabrook ASR Expansion Monitoring Program and the Seabrook Structure Deformation Monitoring Program

2.1 In June 2009, NextEra initially identified pattern cracking typical of ASR at Seabrook in the "B" electrical tunnel, and, subsequently, in several other seismic Category I structures.[20]

2.2 After NextEra submitted a license renewal application for Seabrook in May 2010,[21] the Staff observed, during license renewal audit walkdowns, degradation in concrete structures exposed to groundwater, including the containment enclosure building.[22]

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[20] Exhibit NRC001-R-00-BD01, Staff Testimony at 10; Exhibit INT024-00-BD01, SE encl. 2 at 5; *see* Exhibit NRC019-00-BD01, Confirmatory Action Letter, Seabrook Station, Unit 1 – Information Related to Concrete Degradation Issues, at 1 (May 16, 2012) (ML19205A364) (CAL); Exhibit NRC078-00-BD01, Letter from Paul O. Freeman, NextEra, to NRC, "Seabrook Station Response to Confirmatory Action Letter," encl. 1 at 1 (unnumbered) (May 24, 2012) (ML19205A442) (NextEra Response to CAL).

[21] Letter from Paul O. Freeman, Site Vice President, NextEra, to NRC, "Seabrook Station Application for Renewed Operating License" (May 25, 2010) (ML101590099) (LRA).

[22] Exhibit NRC001-R-00-BD01, Staff Testimony at 10; Letter from Richard Plasse, NRC, to Paul Freeman, NextEra, "Request for Additional Information Related to the Review of the Seabrook Station License Renewal Application (TAC No ME4028) - Aging Management Programs," encl. at 10–11, 16 (Nov. 18, 2010) (ML103090558) (Nov. 2010 RAI); Letter from Paul O. Freeman, NextEra, to NRC, "Seabrook Station, Response to Request for Additional Information, NextEra Energy Seabrook License Renewal Application, Aging Management Programs," encl. 1 at 26, 32–33 (Dec. 17, 2010) (ML103540534) (Dec. 2010 Response to RAI). In its response to the Staff's Request for Additional Information (RAI), NextEra stated that it would perform confirmatory testing and evaluation of the containment enclosure building to determine whether the observed concrete degradation was due to ASR. Dec. 2010 Response to RAI, encl. at 31–33. NextEra subsequently confirmed the presence of ASR in the containment enclosure building. Exhibit NRC079-00-BD01, Enclosure 2 to SBK-L-12106, "The Evaluation, Impact of ASR on Concrete Structures and Attachments," § 3.1.2 at 20 (May 2012) (ML19205A445) (Interim Structural Assessment).

2.3 In August 2010, NextEra confirmed the presence of ASR in concrete in the below-grade walls of several Seabrook structures through petrographic analysis of concrete cores removed from the affected plant structures.[23] In addition to the "B" electrical tunnel, NextEra confirmed ASR in the residual heat removal (RHR) and containment spray (CS) equipment vault, the emergency feedwater pumphouse, the diesel generator building, and the containment enclosure building.[24]

2.4 In September 2010, NextEra initiated prompt operability determinations to assess the safety significance of the ASR issue and the basis for continued plant operation.[25] NextEra concluded that although the ASR-affected structures did not conform to Seabrook's licensing basis (because ASR was not accounted for in the licensing basis), the structures were still operable—they would maintain structural integrity for design basis loads and load combinations under normal, accident, and environmental extreme conditions.[26] As NextEra collected more

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The Seabrook "containment enclosure building" is a "reinforced concrete right cylindrical structure with a hemispherical dome. The inside diameter of the cylinder is 158 feet. The vertical wall varies in thickness from 36 inches to 15 inches; the dome is 15 inches thick. The inside of the dome is 5'-6" above the top of the containment dome." Exhibit NRC007-00-BD01, Seabrook Station Updated Final Safety Analysis Report, Chapter 3, "Design of Structures, Components, Equipment and Systems," Rev. 18, § 3.8.4.1 (October 2017) (ML19205A350) (UFSAR). Inside the containment enclosure building is the Seabrook "containment," which is a "reinforced concrete system with a leaktight steel liner attached to the inside surface" designed to "safely withstand the load combinations … and to provide biological shielding for normal and accident conditions." Exhibit NRC007-00-BD01, UFSAR § 3.8.1.4. It is the "primary containment for containing radioactive release…." Tr. at 858–59. The containment enclosure building and the containment are separated by a "four feet six annulus between the outside of the containment building and the inside of the containment enclosure building." *Id*. at 859.

[23] Exhibit INT024-00-BD01, SE encl. 2 at 5; Exhibit INT010-00-BD01, Original LAR at 8 of 73 (unnumbered).

[24] *See* Exhibit NRC079-00-BD01, Interim Structural Assessment, § 3.1.1 at 19–20 (stating that petrographic examination confirmed the presence of ASR in the "B" electrical tunnel, the RHR & CS equipment vault, the emergency feedwater pumphouse, the diesel generator building, and the containment enclosure building).

[25] Exhibit NRC025-00-BD01, Letter from Christopher G. Miller, NRC, to Kevin Walsh, NextEra, "Seabrook Station, Unit No. 1 - Confirmatory Action Letter Follow-up Inspection - NRC Inspection Report 05000443/2012009, Enclosure, Inspection Report No. 0500044312012009," at 1 (Dec. 3, 2012) (ML19205A373.14) (2012 CAL Follow-up Inspection).

[26] *Id.*, encl. at 4; Exhibit INT024-00-BD01, SE, encl. 2 at 6.

information on the presence of ASR at Seabrook and applied revised analytical techniques, it revised the prompt operability determinations.[27]

2.5 In October 2010, the Staff conducted a nine-day onsite audit of NextEra's aging management programs in connection with the license renewal application.[28] The audit report noted that the Staff had found that "groundwater migrated into the annular space between the concrete enclosure building and concrete containment" and that "[t]he bottom 6 feet of the concrete containment wall was in contact with the groundwater for a long period of time."[29] After noting that ASR-related cracking had been observed in concrete structures at Seabrook, including the containment enclosure building, the audit report stated that the Staff needed further information to evaluate the impact of ASR on the Seabrook aging management programs.[30]

2.6 Between November 2010 and June 2011, the Staff sent NextEra several RAIs regarding NextEra's license renewal application and, specifically, for further information on ASR at Seabrook.[31]

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[27] Exhibit NRC001-R-00-BD01, Staff Testimony at 10; Exhibit NRC025-00-BD01, 2012 CAL Follow-up Inspection, encl. at 1; *see* Exhibit NRC033-00-BD01, Letter from Mel Gray, NRC, to Dean Curtland, NextEra, "Seabrook Station, "Seabrook Station - Inspection Report 05000443/2016008 Related to Alkali-Silica Reaction Affects on Safety-Related Concrete Structures and Notice of Violation," encl. 2 at 1–2 (May 6, 2016) (ML19205A398) (May 2016 Inspection Report).

[28] Exhibit NRC020-00-BD01, Letter from Richard A. Plasse, NRC, to Paul Freeman, NextEra, "Audit Report Regarding the Seabrook Station License Renewal Application (TAC Number ME4028)," encl. at 1 (Mar. 21, 2011) (ML19205A365) (Mar. 2011 Audit Report).

[29] *Id.* encl. at 65.

[30] *Id.* encl. at 65–66; 74–75.

[31] *See, e.g.*, Nov. 2010 RAI, encl. at 10; Letter from Richard A. Plasse, NRC, to Paul Freeman, NextEra, "Request for Additional Information Related to the Review of the Seabrook Station License Renewal Application," encl. at 2–3 (Mar. 17, 2011) (ML110350630); Letter from Richard A. Plasse, NRC, to Paul Freeman, NextEra, "Request for Additional Information for the Review of the Seabrook Station License Renewal Application," encl. at 2–3, 5 (June 29, 2011) (ML11178A338).

2.7 In 2011, the Staff conducted three inspections of Seabrook that included a review of NextEra's prompt operability determinations related to ASR-affected structures.[32]

2.8 In January 2012, the Staff completed an inspection to assess NextEra's progress in developing a corrective plan and schedule to address the ASR degradation issue.[33] This inspection included a review by NRC regional inspectors and headquarters experts of NextEra's prompt operability determinations.[34] After this inspection, the Staff found that (1) NextEra used conservative load factors to ensure that there was sufficient engineering margin, (2) Staff field walkdowns confirmed no significant indications of deformation, distortion, or rebar corrosion, and (3) ASR was localized and occurring slowly based on existing operating experience.[35] Therefore, the Staff concluded that, although Seabrook was not meeting its licensing basis because ASR was not accounted for in the licensing basis, its ASR-affected structures remained capable of performing their safety functions.[36]

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[32] Exhibit NRC001-R-00-BD01, Staff Testimony at 10–11; Exhibit NRC021-00-BD01, Letter from Arthur L. Burritt, NRC, to Paul Freeman, NextEra, "Seabrook Station, Unit No. 1 - NRC Integrated Inspection Report 05000443/2011002" (May 12, 2011) (ML19205A369) (May 2011 Inspection Report); Exhibit NRC022-00-BD01, Letter from Richard J. Conte, NRC, to Paul Freeman, NextEra, "NextEra Energy Seabrook - NRC License Renewal Inspection Report 05000443/2011007" (May 23, 2011) (ML19205A370); Exhibit NRC023-00-BD01, Letter from Arthur L. Burritt, NRC, to Paul Freeman, NextEra, "Seabrook Station, Unit No. 1 - NRC Integrated Inspection Report 05000443/2011003" (Aug. 12, 2011) (ML19205A372) (Aug. 2011 Inspection Report).

[33] Exhibit NRC001-R-00-BD01, Staff Testimony at 11; Exhibit NRC024-00-BD01, Letter from Christopher G. Miller, NRC, to Paul Freeman, NextEra, "Seabrook Station - NRC Inspection Report 05000443/2011010 Related to Alkali-Silica Reaction Issue in Safety Related Structures," at 1 (Mar. 26, 2012) (ML19205A373) (Mar. 2012 Inspection Report).

[34] Exhibit NRC001-R-00-BD01, Staff Testimony at 11; Exhibit NRC024-00-BD01, Mar. 2012 Inspection Report at 1.

[35] Exhibit NRC001-R-00-BD01, Staff Testimony at 11; Exhibit NRC024-00-BD01, Mar. 2012 Inspection Report, encl. at 5–6.

[36] Exhibit NRC001-R-00-BD01, Staff Testimony at 11.

2.9 At an April 2012 public meeting with NextEra, the Staff discussed its concerns for the long-term operability of the ASR-affected structures at Seabrook.[37] Subsequently, by letters dated May 3 and 10, 2012, NextEra described the actions that it would take to address the degraded conditions.[38] The Staff's concerns contributed, in part, to NextEra's development of the ASR expansion monitoring program, which it first submitted as a supplement to its license renewal application on May 16, 2012.[39]

2.10 On May 16, 2012, the Staff issued a confirmatory action letter (CAL) to NextEra to confirm the licensee's commitments with respect to planned actions to evaluate ASR-affected reinforced concrete structures at Seabrook.[40] These commitments included (1) submitting a root-cause analysis for the occurrence of ASR at Seabrook and related corrective action, (2) revising the prompt operability determinations for some plant components, (3) completing both short-term and long-term aggregate expansion testing, and (4) establishing monitoring requirements for selected locations in areas that exhibit ASR.[41]

2.11 After the issuance of the CAL, the Staff created the Seabrook ASR Issue Technical Team (SAITT) consisting of Staff members from various divisions and offices across

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[37] *See* Exhibit NRC080-00-BD01, Memorandum from John G. Lamb, NRC, to Meena Khanna, NRC, Forthcoming Meeting with NextEra Energy Seabrook, LLC (NextEra) Regarding Seabrook Station Concrete Degradation (Mar. 23, 2012) (ML19205A446).

[38] Exhibit NRC081-00-BD01, Letter from Paul O. Freeman, NextEra, to NRC, "Seabrook Station Actions for Resolution of Alkali Silica Reaction (ASR) Issues" (May 3, 2012) (ML19205A447); Exhibit NRC082-00-BD01, Letter from Paul O. Freeman, NextEra, to NRC, "Seabrook Station Actions for Resolution of Alkali Silica Reaction (ASR) Issues" (May 10, 2012) (ML19205A448).

[39] *Compare* Exhibit NRC082-00-BD01 at 3 (committing to submit a license renewal aging management program for ASR-affected structures by May 25, 2012) *with* Letter from Paul O. Freeman, NextEra, to NRC, "Seabrook Station, NextEra Energy Seabrook License Renewal Application, Structures Monitoring Program Supplement-Alkali-Silica Reaction (ASR) Monitoring" (May 16, 2012) (ML12142A323) (augmenting the existing structures monitoring program with a plant-specific ASR expansion monitoring program).

[40] Exhibit NRC001-R-00-BD01, Staff Testimony at 11; Exhibit NRC019-00-BD01, CAL at 1.

[41] Exhibit NRC019-00-BD01, CAL at 2–3.

the agency; the Team coordinated the onsite inspections, in-office technical reviews, and other evaluation and assessment activities associated with NextEra's resolution of the Seabrook ASR issue.[42]

2.12 In a May 24, 2012 letter responding to the CAL, NextEra submitted the results of its root-cause investigation, which concluded that the original concrete mixture designs at Seabrook used a coarse aggregate that was susceptible to ASR.[43] This coarse aggregate used in the concrete mixtures, in combination with groundwater intrusion or other moisture sources during the life of the plant, resulted in the observed ASR in several structures at Seabrook.[44] NextEra also submitted the results of an interim structural assessment, which evaluated the structural adequacy of reinforced concrete structures at Seabrook affected by ASR and system/component anchorages in ASR-affected concrete.[45] The assessment concluded that while the reinforced concrete structures at Seabrook remained suitable for continued service for an interim period, additional actions were required.[46] These additional actions included the proposed LSTP and periodic monitoring of the affected structures at Seabrook.[47]

2.13 In September 2012, the Staff requested approval from the NRC's Executive Director for Operations (EDO) to deviate from the reactor oversight process (ROP) to increase NRC oversight of Seabrook, partly to review NextEra's compliance with the 2012 CAL (2012

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[42] Exhibit NRC045-00-BD01, Memorandum from Eric J. Leeds, NRR, and William M. Dean, Region 1, Seabrook Alkali-Silica Reaction Issue Technical Team Charter (July 9, 2012) (ML19205A393).

[43] Exhibit NRC078-00-BD01, NextEra Response to CAL, encl. 1 at 3 (unnumbered); *see* Exhibit INT024-00-BD01, SE, encl. 2 at 5; Exhibit INT010-00-BD01, Original LAR at 8 of 73 (unnumbered).

[44] Exhibit NRC078-00-BD01, NextEra Response to CAL, encl. 1 at 3 (unnumbered).

[45] Exhibit NRC079-00-BD01, Interim Structural Assessment.

[46] *Id.* at 4–5, 73.

[47] *Id.* at 4–5, 12–13.

Deviation Memo).[48] This increased oversight would allow the Staff to more thoroughly understand the ASR phenomenon and to confirm that ASR-affected structures at Seabrook continue to perform their safety functions.[49] The Staff planned to use this increased oversight of Seabrook to (1) inspect NextEra's completed and planned actions associated with the CAL commitments, (2) evaluate the quality and applicability of results from the licensee's proposed LSTP, (3) provide support for the potential development of technical guidance, and (4) continue to support communications and outreach activities for stakeholders.[50]

2.14 After the EDO approved the deviation from the ROP, the Staff conducted two CAL follow-up inspections to evaluate NextEra's compliance with the commitments in the CAL.[51] The first inspection in the fall of 2012 involved three weeks of onsite inspection and four months of in-office review by NRC region-based inspectors and headquarters reviewers to assess the adequacy of actions taken by NextEra to address the occurrence of ASR in reinforced concrete structures at Seabrook.[52] Additionally, for this inspection, the Staff's review was informed by a separate, independent review by Dr. Kent Harries, Associate Professor of Structural Engineering and Mechanics, University of Pittsburgh.[53] In June 2013, the Staff completed the second CAL follow-up inspection, in which the Staff verified that NextEra had

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[48] Exhibit NRC083-00-BD01, Memorandum from William M. Dean, NRC, to R.W. Borchardt, NRC, "Request for Deviation from the Reactor Oversight Process Action Matrix to Provide Increased Oversight of the Alkali-Silica Reaction Issue at Seabrook" (Sept. 5, 2012) (ML19205A449) (2012 Deviation Memo).

[49] *Id.* at 2.

[50] *Id.*

[51] *See* Exhibit NRC084-00-BD01, Letter from Darrell J. Roberts, NRC, to Kevin Walsh, NextEra, "Deviation from the Reactor Oversight Process Action Matrix for Seabrook Station, Unit No. 1" (Sept. 12, 2012) (ML19205A450).

[52] Exhibit NRC025-00-BD01, 2012 CAL Follow-up Inspection, encl. 1 at 1.

[53] *Id.* encl. 1 at i; Tr. at 801–03.

appropriately assessed and determined that all ASR-affected structures remained operable.[54] The inspection team also confirmed that NextEra's root-cause evaluation was thorough and identified appropriate corrective actions.[55] During both inspections, the Staff reviewed selected procedures and records, observed ASR crack indexing measurements, conducted independent walk-through inspections to evaluate ASR-affected structures, and interviewed Seabrook personnel regarding the adequacy of NextEra's actions to address the impact of ASR on reinforced concrete structures.[56]

2.15 In October 2013, after the completion of the two CAL follow-up inspections, the Staff issued a CAL closure letter, stating that the Staff had verified that NextEra had satisfied the commitments contained in the 2012 CAL.[57] The CAL closure letter noted NextEra's planned LSTP testing and NextEra's continuing commitment to update its operability determinations for ASR-affected structures as additional information from the testing became available.[58] The CAL closure letter also stressed that the Staff was in the process of conducting a separate review of the ASR issue as part of its review of the license renewal application.[59] Separately, the Staff informed NextEra that the exit criteria in the 2012 Deviation Memo had been met and that

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[54] Exhibit NRC026-00-BD01, Letter from Raymond K. Lorson, NRC, to Kevin Walsh, "Seabrook Station, Unit No. 1 - Confirmatory Action Letter Follow-up Inspection - NRC Inspection Report 05000443/2012010," at 1 (Aug. 9, 2013) (ML19205A375) (2013 CAL Follow-up Inspection).

[55] *Id.*

[56] Exhibit NRC025-00-BD01, 2012 CAL Follow-up Inspection, encl. 1 at 11–12; Exhibit NRC026-00-BD01, 2013 CAL Follow-up Inspection, encl. 1 at 13–17.

[57] Exhibit NRC085-00-BD01, Letter from William M. Dean, NRC, Kevin Walsh, NextEra, "Closure of Confirmatory Action Letter 1-12-002, Seabrook Station, Unit 1" (Oct. 9, 2013) (ML19205A451).

[58] *Id.* at 2.

[59] *Id.*

inspection oversight of Seabrook would return to the ROP baseline inspection program.[60] Nonetheless, the Staff made clear that it would continue to provide focused oversight of the testing being conducted for the LSTP and NextEra's continuing assessment of ASR progression in reinforced concrete structures.[61]

2.16 From November 18–20, 2013, the Staff conducted an audit of NextEra's initial program for monitoring ASR at Seabrook.[62] During its audit, the Staff examined the program and its bases documents, interviewed NextEra representatives, and conducted walkdowns of selected ASR-affected structures.[63] The audit concluded, among other things, that the Staff needed additional information before it could determine whether Seabrook's operating experience supported the sufficiency of the program.[64]

2.17 NextEra commissioned MPR Associates (MPR) to conduct the LSTP, in collaboration with the FSEL at the University of Texas at Austin, from late 2013 to February 2016.[65]

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[60] Exhibit NRC086-00-BD01, Letter from Darrell J. Roberts, NRC, to Kevin Walsh, NextEra, "Mid-cycle Performance Review and Inspection Plan – Seabrook Station, Unit No. 1 (Report 05000443/2013006)," at 1 (Sept. 3, 2013) (ML19205A452).

[61] *Id.* at 2.

[62] Exhibit NRC041-00-BD01, Letter from Richard Plasse, NRC, to Kevin Walsh, NextEra, "Aging Management Program Audit Report Regarding the Seabrook Station License Renewal Application TAC No. ME4028)" (Dec. 23, 2013) (ML19205A389).

[63] *Id.*, encl. at 1.

[64] *Id.*, encl. at 8.

[65] *See* Exhibit NRC033-00-BD01, May 2016 Inspection Report, encl. 2 at 1 ("NextEra's testing of large scale ASR-affected test specimens at FSEL commenced in late 2013 and was planned to be completed under NextEra's direction by February 2016."); Exhibit INT019-R-00-BD01, MPR-4273, Rev. 1, Seabrook Station - Implications of Large-Scale Test Program Results on Reinforced Concrete Affected by Alkali-Silica Reaction (July 2016) (ML19170A332) (nonproprietary) (Enclosure 5 to Letter SBK-18072) at 5-1 (PDF p. 139) (MPR-4273, LSTP Report (Rev. 1)). Although the title to INT019-R-00-BD01 appears to indicate that the date of the exhibit is July 2016, the actual document lists March 2018 as the date. INT019-R-00-BD01, LSTP Report (Rev. 1) at PDF p. 98.

NextEra submitted both propriety and nonproprietary versions of MPR-4273, LSTP Report, Rev. 0, as enclosures to the Original LAR. Exhibit INT010-00-BD01, Original LAR at 2; Exhibit NRC008-00-BD01/NRC009-00-BD01, MPR-4273, Rev. 0, "Seabrook Station - Implications of Large-Scale Test

2.18 Staff oversight related to the LSTP involved about 5 weeks of direct inspection by NRC regional inspectors and headquarters structural experts at FSEL to ensure that the results were being appropriately reflected in the operability assessments and evaluations of ASR-affected structures.[66] The inspections of the LSTP, in particular, verified that NextEra and its contractors were adhering to the 10 C.F.R. Part 50, Appendix B, quality assurance requirements and to 10 C.F.R. Part 50, Appendix A, General Design Criterion 1.[67] Staff inspections of the LSTP observed, on a sampling basis, the setup of the program and the facilities, fabrication and concrete pour, and testing of the specimens.[68] During the inspections, the NRC inspectors did

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Program Results on Reinforced Concrete Affected by Alkali-Silica Reaction" (July 2016) (ML19205A352) (nonproprietary) and ML19205A469 (proprietary), respectively) (MPR-4273 (Rev. 0)).

NextEra submitted Rev. 1 of MPR-4273 in the May 2018 MPR Reports Update. Exhibit NRC016-00-BD01, May 2018 MPR Reports Update at 2; INT019-R-00-BD01 (nonproprietary); INT021-00-BD01 (proprietary).

[66] Exhibit NRC001-R-00-BD01, Staff Testimony at 11; s*ee* Exhibit NRC026-00-BD01, 2013 CAL Follow-up Inspection, encl. at 1; Exhibit NRC027-00-BD01, Letter from Glenn T. Dentel, NRC, to Kevin Walsh, NextEra, "Seabrook Station, Unit No. 1 - NRC Integrated Inspection Report 05000443/2013005" (Jan. 30, 2014) (ML19205A376) (Jan. 2014 Inspection Report); Exhibit NRC028-00-BD01, Letter from Glenn T. Dentel, NRC, to Kevin Walsh, NextEra, "Seabrook Station, Unit No. 1 - NRC Integrated Inspection Report 05000443/2014002" (May 6, 2014) (ML19205A377) (May 2014 Inspection Report); Exhibit NRC030-00-BD01, Letter from Glenn T. Dentel, NRC, to Dean Curtland, NextEra, "Seabrook Station, Unit No. 1 - NRC Integrated Inspection Report 05000443/2014005" (Feb. 6, 2015) (ML19205A379) (Feb. 2015 Inspection Report) ((discussing audit conducted at FSEL during the week of October 26, 2015); Exhibit NRC032-00-BD01, Letter from Fred L. Bower, III, NRC, to Dean 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) (ML19205A388) (Feb. 2016 Inspection Report).

[67] Exhibit NRC001-R-00-BD01, Staff Testimony at 14; Tr. at 1054 ("And also in the – the testing program itself verified that all of the procedures, the corrective action process, the training of the staff involved in the testing, and also its applicability to the ACI Codes and consensus standards were up to Appendix B quality assurance.") (Ms. Buford). GDC 1 requires, in relevant part, that licensees establish and implement a quality assurance program "in order to provide adequate assurance that these structures, systems, and components will satisfactorily perform their safety functions." 10 C.F.R. Part 50, App. A, Criterion 1.

[68] Exhibit NRC001-R-00-BD01, Staff Testimony at 14; Exhibit INT024-00-BD01, SE, encl. 2 at 10; Tr. at 1041–43 ("[D]uring their seven visits to [FSEL, the Staff] witnessed all test activities including the extensometers. They saw them in use. And they saw the different varieties of instruments that [were] tested.") (Mr. Simons); *see* Exhibit NRC026-00-BD01, 2013 CAL Follow-up Inspection, encl. at 1, 9; Exhibit NRC027-00-BD01, Jan. 2014 Inspection Report, encl. at 17–19; Exhibit NRC028-00-BD01, May 2014 Inspection Report, encl. at 19–22; Exhibit NRC030-00-BD01, Feb. 2015 Inspection Report, encl. at 23; Exhibit NRC032-00-BD01, Feb. 2016 Inspection Report, encl. at 25–28.

not identify any findings related to the LSTP and determined that appropriate quality assurance program requirements were being implemented.[69]

2.19 The Staff also completed an onsite audit of the LSTP at FSEL from October 27–29, 2015.[70] During the audit, the Staff, among other things, conducted interviews with project staff, consultants, and laboratory technical experts; toured the FSEL facilities including the large-scale concrete testing laboratory and setup for application of loads and data acquisition, core and cylinder testing area, greenhouse for accelerating ASR in test specimens, and formwork for constructing the large-scale specimens; and observed material property testing (e.g., elastic modulus, compressive strength, etc.) of concrete cores removed from test specimens, along with two large-scale shear load tests to failure on the test specimens.[71]

2.20 In May 2016, the Staff documented a finding and associated notice of violation related to NextEra's maintenance of its prompt operability determinations for ASR-related structures at Seabrook.[72]

2.21 NRC inspectors also documented very low safety significance findings associated with discrete, large horizontal cracks in an internal wall of the residual heat removal vaults,[73] cracks in the fuel storage building,[74] and seismic and fire seals in the containment enclosure building that appeared to have been degraded due to differential movement between

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[69] Exhibit NRC001-R-00-BD01, Staff Testimony at 14; Exhibit INT024-00-BD01, SE, encl. 2 at 10; Tr. at 1054.

[70] Exhibit NRC001-R-00-BD01, Staff Testimony at 14; Exhibit NRC018-00-BD01, LSTP 2017 Site Audit Report, encl. at 1–2; Tr. at 1054.

[71] Exhibit NRC018-00-BD01, LSTP 2017 Site Audit Report, encl. at 4.

[72] Exhibit NRC033-00-BD01, May 2016 Inspection Report at 2, encl. 1 at 1–2; encl. 2 at 1.

[73] Exhibit NRC001-R-00-BD01, Staff Testimony at 12; Exhibit NRC029-00-BD01, Letter from Glenn T. Dentel, NRC, to Dean Curtland, NextEra, "Seabrook Station, Unit No. 1 - NRC Integrated Inspection Report 05000443/2014003," encl. at 3, 15–16, (Aug. 5, 2014) (ML19205A378) (Aug. 2014 Inspection Report); *see* Exhibit NRC033-00-BD01, May 2016 Inspection Report at 1, encl. 1 at 1–2.

[74] Exhibit NRC030-00-BD01, Feb. 2015 Inspection Report, encl. at 3, 8–10.

adjoining concrete buildings.[75] These findings contributed, in part, to NextEra's development of the structure deformation monitoring program.[76]

2.22 In August 2016, after the completion of the LSTP in February 2016, NextEra submitted to the NRC (1) the LAR and (2) an update to the license renewal application related to ASR aging management.[77] Both of these documents discussed two separate aging management programs related to ASR: (1) the ASR expansion monitoring program[78] and (2) the structure deformation monitoring program.[79]

2.23 After NextEra submitted these documents, the Staff conducted several inspections to review the adequacy of NextEra's monitoring of ASR-affected structures.[80]

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[75] Exhibit NRC001-R-00-BD01, Staff Testimony at 12; Exhibit NRC031-00-BD01, Letter from Glenn T. Dentel, NRC, to Dean Curtland, NextEra, "Seabrook Station, Unit No. 1 - NRC Integrated Inspection Report 05000443/2015002," encl. at 3, 18–23 (Aug. 5, 2015) (ML19205A387) (Aug. 2015 Inspection Report); *see* Exhibit NRC033-00-BD01, May 2016 Inspection Report at 1, encl. 1 at 1–2.

[76] *See* Exhibit INT010-00-BD01, Original LAR at 1, 23–28, 30 of 73 (unnumbered); Letter from Eric McCartney, NextEra, to NRC, "Seabrook Station, License Renewal Application Relating to the Alkali-Silica Reaction (ASR) Monitoring Program," encl. 4 at 33–36 (Aug. 9, 2016) (ML16224B079) (LRA Supplement) (discussing operating experience that led NextEra to augment the existing structures monitoring program with a plant-specific structure deformation monitoring program).

[77] Exhibit INT010-00-BD01, Original LAR; LRA Supplement.

[78] Exhibit INT010-00-BD01, Original LAR at 30–33 of 73 (unnumbered); LRA Supplement, encl. 3 at 2–4.

[79] Exhibit INT010-00-BD01, Original LAR at 33–34 of 73 (unnumbered); LRA Supplement, encl. 3 at 4.

[80] Exhibit NRC035-00-BD01, Letter from Fred L. Bower, III, NRC, to Eric McCartney, NextEra, "Seabrook Station, Unit No. 1 – Integrated Inspection Report 05000443/2016004," encl. at 17–18 (Feb. 8, 2017) (ML19205A400) (Feb. 2017 Inspection Report); Exhibit NRC036-00-BD01, Letter from Fred L. Bower, III, NRC, to Mano Nazar, NextEra, "Seabrook Station, Unit No. 1 – Integrated Inspection Report 05000443/2017002," encl. at 31–32 (Aug. 14, 2017) (ML19205A401) (Aug. 2017 Inspection Report); Exhibit NRC037-00-BD01, Letter from Fred L. Bower, III, NRC, to Mano Nazar, NextEra, "Seabrook Station, Unit No. 1 – Integrated Inspection Report 05000443/2017004," encl. at 24–27 (Feb. 12, 2018) (ML19205A402) (Feb. 2018 Inspection Report); Exhibit NRC038-00-BD01, Letter from Fred L. Bower, III, NRC, to Mano Nazar, NextEra, "Seabrook Station, Unit No. 1 – Integrated Inspection Report 05000443/2018001," encl. at 8–9 (May 14, 2018) (ML19205A403) (May 2018 Inspection Report); Exhibit NRC039-00-BD01, Letter from Mel Gray, III, NRC, to Mano Nazar, NextEra, "Seabrook Station, Unit No. 1 – Integrated Inspection Report 05000443/2018011," encl. at 7–9 (Aug. 10, 2018) (ML19205A404) (Aug. 2018 Inspection Report); Exhibit NRC040-00-BD01, Letter from Fred L. Bower, NRC, to Mano Nazar, NextEra, "Seabrook Station, Unit No. 1 – Integrated Inspection Report 05000443/2018003" (Nov. 13, 2018) (ML19205A405) (Nov. 2018 Inspection Report).

During these inspections, the Staff performed independent walkdowns of ASR-affected areas, examined crack gauges and the placement of extensometers, and reviewed reports of recently collected measurement data, including in-plane and through-thickness expansion, to verify that the structures were well within the established acceptance criteria.[81] The Staff also conducted three onsite audits of both monitoring programs at Seabrook, as documented in reports dated December 21, 2016,[82] July 26, 2017,[83] and May 21, 2018.[84] During all three onsite audits, the Staff specifically reviewed the calculations and other supporting documentation implementing the ASR expansion monitoring program and the structure deformation monitoring program.[85]

Between the end of the LSTP in February 2016 and NextEra's August 9, 2016 update to the license renewal application, the Staff completed an additional inspection, which included a review of operability determinations related to ASR-affected structures. Exhibit NRC034-00-BD01, Letter from Fred L. Bower, NRC, to Eric McCartney, NextEra, "Seabrook Station, Unit No. 1 – Integrated Inspection Report 05000443/2016002," encl. at 18–20 (Aug. 5, 2016) (ML19205A399).

[81] Exhibit NRC035-00-BD01, Feb. 2017 Inspection Report, encl. at 17–18; Exhibit NRC036-00-BD01, Aug. 2017 Inspection Report, encl. at 31–32; Exhibit NRC037-00-BD01, Feb. 2018 Inspection Report, encl. at 24–27; Exhibit NRC038-00-BD01, May 2018 Inspection Report, encl. at 8–9; Exhibit NRC040-00-BD01, Nov. 2018 Inspection Report, encl. at 9–10.

[82] Exhibit NRC042-00-BD01, Letter from Tam Tran, NRC, to Eric McCartney, NextEra, "Alkali Silica Reaction Monitoring Aging Management Program Audit Report Regarding the Seabrook Station, Unit 1, License Renewal (CAC No. ME4028)" (Dec. 21, 2016) (ML19205A390).

[83] Exhibit NRC043-00-BD01, Letter from Justin C. Poole, NRC, to Mano 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-LLA-0007)," at 1, encl. at 2 (July 26, 2017) (ML19205A391) (July 2017 Site Audit Report) (stating that the Staff conducted the site visit from June 5, 2017 to June 9, 2017).

[84] Exhibit NRC044-00-BD01, Letter from Justin C. Poole, NRC, to Mano 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-LLA-0007)," at 1, encl. at 2 (May 21, 2018) (ML19205A392) (May 2018 Site Audit Report) (stating that the Staff conducted the site visit from March 19, 2018 to March 22, 2018).

[85] Exhibit NRC018-00-BD01, LSTP 2017 Site Audit Report, encl. 1 at 1–3; Exhibit NRC043-00-BD01, July 2017 Site Audit Report encl. 1 at 2–3; Exhibit NRC044-00-BD01, May 2018 Site Audit Report encl. 1 at 3–5.

Additionally, the latter two site visits were conducted as part of a larger regulatory audit of the LAR.[86] The Staff held a public meeting with NextEra on August 24, 2017 to discuss the LAR.[87]

2.24 In total, from 2010 to 2018, the Staff's 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.[88] These 20 inspections included a total of 9 findings related to ASR, one of which resulted in a notice of violation; all 9 findings were of very low safety significance.[89] The Staff also conducted a total of four onsite audits at the Seabrook plant,[90] all four of which specifically reviewed the ASR expansion

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[86] Exhibit INT024-00-BD01, SE, encl. 2 at 33, 35, 39, 40–42, 56, 60–61; Exhibit NRC087-00-BD01, Email from Justin Poole, NRC, to Kenneth Browne, NextEra, "Audit Plan Regarding Seabrook ASR License Amendment Review" (Jan. 13, 2017) (ML19205A443); Exhibit NRC043-00-BD01, July 2017 Site Audit Report at 1; Exhibit NRC044, May 2018 Site Audit Report at 1.

[87] Exhibit NRC046-00-BD01, Summary of August 24, 2017, Meeting with NextEra Energy Regarding License Amendment Request on Alkali Silica Reaction (Oct. 13, 2017) (ML19205A394).

[88] Exhibit NRC001-R-00-BD01, Staff Testimony at 12–14; *see* Tr. at 1054 ("[W]e did use some of the insights from the multiple inspections that were performed in order to come to some of our licensing conclusions.") (Ms. Buford).

[89] Exhibit NRC001-R-00-BD01, Staff Testimony at 14; Exhibit NRC021-00-BD01, May 2012 Inspection Report, encl. at 3–4, 9–10, 11–12 (two findings of very low safety significance related to ASR); Exhibit NRC023-00-BD01, August 2012 Inspection Report, encl. at 14–15 (one finding of very low safety significance related to ASR); Exhibit NRC024-00-BD01, Mar. 2012 Inspection Report, encl. at ii–iii (two findings of very low safety significance related to ASR); Exhibit NRC029-00-BD01, Aug. 2014 Inspection Report, encl. at 3 (one finding of very low safety significance that, while not initially attributed to ASR, was ultimately determined to be related to ASR); NRC031-00-BD01, Aug. 2015 Inspection Report encl. at 3–4 (two findings of very low safety significance related to ASR); Exhibit NRC033-00-BD01, May 2016 Inspection Report at 2 (one cited violation of very low safety significance related to ASR). Footnote eight of the Staff testimony incorrectly cites Exhibit NRC025 instead of Exhibit NRC024 and Exhibit NRC038 instead of Exhibit NRC031. These two typographical errors do not affect the substance of the Staff's testimony—that the 20 total inspections included a total of 9 findings related to ASR.

[90] The NRC Staff's testimony mentions five site audits because it includes the three-day site audit of the LSTP at FSEL. Exhibit NRC001-R-00-BD01, Staff Testimony at 14; Exhibit NRC018-00-BD01, LSTP 2017 Site Audit Report.

monitoring program,[91] and three of which specifically reviewed the structure deformation monitoring program.[92] A list of the inspections is provided in Table 1 below.

Table 1 – Inspection Reports

	Exhibit No.	Inspection Report	Date
1	NRC021-00-BD01	Integrated Inspection Report	May 12, 2011
2	NRC022-00-BD01	License Renewal Inspection Report 05000443/2011007	May 23, 2011
3	NRC023-00-BD01	Integrated Inspection Report	Aug. 12, 2011
4	NRC024-00-BD01	Inspection Report 05000443/2011010 Related to Alkali-Silica Reaction Issue In Safety Related Structures	Mar. 26, 2012
5	NRC025-00-BD01	Confirmatory Action Letter Follow-up Inspection	Dec. 3, 2012
6	NRC026-00-BD01	Confirmatory Action Letter Follow-up Inspection	Aug. 9, 2013
7	NRC027-00-BD01	Integrated Inspection Report	Jan. 30, 2014
8	NRC028-00-BD01	Integrated Inspection Report	May 6, 2014
9	NRC029-00-BD01	Integrated Inspection Report	Aug. 5, 2014
10	NRC030-00-BD01	Integrated Inspection Report	Feb. 6, 2015
11	NRC031-00-BD01	Integrated Inspection Report	Aug. 5, 2015
12	NRC032-00-BD01	Integrated Inspection Report 05000443/2015004 and Independent Spent Fuel Storage Installation Report No.	Feb. 12, 2016
13	NRC033-00-BD01	Inspection Report 05000443/2016008 Related to Alkali-Silica Reaction Affects On Safety- Related Concrete Structures And Notice Of Violation	May 6, 2016
14	NRC034-00-BD01	Integrated Inspection Report	Aug. 5, 2016
15	NRC035-00-BD01	Integrated Inspection Report	Feb. 8, 2017

[91] Exhibit NRC041-00-BD01, encl. at 1–2; Exhibit NRC042-00-BD01, encl. at 2–3; Exhibit NRC043-00-BD01, encl. at 2–3; Exhibit NRC044-00-BD01, encl. at 3–4.

[92] Exhibit NRC042-00-BD01, encl. at 2–3; Exhibit NRC043-00-BD01, encl. at 2–3; Exhibit NRC044-00-BD01, encl. at 3–4.

16	NRC036-00-BD01	Integrated Inspection Report	Aug. 14, 2017
17	NRC037-00-BD01	Integrated Inspection Report	Feb. 12, 2018
18	NRC038-00-BD01	Integrated Inspection Report	May 14, 2018
19	NRC039-00-BD01	Integrated Inspection Report	Aug. 10, 2018
20	NRC040-00-BD01	Integrated Inspection Report	Nov. 13, 2018

2.25 As explained above, NextEra's development of the Seabrook ASR expansion monitoring and structure deformation monitoring programs was both in response to Staff oversight and subject to Staff oversight.[93]

2.26 As part of its review of the LAR, the Office of Nuclear Reactor Regulation (NRR) requested an independent review on the overall adequacy of the LSTP by the separate Office of Nuclear Regulatory Research (RES); Jacob Philip performed this review.[94] Mr. Philip reviewed MPR-4153, Revision 2,[95] MPR-4273, Revision 0,[96] and MPR-4288, Revision 0,[97] concurred with NextEra's LSTP approach in general, and recommended that NextEra corroborate the normalized elastic modulus-expansion curve derived from the LSTP on structures at Seabrook

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[93] *Compare* Exhibit NRC078-00-BD01, NextEra Response to CAL (committing to submit a license renewal aging management program for ASR-affected structures by May 25, 2012) *with* Letter from Paul O. Freeman, NextEra, to NRC, "Seabrook Station, NextEra Energy Seabrook License Renewal Application, Structures Monitoring Program Supplement-Alkali-Silica Reaction (ASR) Monitoring" (May 16, 2012) (ML12142A323) (augmenting the existing structures monitoring program with a plant-specific ASR expansion monitoring program); *see* LRA Supplement at encl. 4 at 33–36 (discussing operating experience that led NextEra to augment the existing structures monitoring program with a plant-specific structure deformation monitoring program).

[94] Exhibit NRC005-00-BD01, Jacob Philip Testimony at 2; Exhibit INT024-00-BD01, SE, encl. 2 at 30–31.

[95] Exhibits NRC011-00-BD01/NRC012-00-BD01, MPR-5153, ASR Monitoring Report (Rev. 2) (nonproprietary and proprietary, respectively).

[96] Exhibit NRC008-00-BD01, MPR-4273 (Rev. 0) (nonproprietary); Exhibit NRC009-00-BD01, MPR-4273 (Rev. 0) (proprietary).

[97] Exhibit INT012-00-BD01, MPR-4288, Structure Deformation Report (Rev. 0) (nonproprietary); Exhibit INT014-00-BD01, MPR-4288, Rev. 0, "Seabrook Station: Impact of Alkali-Silica Reaction on Structural Design Evaluations (July 2016) (Enclosure 2 to Letter SBK-L-16071 [Original LAR]) (proprietary).

(which the Staff subsequently required as part of its license condition).[98] In addition, after reviewing MPR-4273, which describes in detail the LSTP, Mr. Philip concluded that the "LSTP with the use of large specimens is appropriate, greatly minimizes uncertainties associated with scaling, and enables the licensee to apply the test results to the analysis of the ASR condition existing at Seabrook."[99] In particular, Mr. Philip noted that the sizes of the specimens used in the LSTP were of the same order as those at Seabrook and equipped with similar reinforcement.[100] The Staff incorporated Mr. Philip's conclusions into the safety evaluation.[101]

2.27 In September 2018, the Staff completed a draft safety evaluation (SE) for the LAR and a final Safety Evaluation Report (SER) for the Seabrook license renewal application.[102] The Staff provided these documents to the Advisory Committee on Reactor Safeguards (ACRS) to support the ACRS's review of the Staff's efforts related to closing out the license renewal open item on ASR.[103] The ACRS is independent of the Staff and reports directly to the

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[98] Exhibit NRC005, Jacob Philip Testimony at 3–7; Exhibit INT024, SE, encl. 2 at 30-31. RES and NRR both independently determined that NextEra must perform confirmatory corroboration studies. Tr. at 1029.

[99] Exhibit INT024-00-BD01, SE, encl. 2 at 30; *see* Exhibit NRC005-00-BD01, Jacob Philip Testimony at 9–10.

[100] Exhibit INT024-00-BD01, SE, encl. 2 at 30; *see* Exhibit NRC005-00-BD01, Jacob Philip Testimony at 9–10.

[101] Exhibit INT024-00-BD01, SE, encl. 2 at 30.

[102] Safety Evaluation Report Related to the License Renewal of Seabrook Station, Docket No. 50-443, NextEra Energy Seabrook, LLC (Sept. 28, 2018) (ML18254A294) (LRA SER).

[103] Exhibit NRC047-00-BD01, Memorandum from James G. Danna, NRC, to Andrea D. Veil, ACRS, "Seabrook Station, Unit No. 1 - Submission of Alkali-Silica Reaction License Amendment Request Draft Safety Evaluation to Support the Advisory Committee on Reactor Safeguards' Review of Seabrook License Renewal" (Sept. 28, 2018) (ML19205A395).

Commission, which appoints its members.[104] ACRS review and report is required of all license renewal applications.[105]

2.28 The ACRS conducted an independent review of and reported on NextEra's approach for addressing ASR at Seabrook. After reviewing the history of the ASR condition at Seabrook, including reviewing relevant documents and meeting with the Staff and NextEra, the ACRS concluded in its report that "NextEra has undertaken substantial and thorough actions to identify, understand, and address this condition."[106] The ACRS determined that the "two new Aging Management Programs to monitor alkali-silica reaction and building deformation … assure that the effects of [ASR] will be effectively tracked and evaluated through the end of the license renewal application period of extended operation."[107] With respect to the LSTP specifically, the ACRS found that "[t]he LSTP test samples were highly representative of the ASR-affected structures at Seabrook."[108] The ACRS noted that, although there were limited data available on the effects of ASR on highly constrained structures at the time of the discovery of ASR at Seabrook, since then a large body of ASR research similar to the LSTP is ongoing and that this research has "produced similar results to the LSTP" and has chosen "a similar approach of fabricating prototypical, structural-sized test samples, with concrete produced to artificially accelerate ASR."[109] Therefore, the ACRS concluded that while some of the Seabrook

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[104] Atomic Energy Act of 1954, as amended, § 29, Advisory Committee on Reactor Safeguards; composition; tenure; duties; compensation (42 U.S.C. § 2039) (Nov. 10, 1998).

[105] 10 C.F.R. § 54.25. *See also* 10 C.F.R. § 50.58(a) ("An application for an amendment to … a construction permit or operating license may be referred to the [ACRS] for review and report. Any report shall be made part of the record of the application and available to the public….").

[106] Exhibit NRC048-00-BD01, Letter from Michael Corradini, Chairman, ACRS, to Kristine L. Svinicki, Chairman, NRC, "Seabrook Station Unit 1 License Renewal Application: Review of Licensee Program Addressing Alkali-Silica Reaction," at 1 (Dec. 14, 2018) (ML19205A396) (Corradini Letter).

[107] *Id*.

[108] *Id.* at 3 (emphasis added).

[109] *Id.* at 4.

structures are degraded, they are "fully capable of performing their credited function through the requested [period of extended operation] under the committed enhanced monitoring and evaluations."[110] The ACRS report did not make any further recommendations.[111]

2.29 After reviewing the separate, independent reviews of Mr. Philip and the ACRS, on March 11, 2019, the Staff issued its final SE for the LAR.[112]

2.30 In the final SE, the Staff found "that the licensee developed a representative test program and that it is reasonable to apply the conclusions of the MPR/FSEL LSTP to the structures at Seabrook within the bounds and limits of the test program, regardless of the results of material property testing on ASR-affected concrete cores."[113]

2.31 Recognizing that NextEra's proposed ASR expansion monitoring program was "a first-of-a-kind" approach, the Staff included a license condition that requires NextEra to perform actions to confirm the continued applicability of the LSTP to ASR-affected structures at Seabrook. The condition directs NextEra as follows:

> Conduct assessments of expansion behavior using the approach provided in Appendix B of [MPR-4273, LSTP Report], to confirm that future expansion behavior of ASR affected structures at Seabrook Station is comparable to what was observed in the [LSTP] and to check margin for future expansion. Seabrook completed the first expansion assessment in March 2018; and will complete subsequent expansion assessments every ten years thereafter.
>
> Corroborate the concrete modulus-expansion correlation used to calculate pre-instrument through-thickness expansion, as discussed in [MPR-4153 ASR Monitoring Report]. The corroboration will cover at least 20 percent of extensometer locations on ASR-affected structures and will use the approach

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[110] *Id*. at 5.

[111] The ACRS also independently reviewed the Staff's safety evaluations for both the license renewal application and the LAR and described the Staff's review as "deliberate and comprehensive," *id.* at 4, and "provid[ing] thorough assessments and findings," *id*. at 2.

[112] Exhibit INT024-00-BD01, SE at 1.

[113] *Id.* at encl. 2 at 31.

> provided in Appendix C of [MPR-4273, LSTP Report]. Seabrook will complete the initial study no later than 2025 and a follow-up study 10 years thereafter.[114]

2.32 This condition ensures that any issues with (1) ASR expansion in Seabrook structures as compared to ASR expansion in the LSTP test specimens and (2) the concrete modulus-expansion correlation as applied to Seabrook structures will be identified, entered into the Seabrook corrective action program, and subjected to NRC oversight.[115] Thus, if there is indication that the LSTP results do not apply to Seabrook structures, then NextEra would be required to conduct prompt operability determinations to determine whether the structures remain operable or, if they do not, shut down the facility, as dictated by the facility's technical specifications; these activities would be subject to NRC oversight.[116]

2.33 The same day that the Staff issued the final SE, the Staff issued a final no significant hazards consideration determination and issued the license amendment.[117]

2.34 On March 12, 2019, the Staff issued the renewed license for Seabrook.[118]

B. The LAR and its Separate ASR Expansion Monitoring and Structure Deformation Monitoring Programs

2.35 The LAR contained various reports on ASR at Seabrook, including (1) MPR-4288, "Seabrook Station: Impact of Alkali-Silica Reaction on Structural Design Evaluations," which includes NextEra's methodology for performing evaluations of structural adequacy on

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[114] *Id.,* encl. 2 at 59–60.

[115] Exhibit NRC001-R-00-BD01 at 29, 43.

[116] Tr. at 719–20, 739–42, 1012–13.

[117] NextEra Energy Seabrook, LLC; Seabrook Station, Unit No. 1, "License amendment; issuance," 84 Fed. Reg. 9564, 9564 (Mar. 15, 2019). *See* 10 C.F.R. § 2.340(a)(2)(ii) ("In a contested proceeding for the amendment of a[n] … operating license, … where the NRC has made a determination of no significant hazards consideration, … the Director, Office of Nuclear Reactor Regulation, … after making the requisite findings … may issue the amendment before the presiding officer's initial decision becomes effective.").

[118] NextEra Energy Seabrook, LLC; Seabrook Station, Unit No. 1, "License renewal and record of decision; issuance," 84 Fed. Reg. 9563, 9563 (Mar. 15, 2019).

ASR-affected reinforced concrete structures at Seabrook (MPR-4288, Structure Deformation Report),[119] (2) MPR-4273, “Seabrook Station - Implications of Large-Scale Test Program Results on Reinforced Concrete Affected by Alkali-Silica Reaction,” which includes a detailed discussion of the LSTP (MPR-4273, LSTP Report),[120] (3) MPR-4153, “Seabrook Station - Approach for Determining Through-Thickness Expansion from Alkali-Silica Reaction,” which describes the licensee’s methodology for its ASR expansion monitoring program (MRP-4153, ASR Monitoring Report),[121] and (4) Simpson Gumpertz & Heger, Inc. Report, “Development of ASR Load Factors for Seismic Category I Structures (including Containment) at Seabrook Station,” which details the licensee’s methodology for evaluating ASR-related loads on concrete structures at Seabrook.[122]

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[119] Exhibit INT012-00-BD01, MPR-4288, Rev. 0, “Seabrook Station: Impact of Alkali-Silica Reaction on Structural Design Evaluations” (July 2016) (Enclosure 2 to Letter SBK-L-16071 [Original LAR]) (ML19161A382) (nonproprietary) (MPR-4288, Structure Deformation Report (Rev. 0)); Exhibit INT014-00-BD01, MPR-4288, Rev. 0, “Seabrook Station: Impact of Alkali-Silica Reaction on Structural Design Evaluations (July 2016) (Enclosure 2 to Letter SBK-L-16071 [Original LAR]) (Proprietary) (ML19162A017). Although the title of Exhibit INT014-00-BD01 states that it is Enclosure 2 to Letter SBK-L-16071, the Original LAR, the proprietary version of MPR-4288, Rev. 0 is enclosure 5 to the Original LAR; enclosure 2 is the nonproprietary version of MPR-4288, Rev. 0. Exhibit INT010-00-BD01, Original LAR at 2.

[120] Exhibit INT019-R-00-BD01, MPR-4273, LSTP Report (Rev. 1) (nonproprietary); Exhibit INT021-00-BD01, MPR-4273, LSTP Report (Rev. 1) (proprietary); Exhibit NRC008-00-BD01, MPR-4273, LSTP Report, Rev. 0 (nonproprietary); Exhibit NRC009-00-BD01, MPR-4273, LSTP Report (Rev. 0) (proprietary).

[121] Exhibit INT018-R-00-BD01, MPR-4153, Rev. 3, Seabrook Station-Approach for Determining Through-Thickness Expansion from Alkali-Silica Reaction (Sept. 2017) (nonproprietary version) (Enclosure 4 to Letter SBK-18072) (ML19170A331) (MPR-4253, ASR Monitoring Report (Rev. 3)); Exhibit INT020-00-BD01, MPR-4153, Rev. 3, Seabrook Station-Approach for Determining Through-Thickness Expansion from Alkali-Silica Reaction (Sept. 2017) (Proprietary version) (Enclosure 6 to Letter SBK-18072) (Proprietary) (ML19162A018); Exhibit NRC011-00-BD01, Enclosure 3 to Sept. 2016 LAR Supplement, MPR-4153, Rev. 2, “Seabrook Station-Approach for Determining Through-Thickness Expansion from Alkali-Silica Reaction" (July 2016) (nonproprietary) (MPR-4153, ASR Monitoring Report (Rev. 2)) (ML19205A357); Exhibit NRC012-00-BD01, Enclosure 5 to Sept. 2016 LAR Supplement, Rev. 2, “Seabrook Station - Approach for Determining Through Thickness Expansion from Alkali-Silica Reaction” (July 2016) (ML19205A470) (proprietary).

[122] Exhibit INT013-00-BD01, 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) (Enclosure 4 to Letter SBK-L-16071 [Original LAR]) (ML19161A383).

2.36 The LAR was intended to address ASR at Seabrook because, as discussed above, the design basis codes for the affected structures did not account for the impacts of ASR.[123] Specifically, safety-related structures other than containment were designed and constructed to comply with the 1971 edition of American Concrete Institute (ACI) Standard 318, Building Code Requirements for Reinforced Concrete (ACI 318-71) and containment was designed and constructed to comply with the 1975 edition of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code Section III, Division 2, Subsection CC (together, the design basis codes).[124] Neither of these codes, however, includes methods to analyze and address the effects of ASR on structural properties. Therefore, NextEra needed to either change the Seabrook licensing basis to fit the current plant conditions or make changes to the current plant conditions to fit the existing licensing basis.[125] NextEra elected to do a combination of these things through the LAR: (1) the LAR makes specific modifications and supplements to the design basis codes, and (2) the LAR establishes both an ASR expansion monitoring program (based on the LSTP) and a structure deformation monitoring program. The ASR expansion monitoring program and structure deformation monitoring program together ensure either that the conditions at Seabrook remain within the design basis codes, as modified and supplemented, or that physical changes (repairs or

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[123] Exhibit NRC001-R-00-BD01, Staff Testimony at 17; Exhibit INT010-00-BD01, Original LAR, at 8–9, 11 (unnumbered). At Seabrook, safety-related structures other than the containment were designed and constructed to comply with the 1971 edition of American Concrete Institute (ACI) Standard 318, Building Code Requirements for Reinforced Concrete (ACI 318-71). Exhibit INT010-00-BD01, Original LAR, at 8–9, 11. The containment was designed and constructed to comply with the 1975 edition of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code Section III, Division 2, Subsection CC. *Id.* Neither of these codes, however, include methods to analyze and address the effects of ASR on structural properties. *Id.*

[124] Exhibit INT010-00-BD01, Original LAR at 8–9, 11 (unnumbered).

[125] Exhibit NRC001-R-00-BD01, Staff Testimony at 43.

modifications) are made or additional analysis is performed for cases where the amended licensing basis is not met.[126]

2.37 ASR can affect a concrete structure in two primary ways. First, cracking from ASR can affect structural capacity, that is, the load-carrying capacity for critical limit states.[127] Second, cracking from ASR can affect the demand on a structure by introducing a new load.[128] The LAR proposed to address (1) the effect of ASR on structural capacity through the ASR expansion monitoring program,[129] and (2) the effect of ASR on the demand on a structure through the structure deformation monitoring program.[130]

a. The ASR Expansion Monitoring Program

2.38 The ASR expansion monitoring program measures cracks in ASR-affected concrete at Seabrook, first in the in-plane direction using the crack indexing (CI) or combined crack indexing (CCI)[131] method (CI/CCI).[132] Then, when in-plane expansion reaches a specified threshold, the program measures cracks in the through-thickness direction using the readings taken from a snap-ring borehole extensometer (SRBE) combined with a calculation of the

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[126] *Id*.

[127] Exhibit NRC001-R-00-BD01, Staff Testimony at 18; Exhibit INT010-00-BD01, Original LAR at 9–10 (unnumbered).

[128] Exhibit NRC001-R-00-BD01, Staff Testimony at 18; Exhibit INT010-00-BD01, Original LAR at 9–10 (unnumbered).

[129] Exhibit NRC001-R-00-BD01, Staff Testimony at 18; Exhibit INT010-00-BD01, Original LAR at 9–10, 31–33. (unnumbered).

[130] Exhibit NRC001-R-00-BD01, Staff Testimony at 18; Exhibit INT010-00-BD01, Original LAR at 9–10, 33–34 (unnumbered).

[131] The CCI is the weighted average of the CI in the two measured in-plane directions. Exhibit INT024-00-BD01, SE, encl. 2 at 34.

[132] Exhibit NRC001-R-00-BD01, Staff Testimony at 18; Exhibit INT010-00-BD01, Original LAR at 17 (unnumbered); Exhibit INT024-00-BD01, SE, encl. 2 at 9.

through-thickness expansion that had occurred up to the time of the SRBE's installation.[133] The purpose of this monitoring is to ensure that the in-plane, through-thickness, and volumetric (the combination of in-plane and through-thickness expansions)[134] expansions remain below ASR expansion limits for the structural limit states of shear, flexure, reinforcement anchorage, and anchors.[135] The interval for this monitoring is based on the amount of in-plane expansion, categorized into three tiers: (Tier 1) when there is no indication of pattern cracking or water ingress, the inspection frequency is as prescribed in the Seabrook routine structural monitoring program; (Tier 2) when there are areas with pattern cracking that cannot be accurately measured or in-plane expansion of 0.05%, the inspection frequency is 30 months; and (Tier 3) when there is in-plane expansion of 0.1%, the inspection frequency is 6 months.[136]

2.39 Aspects of the ASR expansion monitoring program are based on LSTP data; specifically, as discussed below, the in-plane expansion at which to install SRBEs, the use of SRBEs to measure through-thickness expansion, the calculation of to-date through-thickness expansion, the expansion limits, and the monitoring intervals.[137]

2.40 The use of CI/CCI as part of the ASR expansion monitoring program is not based on LSTP data. Instead, as stated by NextEra expert witness Dr. Bayrak, "[it is] done on the basis of best practices recommendations pulled together by industry experts" and its use is

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[133] Exhibit NRC001-R-00-BD01, Staff Testimony at 18–19; Exhibit INT010-00-BD01, Original LAR at 17 (unnumbered); Exhibit INT024-00-BD01, SE, encl. 2 at 21; *see* INT019-R-00-BD01, LSTP Report, at 5-17–5-18.

[134] Volumetric expansion is the combination of in-plane and through-thickness expansions. Exhibit NRC001-R-00-BD01, Staff Testimony at 19.

[135] Exhibit NRC001-R-00-BD01, Staff Testimony at 19; Exhibit INT010-00-BD01, Original LAR at 30–33 (unnumbered).

[136] Exhibit NRC001-R-00-BD01, Staff Testimony at 19; Exhibit INT010-00-BD01, Original LAR at 33, tbl. 5 (unnumbered).

[137] Exhibit NRC001-R-00-BD01, Staff Testimony at 43.

consistent with the guidance in the U.S. Department of Transportation, Federal Highway Administration, "Report on the Diagnosis, Prognosis, and Mitigation of [ASR] in Transportation Structures" (FHWA Report).[138]

b. The Structure Deformation Monitoring Program

2.41 As described above, in 2015, NRC inspectors documented seismic and fire seals in the containment enclosure building that appeared to have been degraded due to differential movement between adjoining concrete buildings.[139] Both NextEra and the Staff determined that this finding was the result of an effect of ASR that is separate from the expansion effect of ASR that had been addressed by the LSTP.[140] Specifically, structural demand can be added to a structure by an internal self-straining ASR load due to restraint to ASR expansion from reinforcement, geometry, and boundary conditions causing deformation.[141] Stated another way, restraint to ASR expansion applies a self-equilibrating internal tensile force to the reinforcement and an internal compressive force to the concrete, which produces additional demand that must be resisted by the structure.[142]

2.42 Because the LSTP did not address this effect of ASR, NextEra developed an additional monitoring program, called the structure deformation monitoring program,[143] and

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[138] Tr. at 482–83 (citing Exhibit NER013-00-BD01, U.S. Department of Transportation, Federal Highway Administration, "Report on the Diagnosis, Prognosis, and Mitigation of Alkali-Silica Reaction (ASR) in Transportation Structures" (FHWA-HIF-09-004) (Jan. 2010) (ML19205A491) (FHWA Report)).

[139] Exhibit NRC031-00-BD01, Aug. 2015 Inspection Report, encl. at 3, 18–23; *see* Exhibit NRC033-00-BD01, May 2016 Inspection Report at 1, encl. 1 at 1–2.

[140] Exhibit INT024-00-BD01, SE, encl. 2 at 32 ("[I]n addition to an internal prestressing effect, ASR expansion can lead to building deformation that, when restrained, results in load and additional stresses on affected structures.").

[141] Exhibit NRC001-R-00-BD01, Staff Testimony at 8.

[142] *Id.* at 58–59.

[143] The final safety evaluation report for the Seabrook license renewal application refers to this program as the Building Deformation Monitoring Program. LRA SER at 1-8.

included it as part of the LAR along with the separate ASR expansion monitoring program.[144] The structure deformation monitoring program adds the self-straining ASR load to the design basis load combinations and manages building deformation.

2.43 The structure deformation monitoring program involves a three-stage process to evaluate seismic Category I structures.[145] First, in Stage 1, NextEra screens each seismic Category I structure for susceptibility to structural deformation caused by ASR.[146] In Stage 2, NextEra performs an "analytical evaluation" on structures "that the Stage One Screening Evaluation identifies as susceptible to deformation but do not satisfy ACI 318-71 acceptance criteria."[147] In Stage 3, NextEra performs a "detailed design confirmation calculation" when "the Stage Two Analytical Evaluation concludes that some area of a structure does not satisfy ACI 318-71 acceptance criteria or when the structure has sufficient deformation that may impact demands computed in the original design."[148] Both Stage 2 and Stage 3 involve the use of finite element models.[149] Each analysis stage establishes threshold monitoring limits for each structure; the structures are then monitored to ensure that the threshold monitoring limits are not exceeded.[150] Structures classified as Stage 1 are monitored every 3 years, structures classified as Stage 2 are monitored every 18 months, and structures classified as Stage 3 are monitored every 6 months.[151]

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[144] *See* Exhibit INT010-00-BD01, Original LAR at 24, 30, 33–34 of 74 (unnumbered).

[145] *Id.* at 24.

[146] *Id.*

[147] *Id.* at 25.

[148] *Id.*

[149] *Id.* at 25, 33–34.

[150] *See* Exhibit INT010-00-BD01, Original LAR at 25, 33–34.

[151] *Id.*

2.44 The implementation of the structure deformation monitoring program is not based on LSTP data. The LSTP provides the technical basis and expansion limits for using the code-based approach and the structural capacity acceptance criteria against which the structural demands are compared for applicable limit states. The LSTP data do not influence the structural demands calculated by the structural analyses conducted as part of the structure deformation monitoring program.[152]

C. The LSTP, Why It Was Needed as the Basis for the ASR Expansion Monitoring Program, and Why Large-Scale Testing is an Appropriate Approach

2.45 ASR expansion degrades the material properties of concrete.[153] The material properties of concrete include compressive strength, tensile strength, elastic modulus, shear strength, and flexural strength. The compressive strength of a material, including concrete, is its capacity to withstand loads or stresses that tend to compress and reduce its size, as opposed to tensile strength, which is its capacity to withstand loads or stresses that tend to elongate and crack or split the material. The elastic modulus is the ratio of stress (force per unit area) to strain (ratio of change in length to the original length) in the elastic range of material behavior. The elastic range of a material is the range in which the material can be loaded and unloaded without permanent deformation, i.e., an elastic structure deforms when a load is applied and, when the load is removed, it returns to its original state. Shear strength is the ability of a material to resist a shear stress, which is created when two planes of the same object are trying to slide past one another. Flexural strength (or bending strength) is the ability of a structural member to resist a flexural load (moment), or the member's ability to resist bending when loaded.[154]

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[152] Exhibit NRC001-R-00-BD01, Staff Testimony at 21.

[153] *Id.* at 8–9, 58.

[154] *Id*. at 7.

2.46 ASR expansion can also affect structural properties, or a structure's capability to perform its intended function, by (1) reducing structural capacity, or the ability of the structure to carry loads, and (2) adding structural demand, or adding a load to the structure. Structural capacity can be reduced by the ASR cracking and possible reductions in material properties of the concrete. Structural demand can be added to the structure by an internal self-straining ASR load due to restraint to expansion from reinforcement, geometry, and boundary conditions causing deformation.[155]

2.47 With respect to the NRC's regulations, the relevant issue is the effect that a degradation mechanism may have on structural properties and not on material properties.[156] Therefore, the relevant question with respect to the LAR at issue in this proceeding is whether a reinforced concrete structure at Seabrook, as a whole, is capable of fulfilling its intended safety functions despite the presence of ASR.[157]

2.48 The material properties of the concrete within a structure are expected to be considerably better than those of concrete cores that have been removed from the structure.[158] This is because ASR causes micro-cracking and when a core is removed from a structure, the in-situ confinement that was provided by the steel reinforcing bars (rebar) and the surrounding concrete (i.e., the structural context) is lost.[159] Because of the interaction between the rebar

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[155] *Id*. at 8.

[156] *See, e.g.*, 10 C.F.R. Part 50, App. A (discussing "structures, systems, and components important to safety").

[157] Exhibit NRC001-R-00-BD01, Staff Testimony at 8–9, 58.

[158] *Id.* at 9; *see* Tr. at 282–83 ("[M]echanical properties of plain concrete, meaning concrete without reinforcement, is greatly impacted by ASR. But mechanical properties of reinforced concrete can remain and do remain – there is many examples of this in the literature – unimpacted, not influenced by ASR. The reason for that is confinement – internal confinement provided by reinforcing bars enhance the performance of that reinforced concrete element.") (Dr. Bayrak).

[159] Exhibit NRC001-R-00-BD01, Staff Testimony at 9.

and the concrete and the in-situ confinement, the load-carrying behavior of ASR-affected structures is generally better than would be expected from the material properties measured on cores taken from those structures.[160] Therefore, it is important that reinforced concrete structures affected by ASR be evaluated based on the impact of ASR on structural properties, and not necessarily on material properties of extracted cores.[161]

2.49 To address the effect of ASR on structural properties, and because the structural properties of ASR-affected concrete structures cannot necessarily be determined by the material properties of extracted cores, NextEra developed a testing program based on large-scale concrete beams fabricated to be representative of concrete structures at Seabrook.[162] Additionally, the use of concrete beams created specifically for the LSTP, as opposed to cores extracted from Seabrook, allowed for the control of test variables, for testing ASR levels beyond those exhibited in actual Seabrook structures, for the use of test methods consistent with the test data that were relied upon in developing the design basis codes, and for the use of nuclear commercial grade quality assurance.[163] As stated by NextEra expert witness Mr. Bagley, "The data from the [LSTP] is the most representative data in the world of Seabrook Station…."[164]

2.50 The purpose of the LSTP was to determine whether, although concrete material properties can be degraded by ASR, the structural performance of Seabrook reinforced concrete structures could still be conservatively estimated by the design basis codes.[165]

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[160] *Id*.

[161] *Id*.

[162] *See* Exhibit INT024-00-BD01, SE at 6–7; Exhibit NER001-00-BD01, MPR Testimony at 15.

[163] Exhibit NRC001-R-00-BD01, Staff Testimony at 24–25; Tr. at 549–50.

[164] Tr. at 549. NextEra also determined that it could not use literature data instead of large-scale test specimens because the available data did not discuss the specifics of the concrete involved and so NextEra was unable to determine whether these data would be representative of the concrete structures at Seabrook. *Id*.

[165] Exhibit NRC001-R-00-BD01, Staff Testimony at 58.

2.51 The LSTP used large-scale test specimens that reflected the characteristics of ASR-affected reinforced concrete structures at Seabrook. The LSTP tested various levels of ASR cracking to assess its impact on selected structural limit states. The ACRS independently approved this approach, noting that "the National Institute of Standards program (and others) chose a similar approach of fabricating prototypical, structural-sized test samples, with concrete produced to artificially accelerate ASR."[166] The Staff also determined that accelerating ASR expansion in large-scale test specimens was consistent with the literature.[167] C-10 expert witness Dr. Saouma, represented that he has cast large-scale test specimens with artificially accelerated ASR.[168] As stated by NextEra expert witness Dr. Bayrak, "this is very commonly done in laboratory setting[s]…."[169]

2.52 In general, the LSTP data demonstrated that as long as ASR expansion within Seabrook structures remains below the limits established from the LSTP, the structural properties will be unaffected and, therefore, the structural performance of the structures can still be conservatively estimated by the design basis codes, regardless of reductions in concrete material properties due to ASR.[170] As summarized by NextEra expert witness Mr. Sherman, "the whole point … of this entire project, is to know where we are [with respect to ASR expansion at Seabrook], and stay inside that box that's defined by the [LSTP] that shows that we're still inside that design basis."[171]

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[166] Exhibit NRC048-00-BD01, Corradini Letter at 4; *see also* Tr. at 697–98, 806–07 (Mr. Philip discussing the NIST program).

[167] Tr. at 1119.

[168] *Id.* at 409–11, 882.

[169] *Id.* at 411–12.

[170] Exhibit NRC001-R-00-BD01, Staff Testimony at 8–9, 58.

[171] Tr. at 331.

2.53 NextEra used the LSTP data to develop the ASR expansion monitoring program. NextEra separately developed the structure deformation monitoring program. NextEra requested to modify the Seabrook licensing basis to incorporate these programs via the LAR (for the period of current operation) and via a supplement to the license renewal application (for the period of extended operation).[172]

2.54 C-10 argued that, in taking this LSTP approach, NextEra was confusing material strength with structural strength.[173] This argument is not borne out by the LSTP.[174] The LSTP showed, consistent with existing ASR literature, that, when affected by ASR, material properties of concrete are degraded.[175] The purpose of the LSTP, however, was not to tie material strength to structural strength, but, rather, to demonstrate that although concrete material properties may be degraded, the structural performance of the reinforced concrete member can still be conservatively estimated by the design basis code equations for the ASR levels experienced in the LSTP.[176] Thus, NextEra was not confusing material strength with structural strength, it was relying on the LSTP results to demonstrate that structural strength can still be conservatively estimated by the existing Seabrook design basis codes as long as the expansion remains below the LSTP limits, regardless of reductions in material strength.[177]

2.55 C-10 faulted the NRC for not obtaining peer review of the LSTP.[178] C-10 stated that peer review is “a cornerstone of engineering practice” and that peer reviewers must (1) be

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[172] Exhibit INT010-00-BD01, Original LAR; LRA Supplement.

[173] Exhibit INT001-R-00-BD01 at 17.

[174] Exhibit NRC001-R-00-BD01, Staff Testimony at 58.

[175] *Id*.

[176] *Id*.

[177] *Id*.

[178] Exhibit INT001-R-00-BD01 at 35.

sufficiently detached from the project organization (i.e., not ultimately report to the same hierarchy), (2) be familiar with the literature, and (3) have a degree of scientific expertise and rigor that is sufficient to enable them to credibly comment.[179] Such peer review is not required by the NRC's regulations.[180] Nonetheless, the Staff gathered additional information to support its review of the LSTP through mechanisms that largely meet the three elements that C-10 asserts constitute a peer review.[181] First, the ACRS, an independent, statutorily mandated committee that is separate from the Staff and reports directly to the Commission,[182] reviewed the issue.[183] The ACRS is composed of highly qualified technical experts.[184] As part of its review, the ACRS reviewed all of the relevant materials and met with and asked questions of NextEra and the Staff.[185] Second, the Staff office with the responsibility for the review of the LAR, NRR, sought an independent opinion on the validity of the LSTP approach from Mr. Philip, a technical expert otherwise uninvolved with the Staff's review from another Staff office, RES.[186] Mr. Philip reviewed the relevant documents, concurred with the LSTP approach,[187] and determined that the correlation equation derived from the LSTP was "really close" to the best available data that he could find in the literature.[188]

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[179] *Id*

[180] Exhibit NRC001-R-00-BD01, Staff Testimony at 73–74.

[181] *Id*.

[182] 42 U.S.C. § 2039.

[183] Exhibit NRC048-00-BD01, Corradini Letter at 1.

[184] *See* ACRS Membership, https://www.nrc.gov/about-nrc/regulatory/advisory/acrs/membership.html (last visited Nov. 21, 2019); Tr. at 268 (discussing the relevant qualifications of ACRS members).

[185] Exhibit NRC048-00-BD01, Corradini Letter at 1; *see also* Official Transcript of Advisory Committee on Reactor Safeguards License Renewal Subcommittee Open Session (Oct. 31, 2018) (ML18348B117).

[186] Exhibit NRC005-00-BD01, Jacob Philip Testimony at 2; Exhibit INT024-00-BD01, SE, encl. 2 at 30–31.

[187] Exhibit NRC005, Jacob Philip Testimony at 3–10.

[188] Tr. at 1117–21.

2.56 C-10 also faulted the Staff and its independent reviewers for not having expertise on ASR. However, Staff expert witness Mr. Philip has significant experience with respect to ASR. He is an NRC Senior Geotechnical Engineer with about 50 years of diverse experience in geotechnical and foundation engineering design, construction, and research in private industry and government.[189] He has significant expertise with concrete such as the design of concrete foundations for several nuclear power plants, research development and management with respect to the design of durable concrete structures and cementitious materials for nuclear power plants and concrete nuclear waste facilities, and the corrosion of reinforced concrete in nuclear power plants, including from ASR. For the last 7 years at the NRC, Mr. Philip has developed and managed research on ASR.[190] More specifically, Mr. Philip's ASR-specific experience has included his work as the NRC project manager for NRC-sponsored ASR research at the National Institute of Standards and Technology (NIST), and as a member of the Institute for Radiological Protection and Nuclear Safety, France, Observatory of the Durability of Reinforced Concrete Structures Research Technical Group, which manages the technical aspects of a 10–15-year research project on the degradation of concrete in nuclear power plant applications.[191] Mr. Philip also organized and led, with the Canadian Nuclear Safety Commission (CNSC), the Organisation for Economic Co-operation and Development/Nuclear Energy Agency/Committee on the Safety of Nuclear Installations international project "Assessment of Structures Subject to Concrete Pathologies," or ASCET.[192]

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[189] Exhibit NRC006-00-BD01, Statement of Professional Qualifications of Jacob Philip.

[190] *Id.* at 3.

[191] *Id*.

[192] *Id.* ASCET is an international project, where experts from several countries presented their results on blind numerical simulations of benchmark tests conducted by the CNSC at the University of Toronto, Canada, on concrete affected by ASR. *Id.*

2.57 Moreover, as discussed above, the LAR proposed using the LSTP to ensure that the concrete structures at Seabrook will remain within the facility's design basis codes, as modified and supplemented. This codes-based approach focused on the structural properties of the concrete structures at Seabrook, an area in which the Staff and the ACRS have demonstrated expertise. For instance, Staff expert witness Dr. Thomas is a structural engineer with over thirty years of diverse experience in regulatory work, industry, and research, including in the aging management of reinforced and pre-stressed concrete safety-related structures and containments at nuclear power plants;[193] Staff expert witness Ms. Buford is a structural engineer with over 15 years of diverse experience, including in regulatory oversight and licensing safety reviews of concrete degradation issues at nuclear power plants;[194] and Staff expert witness Mr. Lehman is a civil engineer with 15 years of structural experience, more than ten of which has been in nuclear power.[195] With respect to the ACRS, its chairman, Dr. Peter Riccardella, who participated in the ACRS's questioning of NextEra and the Staff regarding the issue of ASR at Seabrook,[196] has 45 years' experience working on the structural integrity of nuclear power plant components and is an authority in the application of fracture mechanics to nuclear pressure vessels and piping.[197] He has made significant contributions to the diagnosis and correction of materials degradation concerns at operating plants.[198]

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[193] Exhibit NRC004-00-BD01 at 1.

[194] Exhibit NRC002-00-BD01 at 1.

[195] Exhibit NRC003-00-BD01 at 1.

[196] *See, e.g.,* Official Transcript of Advisory Committee on Reactor Safeguards License Renewal Subcommittee Open Session at 269 (Oct. 31, 2018) (ML18348B117) (Dr. Riccardella stating that NextEra's approach "represents a very impressive body of work").

[197] ACRS Membership, https://www.nrc.gov/about-nrc/regulatory/advisory/acrs/membership.html (last visited Nov. 21, 2019).

[198] *Id*.

2.58 Based on the foregoing, we find that NextEra has demonstrated by a preponderance of the evidence that the LSTP approach, its development by NextEra and its contractors, and its review by the Staff and its independent reviewers was appropriate.

D. The LSTP's Representativeness of the Progression of ASR at Seabrook

2.59 C-10 has challenged in this proceeding the representativeness of the LSTP by arguing that (1) the test specimens should have been harvested from Seabrook Station, Unit No. 2 rather than fabricated; (2) NextEra failed to scale the test specimens to the actual Seabrook dimensions and apply to the test specimens the actual Seabrook boundary conditions; (3) the aggregates used in the concrete mixture for the test specimens were not identical to aggregates used in the concrete mixture for Seabrook; and (4) NextEra did not account for differences in the type of ASR gel in the test specimens and at Seabrook. We address each of these arguments in turn below, finding 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.

a. Board Findings on Harvesting Concrete from Seabrook Station, Unit No. 2

2.60 C-10 argued that, instead of trying to fabricate representative test specimens, the LSTP should have used segments of the concrete walls of the partially completed Seabrook Station, Unit No. 2.[199]

2.61 NextEra's expert witnesses testified that the use of segments of the concrete walls of Seabrook Station, Unit No. 2 would not have been representative of the walls at Seabrook Station, Unit No. 1. As NextEra expert witness Mr. Carley explained, the Unit No. 2 concrete walls were incomplete; in fact, they were only poured to about ten feet above surface,

[199] Tr. at 548–51.

and, therefore, both sides of the walls have been exposed to the environment.[200] Significantly, this exposure to outside environmental conditions meant that the top of the concrete walls of Unit No. 2 and their rebar are exposed to the environment, potentially providing a moisture path through the concrete internally.[201] Moreover, NextEra expert witnesses Mr. Bagley testified that there was no way of knowing the to-date through-thickness expansion in these concrete walls.[202] Without knowing the to-date through-thickness expansion, NextEra could not correlate any ASR-related expansion in Unit No. 2 to the structures at Unit No. 1.[203]

2.62 We find that NextEra has demonstrated by a preponderance of the evidence that the use of segments of the concrete walls of Seabrook Station, Unit No. 2 would not have been representative of the walls at Seabrook Station, Unit No. 1 because the Unit No. 2 concrete walls were only poured to about ten feet above surface; both sides of the walls have been exposed to the environment; the top of the concrete walls and their rebar are exposed to the environment, potentially providing a moisture path through the concrete internally; and there is no way of knowing the to-date through-thickness expansion in these concrete walls.[204]

b. Board Findings on the Scaling and Boundary Conditions of the LSTP Test Specimens

2.63 C-10 argued that the LSTP was not representative because NextEra had failed to scale the test specimens to the dimensions of the "Seabrook reactor."[205]

2.64 C-10's argument regarding scaling is not relevant because the tests conducted in the LSTP used almost full-scale test specimens representative of a bounding reference location

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[200] Tr. at 551.

[201] *Id.* at 551–52.

[202] *Id*.

[203] *Id.* at 552.

[204] Tr. at 551–52.

[205] Exhibit INT001-R-00-BD01, Staff Testimony at 11.

of a typical wall segment in a Seabrook ASR-affected seismic Category 1 structure (i.e., the "B" electrical tunnel).[206] The width of the specimens were the actual dimensions at the reference location and the height was that of a representative segment (or slice) of that location.[207] The specimens included two-dimensional reinforcement mats using the same reinforcement size and spacing, one along each longitudinal face, and with no shear reinforcement, as in a typical wall at Seabrook.[208] Thus the LSTP involved full-scale load tests to failure and not model tests, as asserted by C-10.[209] Additionally, because the LSTP supplements (rather than replaces) the design code, results from appropriately representative test specimens may be applied to reinforced concrete structures throughout Seabrook.[210]

2.65 C-10 faulted the LSTP for having a rebar ratio in the longitudinal direction that is greater than that in the reference location for its shear test specimens.[211] NextEra expert witness Dr. Bayrak explained, however, that this was necessary in order to study shear.[212] This is because the reference location is designed to ACI 318-71 and, as such, if not modified, would always fail in flexure before failing in shear.[213] Thus, it was necessary to adjust the longitudinal reinforcement ratio so that "a shear crack [would be] observed which informs what concrete contribution to shear strength is."[214]

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[206] Exhibit NRC001-R-00-BD01, Staff Testimony at 52–53.

[207] *Id*.

[208] *Id*.

[209] *Id*.

[210] *Id*.

[211] Tr. at 277.

[212] *Id*. at 278–79.

[213] *Id*.

[214] *Id*.

2.66 C-10 also argued that the test specimens were not subjected to the same boundary conditions (i.e., support, restraints, and load) as at Seabrook and that, therefore, the LSTP cannot be seen as a representative model for Seabrook.[215] Dr. Bayrak, however, explained that any differences between the boundary conditions used for the LSTP and the boundary conditions at Seabrook would not reduce representativeness but, rather, would increase conservatism. Specifically, the boundary conditions at Seabrook involve "external restraint boundary conditions, structural geometry, [and] how that particular cutout portion frames into the rest of the building [, which] improve[s] the behavior of that segment so that would render beam testing not only [on the] conservative side but in many examples greatly so."[216]

2.67 C-10 argued that the test specimens were not representative because their reinforcement is different than that of the containment enclosure building.[217] However, the containment enclosure building is actually more reinforced than the reference location on which the test specimens are based and, therefore, the test specimens are bounding of the containment enclosure building.[218]

2.68 We find that NextEra has demonstrated by a preponderance of the evidence that the test specimens' large size represented the scale and structural context of structures at Seabrook and avoided uncertainties due to scaling effects associated with using smaller

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[215] Exhibit INT001-R-00-BD01 at 11–12; Tr. at 770 (Dr. Saouma stating that he does not consider the boundary conditions to be representative).

[216] Tr. at 282–83.

[217] *Id.* at 770 ("I … consider the reinforcement ratio … for the [containment enclosure building is] not representative.") (Dr. Saouma); *see id.* at 1046–47.

[218] Tr. at 279–80, 700–702, 1047.

specimens.[219] The test specimens were also designed with reinforcement ratios and configurations similar to those at Seabrook.[220] Specifically, the specimens used a two-dimensional rebar mat in the in-plane direction to simulate the rebar in the face of the typical walls at Seabrook.[221] This allowed the structural performance tests to account for the confinement effects provided by the typical Seabrook reinforcement configuration.[222] Further, the test specimens' dimensions and rebar were designed so that the specimens would best represent being part of a larger structure.[223] Finally, the test methods and experimental designs used in the LSTP were consistent with the database of test data that was used to develop the relevant Seabrook design basis code equations.[224] Therefore, with respect to scaling and boundary conditions, the test specimens were representative.

c. Board Findings on the LSTP's Representativeness of the Seabrook Concrete Aggregates

2.69 The Staff determined that NextEra has demonstrated that the concrete of the test specimens reasonably reflected the properties of concrete in Seabrook structures.[225] NextEra considered 11 different concrete mixtures, and the concrete mixture selected for the LSTP was selected because it was the most representative with respect to the structural responses of the test specimens.[226] The concrete mixture design for the test specimens was based on specifications used at Seabrook (e.g., compressive strength, coarse aggregate gradation and

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[219] *See* Exhibit NRC001-R-00-BD01, Staff Testimony at 27–29*; see* Exhibit NRC005-00-BD01, Testimony of Jacob Philip at 8–9; Tr. at 277–79.

[220] *See* Exhibit NRC001-R-00-BD01, Staff Testimony at 27.

[221] *See id.*

[222] *See id.*

[223] *See id.*

[224] *See id*. at 28–29.

[225] Exhibit NRC001-R-00-BD01, Staff Testimony at 27–28.

[226] Tr. at 411–12.

type, water-to-cement ratio, cement type, aggregate proportions, etc.) and, in part, included constituents obtained from sources similar to those used during the construction of the plant.[227]

2.70 The concrete mixture design used at Seabrook included coarse aggregate (gravel) from a quarry in Maine and fine aggregate (sand) from a quarry in New Hampshire.[228]

2.71 The concrete mixture design used for the LSTP test specimens included coarse aggregate of which roughly half came from a quarry in Maine, near the quarry that was used for the concrete at Seabrook, and the other half came from a quarry in New Mexico.[229] The fine aggregate for the LSTP test specimens came from a quarry in Texas.[230] The original quarry in Maine that supplied the aggregates for the concrete at Seabrook was unavailable as it was shutdown,[231] and NextEra selected the aggregates from the New Mexico and Texas quarries for their reactivity to accelerate ASR expansion in the test specimens.[232]

2.72 C-10 argued that the concrete used in the LSTP test specimens was not representative of the concrete at Seabrook because the coarse aggregate and the fine aggregate used in the LSTP were not identical to those used in Seabrook and because NextEra did not state that the gravel and sand came from the same quarry as used for Seabrook.[233]

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[227] *Id*.

[228] Exhibit NER001-00-BD01, MPR Testimony at 34, 49.

[229] Tr. at 382; *see* Exhibit NER001-00-BD01, MPR Testimony at 80–81; Exhibit NER026-00-BD02, MPR-3757, Rev. 4, "Shear and Reinforcement Anchorage Test Specimen Technical Evaluation" (May 2014) (FP100760) at 3-8–3-9 (ML19205A527) (Non-publicly available).

[230] Exhibit NER001-00-BD01, MPR Testimony at 84.

[231] *Id.* at 136.

[232] *Id.* at 80–85; Tr. at 288, 634–35, 637.

[233] Exhibit INT001-R-00-BD01 at 10; Tr. at 287–89.

C-10 argued that this is a material failure because the behavior of concrete is so sensitive to variables and that different sources of aggregate will result in drastically different concrete.[234]

2.73 NextEra's expert witnesses testified that the use of identical aggregate in the LSTP test specimens "was not possible and not practical."[235] First, NextEra's expert witnesses explained that the use of identical coarse aggregate and fine aggregate was not possible because the quarry from which these aggregates were obtained for Seabrook is no longer operating.[236] Moreover, NextEra's expert witnesses testified that "[e]ven 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."[237]

2.74 The Staff expert witnesses also testified that "it would have been impossible to recreate Seabrook concrete exactly, as Dr. Saouma advocates" because "[e]ven if the aggregate and sand were taken from the same source, there would be differences in the final product."[238] The Staff expert witnesses went on to explain that although no two concrete samples will ever be exactly the same due to differences in their constituents (e.g., aggregate, sand, cement, etc.), specific criteria for the concrete mixture (e.g., water-to-cement ratio, compressive strength, etc.) can be followed to create concrete that is similar enough that it can be treated as the same for design purposes.[239]

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[234] Exhibit INT001-R-00-BD01 at 10; Tr. at 287–89.

[235] Exhibit NER001-00-BD01, MPR Testimony at 136.

[236] *Id.*

[237] *Id.*

[238] Exhibit NRC001-R-00-BD01, Staff Testimony at 51.

[239] *Id.* ("To build on Dr. Saouma's example of bread, no two loaves of bread are ever exactly the same; however, recipes can be followed to develop a particular type of bread (e.g., baguette, ciabatta, etc.). Concrete is similar in that no two concrete samples will ever be exactly the same due to differences in the constituents (e.g., aggregate, sand, cement, etc.); however, specifications, or 'recipes,' can be provided that, if followed, will create concrete that is similar enough that it can be treated as the same for design

2.75 Additionally, NextEra explained that the differences in the coarse aggregate and fine aggregate used in the LSTP test specimens versus those used at Seabrook do not affect the representativeness of the specimens.[240] The concrete mixture design for the LSTP test specimens included differences from the concrete mixture at Seabrook to allow for the accelerated development of ASR.[241] As NextEra's expert witnesses explained, "[u]se of a concrete mixture design identical to the plant would not have produced sufficient ASR progression to reach or exceed the condition of the plant in an acceptable timeframe."[242]

2.76 With respect to the coarse aggregate, as indicated above, the original, specific quarry that supplied the aggregate for the concrete at Seabrook was unavailable as it was shut-down.[243] To maximize the representativeness of the test specimens, however, NextEra transported approximately half of the concrete mixture used for the specimens from a quarry in Maine near the quarry that was used for the concrete at Seabrook.[244] The other half of the coarse aggregate came from a quarry in New Mexico that is known to be reactive.[245] The more reactive coarse aggregate allowed NextEra to accelerate ASR expansion in the test specimens.[246] Even though the New Mexico coarse aggregate was more reactive, NextEra expert witness John Simons testified that SGH's petrographer still examined the coarse

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purposes. The LSTP used the original Seabrook recipe and ensured that each ingredient matched the original Seabrook recipe ingredient as closely as reasonably possible in developing its test specimens.").

[240] Exhibit NER001-00-BD01, MPR Testimony at 80–85; Tr. at 288, 634–35, 637.

[241] Exhibit NER001-00-BD01, MPR Testimony at 80–85; Tr. at 288, 634–35, 637.

[242] Exhibit NER001-00-BD01, MPR Testimony at 81.

[243] *Id.* at 82; *see* Exhibit NER026-00-BD01 at 3-8 (Non-publicly available).

[244] Exhibit NER001-00-BD01, MPR Testimony at 80–81, 83; Tr. at 633; Exhibit NER026-00-BD01 at 3-8 (Non-publicly available).

[245] Tr. at 633; *see* Exhibit NER001-00-BD01, MPR Testimony at 81.

[246] Tr. at 634.

aggregate from New Mexico and confirmed that it was similar to the coarse aggregate used at Seabrook.[247] Moreover, NextEra explained that ACI 318-71, the code of record for Seabrook, applies to a broad range of coarse aggregates. NextEra's expert witnesses explained, "[t]he conservative approaches taken by code committees in assembling databases, evaluating test data, etc., make accommodation for variability in local constituent materials. It is not practical that design expressions are specific to all local constituent materials."[248]

2.77 In addition, NextEra stated that the coarse aggregate from both quarries was representative of concrete at Seabrook in that (1) the coarse aggregate was crushed stone, like at Seabrook;[249] and (2) the size of the aggregate was equal to or smaller than the aggregate at Seabrook.[250] The fact that the coarse aggregate was crushed is important because crushed stone promotes aggregate interlock, which, in turn, is important to the strength of the concrete.[251] The size of the aggregate is also important because, as NextEra's expert witnesses testified, "[r]esearch has shown that maximum aggregate size impacts specimen shear strength."[252] Thus, by using coarse aggregate that was equal to or smaller than the

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[247] *Id.* at 633; *see id.* at 382 (We actually did petrography early on to support that effort to make sure that the coarse aggregate that was being used in the testing was … the same mineralogical condition as the original.") (Mr. Sherman); Exhibit NER022-R-00-BD01, MPR-4262, "Shear and Reinforcement Anchorage Testing of Concrete Affected by Alkali-Silica Reaction," Vol. I, Rev. 1 (July 2016) & Vol. II, Rev. 0 (Jan. 2016) (FP100994) at 4-11 (ML19266A048) (Non-publicly available).

[248] Exhibit NER001-00-BD01, MPR Testimony at 84.

[249] Exhibit NER001-00-BD01, MPR Testimony at 80; Tr. at 633–64, 1081–82.

[250] Exhibit NER001-00-BD01, MPR Testimony at 80; Exhibit NER026-00-BD01 at 3-9 (Non-publicly available).

[251] Exhibit NER001-00-BD01, MPR Testimony at 80; *see* Tr. at 432–433, 1006, 1081–82.

[252] Exhibit NER001-00-BD01, MPR Testimony at 80.

aggregate used at Seabrook, the test specimens had slightly lower shear strength than the concrete at Seabrook, which is conservative.[253]

2.78 With respect to the fine aggregate, NextEra deliberatively used the fine aggregate from Texas because of its very high reactivity.[254] NextEra's expert witnesses stated that in testing various concrete mixture designs when planning the LSTP, NextEra determined that the "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 for the LSTP."[255]

2.79 Similarly, the Staff determined that the concrete used in the LSTP test specimens had specifications consistent with the specifications of the Seabrook concrete and used materials as similar to the original materials as reasonably possible.[256] Thus, the LSTP concrete was not "drastically different" from the Seabrook concrete as asserted by Dr. Saouma.[257] Moreover, the LSTP used concrete with ASR expansion greater than that currently present at Seabrook and, therefore, the limits derived from the LSTP are conservative.[258]

2.80 Further, to the extent that there are any substantive differences between the LSTP concrete and the Seabrook concrete, the Staff found that with the license condition, there is additional assurance that these differences will not affect the public health and safety.[259] If any limits in the ASR expansion monitoring program are approached, then NextEra will perform

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[253] *See* Exhibit NER001-00-BD01, MPR Testimony at 80; Exhibit NER026-00-BD01 at 3-9 (Non-publicly available).

[254] Exhibit NER001-00-BD01, MPR Testimony at 84.

[255] Exhibit NER001-00-BD01, MPR Testimony at 136.

[256] Exhibit NRC001-R-00-BD01, Staff Testimony at 50–51.

[257] *Id*; s*ee* Exhibit INT001-R-00-BD01 at 10.

[258] Exhibit NRC001-R-00-BD01, Staff Testimony at 50–51.

[259] *Id*.

reanalysis or remediation, as necessary.[260] NextEra also has a continuing obligation to demonstrate that its structures can perform their safety functions so that, if the Staff was ever to have reason to believe that the design basis codes, as modified and supplemented, were no longer valid, NextEra would be required to demonstrate operability or update the Seabrook licensing basis.[261] Similarly, NextEra is obligated, through its operating experience and corrective actions programs, to evaluate relevant operating experience and evaluate whether a change to its programs is needed.[262]

2.81 We find that NextEra has demonstrated by a preponderance of the evidence that while the aggregates used in the concrete of the LSTP test specimens were not identical to the aggregates used in the concrete at Seabrook, they are similar enough that the concrete can be treated as the same for design purposes.[263] Importantly, the characteristics of the aggregates that had structural implications for the specimens matched the concrete at Seabrook as closely as reasonably achievable.[264] Therefore, these differences did not affect the representativeness of the LSTP data.

d. Board Findings on the LSTP's Representativeness of the ASR Gel at Seabrook

2.82 C-10 expert witness Dr. Saouma testified that different minerology in concrete can create different types of ASR "gels," which, in turn, can "affect the type of cracks that one has."[265] Dr. Saouma explained that the chemical composition of the ASR gel may "have an

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[260] Tr. at 392.

[261] *Id.* at 575.

[262] *Id.* at 1136–37.

[263] *See* Exhibit NRC001-R-00-BD01, Staff Testimony at 51.

[264] *See* Exhibit NER001-00-BD01, MPR Testimony at 80–85; Tr. at 288, 634–35, 637.

[265] Tr. at 984 ("[T]he gel is reflective of the type of mineralogy that we have.") (Dr. Saouma).

impact on the rate at which the elastic properties and tensile strengths are affected."[266] Based on this, he concluded that the LSTP was not sufficiently representative of the concrete at Seabrook because NextEra did not consider the ASR gel type produced in the test specimens.[267]

2.83 NextEra stated that the variation in ASR gel type has no bearing on the representativeness of the LSTP. As NextEra explained, when evaluating the structural performance of concrete, the important consideration is the level of expansion of the cracking as opposed to the chemical composition of the ASR gel.[268] NextEra's expert witnesses testified that while "different types of ASR may cause different levels of expansion," "for a given level of ASR-induced expansion, similar levels of structural impacts are to be expected, regardless of the chemical composition of the ASR gel causing the expansion."[269] At the evidentiary hearing, NextEra expert witness Mr. Bagley further explained that "some variation in the chemical structure of the ASR gel doesn't have an impact on the representativeness of the test program because really what we are talking about is expansion and the amount of strain that has occurred in the concrete."[270]

2.84 NextEra's expert witnesses also testified that industry guidelines and published research on the structural impacts of ASR "do not point to differentiation based on differences in the chemical composition of ASR gel."[271] More specifically, at the evidentiary hearing, NextEra expert witness Mr. Sherman testified that the FHWA Report "mentions gel 109 times and never

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[266] *Id.* at 984; *see also id.* at 985–86, 988.

[267] Exhibit INT001-R-00-BD01 at 10–11; Tr. 981–982, 984–85.

[268] Exhibit NER001-00-BD01, MPR Testimony at 82–83; Tr. at 982–986, 990–96.

[269] Exhibit NER001-00-BD01, MPR Testimony at 82–83.

[270] Tr. at 982–83.

[271] Exhibit NER001-00-BD01, MPR Testimony at 83; *see* Tr. at 994–95.

differentiates between type of gel[,] [t]he U.K. Institute of Structure Engineers document never mentions the type of gel[,] [a]nd the Canadian standard document mentions gel 19 times and never differentiates between type."[272] In fact, NextEra expert witness Dr. Bayrak testified that "[t]o our knowledge, there is no data reported in the literature that would support" the argument that two different types of ASR gels that have the same level of expansion would result in different structural characteristics in the concrete.[273]

2.85 The Staff expert witnesses agreed with NextEra that the chemical composition of the ASR gel is not a factor important to representativeness because "[t]he key is the expansion caused by the [ASR] gel" as opposed to the chemical composition of the ASR gel.[274] Staff expert witness Mr. Lehman also testified that the Staff agreed with NextEra that the published research on structural impacts of ASR does not differentiate between different types of ASR gels.[275] Staff expert witness Ms. Buford also explained that ASR research from Oak Ridge National Laboratory and NIST "does not differentiate between type of [ASR] gel in terms of the structural context."[276]

2.86 At the evidentiary hearing, Dr. Souma admitted that the industry guidance documents discussed by all parties (e.g., the FHWA Report[277] and the Institution of Structural

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[272] Tr. at 994–995; *see generally* Exhibit NER013-00-BD01, FHWA Report; Exhibit NER012-00-BD01, The Institution of Structural Engineers, "Structural Effects of Alkali-Silica Reaction" (July 1992) (ML19205A524) (Non-publicly available); Exhibit NRC076-00-BD01, Canadian Standards Association (CSA) A864-00, "Guide to the Evaluation and Management of Concrete Structures Affected by Alkali-Aggregate Reaction" (Feb. 2000) (Reaffirmed 2005) (ML19205A476) (Non-publicly available).

[273] Tr. at 985.

[274] *Id.* at 986.

[275] *Id.* at 994.

[276] *Id.* at 996.

[277] Exhibit NER013-00-BD01, FHWA Report.

Engineers report, “Structural effects of [ASR]” (ISE Report)[278]) do not differentiate based on differences in the chemical composition of the ASR gel.[279] Instead, Dr. Saouma postulated that “[w]e need to open our minds” and “look through a variety of documents, and then make an assessment as whether or not the gel has a role or not.”[280]

2.87 We find that NextEra has demonstrated by a preponderance of the evidence that that the type of ASR gel is not relevant to the issue of the representativeness of the LSTP specimens because the cracking caused by the gel, as opposed to the chemical composition of the gel itself, is what drives ASR’s impact on the structural performance of a concrete structure. On this point, we note that Dr. Saouma provided no support for his assertion that NextEra must account for possible differences in chemical composition of the ASR-gel beyond his bare assertion that the parties “need to open our minds” to “make an assessment as whether or not the gel has a role or not.”[281]

E. The Representativeness of the LSTP’s Program Elements

2.88 The LSTP consisted of three key test program elements to evaluate the impact of ASR on (1) the shear capacity of reinforced concrete (the Shear Test Program), (2) the performance of expansion and undercut anchors installed in concrete (the Anchor Test Program), and (3) the reinforcement anchorage of rebar lap splices and flexural strength and stiffness (the Reinforcement Anchorage Test Program).[282] NextEra selected these three elements based on the 2012 interim structural assessment for Seabrook structures. The interim

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[278] Exhibit NER012-00-BD01.

[279] Tr. at 988.

[280] *Id*.

[281] *Id*.

[282] Exhibit NRC001-R-00-BD01, Staff Testimony at 23–24; Exhibit INT024-00-BD01, SE, encl. 2 at 7; Exhibit INT010-00-BD01, Original LAR at 16 of 74 (unnumbered); Exhibit INT019-R at 1-2–1-3 (PDF pp. 111–112).

assessment identified these limit states as areas where gaps existed in available literature or where available margins in Seabrook structures were low.[283] A fourth test program (the Instrumentation Test Program) evaluated instruments for monitoring through-thickness expansion in Seabrook reinforced concrete structures.[284] By his own admission, C-10 expert witness Dr. Saouma focused only on the Shear Test Program.[285]

a. Board Findings on the Representativeness of the Shear Test Program

2.89 We find that NextEra has demonstrated by a preponderance of the evidence that the Shear Test Program was representative of ASR-affected reinforced concrete structures at Seabrook for four reasons. First, the program used representative control and test specimens for differing levels of ASR.[286] Second, it used a large number of load tests to failure that were consistent with the applicable Seabrook design basis code.[287] Third, it had test results that were all bounded by the strength calculated based on the ACI code provisions.[288] Fourth, the test results were consistent and repeatable.[289] Additionally, the Shear Test Program's results were similar to those reported in a recently published journal article.[290] Finally, the quantity of

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[283] Exhibit NRC001-R-00-BD01, Staff Testimony at 23–24; Exhibit INT024-00-BD01, SE, encl. 2 at 7; Exhibit INT019-R-00-BD01, LSTP Report at 1-2–1-3 (PDF pp. 111–112).

[284] Exhibit NRC001-R-00-BD01, Staff Testimony at 23–24; Exhibit INT024-00-BD01, SE, encl. 2 at 7; Exhibit INT019-R-00-BD01, LSTP Report at 1-2–1-3 (PDF pp.111–112).

[285] Tr. at 264–65 (In response to Judge Mtingwa's question that "[y]ou seem to concentrate strictly on the shear," Dr. Saouma responded "[c]orrect.").

[286] *See* Exhibit NRC001-R-00-BD01, Staff Testimony at 31–32.

[287] *See id.*

[288] *See id.*

[289] *See id.*

[290] *See id.*; *see also* Exhibit NRC056-00-BD01, Madhu M. Karthik, et. al., "Experimental Behavior of Large Reinforced Concrete Specimen with Heavy ASR and DEF [delayed ettringite formation] Deterioration," J. Struct. Eng. (2018) (published online May 31, 2018) (ML19205A484) (Non-publicly available).

the reinforcement was adjusted to preclude flexural failure, which allowed for observation of the concrete contribution to shear strength.[291]

2.90 C-10 argued that, with respect to the Shear Test Program, if the program had been properly performed, cracking would have occurred in a zone without reinforcement.[292] According to Dr. Saouma, however, the load-displacement curve in MPR-4273, Rev. 1, Figure 5-5[293] is not indicative of a shear failure with minimum or no reinforcement and, therefore, some shear reinforcement must have been present.[294] Specifically, pointing to Figure 5 in his initial pre-filed written testimony, Dr. Saouma argued that what likely happened was a crack in a zone of the beam with shear reinforcement.[295]

2.91 Dr. Saouma's Figure 5, however, is an inaccurate depiction of the Shear Test Program because in the program, unlike in the figure, the left support of the beam was located to the right of the end area with stirrups and, therefore, contrary to Dr. Saouma's assertion, the program's test span did not include any shear stirrups.[296] ACI 318-71 determines shear capacity (strength) based on the onset of diagonal (tension) or inclined cracking,[297] which occurred in the Shear Test Program's specimens at the "blip[s]," as Dr. Saouma called them,[298]

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[291] Tr. at 278–79.

[292] Exhibit INT001-R-00-BD01 at 13.

[293] Exhibit INT021-00-BD01, MPR-4273, LSTP Report (Rev. 1), fig. 5-5 at 5-7 (Non-publicly available).

[294] Exhibit INT001-R-00-BD01 at 13–14.

[295] *Id*. at 14.

[296] Exhibit NRC001-R-00-BD01, Staff Testimony at 55–56.

[297] Exhibit NRC049-00-BD01, American Concrete Institute (ACI) Standard 318-71, Building Code Requirements for Reinforced Concrete §§ 11.4.1, 11.4.2, 11.2.3, 11.2.4 (1971) (ML19205A479) (Non-publicly available) (ACI 318-71).

[298] Exhibit INT-001-R-00-BD01 at 14.

in Figure 5-5 of MPR-4273.[299] Accordingly, these points were determined to be the shear capacity. The fact that "the curve proceeds," as Dr. Saouma stated,[300] is not unexpected. On the contrary, the fact that a new shear carrying mechanism, which is capable of sustaining further load, can develop in a reinforced concrete beam without shear reinforcement after the formation of diagonal cracks is well known in the literature.[301]

2.92 C-10 also argued that the unanticipated crack shown in MPR-4273, Rev. 1, Figure 4-2[302] should be of the utmost concern as it jeopardizes the representativeness of the ensuing test and would cause the results to be unreliable.[303] As discussed below, NextEra confirmed that this crack was an "edge effect" crack that penetrated only a few inches into the specimen.[304] This crack did not compromise the representativeness of the test region because away from the edges, expansion was of about the same magnitude as the edge effect crack but distributed into finer cracks across the specimen cross sections.[305]

b. Board Findings on the Representativeness of the Anchor Test Program

2.93 We find that NextEra has demonstrated by a preponderance of the evidence that the Anchor Test Program was representative of ASR-affected reinforced concrete structures at Seabrook for three reasons. First, the program was performed consistent with the Seabrook

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[299] Exhibit INT021-00-BD-01, MPR-4273, LSTP Report (Rev. 1), fig. 5-5 at 5-7 (Non-publicly available).

[300] Exhibit INT-001-R-00-BD01 at 14.

[301] Exhibit NRC001-R-00-BD01, Staff Testimony at 55–56; *see* Exhibit NRC072-R-00-BD01, R. Park and T. Paulay, "Reinforced Concrete Structures," at 276 (John Wiley & Sons, Inc. 1975) (ML19261B304) (Non-publicly available); Exhibit NRC073-00-BD01, David Darwin, Charles W. Dolan, and Arthur H. Nilson, "Design of Concrete Structures" at 138–141 (McGraw Hill, Inc., 15th Ed. 2016) (ML19205A474) (Non-publicly available).

[302] Exhibit INT021-00-BD01, MPR-4273, LSTP Report (Rev. 1), fig. 4-2 at 4-4 (Non-publicly available).

[303] Exhibit INT001-R-00-BD01 at 15–16.

[304] Exhibit INT021-00-BD01, MPR-4273, LSTP Report (Rev. 1) at 4-4–4-5 (Non-publicly available); Exhibit NRC001-R-00-BD01, Staff Testimony at 57.

[305] Exhibit NRC001-R-00-BD01, Staff Testimony at 57.

design basis for anchor bolts.[306] Second, consistent with industry standards and accepted practices that the path through which load is transferred from an anchor to concrete is the primary consideration for the selection of representative anchors, the program used Hilti Kwik Bolt 3 expansion anchors and Drillco Maxi-Bolt undercut anchors.[307] Hilti Kwik Bolt 3 expansion anchors are the current standard at Seabrook and are similar to the Hilti Kwik Bolt 1 and 2 anchors that have been previously installed at Seabrook.[308] Drillco Maxi-Bolt is the only undercut anchor used at Seabrook.[309] Third, the program was performed at various levels of ASR expansion, on anchors installed before and after ASR development, and using a range of anchor sizes and embedment depths consistent with the anchor population at Seabrook.[310] C-10 did not provide any support to challenge the Anchor Test Program; as stated by Dr. Saouma, "I have not reviewed any aspect of the anchors"[311] and "I confess full ignorance about anchors."[312]

c. Board Findings on the Representativeness of the Reinforcement Anchorage Test Program

2.94 We find that NextEra has demonstrated by a preponderance of the evidence that the Reinforcement Anchorage Test Program was representative of ASR-affected reinforced concrete structures at Seabrook for four reasons. First, the program used representative control

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[306] *See* Exhibit NRC001-R-00-BD01, Staff Testimony at 30–31.

[307] *See id*. Hilti Kwik Bolt 3 expansion anchors were used for the transfer of load from the bolt to the concrete using the frictional resistance of the expansion wedge on the concrete and Drillco Maxi-Bolt undercut anchors were used for the transfer of load to concrete using a positive bearing surface. *Id*.

[308] *See id*.; Tr. at 673. Hilti Kwik Bolt 1 and 2 anchors are no longer readily commercially available. Tr. at 672.

[309] *See* Exhibit NRC001-R-00-BD01, Staff Testimony at 30–31; Tr. at 671–74.

[310] Exhibit NRC001-R-00-BD01, Staff Testimony at 30–31.

[311] Tr. at 265.

[312] *Id.* at 674.

and test specimens of differing levels of ASR that each contained reinforcement lap splices at the center constant moment region.[313] Second, the program used a large number of load tests to failure.[314] Third, its results were consistent and repeatable.[315] Fourth, the flexure strength of the test specimens exceeded that of the control and the nominal flexural capacity calculated based on the ACI code provisions.[316] Additionally, the Reinforcement Anchorage Test Program's results were similar to those reported in a recently published journal article.[317]

2.95 With respect to compression, existing literature provides that ASR expansion does not reduce the compression capacity of confined concrete in its structural context.[318] The results of the Reinforcement Anchorage Test Program were consistent with this existing literature; if compression capacity had been reduced, a compression zone failure would have occurred in the test specimens before the full flexural capacity was realized, which was not observed here.[319] Therefore, for the same reasons that the Reinforcement Anchorage Test Program was representative, we find that NextEra's conclusion regarding compression was also representative of ASR-affected reinforced concrete structures at Seabrook within the expansion limits achieved during the testing.[320]

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[313] *See* Exhibit NRC001-R-00-BD01, Staff Testimony at 32–33.

[314] *See id.*

[315] *See id.*

[316] *See id.*

[317] *See id.*; *see also* Exhibit NRC057-00-BD01, M. Kathleen Eck Olave, et. al., "Performance of RC Columns Affected by ASR. II: Experiments and Assessment," Vol. 20. ASCE J. of Bridge Eng'g (March 2015) (published online June 12, 2014) (ML19205A485) (Non-publicly available).

[318] *See* Exhibit NRC001-R-00-BD01, Staff Testimony at 34.

[319] *See id.*

[320] *See id.*

2.96 With respect to reinforcement fracture, the existing literature identifies examples of reinforcement fracture in ASR-affected reinforced concrete structures, but only in bend diameters smaller than those permitted by U.S. design codes.[321] FSEL performed bend tests of rebars bent to the allowable limits of Seabrook design codes and did not see evidence of compression crack formation.[322] Based on the combination of the existing literature and the results of the bend tests, NextEra concluded that the reinforcing bars in the ASR-affected reinforced concrete structures at Seabrook are not susceptible to brittle fracture.[323] We agree with the Staff's conclusion that this determination was bounding for Seabrook.[324] Dr. Saouma also agreed that the reinforcing bars in the ASR-affected reinforced concrete structures at Seabrook are not susceptible to brittle fracture.[325]

2.97 The LSTP also assessed the issue of seismic response.[326] The LSTP showed that, for heavily loaded members (i.e., members with flexural cracking), the flexural stiffness increased as ASR expansion increased within the expansion levels tested.[327] The Seabrook design-basis seismic-ground-response spectrum shows that seismic demands decrease for frequencies larger than approximately 3 Hz.[328] Since all the structures at Seabrook have a natural frequency of at least 4 Hz and since an increase in stiffness will increase a structure's

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[321] *See id.* at 35.

[322] *See id.*

[323] *See id.*

[324] *See id.*

[325] Tr. at 743–45 ("[Brittle fracture] does not concern me. That is unlikely to happen at Seabrook."); *id.* at 1137 ("I believe I have mentioned yesterday that I'm not consider [rebar rupture] as a factor for Seabrook.").

[326] *See* Exhibit NRC001-R-00-BD01, Staff Testimony at 35–39.

[327] *Id.* at 35–36; Exhibit NRC007-00-BD01, UFSAR § 3.7(B); Exhibit INT024-00-BD01, SE, encl. 2 at 20; *see* Exhibit INT012-00-BD01, MPR-4288 (Rev. 0), Structure Deformation Report, fig. 6-1 at 6-6.

[328] Exhibit NRC001-R-00-BD01, Staff Testimony at 36; Exhibit INT024-00-BD01, SE, encl. 2 at 20.

frequency, the Staff noted that, for heavily loaded members, ASR will not have an adverse impact on seismic response.[329] Conversely, the LSTP showed that, for lightly loaded members (i.e., members with no flexural cracking), the flexural stiffness decreased as ASR expansion increased within the expansion levels tested.[330] This is not a concern with respect to the Seabrook design-basis seismic-ground-response spectrum because (1) all the structures at Seabrook have a natural frequency of at least 4 Hz, (2) the Seabrook seismic design uses a +/- 10% peak broadening in the response spectra, and (3) there is a square root relationship between stiffness and natural frequency. Therefore, the Staff noted that, for lightly loaded members, this reduction in flexural stiffness will not have a significant impact on the seismic response of the structure for the amount of ASR observed at Seabrook.[331] Based on its review, the Staff concluded that the LSTP was bounding for Seabrook with respect to seismic response.[332] Nothing in the record leads this Board to a conclusion different than the Staff on the issue of seismic response.

d. Board Findings on the Representativeness of the Instrumentation Test Program

2.98 The Instrumentation Test Program evaluated, over a one-year period, three candidate instruments for measuring through-thickness expansion: a vibrating wire deformation meter (VWDM), a snap-ring borehole extensometer (SRBE), and a hydraulic borehole extensometer.[333] The program evaluated these instruments on a representative large-scale

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[329] Exhibit NRC001-R-00-BD01, Staff Testimony at 36; Exhibit INT024-00-BD01, SE, encl. 2 at 20.

[330] Exhibit NRC001-R-00-BD01, Staff Testimony at 36; Exhibit INT024-00-BD01, SE, encl. 2 at 20.

[331] Exhibit NRC001-R-00-BD01, Staff Testimony at 35–77; Exhibit INT024-00-BD01, SE, encl. 2 at 20.

[332] Exhibit NRC001-R-00-BD01, Staff Testimony at 35–39; Exhibit INT024-00-BD01, SE, encl. 2 at 20.

[333] Exhibit NRC001-R-00-BD01, Staff Testimony at 39–40; Exhibit INT024-00-BD01, SE, encl. 2 at 20–21; NRC008-00-BD01, MPR-4273 (Rev. 0) § 5.4.1 at 5-16; Exhibit INT019-R-00-BD01, MPR-4273 (Rev. 1) § 5.4.1 at 5-16.

beam test specimen with regard to quality of data, ease of installation, and reliability.[334] In particular, the program involved installing the extensometers at different points in time to capture different levels of ASR expansion. The program then tracked how the extensometers performed over time by comparing the measurements from the extensometers against mechanical measurements of the thickness of the beam, which was accomplished with boreholes on either side of each extensometer and a depth micrometer.[335]

2.99 We find that NextEra has demonstrated by a preponderance of the evidence that the Instrumentation Test Program properly determined that the SRBE was the best instrument for measuring through-thickness expansion for six reasons. First, its data agreed closely with the reference data.[336] Second, it directly measures physical expansion.[337] Third, it does not rely on additional equipment.[338] Fourth, it contains no electronics and does not require field calibration.[339] Fifth, it did not exhibit reliability problems.[340] Sixth, it was easier to install than

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[334] Exhibit NRC001-R-00-BD01, Staff Testimony at 39–40; Exhibit INT024-00-BD01, SE, encl. 2 at 21; NRC008-00-BD01, MPR-4273 (Rev. 0) § 5.4.2 at 5-17–5-18; Exhibit INT019-R-00-BD01, MPR-4273 (Rev. 1) § 5.4.2 at 5-17–5-18.

[335] Tr. at 1043.

[336] Exhibit NRC001-R-00-BD01, Staff Testimony at 39–40; Exhibit INT024-00-BD01, SE, encl. 2 at 21; NRC008-00-BD01, MPR-4273 (Rev. 0) § 5.4.2 at 5-17–5-18; Exhibit INT019-R-00-BD01, MPR-4273 (Rev. 1) § 5.4.2 at 5-17–5-18; Tr. at 1044.

[337] Exhibit NRC001-R-00-BD01, Staff Testimony at 39–40; Exhibit INT024-00-BD01, SE, encl. 2 at 21; NRC008-00-BD01, MPR-4273 (Rev. 0) § 5.4.2 at 5-17–5-18; Exhibit INT019-R-00-BD01, MPR-4273 (Rev. 1) § 5.4.2 at 5-17–5-18.

[338] Exhibit NRC001-R-00-BD01, Staff Testimony at 39–40; Exhibit INT024-00-BD01, SE, encl. 2 at 21; NRC008-00-BD01, MPR-4273 (Rev. 0) § 5.4.2 at 5-17–5-18; Exhibit INT019-R-00-BD01, MPR-4273 (Rev. 1) § 5.4.2 at 5-17–5-18.

[339] Exhibit NRC001-R-00-BD01, Staff Testimony at 39–40; Exhibit INT024-00-BD01, SE, encl. 2 at 21; NRC008-00-BD01, MPR-4273 (Rev. 0) § 5.4.2 at 5-17–5-18; Exhibit INT019-R-00-BD01, MPR-4273 (Rev. 1) § 5.4.2 at 5-17–5-18.

[340] Exhibit INT024-00-BD01, SE, encl. 2 at 21; NRC008-00-BD01, MPR-4273 (Rev. 0) § 5.4.2 at 5-17–5-18; Exhibit INT019-R-00-BD01, MPR-4273 (Rev. 1) § 5.4.2 at 5-17–5-18.

the VWDMs.[341] NRC inspectors who were on site at the LSTP performed an independent review of the Instrumentation Test Program, which assessed the efficacy of strain gauges against pin-to-pin strain measurements and verified that the program was valid.[342] Therefore, the Staff determined that there was reasonable assurance that the use of SRBEs to measure future through-thickness expansion of Seabrook structures would be effective.[343]

2.100 C-10 argued that instead of SRBEs, the Damage Rating Index (DRI) method should be used to characterize through-thickness expansion.[344] As noted in the FHWA Report, while the DRI method may be useful for quantitative assessment of internal damage in concrete, there is no standard procedure for its use.[345] The method is fairly subjective and the results can be quite variable from one petrographer to another.[346] Even Dr. Saouma cautioned that "[DRI] is a delicate test that should only be performed by a very qualified petrographer, and should be performed repeatedly by the same one."[347] Instead of relying on a delicate test and only one dedicated petrographer, NextEra chose to use an SRBE installed to a depth almost through the entire thickness of the concrete member (i.e., within a few inches of the far surface) to monitor

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[341] Exhibit NRC001-R-00-BD01, Staff Testimony at 39–40; Exhibit INT024-00-BD01, SE, encl. 2 at 21; NRC008-00-BD01, MPR-4273 (Rev. 0) § 5.4.2 at 5-17–5-18; Exhibit INT019-R-00-BD01, MPR-4273 (Rev. 1) § 5.4.2 at 5-17–5-18.

[342] Tr. at 1041–43 ("[D]uring their seven visits to [FSEL, the Staff] witnessed all test activities including the extensometers. They saw them in use. And they saw the different varieties of instruments that [were] tested.") (Mr. Simons).

[343] Exhibit NRC001-R-00-BD01, Staff Testimony at 39–40; Exhibit INT024-00-BD01, SE, encl. 2 at 21.

[344] Exhibit INT001-R-00-BD01 at 20, 31–32. DRI "evaluates the condition of concrete by counting the number of typical petrographic features of ASR on polished concrete sections…." Exhibit NER013-00-BD01, FHWA Report at 25.

[345] Exhibit NER013-00-BD01, FHWA Report at 96.

[346] *Id*.

[347] Exhibit INT001-R-00-BD01 at 31.

through-thickness expansion progression.[348] The Staff's review of the SRBE method of measuring through-thickness expansion found this approach effective.[349] The Staff also determined that the SRBE method provides a more accurate and meaningful measure of through-thickness expansion than the DRI method.[350] Nothing in the record leads this Board to a conclusion different than the Staff on the issue of the Instrumentation Test Program.

F. The Adequacy of the Seabrook ASR Expansion Monitoring Program's Monitoring, Acceptance Criteria, and Inspection Intervals Derived from the LSTP

2.101 The Seabrook ASR expansion monitoring program measures cracks in ASR-affected concrete, first in the in-plane direction using CI/CCI and then, when in-plane expansion reaches a specified threshold, in the through-thickness direction using (1) a calculation to determine to-date expansion and (2) an SRBE to measure expansion thereafter.[351] The purpose of this monitoring program is to ensure that the in-plane, through-thickness, and volumetric expansions remain below the expansion limits, which ensures that the structural performance of the Seabrook reinforced concrete structures can still be conservatively estimated by the design basis codes.[352]

2.102 NextEra used the data from the LSTP to develop various aspects of the ASR expansion monitoring program. First, the program's ASR expansion limits are from the LSTP.[353] For the Shear and Reinforcement Anchorage Test Programs, the LSTP determined that there

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[348] Exhibit NRC001-R-00-BD01, Staff Testimony at 65.

[349] *Id*.

[350] *Id*. at 39–40.

[351] *Id*. at 18–19; Exhibit INT024-00-BD01, SE, encl. 2 at 21–22, 53–55.

[352] Exhibit NRC001-R-00-BD01, Staff Testimony at 19; Exhibit INT024-00-BD01, SE, encl. 2 at 21–22, 25, 53–55. *See also* Tr. at 331 ("[T]he whole point … of this entire project, is to know where we are, and stay inside that box that's defined by the testing program that shows that we're still inside that design basis.").

[353] Exhibit NRC001-R-00-BD01, Staff Testimony at 41–42, 45.

was no adverse effect on structural limit states at the expansion levels tested.[354] Therefore, NextEra used the lower of the highest through-thickness expansion levels tested in the Shear and Reinforcement Anchorage Test Programs, which was for shear, as the ASR expansion limit for the shear, flexure, and reinforcement anchorage structural limit states.[355] For the Anchor Test Program, the LSTP found that anchor capacity is insensitive to through-thickness expansion and time of installation relative to ASR expansion.[356] Therefore, NextEra set the ASR expansion limit for the anchors structural limit state to the greatest percentage of in-plane expansion that was tested without showing a reduction in anchor capacity.[357]

2.103 Second, NextEra set the point at which to transition from measuring in-plane expansion to measuring through-thickness expansion at 0.1% in-plane expansion.[358] The Staff determined that this approach was appropriate because it was consistent with the data obtained from the LSTP and also corresponds to a very low level of ASR degradation.[359] As discussed below, when making this transition, the through-thickness expansion to date is calculated. In all instances, the calculated through-thickness expansion to date at 0.1% in-plane expansion at Seabrook has been "much, much less than" the through-thickness limit and even the highest expansion calculated was significantly less than the limit.[360] Therefore, according to NextEra expert witness Mr. Simons, "So that tells you that the criterion of installing extensometers around [0.1%] is appropriate. It says it's not gotten far away from us. It hasn't gotten so close to

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[354] *Id.* at 26–27.

[355] *Id*.

[356] *Id*.

[357] *Id*.

[358] *Id*.

[359] *Id*.; Tr. at 518 ("[NextEra] is only using CCI up to a very small expansion which then they switch to the volumetric measurement and also through wall thickness.").

[360] Tr. at 510.

our limit that we need to be concerned about it."[361] Similarly, NextEra expert witness Mr. Bagley stated that, even if, as postulated by C-10 expert witness Dr. Saouma, there was some delay in surface crack manifestation as compared to interior cracking, the ASR expansion monitoring program would require the measurement of through-thickness expansion "well before" the limits are reached.[362] This aspect of the ASR expansion monitoring program is also consistent with the FHWA Report guidance of using CI/CCI as an initial monitoring tool.[363] Dr. Saouma agrees that "everybody recommends initiating the crack index as the starting point."[364]

2.104 Third, NextEra developed an equation to calculate through-thickness expansion to date in Seabrook concrete.[365] The Staff determined that this calculation was appropriate because it was consistent with the LSTP data and the existing literature data and incorporated conservativisms.[366] Specifically, to develop the equation, NextEra reviewed data from the LSTP and from the existing literature and determined that the reduction in concrete elastic modulus is more sensitive to ASR development than other properties that have been studied.[367] Therefore, using the LSTP data, NextEra developed an equation to correlate normalized elastic modulus and through-thickness expansion (correlation equation).[368] NextEra compared literature data to this equation and noted that the trend from the literature data compared favorably with the

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[361] *Id*.

[362] *Id.* at 548.

[363] *See id.* at 510–11, 1132.

[364] *Id.* at 328–29; *see also id.* at 494 ("I am not disputing that [CI/CCI] is the very first line of defense.").

[365] Exhibit NRC001-R-00-BD01, Staff Testimony at 42.

[366] *Id*.

[367] *Id*.

[368] *Id*.

equation.[369] The Staff independently determined that the equation was "really close" to the best available data that it could find in the literature.[370] Additionally, since the calculation of the normalized elastic modulus requires the calculation of the original (28-day) modulus of the affected Seabrook concrete—either through estimation or the use of Seabrook concrete not impacted by ASR—NextEra applied a reduction factor to the correlation equation, which conservatively overestimated the expansion.[371] Specifically, the reduction factor attempts to bound the data from the LSTP.[372] Conservatism is also introduced by the fact that NextEra is measuring the worst portion of a particular wall at Seabrook (i.e., the portion with the most significant surface cracking) and assuming that the entire wall is in that condition.[373]

2.105 Fourth, the monitoring intervals are derived from the LSTP and the Staff independently determined that they are conservative.[374] Once SRBEs are installed at 0.1% in-plane expansion, which, as discussed above, is already conservative, the monitoring interval is similarly conservatively reduced to once every six months.[375] Staff expert witness Ms. Buford stated that the Staff did not have any concern that "the structural integrity could be challenged within the [six months'] time before the next inspection" based on the literature and the data obtained at Seabrook to date.[376] Staff expert witness Mr. Lehman similarly stated that the Staff hasn't seen any evidence at Seabrook or in the literature of ASR occurring more quickly than a

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[369] *Id*.

[370] Tr. at 1117–21.

[371] *Id*.; Exhibit INT024-00-BD01, SE, encl. 2 at 22–23; Exhibit NRC011-00-BD01, MPR-4153 ASR Monitoring Report (Rev. 2) § 3.3.

[372] Tr. at 544–46.

[373] *Id.* at 480, 543–48, 1147.

[374] *Id.* at 420–21, 1121–24.

[375] *Id.* at 1124.

[376] *Id.* at 692–95.

time period on the order of years except in experiments where ASR is purposefully being accelerated.[377] Therefore, even if Seabrook was experiencing the most rapid rate of ASR expansion, the six-month monitoring frequency would not be challenged.[378] In fact, to date, NextEra has measured a 0.02 percent per year through-thickness expansion meaning that, even at the location with the highest through-thickness expansion, this rate could increase 1,000 percent in six months and the location would still be "well below the limit."[379]

2.106 Based, in part, on its determination that NextEra appropriately used the LSTP data to develop the ASR expansion monitoring program, the Staff concluded that NextEra has provided reasonable assurance that Seabrook will continue to meet the applicable NRC requirements and will not endanger the health and safety of the public.[380]

2.107 As explained in detail as follows, we find that NextEra has demonstrated by a preponderance of the evidence that the aspects of the Seabrook ASR expansion monitoring program derived from the LSTP are adequate.

a. Board Findings on the Use of the CI/CCI Method

2.108 CI/CCI is a commonly used conservative method for monitoring crack progression or in-plane expansion due to ASR, as discussed in ASR-monitoring specific guidance documents.[381] For example, the FHWA Report recognizes CI/CCI as an in-situ

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[377] *Id.* at 1126–27.

[378] *Id*. at 1121–24.

[379] *Id.* at 685–86, 695–96, 1135–36, 1194, 1202.

[380] Exhibit INT024-00-BD01, SE, encl. 2 at 31–32.

[381] Exhibit NRC001-R-00-BD01, Staff Testimony at 62; Exhibit NER013-00-BD01, FHWA Report; *see also* Tr. at 482–83 ("The use of cracking index at Seabrook and at all other structures in the United States and around the world is not done on the basis of [the LSTP]. It's done on the basis of best practices recommendations pulled together by industry experts. Some of those experts have been named by Dr. Saouma in his testimony. They pulled together the [FHWA Report] that does make explicitly recommendation on crack indexing twice a year…. The second document is Institutional Structural Engineers from the United Kingdom. Last but not least …[t]he Swiss dam document that Dr. Saouma references, that [described] cracking index being the golden standard on this activity.").

method that gives a quantitative assessment of the extent of cracking in structural members, which is related to the overall amount of expansion reached in the affected concrete member.[382] The FHWA Report includes CI/CCI and monitoring of deformations/movements as recommended in-situ methods that can be used for estimating the expansion to date in ASR-affected concrete members.[383] This is exactly what was done by NextEra—at Seabrook, CI/CCI is used to estimate the expansion-to-date in the in-plane direction of ASR-affected structures.[384] Moreover, the use of CI/CCI is conservative because, although surface cracking can also be influenced by other mechanisms such as temperature variation, drying and wetting cycles, and shrinkage, all the cracking is attributed to ASR.[385] Therefore, the Staff determined that the use at Seabrook of CI/CCI to characterize and monitor the progression of in-plane ASR expansion is consistent with industry practice and acceptable.[386]

2.109 C-10 argued, however, that at Seabrook, CI/CCI must be ruled out completely as a monitoring measure.[387] C-10 expert witness Dr. Saouma theorized that because of gradients within the Seabrook walls that may exist with respect to humidity and temperature, coupled with the rebar being located close to the surface of the walls, cracking on the surface of the walls will not be representative of cracking in the interior.[388]

2.110 The Staff testified that Dr. Saouma's theory was not a concern because the LSTP was representative of the structures at Seabrook and interior cracking without surface

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[382] Exhibit NRC001-R-00-BD01, Staff Testimony at 62; Exhibit NER023-00-BD01, FHWA Report at 23.

[383] Exhibit NER023-00-BD01, FHWA Report at 23, 31.

[384] Exhibit NRC001-R-00-BD01, Staff Testimony at 62–63.

[385] *Id.*; Tr. at 453–54; *see* Tr. at 1156 (Dr. Saouma stating that "shrinkage did occur" at Seabrook).

[386] Exhibit NRC001-R-00-BD01, Staff Testimony at 62–63.

[387] Exhibit INT001-R-00-BD01 at 21.

[388] *See* Tr. at 1132.

cracking was not observed during the LSTP; instead, the LSTP demonstrated that interior and surface cracking advanced together until surface cracking plateaued.[389] At that point, which is a very low ASR severity, monitoring at Seabrook moves from CI/CCI to through-thickness.[390] The Staff testified that it hasn't seen, "in either the literature or the [LSTP], any evidence of there being no indications of ASR in the planar directions visible, and then significant ASR occurring through the thickness of the concrete."[391] Additionally, 200 cores have been taken at Seabrook and none of them showed internal cracking without surface cracking.[392] Therefore, the Staff concluded that it has "reasonable assurance that there is not extensive damage happening that is not visible – that wouldn't be visible by either in-plane cracking or some sort of deformation, which is being monitored and managed in a separate program."[393]

2.111 Dr. Saouma argues, by reference to Figure 1 in the FHWA Report,[394] that Section 2.2 of this report indicates that CI/CCI can only be used in conjunction with petrography.[395] Section 2.2 of the FHWA Report is entitled, "ASR Investigation Program Level 2: Preliminary Studies for the Diagnosis of ASR," and the portion of its Figure 1 to which Dr. Saouma refers is marked as "Level 2 Preliminary Investigation Program."[396] And further examination of the context of the FHWA Report's recommendation to use petrography in

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[389] Tr. at 1132–33.

[390] *Id*.

[391] *Id*.

[392] *Id*. at 1097–98.

[393] *Id.* at 1133–34. *See also id.* at 554 (NextEra expert witness Dr. Bayrak stating that "[t]here's always surface manifestation of what goes on inside in my experience").

[394] Although Dr. Saouma refers to this Figure as "Figure 12," the cited figure is Figure 1 in the FHWA Report. Exhibit NER023-00-BD01, FHWA Report at 5.

[395] Exhibit INT001-R-00-BD01 at 19–20.

[396] Exhibit NER023-00-BD01, FHWA Report at 3, 5.

addition to CI/CCI only shows that this recommendation relates to the early detection and diagnosis of ASR in concrete.[397] This guidance, therefore, is not relevant to Seabrook: ASR has already been diagnosed and confirmed at Seabrook based on the petrographic examination of cores. Further, NextEra has conservatively decided to attribute any future visual indications of concrete degradation to ASR, which means that the detection and diagnosis contemplated in the FHWA report is not necessary here.[398]

2.112 Based on the foregoing, we find that NextEra has demonstrated by a preponderance of the evidence that the use of the CI/CCI Method was appropriate.

b. Board Findings on the Possibility of Delamination Cracks Without Surface Indication in Seabrook Structures

2.113 C-10 expert witness Dr. Saouma argued that delamination cracks may form inside the walls of Seabrook and that these cracks will not be capable of detection by surface measurements of CI/CCI.[399] Dr. Saouma theorized that such "internal and hidden/sleeping crack[s]" may result from the "perfect storm" of (1) the expansion being out of plane because it is constrained in the other two directions, (2) the cracks propagating vertically because the wall is under compression, and (3) tensile stress in the orthogonal direction because of the axial longitudinal compression.[400] Dr. Saouma did not provide any support for this theory as part of his pre-filed written testimony except for two pictures, which he claimed to be "[e]xamples of ASR driven delamination in surface reinforced concrete retaining walls in Switzerland."[401] He

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[397] Exhibit NRC001-R-00-BD01, Staff Testimony 62.

[398] *Id*.

[399] Exhibit INT028-00-BD01 at 28–33; *see also* Tr. at 557 ("[T]here is a possibility – a very strong possibility of having an internal hidden crack, which does not manifest itself on the surface….").

[400] Exhibit INT028-00-BD01 at 30, 33.

[401] *Id.* at 32–33.

only attributed these pictures as "Courtesy Dr. Leemann, EMPA, Switzerland."[402] At the evidentiary hearing, Dr. Saouma testified that the source of these pictures was a Swiss document.[403] He stated that C-10 intended to submit this document into evidence.[404] Subsequently, C-10 stated that it would not try to introduce the source of the pictures into evidence;[405] therefore, the pictures are wholly unsupported. Instead of the pictures, C-10 stated that it would rely on Dr. Saouma's testimony regarding the ISE Report.[406] Specifically, Dr. Saouma testified that the ISE Report provides that "when there [are] two planes of reinforcement and no reinforcement in between. We start with microcracking, which eventually can coalesce into [macrocracks]."[407]

2.114 NextEra and the Staff demonstrated that nothing in the literature, nothing in the data from Seabrook, and nothing from the LSTP supports Dr. Saouma's theory that delamination cracks can occur at Seabrook without surface indications.

2.115 With respect to the literature, as recognized by NextEra expert witness Dr. Bayrak, there is no way of telling from the pictures provided by Dr. Saouma whether the retaining walls have anything in common with the structures at Seabrook.[408] Additionally, the pictures do not represent hidden cracks because the cracks are visible.[409] Finally, the tops of

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[402] *Id*.

[403] Tr. at 557.

[404] *Id*.

[405] *Id.* at 959.

[406] *Id*. ("[C-10] will not try to introduce [into evidence the Swiss article], and … will rely on [Dr. Saouma's] testimony about [Exhibit NER-012].").

[407] *Id.* at 890–91.

[408] *Id.* at 563 ("[W]e have no idea about the structural details of what we're looking at here" and "what condition led up to this cracking….").

[409] Tr. at 563, 572.

the walls in the pictures are exposed to the environment where the cracks are visible, whereas the tops of the walls at Seabrook are not.[410]

2.116 With respect to the data from Seabrook, as part of the Seabrook structures monitoring program, NextEra "document[s] essentially every crack that is located and evaluate[s] it…."[411] NextEra has taken over 200 cores and inspected them and not seen any evidence of delamination.[412] The Staff independently observed the removal of cores at Seabrook and similarly is "not aware of any instance where there was any sort of delamination identified."[413]

2.117 With respect to the LSTP, as ASR progressed in test specimens, a relatively large crack was observed near the center of the surfaces between the reinforcement mats, as depicted in Figure 4-2 of MPR-4273.[414] Dr. Saouma argued that this is an example of a delamination crack and that there is "a strong likelihood that a similar phenomenon would occur" at Seabrook.[415]

2.118 NextEra, however, confirmed that this crack was an "edge effect" that penetrated only a few inches into the specimen.[416] NextEra did this by taking cross sections of the affected section of the test specimen.[417] NextEra noted that the cracks were "essentially straight lines"

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[410] *Id*.

[411] *Id.* at 573.

[412] *Id.* at 572.

[413] *Id.* at 560.

[414] Exhibit NRC001-R-00-BD01, Staff Testimony at 57; Exhibit INT021-00-BD01, MPR-4273, LSTP Report (Rev. 1), fig. 4-2 at 4-4 (Non-publicly available).

[415] Tr. at 561–62.

[416] Exhibit INT021-00-BD01, MPR-4273, LSTP Report (Rev. 1) at 4-4–4-5 (Non-publicly available); Exhibit NRC001-R-00-BD01, Staff Testimony at 57; Tr. at 564–66.

[417] Tr. at 564–66; Exhibit NER022-R-00-BD01 at PDF page 880.

as opposed to the "curled up shape" that Dr. Saouma testified that a delamination crack would take.[418] NextEra also noted that the thickness of the specimens was measured and that there was no discernible curling, instead, the sides remained fairly flat.[419] Further, NextEra demonstrated that the summation of crack widths through the length of the specimen added up to the same level of expansion, in that there were fewer cracks at the surface, but they were wider; whereas there were more cracks at the center of the specimen, but they were narrower.[420] Therefore, NextEra explained that the cracks were a consequence of using beams that were essentially cut-outs from a structural wall.[421] Specifically, if, as in the actual walls at Seabrook, each of these beams were stacked on top of each other, there would be no edge regions exposed to the environment and, thus, no cracks on the edges.[422] Consequently, NextEra determined that these cracks were edge effect cracks and are not expected to occur in Seabrook structures due to the confinement effects provided by adjoining structural members.[423]

2.119 Because the LSTP did not identify delamination cracks, NextEra expert witness Dr. Bayrak concluded that, even if the ISE Report demonstrates that delamination cracking is possible, there is no indication that it will occur in Seabrook's walls.[424]

2.120 Finally, even if delamination cracking were to occur in Seabrook's walls, as with all other internal cracking, it would be accompanied by surface cracking. Because SRBEs are

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[418] Tr. at 565.

[419] *Id.* at 566–67 (discussing Exhibit NER022-R-00-BD01 at PDF page 57).

[420] *Id.* at 567–68 (discussing Exhibit NER022-R-00-BD01 at PDF page 111).

[421] *Id.* at 568–69.

[422] *Id*.

[423] *Id*.

[424] Tr. at 1002–03.

installed at surface cracking that meets the conservatively low level threshold of in-plane expansion of 0.1%, the corresponding delamination cracking would be actively monitored by an SRBE.[425] This addresses Dr. Saouma's concern that SRBEs may not be installed at the actual locations of "ASR hot-spots…."[426]

2.121 Based on the foregoing, we find that NextEra has demonstrated by a preponderance of the evidence that the monitoring method selected was appropriate.

c. Board Findings on Testing to Maximum ASR Expansion

2.122 C-10 argued that the lack of accelerated expansion testing precludes NextEra from reaching any conclusions about the maximum likely degree of expansion.[427]

2.123 C-10 is correct that NextEra did not run tests to estimate the remaining ASR expansion or to predict when ASR would stop occurring at Seabrook; however, C-10 did not explain why this is a safety concern.[428] NextEra has chosen a different engineering evaluation approach to ensure the safety of Seabrook structures that does not involve predictions of ASR kinetics and ultimate expansion.[429] The Staff determined that NextEra has identified reasonable and justifiable expansion limits, which account for potential future expansion, by setting the maximum level of expansion at which the code acceptance criteria are met.[430] Further, NextEra is actively monitoring structures to ensure that they remain within these limits.[431] The ultimate expansion of ASR at Seabrook is not relevant to the approach chosen by NextEra because

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[425] *Id.* at 1132–33.

[426] Exhibit INT028-00-BD01 at 31.

[427] Exhibit INT001-R-00-BD01 at 11, 26, 31.

[428] Exhibit NRC001-R-00-BD01, Staff Testimony at 71–72.

[429] *Id*.

[430] *Id*.

[431] *Id*.

under the approach approved in the LAR, NextEra will monitor the Seabrook structures to ensure that their expansion remains below the limits from the LSTP.[432]

2.124 At the hearing, C-10 expert witness Dr. Soauma conceded that testing to maximum expansion is not necessary.[433]

2.125 Based on the foregoing, we find that NextEra has demonstrated by a preponderance of the evidence that testing to maximum ASR expansion is not necessary.

d. Board Findings on Knowing the Rate of ASR Expansion at Seabrook

2.126 C-10 stated that a "[s]igmoid curve representative of [ASR] expansion … can be obtained from accelerated expansion tests."[434] The Staff agreed that a sigmoid curve can generically describe the general progression of ASR,[435] and that there is no such curve specific to the ASR at Seabrook.[436]

2.127 C-10 argued that NextEra's failure to account for the progression of ASR over a sigmoid curve at Seabrook undermined the reliability of NextEra's assessment of ASR at Seabrook.[437] Therefore, although conceding that testing to maximum expansion was not necessary, C-10 expert witness Dr. Saouma maintained that "[w]e need to know where we are on that curve"[438] because "it is important in the context of assessing when … the next

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[432] *Id*.

[433] Tr. at 386 ("We don't want to expand it all the way failure, that to ultimate expansion, that's fine."); Tr. at 401 ("No, we're not talking about the final point.").

[434] Exhibit INT001-R-00-BD01 at 32.

[435] Tr. at 401–02.

[436] *Id.* at 404.

[437] C-10 Research and Education Foundation, Inc. Rebuttal Statement of Position on C-10's Contentions Regarding NextEra's Program for Managing ASR at Seabrook Station Nuclear Power Plant, at 5–6 (Aug. 23, 2019) (ML19235A317); Exhibit INT028-00-BD01 at 12–13; Tr. at 386.

[438] Tr. at 386.

inspection" should be.[439] Further, he opined, without support, that "Seabrook is most likely in the very early slower phase, but the rate of expansion will accelerate at some point."[440]

2.128 NextEra expert witness Mr. Sherman described the generic sigmoid curve as consisting of "a dormant period, an active period, and … a period where [ASR is] petered out."[441] He stated that the modulus testing at Seabrook places Seabrook in the active period[442] or, as NextEra expert witness Mr. Simons called it, "the steep part of the curve" beyond the inflection point.[443] Mr. Simons concluded that even on the steep part of the curve, there is "decades of margin" before an expansion limit would be reached and, thus, "clearly a six-month interval is completely acceptable for monitoring…."[444]

2.129 The Staff testified that where Seabrook is on the sigmoid curve "had no bearing on [its] reasonable assurance determination."[445] This is because, given that through-thickness expansion is measured starting at the relatively small in-plane expansion level of 0.1%[446] and because it is measured every six months, even the fastest possible expansion could not result in the exceedance of the expansion limits before the end of the monitoring interval.[447] This is borne out by the data obtained at Seabrook to date and the data in the literature.[448] For

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[439] *Id.* at 413–15.

[440] Exhibit INT028-00-BD01 at 12–13.

[441] Tr. at 387.

[442] *Id.* at 389–90.

[443] *Id.* at 399–400; 415. The Staff also pointed out that, according to the ISE Report, once cracking is established, cracks grow at a broadly linear rate. *Id.* at 1124 – 25 (citing Exhibit NER012 at PDF page 4).

[444] *Id.* at 415–16.

[445] *Id.* at 1122–23.

[446] Tr. at 518.

[447] *Id.* at 1121–24.

[448] *Id.* at 692–95, 1126–27.

instance, the current rate of expansion at Seabrook could increase 1,000 percent in six months in the location with the highest through-thickness expansion and still be well below the limit.[449] Even in the LSTP where all the factors were manipulated to accelerate expansion, it still took on average a year to get to the expansion limits.[450] Moreover, the Staff stated that "[t]here has been no case history where we [have] seen that ASR was the primary cause of the structural failure of collapse" and that "the risk related to ASR is relatively low, provided it's monitored and managed."[451] Therefore, knowing the rate of ASR expansion at Seabrook was not necessary for the Staff to conclude that the license amendment provided reasonable assurance that Seabrook will continue to meet the applicable NRC requirements and will not endanger the health and safety of the public.[452]

2.130 Based on the foregoing, we find that NextEra has demonstrated by a preponderance of the evidence that knowing the rate of ASR expansion at Seabrook is not necessary.

e. Board Findings on the Use of the Correlation Equation to Calculate Through-Thickness Expansion to Date

2.131 As discussed previously, when in-plane expansion at a particular location, as measured by CI/CCI, reaches 0.1%, an SRBE is installed to measure through-thickness expansion going forward. Through-thickness expansion up to the date of the installation of the SRBE, however, is calculated using an equation to correlate normalized elastic modulus and through-thickness expansion (correlation equation).[453] To obtain the normalized elastic

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[449] *Id.* at 685–86, 695–96, 1135–36, 1194, 1202.

[450] *Id.* at 397.

[451] *Id.* at 1115.

[452] Tr. at 1122–23; 1126–27.

[453] Exhibit NRC001-R-00-BD01, Staff Testimony at 42.

modulus for use in this equation, it is necessary to know the original (i.e., 28-day) modulus of the affected Seabrook concrete; however, this elastic modulus was not measured during Seabrook's construction.[454] Therefore, NextEra provided two approaches by which the original modulus could be determined—(1) use the equation from ACI 318-71, Section 8.3.1[455] to estimate the modulus based on the measured 28-day compressive strength of concrete cylinders cast at the time of Seabrook construction or (2) use reference Seabrook cores representative of original construction and not affected by ASR. Because both approaches can introduce uncertainty, NextEra applied a "reduction factor" to the normalized modulus term of the correlation equation, which would conservatively result in overestimating the through-thickness expansion to date in Seabrook structures. The reduction factor attempts to bound the data from the LSTP.[456]

2.132 Based on considerations of statistical measures of goodness of fit, the Staff determined that the correlation equation was reasonable because it accounts for a large majority of the variance in the LSTP data, as well as similar trends seen in the existing literature data.[457]

2.133 Besides the reduction factor, the correlation equation involves numerous conservatisms. First, the equation naturally gets more sensitive as you get to greater levels of degradation.[458] Since SRBEs are installed at a very low level of in-plane expansion, this means that any potential error would "largely be muted…."[459] This is borne out by the through-

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[454] Exhibit NRC090-00-BD01 at 2–3.

[455] Exhibit NRC049-00-BD01 at 22.

[456] Tr. at 544–46.

[457] *See* Exhibit NRC090-00-BD01 at 3.

[458] Tr. at 558–59.

[459] *Id.* at 559.

thickness expansions measured to date, which have primarily been very low.[460] Second, the ASR expansion monitoring program assumes that the entire wall has the through-thickness expansion calculated for the location of the installation of the SRBE, which is the portion of the wall with the most significant surface cracking.[461] Third, the correlation equation is subject to a license condition, which requires a confirmatory corroboration study of the equation on Seabrook structures to provide additional assurance of the continued applicability of the equation. The corroboration study is required to cover at least 20 percent of extensometer locations on Seabrook ASR-affected structures and to use the approach provided in Appendix C of Report MPR-4273, Revision 1. It is required to be completed no later than 2025, with a follow-up study 10 years thereafter, and NextEra is required to notify the NRC each time a study is completed. Finally, NextEra has a continuing obligation to demonstrate that its structures can perform their functions. Therefore, if, based on the results of a corroboration study, the Staff were ever to question whether the design basis codes, as modified and supplemented, were no longer valid, NextEra would be required to demonstrate operability or update the Seabrook licensing basis.[462] Similarly, NextEra is obligated, through its operating experience and corrective actions programs, to evaluate relevant operating experience and determine whether a change to its programs is needed.[463]

2.134 C-10 expert witness Dr. Saouma argued that the correlation equation carries "substantial uncertainties…."[464] He based this argument, in part, on his belief that the normal

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[460] *Id*.

[461] *Id*. at 480, 543–48, 1147.

[462] *Id.* at 575.

[463] *Id.* at 1136–37.

[464] Exhibit INT028-00-BD01 at 36; Exhibit INT030-R-00-BD01 at 1.

variability of +/- 20 percent in the measured data in ACI 318-71 is a margin of error.[465] Rather, the +/- 20 percent is a reference to the variability of the experimental data on which the ACI 318-71 empirical equation for concrete modulus of elasticity was developed.[466] Section 8.3.1 of ACI 318-71 states that for normal weight concrete, the modulus of elasticity (Ec) may be considered to be 57,000√f'c.[467] The code does not require the modulus of elasticity value calculated using the empirical equation to include a +/- 20 percent margin of error.[468] Therefore, Dr Saouma mischaracterized normal variability in the data underlying the code equation as a margin of error in the code equation. Additionally, the original elastic modulus for locations of installed extensometers at Seabrook is calculated using the average of the 28-day compressive strength data available for the location[469] and not just using an individual cylinder test, thereby accounting for variability to obtain a representative modulus for the location and not one that is susceptible to a +/- 20 percent margin of error, as Dr. Saouma asserted.[470]

2.135 Similarly, C-10 faulted the correlation equation for not using "error bars."[471] However, the correlation equation is used in the context of the design basis codes, which do not use error bars; instead, they incorporate error into their equations.[472] As stated by NextEra expert witness Dr. Bayrak, "[w]ith respect to science and engineering and error bars, ACI code committees over the span of the past half a century have successfully conducted reliable

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[465] Exhibit INT028-00-BD01 at 36–40.

[466] Exhibit NRC090-00-BD01 at 4.

[467] Exhibit NRC049-00-BD01 at 22.

[468] Exhibit NRC090-00-BD01 at 4.

[469] Exhibit INT020-00-BD01 at 108-09.

[470] Exhibit NRC090-00-BD01 at 4.

[471] Tr. at 797.

[472] *Id.* at 780–81, 795.

designs, strong designs, without [en]dangering the public safety in the absence of error bars. So, the statement that structural engineers must use error bars to ensure safety, or even imply that such is a necessity, is, is just categorically wrong."[473]

2.136 Dr. Saouma argued that the correlation equation does not account for the increase in the compressive strength of concrete over time and that this would cause the calculation to underestimate through-thickness expansion. Dr. Saouma asserts that compressive strength after five years can be as much as 20% higher than the value measured at 28 days.[474] Even if this were the case at Seabrook, then the reduction factor in the correlation equation would bound this uncertainty. This is because applying an increase in compressive strength of a factor of 1.2 (i.e., 20 percent) to the ACI 318-71 equation for elastic modulus, which is a function of the square root of compressive strength, would result in the initial modulus being higher by a factor of the square root of 1.2, which is 1.095; consequently, the resulting normalized modulus would be lower by a factor of 0.91 (i.e., 1/1.095).[475] The reduction factor in NextEra's correlation equation is smaller than this value and, therefore, adequately accounts for this uncertainty.

2.137 The LSTP had a specification for the range of strength acceptable in the test specimen concrete.[476] Dr. Saouma pointed to this range and stated that, because of this range, there are differences in strength between the LSTP concrete and the Seabrook concrete, which, in turn, create uncertainties in the correlation equation that are not accounted for.[477] The range of strength of the actual test specimens, though, as opposed to the generic specification range,

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[473] *Id.* at 784.

[474] Exhibit INT030-R-00-BD01 at 1.

[475] Exhibit NRC090-00-BD01 at 4.

[476] Tr. at 596, 1144.

[477] *Id.* at 1144–46.

is much narrower and it represents strengths typical of concrete structures at Seabrook.[478] As Dr. Bayrak explained, the specification range provided the "limits" for the test specimens and the narrower range that was actually achieved was the "target" for the test specimens.[479] Therefore, there is not a representativeness issue and, consequently, there is not an uncertainty related to differing concrete strengths that is not accounted for by the correlation equation.

2.138 Based on the foregoing, we find that NextEra has demonstrated by a preponderance of the evidence that the use of the correlation equation to calculate through-thickness expansion to date is appropriate.

G. NextEra's Implementation of the Structure Deformation Monitoring Program is Not Within the Scope of this Proceeding

2.139 The contention admitted in this proceeding, as reformulated by the Board, challenges the LSTP and its data and the proposed monitoring, acceptance criteria, and inspection intervals derived from that data.[480]

2.140 C-10 advanced numerous arguments that are unrelated to the LSTP and its data and the proposed monitoring, acceptance criteria, and inspection intervals derived from that data. Specifically, all of C-10's arguments regarding the implementation of the structure deformation monitoring program and the finite element analyses employed in that program are unrelated to the admitted contention.

2.141 As explained above, the LAR at issue in this proceeding is made up of two portions—the ASR expansion monitoring program and the structure deformation monitoring program—and only the former portion is related to the admitted contention.[481]

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[478] *Id.* at 596–97.

[479] *Id.* at 597–98.

[480] LBP-17-7, 86 NRC at 127.

[481] *See* Exhibit INT010-00-BD01, Original LAR at 31–34 of 73 (unnumbered) (discussing each program in a separate section).

2.142 The structure deformation monitoring program addresses the additional ASR-induced structural demand due to cumulative effects of ASR expansion and cracking in combination with other design-basis loads.[482] The structure deformation monitoring program does not rely on LSTP data as direct numerical input for the structural analysis to determine the structural demand under design basis loads, including ASR.[483] As part of the structure deformation monitoring program, the ASR load developed for each ASR-affected structure at Seabrook is estimated based on field data from the actual structures and is not derived from the LSTP.[484] Specifically, the structure deformation monitoring program uses CI/CCI to estimate the ASR strain in a concrete member.[485] The structure deformation monitoring program may also use other appropriate field measurements (e.g., seismic gaps, annulus gaps, relative displacements, etc.) and observations using commonly used measurement tools.[486] The only overlap of the structure deformation monitoring program with the LSTP is that the program's acceptance criteria are tied to the point at which a structure would meet the limits identified in the LSTP; the entire process used by NextEra to implement the structure deformation monitoring program up to this point, including finite element analyses, is separate from the LSTP.[487]

2.143 The bases addressed by the Board in admitting the contention demonstrate that its use of the terms "monitoring, acceptance criteria, and inspection intervals"[488] is specific to the

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[482] Exhibit NRC001-R-00-BD01 at 20.

[483] *Id.* at 21.

[484] *Id*.

[485] *Id.*

[486] *Id*. at 21–23.

[487] *Id*.

[488] LBP-17-7, 86 NRC at 127.

ASR expansion monitoring portion of the LAR. For instance, in LBP-17-7, the Board discusses whether the LSTP supports CI/CCI, SRBEs, and empirical calculations as valid means of determining ASR expansion at Seabrook (i.e., "monitoring"),[489] whether the LSTP supports that the ASR expansion limits in LAR Table 4 are applicable to Seabrook (i.e., "acceptance criteria"),[490] and whether the ASR expansion monitoring intervals in LAR Table 5 are valid at Seabrook (i.e., "inspection intervals")[491]—all of which are discussed in the ASR expansion monitoring portion of the LAR.[492]

2.144 The structure deformation monitoring portion of the LAR discusses different monitoring (i.e., finite element analyses of susceptible structures), different acceptance criteria (i.e., threshold monitoring limits that are specific to each structure), and different inspection intervals (i.e., as provided in LAR Table 6).[493] The structure deformation monitoring categories (i.e., Stages 1, 2, and 3) are distinct from the ASR expansion monitoring categories (i.e., Tiers 1, 2, and 3).[494] On this point, it bears noting that C-10 challenged the monitoring intervals in LAR Table 5 and not the monitoring intervals in LAR Table 6.[495] Even Dr. Saouma, when asked during the evidentiary hearing whether the inspection intervals that he was disputing were those in LAR Table 5, stated "[t]hat's the only one that I'm aware of…."[496]

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[489] *Id*. at 98-102; *see also id*. at 93 ("C-10 contests the sufficiency of the methods proposed in the LAR for monitoring the anticipated progression of ASR at Seabrook.").

[490] *Id*. at 106; *see also id.* at 114 n.353 ("We understand that the phrase 'acceptance criteria,' as used by the Staff, refers to the expansion limits in LAR Table 4.").

[491] *Id*. at 124.

[492] *See* Exhibit INT010-00-BD01, Original LAR at 30–32 of 73 (unnumbered).

[493] *Id*. at 23–27, 32–33 of 73 (unnumbered).

[494] *Id.* at 34, tbl. 6.

[495] LBP-17-7, 86 NRC at 124.

[496] Tr. at 417–18.

2.145 C-10 attempted to enlarge the scope of the admitted contention by pointing out that the ASR expansion monitoring program refers to the structure deformation monitoring program. Specifically, Dr. Saouma pointed out that Table 5 of the LAR provides that the recommended actions for Tier 3 structures, those with in-plane expansion of 0.1%, are enhanced ASR monitoring and a "[s]tructural evaluation."[497] This, though, does not, as Dr. Saouma claims, make the process used in the structure deformation monitoring program "an integral part of ASR expansion monitoring;"[498] rather, the term "[s]tructural evaluation" is simply a pointer for the Seabrook staff to initiate a process or evaluation separate from the ASR expansion monitoring program.[499] Stated another way, when in-plane expansion reaches 0.1%, the ASR expansion monitoring program triggers two follow-on actions—(1) implementing enhanced ASR monitoring under the ASR expansion monitoring program (i.e., installing an SRBE to measure through-thickness expansion) and (2) initiating a structural evaluation.[500] This "[s]tructural evaluation" may follow the separate process described in Sections 3.3 and 3.5.2 of the LAR and summarized in the separate Table 6 of the LAR.[501] Thus, the "[s]tructural assessment" under the structure deformation monitoring program may be triggered by the ASR expansion monitoring program, but it is not a part of the ASR expansion monitoring program.[502]

2.146 Dr. Saouma also tried to conflate the two programs by noting that Section 3.5.2 of the LAR is titled "Structure Deformation" and not "[S]tructure [D]eformation Monitoring,"[503] but

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[497] Exhibit INT010-00-BD01, Original LAR at 33 of 73 (unnumbered); Exhibit INT001-R-00-BD01 at 24.

[498] Exhibit INT001-R-00-BD01 at 24.

[499] Exhibit NRC001-R-00-BD01, Staff Testimony at 66.

[500] *Id*.

[501] *Id*.; *see* Exhibit INT010-00-BD01, Original LAR at 34 of 73 (unnumbered).

[502] Exhibit NRC001-R-00-BD01, Staff Testimony at 66–67.

[503] Exhibit INT001-R-00-BD01 at 23.

this does not somehow mean that Section 3.5.2 is a part of the ASR expansion monitoring program.[504] On the contrary, a plain language reading of the LAR indicates that Section 3.5.2 has to do with only the structure deformation monitoring program and not the ASR expansion monitoring program—Section 3.5 is titled "Monitoring" and it is broken up into Section 3.5.1, "ASR Expansion [Monitoring]," and Section 3.5.2, "Structure Deformation [Monitoring]."[505]

2.147 Based on the foregoing, we find that C-10's arguments regarding NextEra's implementation of the structure deformation monitoring program are not within the scope of this proceeding.

H. Board Findings on NextEra's Implementation of the Structure Deformation Monitoring Program

2.148 We find that, even if we were to consider C-10's out-of-scope challenges to the structure deformation monitoring program, C-10 has not shown any reason to question the adequacy of the program. First, C-10's arguments are based on Simpson, Gumpertz, & Heger, Inc., "Evaluation and Design Confirmation of As-Deformed CEB, 150252-CA-02," Revision 0, July 2016;[506] whereas, the LAR was based on a substantially revised version of this report (i.e., Revision 2).[507] Second, as explained in detail below, C-10's individual arguments regarding the implementation of the structure deformation monitoring program are not persuasive.

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[504] Exhibit NRC001-R-00-BD01, Staff Testimony at 66–67.

[505] *Id*.; Exhibit INT010-00-BD01, Original LAR at 30, 31, 33 of 73 (unnumbered).

[506] Exhibit INT001-R-00-BD01 at 24–28; *see* Exhibit INT015-00-BD01, Simpson Gumpertz & Heger, Inc., "Evaluation and Design Confirmation of As-Deformed CEB, 150252-CA-02," Rev. 0, July 2016 (Seabrook FP#100985) Enclosure 2 to Letter SBK-L-16153, re: Seabrook Station (Sept. 30, 2016) (ML19162A255).

[507] Exhibit NRC001-R-00-BD01, Staff Testimony at 67.

a. Board Findings on the Use of Linear Elastic Analysis

2.149 C-10 argued that ASR and its impact at Seabrook cannot be analyzed using linear elastic methods.[508] Linear elastic methods, also referred to as "linear, elastic behavior" by NextEra, is when the deformation of the concrete increases proportionately to the load.[509] As NextEra's expert witnesses explained, linear, elastic behavior is when "the load-deformation relationship is a straight-line, or linear."[510]

2.150 C-10 expert witness Dr. Saouma, however, argued that a safety assessment of Seabrook concrete "can only be performed through a nonlinear analysis."[511] Dr. Saouma testified that "[i]n analyzing the safety of existing safety structures, one has to determine the exact nonlinear response beyond the elastic limit" because, according to Dr. Saouma, linear elastic analysis "will under-estimate the displacements and cannot capture either the failure load or the deformation."[512] Non-linear behavior is when the structure deformation increases faster than the load increases. As NextEra's expert witnesses stated, "[t]he point at which the behavior becomes nonlinear in reinforced concrete corresponds to the onset of yielding of the reinforcement steel accompanied by increased cracking of the concrete."[513]

2.151 NextEra's use of linear elastic methods is grounded in the Seabrook design basis codes, sometimes referred to as "codes of record," as documented in the Seabrook Updated Final Safety Analysis Report (UFSAR).[514] For Seabrook seismic Category I structures other

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[508] Exhibit INT001-R-00-BD01 at 24–26, 31–32 36; *see* Exhibit INT028-00-BD01 at 42.

[509] Exhibit NER004-00-BD01, Testimony of NextEra Witnesses Said Bolourchi, Glenn Bell, and Matthew Sherman at 53 (ML19205A501) (SGH Testimony).

[510] *Id.* at 52.

[511] Exhibit INT001-R-00-BD01 at 7.

[512] *Id*.

[513] Exhibit NER004-00-BD01, SGH Testimony at 53.

[514] Exhibit NRC001-00-BD01 at 68; Exhibit NER004-00-BD01, SGH Testimony at 51–56; *see* Exhibit INT024-00-BD01, SE at 48 ("As required by the structural design in the Seabrook UFSAR Sections

than containment, the code of record is ACI 318-71.[515] The code of record for containment is ASME Code, Section III, Division 2.[516] Both codes employ linear, elastic methods.[517]

2.152 In criticizing NextEra's reliance on linear elastic methods, Dr. Saouma acknowledged that the assumption that the response up to failure will be linear "is indeed code-driven."[518] Therefore, the parties agree that NextEra's use of linear elastic methods is consistent with the design basis codes for Seabrook.[519]

2.153 NextEra argued that the results of the LSTP justify NextEra's continued reliance on the design basis codes and, therefore, linear elastic analysis.[520] As NextEra expert witness Mr. Bell testified, "[t]he original codes of records were based on linear elastic analysis and so the entire evaluation that we did assured—is to assure that everything stays within the design limits using the original codes and equations and the approaches to analysis therein."[521]

2.154 The Staff expert witnesses testified that the LSTP data support NextEra's continued reliance on the design basis codes because the load-deformation plots of the LSTP

3.8.4.3 and 3.8.4.5 (corresponding UFSAR subsections for containment internal structures are 3.8.3.3 and 3.8.3.5), stresses and strains in the structures shall be maintained within elastic limits under normal operating (service) load conditions."); *see also, e.g.,* Tr. at 303, 577–79, 853, 857–859, 865, 897, 923, 946 (referring to the design basis codes as the "codes of record").

[515] Exhibit NRC001-R-00-BD01 at 68; *see* Exhibit NRC049-00-BD01, American Concrete Institute (ACI) Standard 318-71, Building Code Requirements for Reinforced Concrete (1971) (ML19205A479) (Non-publicly available).

[516] Exhibit NRC001-00-BD01 at 68; *see* Exhibit NRC050-00-BD01, Section III, Division 2, of the 1975 Edition of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code) for Containment (ML19205A480) (Non-publicly available).

[517] Exhibit NER004-00-BD01, SGH Testimony at 52.

[518] Exhibit INT001-R-00-BD01 at 7; *see* Exhibit INT028-00-BD01 at 3–4.

[519] *See, e.g.,* Exhibit INT001-R-00-BD01 at 7; Exhibit NER004-00-BD01, SGH Testimony at 52; Exhibit NRC001-R-00-BD01 at 68–69.

[520] *See, e.g.*, Tr. at 973 ("[The] LSTP confirmed that the code equations are valid.") (Mr. Bolourchi); Exhibit NER004-00-BD01, SGH Testimony at 57.

[521] Tr. at 303; *see* Tr. at 857–859.

specimens that were tested to failure generally showed linear behavior up to the point of flexural yielding (in the Reinforcement Anchorage Test Program) or initiation of the diagonal crack (in the Shear Test Program) similar to the behavior of the control specimens and the assumptions in the code.[522] Therefore, the LSTP results indicated that the behavior of Seabrook ASR-affected structures may be considered to be bounded by original design methods, that is, that the code equations provide a lower bound estimate of structural capacity of Seabrook ASR-affected concrete members.[523] The Staff's expert witnesses also pointed out that NextEra's conclusion on the continued applicability of the codes of record is consistent with those made based on large-scale testing by other researchers.[524]

2.155 NextEra and the Staff argued that the non-linear analysis advocated by Dr. Saouma would require a complete departure from Seabrook's design basis codes.[525] And, indeed, Dr. Saouma repeatedly criticized NextEra's and the Staff's reliance on the design basis codes.[526] At bottom, Dr. Saouma took issue with NextEra's entire analytical approach with the LSTP, which was to determine whether the design basis codes still applied, notwithstanding the

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[522] *Id.*; *see* Exhibit INT020-00-BD01, MPR-4253, ASR Monitoring Report (Rev. 3), fig. 5-5 at 5-7, fig. 5-7 at 5-11 (Non-publicly available); Tr. at 1055–58, 1083–88.

[523] Exhibit NRC001-R-00-BD01, Staff Testimony at 68.

[524] *Id.*; *see* Exhibit NRC074-00-BD01, Stéphane Multon, et. al., "Flexural Strength of Beams Affected by ASR," 12th International Conference on Alkali-Aggregate Reaction, Beijing, China (2004) at § 6 (ML19205A475); Exhibit NRC075-00-BD01, Dean J., Deschenes, et. al., "ASR/DEF-Damaged Bent Caps: Shear Tests and Field Implications," Technical Report No. 12-8XXIA006 summarizing work conducted for the Texas Department of Transportation at Ferguson Structural Engineering Laboratory, The University of Texas at Austin (August 2009) at 226 (ML19205A441).

[525] *See, e.g.,* Tr. at 852–53; Exhibit NER001-00-BD01, MPR Testimony at 132–33 ("[T]he non-linear analysis [advocated by Dr. Saouma] would be a complete departure from the ACI and ASME Codes that form the design basis for Seabrook."); Exhibit NER004-00-BD01, SGH Testimony at 47, 46.

[526] *See, e.g.,* Exhibit INT001-R-00-BD01 at 30–31; Exhibit INT028-00-BD01 at 3–4; Tr. at 301 ("We cannot assume a factor of safety embedded in the ACI code. We have to determine the factor of safety ourself."); Tr. at 342 ("This problem is way too complex to limit its solution to a mere satisfaction of a design code."); Tr. at 863 ("We are dealing with a structure where we cannot afford the luxury of relying on the simplistic approach of the ACI code.").

presence of ASR.[527] According to Dr. Saouma, the very fact that the codes do not account for ASR renders them wholly outdated and unreliable.[528] Instead, to address the complexity of ASR at Seabrook, Dr. Saouma testified that NextEra has to "go beyond the existing code."[529]

2.156 NextEra's expert witnesses, however, testified that the LSTP confirmed the continued applicability of the codes of record to ASR-affected concrete structures at Seabrook. NextEra's use of a linear elastic analysis, consistent with those codes, in its structure deformation monitoring program is conservative.[530] NextEra's witnesses explained that, contrary to Dr. Saouma general criticisms of the codes, "the codes of record generally limit the stresses and strains to conservative levels."[531] Thus, a nonlinear analysis that would extrapolate the point at which the structure would fail is inapplicable because the codes of record limit the stresses and deformations to below yield levels.[532]

2.157 The Staff expert witnesses also made clear that if Seabrook ever approached or exceeded the limits of its codes of record, NextEra would be in the same position that it had faced when it first discovered the presence of ASR at Seabrook—NextEra would have to

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[527] *See e.g.,* Tr. at 311, 342, 385, 574, 576, 988.

[528] *See, e.g.*, Exhibit INT028-00-BD01 at 4 (describing one of the codes of record as an "outdated and flawed tool"); Tr. at 311, 952, 988 1065–66; *see also* Tr. at 385 ("If you want to restrict ourselves only to code, there is very little we can do to assess the safety of the structure. We might as well close it immediately. We have to go beyond that to make sure that it is operational, safety operational, and we know whether it is safety operational."); Tr. at 574 ("We're dealing with an extra identity problem here, which requires to think a little bit outside the envelope and the envelope being those existing codes. Those codes were not written for a structure like this one, which is suffering from ASR. So we have to broaden our mind a little bit."); Tr. at 576 (Dr. Saouma challenging the applicability of the 1971 ASME code to Seabrook).

[529] Tr. at 988.

[530] *Id.* at 857–860 (Mr. Bell).

[531] *Id.* at 857.

[532] *Id.* at 857–860 (Mr. Bell).

perform prompt operability determinations and, ultimately, come into compliance with its licensing basis or seek approval for a license amendment.[533]

2.158 Moreover, the Staff testified that selecting a methodology that would require a wholesale departure from Seabrook's licensing basis, as Dr. Saouma advocated, would be difficult to justify in light of the NRC's overall licensing framework.[534] As Staff expert witness Ms. Buford explained, "it was reasonable to the staff for the applicant to use [an LSTP] because … the purpose of that was to verify that the applicant was going to be able to use their codes of record rather than throw out the codes of record, and develop a new approach. [The Staff] found that very reasonable … since … this is the regulatory framework that they're designed and licensed to, as opposed to taking an experimental approach … that the [S]taff has not, approved or considered … [and] that would go beyond or throw out … the licensing basis, the ACI 318 codes."[535]

2.159 Based on the foregoing, we find that NextEra has demonstrated by a preponderance of the evidence that the use of linear elastic analysis is appropriate to NextEra's codes-based approach.

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[533] Tr. at 739–40, 946, 1025–26.

[534] *See* Tr. at 574 (T]he burden on the licensee and what [the Staff is] reviewing is that the structures are required to remain operable. And they are required to continue to stay within their design and licensing bases. And so what the licensee opted to do to demonstrate that the design codes and licensing basis remains intact was the charge of the staff to review. So looking beyond the codes is outside of the scope of the requirement for the structures to remain operable and to stay within the bounds of their licensing basis."); *see also* Exhibit NER004-00-BD01, SGH Testimony at 56 ("In other words, to comply with Seabrook's licensing basis, loads, analytical techniques, and determination of performance against acceptability criteria all go hand-in-hand and must be in accordance with the codes and standards detailed in the UFSAR that form the licensing basis for Seabrook. Thus, the non-linear analysis Dr. Saouma demands is not applicable or relevant to structural behavior at Seabrook.").

[535] *Id.* at 852–53; *see also id.* at 859 ("[T]he desire to tie back to the codes of record through the design basis is the methodology that is always the first choice here, and that's what we've done.") (Mr. Bell); *id.* at 947 ("[W]hen we went outside the bounds of our design bases, that requires prior approval from the Commission. And that's what we did with the license amendment request. We would never go outside of our licensing bases to evaluate a problem and use that for real plant modifications or analysis unless it's been prior approved by the Commission via a license amendment request.") (Mr. Collins).

b. Board Findings on the Potential for NextEra to Use a Probabilistic-Based Analysis Instead of its Codes-Based Approach

2.160 C-10 argued that a probabilistic-based analysis should be performed for the Seabrook structural evaluation because of the high risks associated with an accident at Seabrook and the uncertainties associated with capacity and demand.[536] Specifically, C-10 expert witness Dr. Saouma advocated for the use of a structural assessment model that accounts for uncertainties.[537] Dr. Saouma conceded, however, that "this would be outside the scope" of the proceeding[538] and stated that, "yes, I am also aware that this is not required."[539] Nevertheless, he insisted that "the best approach, the most intelligent approach, is to say be humble, recognize that we do not have everything … known."[540]

2.161 As recognized at the evidentiary hearing by Judge Trikouros, a probabilistic-based analysis is not required for this LAR.[541] NextEra expert witness Mr. Bell testified that (1) a probabilistic-based analysis is not necessary because Seabrook is staying within its design basis and (2) a probabilistic-based approach is "just not practical in this context."[542] The claim that a probabilistic-based analysis could have been performed instead of the approach proposed in the LAR is also not relevant to the NRC review of the LAR. The Staff found that NextEra's proposed codes-based approach provided reasonable assurance that the ASR-

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[536] Exhibit INT001-R-00-BD01 at 29.

[537] Tr. at 810.

[538] *Id*. at 811.

[539] *Id*. at 813.

[540] *Id*. at 812–13.

[541] *Id*. at 810–11 ("[Y]ou understand that that is not required in licensing space for Seabrook or any plant?") (Judge Trikouros); *see also id*. at 815 ("[P]robabilistic risk assessments … are not part of the licensing requirement here. They are generally done, as has been stated, when the design basis has been exceeded and it's necessary to understand the implications of that. That isn't the purpose of what we're doing here.") (Mr. Bell).

[542] *Id*. at 815–16.

affected structures at Seabrook remain capable of performing their intended safety functions.[543] Therefore, C-10's assertion that a better approach is available, without more, is not relevant to this proceeding.[544]

2.162 Based on the foregoing, we find that NextEra has demonstrated by a preponderance of the evidence that the potential for NextEra to use a probabilistic-based analysis instead of its codes-based approach is not relevant.

III. CONCLUSIONS OF LAW

3.1 With respect to the admitted contention, the Board has considered all the filings in this proceeding, the exhibits received in evidence, and the transcript of the evidentiary hearing. Based on its review of the record, the proposed findings of fact and conclusions of law submitted by the parties, and the findings of fact set forth above, which are supported by reliable, probative, and substantial evidence in the record, the Board has decided all matters in controversy concerning this contention in favor of NextEra and reaches the following conclusions of law.

3.2 Under 10 C.F.R. § 50.90, whenever a holder of a license wishes to amend its license, including technical specifications in the license, an application for amendment must be filed with the NRC. Under 10 C.F.R. § 50.92(a), the NRC is guided by the considerations that govern the issuance of initial operating licenses, to the extent applicable and appropriate, in determining whether to grant an amendment to an operating license. In turn, both the common standards for construction permits and operating licenses in 10 C.F.R. § 50.40(a), and those specifically for issuance of operating licenses in 10 C.F.R. § 50.57(a)(3), provide that there must be "reasonable assurance" that the activities at issue will comply with the regulations and can be conducted without endangering the health and safety of the public. As the Commission has

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[543] Exhibit NRC001-R-00-BD01, Staff Testimony at 71.

[544] *Id*.

stated, "[a] license amendment request must provide sufficient documentation and analysis to show that the licensee has complied with the relevant requirements, thereby demonstrating that the amended license will continue to provide reasonable assurance of adequate protection of public health and safety."[545]

3.3 Seabrook UFSAR Section 3.1, "Conformance to NRC General Design Criteria," discusses the extent to which the design criteria for Seabrook structures, systems, and components important to safety meet the NRC General Design Criteria for Nuclear Power Plants, specified in 10 C.F.R. Part 50, Appendix A (GDC).[546]

3.4 The GDC that are applicable to the UFSAR changes proposed in the LAR are GDC 1 (Quality Standards and Records),[547] 2 (Design Bases for Protection Against Natural Phenomena),[548] 4 (Environmental and Missile Design Bases),[549] 16 (Containment Design),[550] and 50 (Containment Design Basis).[551] Of these, GDC 1, 2, and 4 apply to all Seabrook seismic Category I structures, including containment; GDC 16 and 50 apply only to containment.[552] In relevant part, these GDCs state as follows:

> *Criterion 1—Quality standards and records*. Structures, systems, and components important to safety shall be designed, fabricated, erected, and tested to quality standards commensurate with the importance of the safety functions to be performed.

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[545] *Entergy Nuclear Operations, Inc.* (Palisades Nuclear Plant), CLI-15-22, 82 NRC 310, 316 (2015).

[546] Exhibit NRC007-00-BD01, UFSAR § 3.1; *see* 10 C.F.R. Part 50, App. A.

[547] *Id.* § 3.1.1.1 at 1–2; *see* Exhibit INT024-00-BD01, SE, encl. 2 at 2; Exhibit INT010-00-BD01, Original LAR at 35 of 73 (unnumbered).

[548] Exhibit NRC007-00-BD01, UFSAR § 3.1.1.2 at 2–3; *see* Exhibit INT024-00-BD01, SE, encl. 2 at 2; Exhibit INT010, Original LAR at 35 of 73 (unnumbered).

[549] Exhibit NRC007-00-BD01, UFSAR § 3.1.1.4 at 3–4; *see* Exhibit INT024-00-BD01, SE, encl. 2 at 2; Exhibit INT010-00-BD01, Original LAR at 35 of 73 (unnumbered).

[550] Exhibit NRC007-00-BD01, UFSAR § 3.1.2.7 at 8–9; *see* Exhibit INT024-00-BD01, SE, encl. 2 at 2; Exhibit INT010-00-BD01, Original LAR at 35 of 73 (unnumbered).

[551] Exhibit NRC007-00-BD01, UFSAR § 3.1.5.1 at 29–30; see Exhibit INT024-00-BD01, SE, encl. 2 at 2; Exhibit INT010-00-BD01, Original LAR at 35 of 73 (unnumbered).

[552] Exhibit INT024-00-BD01, SE, encl. 2 at 2.

Where generally recognized codes and standards are used, they shall be identified and evaluated to determine their applicability, adequacy, and sufficiency and shall be supplemented or modified as necessary to assure a quality product in keeping with the required safety function. A quality assurance program shall be established and implemented in order to provide adequate assurance that these structures, systems, and components will satisfactorily perform their safety functions….

Criterion 2—Design bases for protection against natural phenomena. Structures, systems, and components important to safety shall be designed to withstand the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, floods, tsunami, and seiches without loss of capability to perform their safety functions. The design bases for these structures, systems, and components shall reflect: (1) Appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding area, with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated, (2) appropriate combinations of the effects of normal and accident conditions with the effects of the natural phenomena and (3) the importance of the safety functions to be performed.

Criterion 4—Environmental and dynamic effects design bases. Structures, systems, and components important to safety shall be designed to accommodate the effects of and to be compatible with the environmental conditions associated with normal operation, maintenance, testing, and postulated accidents, including loss-of-coolant accidents. These structures, systems, and components shall be appropriately protected against dynamic effects, including the effects of missiles, pipe whipping, and discharging fluids, that may result from equipment failures and from events and conditions outside the nuclear power unit….

Criterion 16—Containment design. Reactor containment and associated systems shall be provided to establish an essentially leak-tight barrier against the uncontrolled release of radioactivity to the environment and to assure that the containment design conditions important to safety are not exceeded for as long as postulated accident conditions require.

Criterion 50—Containment design basis. The reactor containment structure, including access openings, penetrations, and the containment heat removal system shall be designed so that the containment structure and its internal compartments can accommodate, without exceeding the design leakage rate and with sufficient margin, the calculated pressure and temperature conditions resulting from any loss-of-coolant accident….

3.5 In addition, Appendix B to 10 C.F.R. Part 50 establishes quality assurance requirements for the design, manufacture, construction, and operation of structures, systems, and components that prevent or mitigate the consequences of postulated accidents that could

cause undue risk to the health and safety of the public.[553] Activities related to the changes proposed in the LAR include procurement control measures on purchased materials, equipment, services, and design control measures.[554] Section III, "Design Control," of Appendix B to 10 C.F.R. Part 50, requires that the design control measures be established to ensure that applicable regulatory requirements and the design basis are correctly translated into specifications, drawings, procedures, and instructions.[555] These measures must include provisions to ensure that appropriate quality standards are specified and included in design documents and that deviations from such standards are controlled.[556] Design changes, including field changes, must be subject to design control measures commensurate with those applied to the original design.[557]

3.6 In this proceeding, NextEra carries the burden of proof on whether there is reasonable assurance that operation in the manner proposed by the LAR will comply with applicable regulations and will not endanger the health and safety of the public.[558] The Commission has cautioned that "'[r]easonable assurance' is not quantified as equivalent to a 95% (or any other percent) confidence level, but is based on sound technical judgment of the particulars of a case and on compliance with our regulations."[559] To satisfy this reasonable assurance standard, NextEra "must make a showing that meets the 'preponderance of the

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[553] 10 C.F.R. Part 50, Appendix B.

[554] Exhibit INT024-00-BD01, SE, encl. 2 at 5.

[555] 10 C.F.R. Part 50, Appendix B § III.

[556] *Id*.

[557] *Id*.

[558] *See* 10 C.F.R. § 2.325; *Duke Power Co*. (Catawba Nuclear Station, Units 1 and 2), CLI-83-19, 17 NRC 1041, 1048 (1983) (citing *Consumers Power Co*. (Midland Plant, Units 1 and 2), ALAB-283, 2 NRC 11, 17 (1975)).

[559] *AmerGen Energy Co., LLC* (Oyster Creek Nuclear Generating Station), CLI-09-7, 69 NRC 235, 262–63 (2009).

evidence' threshold of compliance with the applicable regulations…."[560] As indicated above, the applicable regulations in this proceeding are GDC 1, 2, 4, 16, and 50 and Appendix B to 10 C.F.R. Part 50.[561]

3.7 After full consideration for all of C-10's arguments, the facts in this proceeding show that NextEra has demonstrated, by a preponderance of the evidence, reasonable assurance that, with activities authorized by the approval of the LAR, Seabrook will continue to meet GDC 1, 2, 4, 16, and 50 and Appendix B to 10 C.F.R. Part 50 without endangering the health and safety of the public.

Respectfully submitted,

/Signed (electronically) by/

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Dated at Rockville, Maryland
this 21st day of November 2019

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[560] *Id.*; *see Pac. Gas & Elec. Co.* (Diablo Canyon Nuclear Power Plant, Units 1 and 2), ALAB-763, 19 NRC 571, 577 (1984) ("to prevail on … factual issues, the applicant's position must be supported by a preponderance of the evidence"); *Tennessee Valley Authority* (Hartsville Nuclear Plant, Units 1A, 2A, 1B, and 2B), ALAB-463, 7 NRC 341, 360 (1978), *reconsideration denied*, ALAB-467, 7 NRC 459 (1978) ("Absent some special statutory standard of proof, factual issues … are determined by a preponderance of the evidence.").

[561] Although in this proceeding the Staff has issued the challenged license amendment prior to the hearing, this does not shift the burden of proof; the burden remains on NextEra. *See Crow Butte Res., Inc.* (In Situ Leach Facility, Crawford, Nebraska), CLI-15-17, 82 NRC 33, 41 (2015) (stating that the issuance of a materials renewal license where a hearing was pending did not shift the burden of proof because "regardless of the issuance of the license, the burden remains on the applicant, and, with respect to NEPA compliance, on the Staff").

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

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

CERTIFICATE OF SERVICE

Pursuant to 10 C.F.R. § 2.305, I hereby certify that copies of the foregoing "NRC STAFF PROPOSED FINDINGS OF FACT AND CONCLUSIONS OF LAW FOR THE ADMITTED CONTENTION," dated November 21, 2019, have been filed through the Electronic Information Exchange, the NRC's E-Filing System, in the above-captioned proceeding, this 21st day of November 2019.

/Signed (electronically) by/

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