**RESEARCH & EDUCATION FOUNDATION**

*Towards a clean, safe energy future for the seacoast region*

April 10, 2017
*Via electronic submission*

UNITED STATES NUCLEAR REGULATORY COMMISSION
ATOMIC SAFETY AND LICENSING BOARD

In the Matter of: *NextEra Energy Seabrook Station Unit 1 - License Amendment Request 16-03 dated August 1, 2016*
Docket No. 50-443: NextEra Energy Seabrook LLC, Seabrook Station, Unit No. 1, Rockingham County, New Hampshire

**C-10 Research and Education Foundation, Inc.**
**Petition for leave to intervene: Nuclear Regulatory Commission Docket No. 50-443**

## I. Introduction

For reasons stated herein, the C-10 Research and Education Foundation, Inc. (C-10 Foundation or C-10) respectfully requests a public hearing and submits this petition for leave to intervene in the Nuclear Regulatory Commission (NRC) Docket # 50-443, relative to NextEra Energy Seabrook LLC's (NextEra) License Amendment Request (LAR) 16-03.

The C-10 Foundation is a non-profit 501 (c)(3) membership organization whose mission is to protect public health and the environment surrounding the Seabrook Station nuclear power plant in Seabrook, New Hampshire. Our vision is a clean, safe, sustainable energy future. Named for the citizens within the ten-mile radius of the plant designated as the "Emergency Planning Zone" (EPZ), the C-10 Foundation's core service is to operate a field monitoring network to measure real-time radiological emissions from the plant, under contract with the Massachusetts Department of Public Health's Bureau of Environmental Health. The C-10 Foundation has over twenty years of monitoring data and technical knowledge of plant safety and security issues. We are an informational resource for the public, partner organizations and the scientific community.

Our office is located within the EPZ of Seabrook Station nuclear power plant; our board of directors and most of our members reside in the communities adjacent to the plant. The safety of operations at the plant, the release of radiological emissions by air and water on an ongoing basis as well the prevention of a catastrophic event are all germane to the health, well-being, livelihoods and property of the people we represent: the citizens within a ten-mile radius of Seabrook Station. Should the NRC accept the License Amendment Request submitted in this proceeding, the C-10 Foundation believes that could put the public at serious risk by allowing NextEra to continue to operate Seabrook Station's nuclear reactor with no way to adequately remedy the plant's deteriorating concrete.

## II. Summary of Contentions of the C-10 Foundation in requesting a hearing and leave to intervene

The C-10 Foundation submits the following contentions for litigation by the Nuclear Regulatory Commission of the License Amendment Request (LAR 16-03) {Seabrook Station License Amendment Request 16-03: Revise Current Licensing Basis to Adopt a Methodology for the Analysis of Seismic Category 1 Structures with Concrete Affected by Alkali-Silica Reaction}, August 1, 2016, 10 CFR 50.90, Docket No. 50-443, SBK-L-16071.

C-10 has raised concerns about NextEra's proposed management of concrete degradation at Seabrook often in recent years, including submitting formal comments on the subject license amendment request on March 9, 2017. Based on information made available to us, we do not believe that the NRC's safety evaluation prepared in support of the proposed approval of the license amendment request sufficiently addresses or resolve our concerns; hence our need to contest the amendment, request a hearing and seek status as an intervening party.

These contentions are intended to demonstrate that the LAR and therefore the Current Licensing Basis (CLB) are inadequate to the stated Nuclear Regulatory primary mission of protection of public health and safety, because they do not provide for the accurate assessment of the current, actual, physical condition of the concrete structural components of Seabrook Station. By logical extension, the LAR further does not provide for the accurate assessment of Alkali-Silica Reaction (ASR) on the plant structures going forward—through the plant's current license period to its termination date of 2030, and through the 20 additional years from 2030-2050 of the plant's owner NextEra's requested license extension period. Our contentions are as follows:

**A. Visual inspection, crack width indexing, and extensometer deployment are not sufficient tools for determining the presence and extent of ASR in safety-related structures at Seabrook Station**. A misinterpretation of data resulting from these tests could cause a serious underestimation of the current extent of degradation due to ASR.

**B. Expansion occurring within a reinforced concrete structure due to ASR is not equivalent to a "pre-stressing"** effect. Any mitigation of lost structural capacity due to reinforcement is temporary and unpredictable, because of the non-linear progression of ASR. False assumptions concerning the strength of concrete at Seabrook Station made as a result of this misapprehension could result in potentially disastrous consequences for the safety of surrounding communities.

**C. Thorough petrographic analysis, including core sample testing of Seabrook's *in-situ* concrete, must be integral to NRCs determination of the advance of ASR.** NextEra's choice not to continue core sample testing is based on false assumptions, and could endanger the public health and safety.

**D. The Large-Scale Test Program, undertaken for NextEra at the Ferguson Structural Engineering Laboratory (FSEL), has yielded data that are not "representative" of the progression of ASR at Seabrook Station**, and therefore cannot be substituted for the required comprehensive petrographic analysis of in-situ concrete at the Seabrook reactor—now many years overdue. Allowing the FSEL data to "stand in" for the actual, non-linear progression of ASR in Seabrook's concrete could lead to disastrous consequences, and should not be allowed.

**E. NextEra's insistence that data from the FSEL testing are proprietary is not good science, and undermines any trust within the nearby communities that the ASR problem is being handled with the public's best interests at heart.** In addition, this lack of transparency hinders the awareness of and associated management of this concrete degradation mechanism at other nuclear power plants in the United States. NextEra's attempt to withhold this data harms the interests of the communities around Seabrook as well as the wider interests of citizens concerned with safety protocols in the nuclear industry. C-10 anticipates that the proceeding initiated by our filing will result in this data seeing the light of day for the benefit of many.

**F. Assumptions made by NextEra and MPR Associates, Inc. (MPR) concerning the continued robustness of reinforcing steel at the Seabrook reactor are at odds with clear evidence of the in-situ chemistry necessary for corrosion.** Only direct testing will ensure that corrosion does not further degrade the strength of already impaired concrete. Reliance on spurious assumptions of robustness could cause a significant over-estimation of the strength of concrete in "constraint," thereby leading to an unforeseen failure of concrete spans within Seabrook's safety-related structures.

**G. While there is acknowledgement of the progressive nature of ASR, to our knowledge, there has been no testing, nor proposed future testing, to the point of failure/limit state**—of either manufactured test concrete samples (FSEL) nor of in-situ concrete from Seabrook Station itself**.**

**H. The LAR's proposed inspection intervals cannot effectively measure the ongoing effects of ASR to structures at the Seabrook Nuclear Power Plant in a timely manner**—because these intervals are too long, and too rigid.

**I. Completely omitted from the LAR is any accounting for the change in impact of ASR on the portions of the plant exposed to, or affected by, increasingly severe coastal storms and predicted sea level rise**.

**J. The language used in LAR 16-03 is inappropriate for a document written for the purpose of demonstrating objectivity in the testing**—and the conclusions of that testing—by MPR / FSEL, on its manufactured concrete specimens.

## III. Discussion

**A. Visual inspection, crack width indexing, and extensometer deployment are not sufficient tools for determining the presence and extent of Alkali-Silica Reaction (ASR) in safety-related structures at Seabrook Station.**

NextEra continues to rely on visual "walkdown" inspections, superficial crack indexing, and extensometer deployment in order to gauge the progression of ASR.

> "There are limited localized ASR locations on the exterior surface of the containment building cylinder with closely spaced pattern cracking and some regions of widely-spaced pattern cracks indicative of lower levels of ASR based on available field inspections and crack indexing measurements. A confirmatory visual walk-down inspection of the building exterior wall will be performed to further characterize the extent of ASR degradation." (Seabrook Station, License Amendment Request 16-03, [Hereafter referred to as "LAR"], Enclosure 7: "NextEra Energy Seabrook's Evaluation of the Proposed Change"; 3.3.3, "Evaluation of Self-Straining Loads and Deformations for Containment Building")
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> Continued reliance on visual inspection and crack width indexing as gauges of the extent of ASR is neither appropriate nor reliable, especially with regard to safety-related structures at Seabrook Station. Since 2010, NRC has acknowledged that the Seabrook complex is affected by ASR. Because it is known that ASR can be present within the matrix of a given structure and yet not be visible, the only safe course for determining the presence and extent of ASR is to test the in-situ concrete.

The shortcomings of visual inspection are reviewed in a 2013 report from the Union of Concerned Scientists (UCS):

"Observing surface damage of a concrete structure is not a reliable way to understand the extent of damage within the concrete. This is especially true in concrete with internal reinforcing bars, which constrain crack widths but do not limit the progression of the ASR." (David Wright, Ph.D., Co-Director Global Security Program, UCS; Paul Brown, Ph.D., retired Professor of Ceramic Science and Engineering, Pennsylvania State University: "Continuing Problems with Monitoring Concrete Damage at Seabrook", p3, UCS,11/4/13)

NextEra has used a crack index model described in their 5/24/12 report, "Impact of Alkali-Silica Reaction on Concrete Structures and Attachments." It states: "the Cracking Index is the summation of the crack widths on the horizontal or vertical sides of a 20-inch by 20-inch square on the ASR-affected concrete surface." They further endorse the use of the crack index in the LAR: "Expansion measurements from the large-scale test programs have shown that crack index provides a reasonable and conservative approximation of true engineering strain for reinforced concrete members undergoing ASR expansion." (LAR, Enclosure 7, 3.3.4, "Factored Self-Straining Loads")

Here we have a case of a potentially dangerous false assumption based on a skewed reading of test data. The misapprehension of data is addressed within the following contention (B.) regarding ASR-induced expansion. On the reliability of crack index data, Dr. Brown describes how the "restraint" created by reinforcement changes the cracking profile:

"A crack index that only considers crack width is not an appropriate measure of an expansive reaction in a structure restrained by reinforcement. Because of the restraint, an index that instead reflects the total lengths of cracks on a given cross sectional plane is expected to be a more reliable indicator of the extent of ASR." (P. Brown, Ph.D., Commentary on SBK-L-12106, "Impact of Alkali-Silica Reaction on Concrete Structures and Attachments" p6, UCS March, 2013.)

"An acceptance criterion claimed to be indicative of the lack of meaningful ASR damage to the in-place concrete being promoted on behalf of Seabrook is one that involves using crack displacement as an indicator of the severity of the ASR. This would be sensible in a non-reinforced or lightly reinforced structure. However, its validity for a heavily reinforced structure is questionable. One should really give consideration to the mechanisms of damage depending on the nature of the reinforcement. In a structure that is truly reinforced in 3 dimensions, *ASR under such constraint will manifest by creating networks of microcracks.* Consequently, although crack widths will be narrow, the concrete will turn to mush." [Italics added.] (P. Brown, Ph.D., "Seabrook Issues: Crack Displacement and Reinforcement," 6/19/13)

In fact, tests conducted for NextEra at FSEL revealed a relatively high-level expansion that seemed to undercut NextEra's reliance on crack index data:

"NextEra and the UT-Austin FSEL staff have observed in the large-scale test specimens the X- and Y-direction deep pin expansion measurements (comparable to the Seabrook vertical and horizontal wall surface CCI measurements) do not appear to correlate with the through-wall (e.g., out-of-plane, or Z-direction) deep pin expansion measurements after the initial phase of ASR expansion. *X- and Y-direction expansion appears to plateau while the Z-direction expansion continues to trend upward (increase).* All large-scale reinforcement anchorage and shear specimens have demonstrated this expansion trend. The *Z-direction expansion in the test specimens has been observed to be 10 times greater than the X- and Y- expansions after approximately one year.*

The preliminary implication of these test specimen expansion measurement trends is that the X- and Y- expansion measurement methods *(CCI and crack width) currently used for monitoring the progression of ASR on Seabrook Station structure surfaces (per the Structures Monitoring Program) may not provide alone, an adequate means to monitor (1) ASR progression and (2*) by inference (pending the completion of the testing program), the *ASR impact on the affected building's structural performance.* The validation of the use of the CCI and crack width measurements for monitoring the structural impact of ASR has been an objective of the large specimen testing program." [italics added.]
(NRC Integrated Inspection Report 05000443/2014002, 5/16/14)

Finally, extensometers are another valuable tool being used to make determinations about the interior changes to concrete structures that they are not designed to accomplish:

"Snap ring borehole extensometers (SRBEs) provided accurate and reliable measurements for monitoring through-thickness expansion." (LAR, Enclosure 7, 3.2.1)

"…while extensometers are being installed, they can only provide information as to the overall dimensional change; they cannot determine the specific locations of expansion. Consequently, very localized and intensely damaging expansion could occur in planes parallel to the planes of the walls which would not result in a significant through-wall dimensional change." (P. Brown, Ph.D., "Commentary of Seabrook Station License Amendment Request 16-03," p2, 9/30/16)

We have known for seven years that the concrete at Seabrook Station is under attack from ASR. Visual inspections may not reveal the presence of ASR in a given area, because it may not show on the surface. Cracking index can give a false indication of the rate of ASR advancement, since *concrete restrained by reinforcement will cause microcracks of greater number*, without restricting the length of cracks. Extensometers can completely miss localized damage propagating in-plane from ASR.

While each of these is a legitimate tool that can, and should, be used to analyze the advancement of ASR, only sample testing of in-situ concrete can accurately gauge the extent of ASR within a given concrete matrix. Reliance on these methods, without the necessary accompanying in-situ testing, is not sufficient.

**B. Expansion occurring within a reinforced concrete structure due to Alkali-Silica Reaction is <u>not</u> equivalent to a pre-stressing effect. Any mitigation of lost structural capacity, due to reinforcement, is temporary and unpredictable.**

Among the justifications for the LAR, NextEra relies heavily on a concept that is, from C-10's perspective, based on a flawed understanding of the forces that ASR has imposed:

"When reinforcement is present to restrain the tensile force exerted by ASR expansion, an *equivalent* compressive force develops in the concrete that is comparable to prestressing." [Italics added.] (LAR Enclosure 2, MPR-4288, "Seabrook Station: Impact of Alkali-Silica Reaction on Structural Design Evaluations," 4.2, July, 2016)

"ASR may affect the material properties of concrete (compressive strength, elastic modulus, tensile strength). The property most notably affected is the elastic modulus (Reference 4). However, the change in material properties does not necessarily result in a corresponding decrease in capacity of a reinforced concrete structure. *ASR-induced expansion in reinforced concrete has a pre-stressing effect that mitigates the loss of structural capacity* that would be assumed based on the change in material properties." [Italics added.] (LAR, 2.1, "Background of ASR at Seabrook Station")

NextEra seems to equate the smaller crack dimensions noted above (section A. p3) with the "mitigation" of loss of structural capacity—owing to the "restraint" provided by steel reinforcement. Unfortunately, this is wishful thinking, and a potentially dangerous interpretation of the forces therein at work. Dr. Brown declares:

"The understanding of ASR as stated in this NextEra report [LAR] is superficial to the point of being misleading. ASR gel is not a compound of fixed composition. It has a variable monovalent cation-to-calcium ratio and a compositionally dependent viscosity. A high ratio produces a gel which is fluid and will accommodate to the pores and voids. As this ratio decreases the gel becomes sufficiently viscous that osmotic effects can place stress on the surrounding concrete. A local source of restraint can, for some period of time, minimize dimensional instability and cracking. However, restraint does not stop the progress of the reaction. The course of ASR in restrained samples is known to initially cause pore filling, resulting in densification, which will for some period of time counteract the loss of structural capacity. This has been observed in other expansive forms of concrete deterioration, such as a sulfate attack. However, eventually cracking does occur with an abrupt loss of mechanical properties…" (P. Brown, Ph.D., "Commentary on Seabrook Station License Amendment Request 16-03", p3-4, 9/30/16)

With regard to the actual change of properties for ASR-affected reinforced concrete, Dr. Brown notes:

"…the total length of cracks is important for assessing structural damage, and an increase in crack length is commonly observed for deleterious expansive reactions in concrete. In areas where restraint of concrete by reinforcement is absent, microcracks that are present grow and macroscopic cracking is observed. In areas where there is restraint by reinforcement, the processes that lead to crack *widening* are inhibited. However, there is no evidence to indicate that cracking per se is inhibited by restraint of the concrete. Rather, concrete responds to expansive ASR reaction in concrete under restraint by producing *higher densities of microcracks*, which reduces the strength of the concrete…. ASR-induced expansion in areas of constraint can be regarded as causing softening of the concrete because of a tendency to produce high density networks of fine microcracks."(P. Brown, Ph.D., "Commentary on 'Seabrook Station: Impact of Alkali-Silica Reaction on Concrete Structures and Attachments", p2, UCS, 3/13)

The danger in misconstruing the effects of ASR, acting within the restraint imposed by reinforcing steel, is that serious degradation that may go unnoticed without employing *thorough* petrographic analysis.

"When concrete is in a compressive mode, a crack must be rather wide before the effect of aggregate interlock is lost. This is less true in a tensile or shear mode. However, a degradation mechanism, such as ASR, that leads to cracking has an autocatalytic aspect to it. In other words, the worse it gets, the worse it gets. This is because the cracks serve as high conductivity paths for the movement of water and aggressive species." (P. Brown, Ph.D., commentary on Advisory Committee on Reactor Safety [ACRS] Transcript ML122070401, p6, 9/15/12)

The notion put forward by NextEra that ASR-attacked concrete, held under "restraint" by reinforcing steel, actually increases in strength reflects a false understanding of the forces at work. Concrete may well show a *temporary* increase in certain measures of strength, but irrevocably will advance toward failure. Because the course of ASR is non-linear in this way, the *"autocatalytic"* aspect of the latter stage of ASR-induced deterioration makes this not only an inaccurate portrayal of ASR's true character—but a dangerous conclusion.

**C. Thorough petrographic analysis, including core sample testing of Seabrook's in-situ concrete, must be integral to NextEra's assessment of the advance of ASR. Because of the extreme danger imposed by the radioactive substances contained within their walls, petrographic analysis of concrete from the Containment structures and the Spent Fuel Pool should be required by NRC. NextEra's choice not to continue core sample testing—especially for safety-related structures—is based on spurious assumptions, leaves inspectors and the surrounding communities with an unnecessarily incomplete picture of the actual state of concrete degradation, and could endanger the public health and safety.**

C-10's understanding based on public documents is that core samples were extracted from Seabrook Station structures seven years ago. An incomplete battery of tests was performed on the samples; many of those from safety-related structures showed significant reductions in compressive strength. NRC engineering staff, in testimony before the Advisory Committee on Reactor Safety (ACRS), revealed a 22% reduction in compressive strength, when the concrete should have actually strengthened by 20% during that time period. (Abdul Sheikh, Senior Structural Engineer for the Office of Nuclear Regulation, testimony before the Plant License Review Subcommittee, ACRS, July 2012.

Dr. Brown discusses the omitted tests for tensile strength:

"ASR reduces stiffness and tensile strength of concrete because these properties are particularly sensitive to microcracking. Using the expansive reaction associated with sulfate attack as an analog, a study carried out by the Bureau of Reclamation determined that sulfate-attacked concrete did not show a meaningful reduction in compressive strength, but did show a 95% reduction in tensile strength.

Yet despite the importance of tensile strength, while multiple cores were extracted for analysis at Seabrook, no splitting tensile strength determinations appear to have been done… the NextEra report describes various physical tests carried out on Seabrook concrete. These include only compressive tests and determinations of elastic moduli…"
(P. Brown, Ph.D., "Commentary on 'Seabrook Station: Impact of Alkali-Silica Reaction on Concrete Structures and Attachments,'" p3, March, 2013)

Since that time, and perhaps due to the public outcry over the 22% loss in compressive strength reported for certain safety-related areas, NextEra has avoided core sampling for the purpose of petrographic analysis. They have developed a rationale for not testing the in-situ concrete, which involves properties of the concrete changing when it is no longer "confined". The terms "confinement" and "restraint" are used to connote the characteristics of concrete within a steel-reinforced structure:

"Once removed from the structural context (e.g., reinforcement or *confining* loads) the behavior of the cores no longer reflects that of the confined structure." [Italics added.] (Seabrook Station Updated Final Safety Analysis Report, Revision 16, Section 3.8, p147)

The concrete prestressing effect is only present when the concrete is confined. The concrete prestressing effect is lost when the concrete is taken out of the stress field (e.g., core removal from a wall). A core taken from a confined ASR-affected structure will lose its confinement and no longer represents the context of the structure. Measured mechanical properties from a core taken from a confined ASR-affected structure have limited applicability to the in situ performance and only represent the performance of an unconfined or unreinforced structure." ("Impact of Alkali-Silica Reaction on Concrete Structures and Attachments", Enclosure 2 of the "Response to Confirmatory Action Letter, SBK-L-12106, NextEra, 5/24/12)

Dr. Brown has made numerous comments on the veracity of this claim:

"This is a strategically convenient position but the report provides no evidence to support a claim that the properties of the concrete have changed, beyond those recognized in ASTM Standards C39 and C42, merely because it has been removed from the structure… since this issue is central to the analysis it needs to be thoroughly supported by evidence." (P. Brown, Ph.D., "Commentary…", March, 2013, p2)

"It is also being argued in support of LAR approval that the expansive reaction in highly reinforced structures can be regarded as the equivalent of prestressing." [Reference to: SBK-L-16071, Enclosure 2, MPR-4288, Revision 0, "Seabrook Station: Impact of Alkali-Silica Reaction on Structural Design Evaluations," July 2016] "However, the tensile strength range for prestressing steel is 1725-1860 MPa while that of rebar is no greater than 690 MPa. This is far from equivalence. A logical extension of this argument suggests that the properties of the concrete *per se* don't matter." (P. Brown, Ph.D., "Commentary on Seabrook Station License Amendment Request 16-03", p3-4, 9/30/16)

"It is well understood that drilled cores are extracted from an existing structure and have been subjected to the service environment associated with that structure. This in no way invalidates the result of the testing. The results of core testing are generally understood within the relevant engineering community. The NextEra preposition misuses the cautionary language of ASTM C42 and appears to be an attempt to avoid accumulating data which might be regarded as problematic." (P. Brown, Ph.D., "Continuing Problems with Monitoring Concrete Damage at Seabrook", p3, UCS, 11/4/13)

Furthermore, as explained earlier (pp4-6), the seeming benefit gained by the "confined" environment—mitigating the deleterious impact of the ASR attack on concrete—is in fact a temporary reprieve from the unpredictable and irreversible march toward structural failure.

Although NextEra seems to make an effort to avoid and even discredit the well-understood methods of core sampling in reinforced structures, the scientific consensus remains that thorough petrography must include core sampling and testing. The testing and analysis protocols for core sampling, as a part of petrographic analysis, are delineated by groups long familiar to both NextEra and NRC: American Concrete Institute's ACI 349.3R, and American Society for Testing and Material's ASTM C 856-11.

"Compression and splitting tensile tests on cores are routinely done. It is not expensive or exotic to do. It seems to me that this should be done on an ongoing basis as an aspect of conditional assessment." (P. Brown, Ph.D., Commentary on ACRS transcript ML122070401, p4, 9/15/12)

"Core extraction is an inexpensive test that allows assessment of compressive and tensile properties. Core samples should be extracted from the affected concrete and compared with cores taken from unaffected concrete in the same structure." (David Wright, Ph.D., Paul Brown, Ph.D., "Continuing Problems with Monitoring Concrete Damage at Seabrook", p3, UCS, 11/4/13

"A key element of the work carried out by NextEra has been to attempt to discredit compressive testing of core samples that was carried out relatively shortly after ASR had been reported.

However, models for predicting the path of ASR in reinforced structures have been described in papers including "On Mechanical Degradation of Reinforced Concrete Affected by Alkali-Silica Reaction" by Winnicki and Pietruszczak in *The Journal of Engineering Mechanics* (Vol. 134, 2008), which specifically cites the need to carry out compressive [core] testing if the response of reinforced concrete to ASR is to be predicted. **While a variety of models have been developed to predict the mechanical consequences of ASR, none have been referenced in this LAR.** This is an important limitation of the…NextEra analysis. The above-cited model is particularly relevant because it specifically addresses reinforced concrete." [italics and bold-face original.] (P. Brown, Ph.D., "Commentary on Seabrook Station License Amendment Request 16-03", p4, UCS, 9/30/16)

The burden of proof for safety is greatest where the risk of environmental and human consequence is greatest. The Seabrook reactor complex presents just such risk of consequence, due to the use and storage of highly radioactive substances, all of which are carcinogenic, mutagenic, or teratogenic—some of which are all three together. These substances can be found, always, inside the concrete walls of the containment structures and the spent fuel pool, by virtue of their being used and stored there.

Because thorough petrography requires core sampling and comprehensive testing—and because the aforementioned structures have such risk associated with their functions—NextEra must subject these structures to core testing and thorough petrographic analysis, in order to carry on their business in a way that protects the health and safety of surrounding communities. But to our knowledge, they are not doing so; and NRC heretofore has chosen not to require such testing.

Since core sampling at Seabrook Station in 2010 revealed the significant degradation in the strength of tested structures described earlier (p7), NextEra has avoided further use of this essential tool for petrographic analysis. Instead, they have promoted the unverifiable claim that concrete samples removed from their "confinement" cannot "represent" ASR-attacked concrete in its confined state. They cite a "prestressing" effect, claiming this counteracts the deleterious impact of ASR on the concrete. However, the assertion of "equivalence", attributed to ASR-attacked concrete in relation to prestressing, is completely refuted by known science. The discernable benefit from ASR expansion in confinement is temporary, because the micro-cracking under way during this phase of deterioration leads to an autocatalytic collapse of the concrete's properties.

Core data are always analyzed in the context of their service environment, so that "confinement" is accounted for. Furthermore, existing models that have been devised to predict the advancement of ASR for concrete in confinement have not been referenced in the LAR. NextEra simply seems to be avoiding the discovery of data from Seabrook's in-situ concrete that it might find problematic. Until thorough petrographic analysis is performed on Seabrook's concrete structures, NextEra has no real basis by which it can reassure the surrounding families, or the NRC, that Seabrook's ASR progression is truly understood.

**D. The Large-Scale Test Program, undertaken for NextEra at the Ferguson Structural Engineering Laboratory (FSEL), has yielded data that are not "representative" of the progression of ASR at Seabrook Station, and therefore cannot be substituted for the required comprehensive petrographic analysis of in-situ concrete at the Seabrook reactor—now many years overdue.**

When the results of the first core testing were revealed in 2012, the public alarm generated was understandable: NRC staff members openly discussed the 22% reduction of compressive strength found in some of Seabrook's safety-related structures. Since those revelations, NextEra has assiduously avoided the necessary petrographic analysis of their reactor complex's own concrete. Instead they created a novel protocol, testing concrete remotely fashioned in a laboratory setting, meant to "stand in" for strength testing in lieu of Seabrook Station's actual material:

"While most research on ASR has focused on the science and kinetics of ASR, there is a substantial body of knowledge that exists in the literature on structural testing of ASR-affected concrete specimens. However, the application of the conclusions from the literature to structures at Seabrook Station can be *challenged by lack of representativeness.* As a result, for selected structural limit states, NextEra commissioned MPR/FSEL to perform large-scale structural testing using specimens that were designed and fabricated to be representative of structures at Seabrook Station." [Italics added.] (MPR-4288, Revision 0, "Seabrook Station: Impact of Alkali-Silica Reaction on Structural Design Evaluations," 4.1, July 2016)

MPR reiterates the claim debunked earlier (section B. p5-7) that concrete containing the proper reinforcement configurations will behave in a manner "equivalent" to prestressing. From there, they advance the mild-seeming notion that concrete members formed in this way can "represent" the concrete in "confinement" within the walls at Seabrook:

"The presence of confinement is a central factor for the effect of ASR on structural performance… Confinement limits ASR expansion of the in-situ structure, which reduces the extent of deleterious cracking and the resultant decrease in structural performance… When reinforcement is present to restrain the tensile force exerted by ASR expansion, an equivalent compressive force develops in the concrete that is comparable to prestressing… In some cases, literature indicates that the prestressing effect of ASR creates a stiffer structural component with a higher ultimate strength than an unaffected member…" (Ibid, 4.2)

"The test specimens fabricated for the MPR/FSEL test program were designed to be representative of the structural characteristics of safety-related structures of Seabrook Station." (Ibid, 4.3)

What at first seems to be a nuanced claim about "representativeness" becomes something much more ominous. NextEra intends to use these ideas about "representativeness" and "confinement" to advance the case for analyzing the advancement of ASR at their working atomic reactor, without having to properly and fully test the actual concrete at the plant! It is surprising that a firm (MPR) with the engineering expertise necessary to carry out the level of testing undertaken at FSEL, would knowingly contradict decades of accumulated wisdom concerning the behavior of ASR-attacked concrete, in order to create a data stream that in all likelihood *misrepresents* the progression of ASR degradation at a nuclear power facility. In fact, they do make clear their own disclaimer:

"Execution of a multi-year large-scale test program to support evaluation of ASR-affected reinforced concrete structures is unique in the industry in purpose, scale and methodology. Application of the results of the FSEL test program requires that the test specimens be representative of reinforced concrete at Seabrook Station and that expansion behavior of concrete at the plant be similar to that observed in the test specimens." (MPR-4273, Seabrook Station – Implications of Large-Scale Test Program Results on Reinforced Concrete Affected by Alkali-Silica Reaction," 6.1.5, "Recommendations for Implementation", July, 2016)

Following this, MPR explicitly calls for testing of Seabrook Station's in-situ concrete, as one of several specific recommendations that must be followed to validate the FSEL findings—although their recommendation for core samples only discusses testing "for determining through-thickness expansion for mid-plane cracks." What we believe is needed, in fact, is the full range of petrographic testing, because only then do we know that the testing done in Texas has any relevance to Seabrook.

"Professor Brown has stated that although NextEra's plan to utilize some non-standard tests may have merit, they are incomplete. In his opinion, NextEra must also systematically evaluate the concrete via petrography and physical testing of cores, and evaluate the expansive capacity of ASR based on ASTM standard tests as promulgated by ASTM Committee C-9 on Concrete and Aggregates…"

According to Brown, degradation due to ASR is not a linear phenomenon, as there is some period during which the occurrence of ASR… actually results in higher strength when compared to a control sample not experiencing ASR. But as the available local pore volumes become filled, cracking initiates. Crack formation and growth are not linear with time. In concrete restrained by reinforcement, mechanical testing of extracted concrete cores to establish compressive strength and Young's moduli are appropriate." (David Wright, Ph.D., UCS, Letter to William M. Dean, Regional Administrator Region 1, NRC, p2-3, 9/13/12)

In terms of "setting the bar" for the degree of "representativeness" to be achieved through the FSEL project, MPR's stated goal has little grounding in engineering science—understandable for a seemingly impossible mission:

"In support of long-term evaluations, MPR conducted large-scale test programs at [FSEL] using specimens that were designed and fabricated to represent reinforced concrete at Seabrook Station *to the maximum extent practical."* [Italics added.] (MPR-4273, 1.2.2)

Given all the variables for concrete mix, reinforcing, introduction of ASR attack, and much more to be sure, MPR/FSEL made great effort. However, the lack of clear definition for the level of "representativeness" sought introduces doubt, right at the outset, as to the applicability of FSEL data to Seabrook's in-situ characteristics. An example is instructive:

"To simulate the potential presence of groundwater on one side of the reinforced concrete at Seabrook Station, FSEL wetted absorbent fabric that was placed on the top side of each specimen. Misters in the [Environmental Conditioning Facility] ECF maintained a humid environment during wet cycles.

Comparison of expansion data from both sides of the test specimens did not identify a discernible bias in ASR development resulting from the wet fabric." (MPR-4273 4.2.6)

For an engineering firm to assert that putting wet towels against a concrete member for a 28-day test can in any way "represent" the 28-year inundation of concrete foundation walls—for the purpose of testing and analysis—completely strains credulity.

A rough outline of the facts is as follows: over the relatively brief course of their project, MPR/FSEL purpose-formed reinforced concrete structures from available concrete sources (chemically as similar to Seabrook's *as was practical*), within which ASR was encouraged to propagate. These members were subjected to a sophisticated battery of tests, from which data was gathered. This is appears to be an overly-simplified and incomplete depiction of a detailed and carefully run project carried out with professionalism.

What the MPR/FSEL effort hopes to "represent" with their test design is this: the non-linear advancement of ASR over the course of 35-40 years, within concrete structures formed from components some sources of which are no longer available; many of those structures have been submerged at their footings by as much as six feet for all of that time; and for some of that time, the water inundating those foundations has had a relatively high salt content. Furthermore, some of those concrete structures have been subjected to significant, even high levels of heat; and some of those structures have been subjected to significant, and even high levels of radiation and the resulting neutron bombardment.

In light of these characteristics for Seabrook Station's concrete, when MPR/FSEL cites the level of "representativeness" sought as "to the maximum extent practical," one can only wonder whether the result of all this hard-won data from Texas has any real relevance whatsoever to New England's biggest ASR problem.

The effect of radiation in particular, on the progressive weakening of concrete through ASR, is notable. Indeed, an NRC publication highlights the changes that radiation (and heat) can bring about:

"It was noted in Section 6.1 of this report that there may be a coupling effect between radiation and ASR that can potentially accelerate ASR activity or cause ASR to occur with aggregates that are not normally reactive. As plants age, the potential of ASR to occur in structures forming the biological shield or support for the reactor pressure vessel may increase as these structures are located in areas in which they are subjected to moderate elevated temperature in combination with radiation." (NUREG/CR-7171, "A Review of the Effects of Radiation on Microstructure and Properties of Concretes Used in Nuclear Power Plants," 8.2.2 "ASR potential of existing concrete and detection")

Another mention of "practicality," in this case on the part of NextEra, deserves mention here:

"Load testing of as-built structures is impractical for the Seabrook Station ASR issue." (LAR, 3.2, "Impact of ASR on Seabrook Structures")

No rationale has ever been given for this assertion; and without any justification, it remains a false assumption. However, C-10 proposes that "mining" the necessary concrete beams from the unused Unit 2 for a thorough petrographic regimen, would get us all much closer to data that is truly "representative" of the ASR dynamics at work in Unit 1—minus of course effects from heat and radiation, which would have to be factored in. Can that in any way be less "practical" than attempting to find a realistic correlation between the FSEL data and Seabrook's actual, ongoing, degrading condition?

Having turned away from core sampling after the core sample revelations of 2012, NextEra devised a narrative that suited their predicament: because of the "prestressing effect" brought about by ASR's advance in "confinement," the conventional practices for analysis of ASR's effect on strength characteristics of concrete were deemed not "representative" of Seabrook's actual condition. MPR agreed to carry out a multi-year study at FSEL in Austin, Texas, where concrete members were formed with the appropriate reinforcement to resemble configurations found at Seabrook—and purposely infused with chemical properties encouraging the propagation of ASR. These were subjected to a series of tests to analyze the effect of ASR on this purpose-formed concrete; and the data derived from those tests was said to be "representative" of the in-situ Seabrook Station concrete.

There many problems with this methodology. The goal set for representativeness— "to the maximum extent practical"—sets no definitive parameters to establish a relationship between the FSEL findings and the ongoing ASR attack at Seabrook. The basic assumptions underlying the FSEL project—that "confinement" within a reinforced concrete matrix mitigates ASR expansion while creating the benefit of "prestressing," which then in turn counteracts the loss in strength from ASR's advance—had already been disproven by the known science surrounding the study of ASR, long before the FSEL project was undertaken!

Furthermore, the concrete walls of Seabrook, sitting in a salt marsh on the New Hampshire coast, present far too many variables to allow even a well-performed set of tests (as the FSEL tests obviously were) in Texas to reflect their characteristics: their age; the length of time ASR has propagated; the effect of the fresh water at varying levels; the effect of the salt in the water at varying levels of height and concentration; the effects of heat; the effects of radiation on certain vital structures; etc.

While the testing at FSEL yielded important and valuable data about the behavior of short-term ASR progression in "confinement," the FSEL data cannot, in any meaningful way, "stand in" for or "represent" the current state of in-situ concrete at the Seabrook reactor, under sustained attack from Alkali-Silica Reaction. Even MPR, who partnered with FSEL to carry out the project, stopped short of declaring that such a "representation" is valid. The FSEL data cannot, and should not be allowed to replace thorough petrographic analysis of the actual concrete in question.

**E. NextEra's insistence that data from the FSEL testing is proprietary is not good science. The redaction of findings for any aspect of Seabrook's ASR testing creates an air of secrecy that prevents review, and undermines any trust within the nearby communities that the problem is being handled with the public's best interests at heart. NextEra's cloaking this data behind a proprietary curtain harms the interests of the community around Seabrook as well as the nuclear community. C-10 anticipates that the proceeding initiated by our filing will result in this data seeing the light of day for the benefit of many.**

The data derived from NextEra's ASR testing should not be allowed 'proprietary' status—and thereby kept out of the public domain—for two important reasons. First, the families who have to live in the ingestion pathway of Seabrook Station have the right to know just how safe, or unsafe, the most dangerous components of the reactor facility are—especially since NextEra currently seeks a 20-year extension to its operating license. Second, publication of test results would allow the larger engineering community to have access to the data, so that the proper feedback mechanisms for review are established. This is all the more important with regard to the FSEL project, where the engineering groups involved know that they are attempting something unprecedented—as stated above. Obviously, there is controversy around this methodology. Allowing the data to be seen and analyzed by the wider scientific and engineering communities would facilitate the needed debate.

"The redaction of data from these documents is problematic. The statement at the top of Enclosure 1, "The information to be redacted includes details of test programs that MPR conducted and results from the test programs. Release of this information would concede intellectual property. Release of this information would also constitute a loss of competitive advantage relative to others engaged in assessment of structural impacts of alkali-silica reaction." is entirely inconsistent with the stated goal of the report to advance the body of knowledge of the effects of ASR under conditions of restraint.

This is an extraordinary point of view. It is difficult to understand how withholding pertinent information, which would allow an independent assessment of the test results used to support the claims of NextEra, could reasonably be interpreted in this way. It is usual to actually submit such results for peer review to provide a basis for consensus among the relevant scientific community." (P. Brown, Ph.D., "Commentary on Seabrook Station License Amendment Request 16-03, p3, UCS, 9/30/16)

NRC's acquiescence to the secrecy surrounding any hard data for Seabrook's advancing ASR debilitation impedes the awareness of, and associated management of, this concrete degradation mechanism at other nuclear power plants in the United States. We have urged the NRC to allow the disclosure of ASR testing and analysis for Seabrook Station. In addition, NextEra must accept any sacrifice of 'competitive advantage' as part of the price of continued operation of a reactor with "degraded but operable" characteristics. Sharing operating experience should be nuclear safety hallmark—

sharing good practices as well as bad ones. In this respect, both the local residential community, and the nuclear engineering community, remain informed.

**F. Assumptions made by NextEra and MPR concerning the continued robustness of reinforcing steel at the Seabrook reactor are unsupported by direct evidence. The long-term inundation, from brackish water, of foundation walls in safety-related areas of the complex, has exposed the concrete to elevated levels of salt. When combined with the chemical processes of ASR propagation through the concrete, this has likely created the conditions for corrosion of reinforcing steel to set in. Only in-situ monitoring for evidence of these impacts can ensure corrosion does not further degrade the strength of already impaired concrete.**

There is little mention of steel deterioration anywhere in the LAR and supporting documents. MPR states a basic assumption about the quality of construction that seems to put their single concern for steel strength to rest:

"Seabrook Station was designed and constructed in accordance with codes that do not permit rebar bending to the extent that would be required for susceptibility to rebar fracture. Additionally, quality control requirements in effect during original construction of Seabrook Station would have prevented the poor construction practices that resulted in the observed rebar fractures in Japan." (MPR-4288, 6.2.3 "susceptibility of Reinforcement to Fracture at Seabrook Station.")

Of course, MPR can't be blamed for not knowing that NRC issued what may have been the only "Non-Compliance of Construction Procedure" against Public Service Company of New Hampshire during construction of Seabrook Station, because of *poor quality control—resulting in large sections of reinforcing steel being cut* during a 72-hour concrete pour session. (The construction worker who reported the error to the authorities on-site was fired the next day.) Therefore, we cannot assume that all reinforcing steel procedures were carried out to the highest standards.

Dr. Brown has made repeated efforts, through his commentary on the ASR issue at Seabrook, to caution NRC that the imbedded steel is in fact vulnerable for reasons that are site specific, as well as characteristic of ASR's attack. As to the site-specific mechanisms at work at Seabrook:

"SKB-L-10204 [Seabrook Station, 'Response to Request for Additional Information, NextEra Energy Seabrook License Renewal Application, Aging Management Program'] p. 36 cites that below-grade concrete has experienced ground water infiltration…. p.32 indicates natural water sources in contact with Seabrook concrete have chloride concentrations ranging from 19 to 3900 ppm. Exposure of reinforced concrete to chloride can induce deterioration by two separate mechanisms. Steel imbedded in concrete does not normally corrode because the elevated pH of concrete pore solution facilitates the formation of thin, adherent and protective layers of oxide on the steel surfaces. The phenomenon is called *passivation*. The presence of chloride ion in the pore solution adjacent to the reinforcing steel reduces the integrity of the passive layer; the process is called *depassivation. This renders the embedded steel susceptible to corrosion regardless of the elevated pH of the concrete pore solution.* Exposure conditions should be systematically characterized to establish the probability of corrosion of reinforcing steel that may be accompanying ASR.

While chloride is more potent, sulfate also has the capacity to depassivate embedded steel. The sulfate exposure was reported as 10-100 ppm. While substantially lower than the chloride concentrations, sulfate-containing water having concentrations in this range can be aggressive to concrete...

The accumulation of chloride in the Seabrook concrete can be established by petrographic means using scanning electron microscopy." [Italics added.] (P. Brown, Ph. D., "Commentary on the Alkali-Silica Reaction in Concrete Structures at the Seabrook Nuclear Plant," p5-6, "Variability in concrete exposure conditions and effects on durability," 3/14/12)

"If a reinforced concrete structure with a 3000 psi 28-day strength is immersed in a 3500-ppm sodium chloride solution, as are some of the structures at Seabrook, there is going to be corroded reinforcement… That water had been found to have intruded the structure for 30 years further increases the probability of corrosion of embedded steel."

"…It is commonly and correctly understood that the elevated pH of the internal concrete pore solution confers passivity to embedded steel. However*, once chloride finds its way to the steel, that passivity is lost. Consequently, given the service environment at Seabrook, I think there a reasonable basis to anticipate that the reinforcement at some locations is likely to have undergone significant corrosion.*

This issue seems not to have received meaningful attention." [Italics added.] (P. Brown, Ph. D., "Seabrook Issues," "Corrosion," p6, 6/19/13)

The dynamic interplay of ASR products with water saturating the concrete, may be indicative of steel corrosion within. According to Dr. Brown, the conditions for this are present at Seabrook Station:

"Inspections [at Seabrook] revealed the accumulation of salts on the interior faces of concrete walls at various locations. This is an indication that significant amounts of moisture have migrated entirely through the walls. It is not unusual to observe this on subterranean walls and the material that has accumulated is often calcium hydroxide. As the calcium hydroxide solution reaches the concrete surface, it is exposed to atmospheric CO2, and calcium carbonate precipitates and typically forms an adherent deposit.

If ASR is occurring, it is not uncommon for ASR gel also to extrude out of cracks, undergo a carbonation reaction and form deposits at evaporative fronts on interior surfaces. *If the water source contains chloride or sulfate, sodium sulfate or calcium sulfate and sodium chloride deposits can form*… There is a diagnostic benefit in sampling the deposits observed at the Seabrook facility and carrying out compositional determinations…

Establishing whether the deposits contain chloride is of significant importance in establishing the vulnerability of embedded steel to chloride-induced corrosion. *The NextEra response on page 26 of SKB-L-10204, comments that risk of damage to concrete due to corrosion of embedded steel is very low. However, this is only true in the absence of carbonation at the level of the steel, in the absence of a chloride exposure. Neither of these appears to be the case.* SKB-L-10204 reports the observation of heavy corrosion at certain locations. Representative samples of corrosion product should be obtained and analyzed to their chloride contents." [Italics added.] (P. Brown, Ph.D., "Commentary on the Alkali-Silica Reaction in Concrete Structures at the Seabrook Nuclear Plant," p4, 3/14/12)

Although this contention does not specifically address the quality of steel emplacement at the time of construction, the quality-control measures for steel installation cannot be the basis for an assumption of durability—since the improper handling of steel was cited by NRC during construction.

The dynamic chemistry involving ASR products on the surface of the concrete, interacting with the elevated salt content of water from the surrounding salt marsh, forms compounds that can cause de-passivation and subsequent corrosion of the reinforcing steel. As ASR cracking increases, the process of steel corrosion is accelerated. The conditions necessary for de-passivation and steel corrosion have been present for more than 30 years.

Therefore, the assumption that the steel reinforcement requires no testing for interior corrosion is false. This assumption on the part of NextEra and MPR is mystifying because so much of their FSEL project's credibility seems to rely on the notion that ASR-expanded concrete is held "in confinement" by the strength of the imbedded steel. It seems irresponsible even to their own hypothesis, not to test that same steel to be certain that its strength is not corroding away. (Of course, the results of such tests would need to be made public, for reasons stated earlier.)

**G. Omitted from the LAR 16-03 is the "tipping point" concept. While there is acknowledgement of the progressive nature of ASR, there has been no testing nor proposed future testing of either manufactured concrete samples as in the FSEL (Ferguson Structural Engineering Laboratory) Texas tests nor of actual concrete from Seabrook Station itself to the point of failure/limit state.**

The tipping point concept is that all seems to be going well until a certain (unexpected) "wall" is hit and the situation changes abruptly. This concept is easiest to understand from a mechanical perspective, and, in fact, that is the appropriate perspective from which to look at the ASR situation at the Seabrook Nuclear Power Plant. Progressive ASR will continue to weaken structures gradually over time. Then, one day, there may well be a profound failure because, even if the speed of progression of ASR damage did not change, that "tipping point" of structural failure is reached.

In section 1 of ML16216A240, Section 3.2.1, it is stated that, "the number of test specimens and the nature of testing prohibited testing out to ASR levels where there was a clear change in limit state capacity" In other words, there was no testing to the point of failure, which means that the testing did not establish the percentages/degree of ASR damage that leads to structural failure/deformation due to loss of material properties.

Even though the above paragraph describes the (lack of) testing scope of the FSEL Texas tests, a chart appears in the LAR 16-03 document (percentages redacted) that purports to show the levels at which limit state (failure) is reached. (LAR 160-03 Section 3.5.1., Table 4.) According to this chart/table, four structural limit states/failure is reached for four elements: shear, flexure, reinforcement anchorage and anchors. Each cites a percentage of "ASR expansion limit" before failure/limit state is reached. Again, the percentages are redacted.

It is unclear how the LAR can document the percentages of ASR damages at which failure occurs a few report sections after which it states that no testing was done to the point of limit state/failure.

Further, the speed of progression of ASR is unknown: further cracking leads to further penetration by water, which in turn intensifies the ASR damage. It seems clear that the speed of concrete degradation may be gaining in momentum; therefore, the tipping point concept needs to be incorporated into this LAR.

In a 2012 structural evaluation of Seabrook cited in the LAR Section 2.1.1 it was found that structures "remain suitable for continued service for an interim period". The term "interim period" is defined further along in that document as, "at least for several years". It has been five years since the "several years" structural evaluation, significantly more than "several years". NextEra is now seeking a license extension of 20 more years, which would put a plant with a design basis of 40 years of operating life into a 40-60-year framework of operation. The original design basis did not take into consideration the current and ongoing, but originally unforeseen, ASR structural damage. The Seabrook Station UFSAR, Revision 10, Section 3.8, page 151, section d, states, "No special allowance has been made for variation of material properties over the life of the structure, beyond that which is taken into account is establishing allowable stresses, strains, capacity function factors, concrete protection of reinforcing, and crack control as outlined in the referenced ACI and AISC codes."

"…eventually cracking does occur with an abrupt loss of mechanical properties. Not having carried out the above-cited tests" (compressive strength and splitting tensile strength tests) "severely limits the ability to predict such a possible change in behavior or, more relevantly, provide a firm basis to assert that abrupt changes in structural capacity will not occur during the operating life of the facility". (Commentary on Seabrook Station License Amendment Request 16-03, P.W. Brown, Ph.D., September 30, 2016)

"Since it is understood that ASR causes the degradation of material properties of concrete, and the criteria for an operability determination is whether the material properties are affected, it is unconservative to assume there is no degradation in material properties, especially since this has been observed elsewhere on site. C-10 believes the licensee would have to demonstrate that the material properties remain within its CLB (the ACI 318 limits). If not, it is outside of its CLB and would have to perform a proper technical evaluation…There is plenty of literature to the opposite effect showing structures degrading to beyond their load-carrying capabilities." (Angela R. Buford, Structural Engineer, Division of License Renewal, U.S. Nuclear Regulatory Commission, September 12, 2012, Comments on the latest draft of the rebar and core sampling position papers)

Section 2.2 of the LAR 16-03 states that prestressed concrete maintains a "self-equilibrating state", in that the expansion pressure of the concrete on the rebar is balanced by the outward pressure of the rebar on the expanding concrete. In fact, these pressures are not equal and logically, over time, cause failure:

"It is being argued in support of LAR approval that the expansive reaction in highly reinforced structures can be regarded as the equivalent of prestressing. However, the tensile strength range for prestressing steel is 1725-1860 MPa while that of rebar is no greater than 690 MPa. This is far from equivalence." (Commentary on Seabrook Station License Amendment Request 16-03, P. W. Brown, Ph.D., September 30, 2016, page 3)

Due to this documented differential in the internal forces of the structures and to the accepted progressive nature of ASR, material and thence structural failure is the only logical outcome.

The following conversation is from the Official Transcript of Proceedings of the Nuclear Regulatory Commission, Advisory Committee on Reactor Safeguards, Structural Analysis/Plant License Renewal Subcommittee. The conversation is between Committee Member Brown and concrete expert Dr. Paul W. Brown. "Member Brown: …Everybody talked about expansive, the ACR (sic) being and expansive process. Or ASR. Excuse me. And I was trying to calibrate myself what that means. That means there's internal tensile forces being built up as a result of the expansions inside? That's what – okay, all right. I understand. Dr. Brown: Yes. Either the aggregate itself is expanding and pushing against the cement base or the gel is getting – Member Brown: But you're introducing the compressive nature of the overall, the overall structural capacity by the internal tensile – Dr. Brown: Yes. Member Brown: forces? Okay. Chair Riccardella: It could also be trying to push, you know, stress against the rebar, right? Dr. Brown: Oh, yes. Sure. Member Brown: Got that. Got that. Dr. Brown: And there was on study cited in Japan, and maybe you guys are more aware of it than I am, but where that happened. The ASR actually blew the rebar. Chair Criccardella: Yes, I think one of the NIST presentations showed that, showed the rebar, the cracking of the rebar."

Any LAR needs to set out methodology to test materials to and past their limit state/failure/tipping point. This one does not and therefore must be rejected by the Nuclear Regulatory Commission.

**H. The proposed inspection intervals laid out in LAR 16-03 are too long, and too fixed, to effectively measure the ongoing effects of ASR to structures at the Seabrook Nuclear Power Plant in a timely manner.**

One part of the SMP (Structural Monitoring Program) is the schedule of inspections. Table 5 in Section 3.5.1 of LAR 16-03 lays out the fixed schedule. Tier 2 structures - areas with pattern cracking that "cannot accurately be measured" and areas with up to .05% -.1% cracking- are scheduled to be monitored every 30 months, while Tier 3 areas with in-plane expansion measured at .1% or more are scheduled to be inspected every six months.

At this time, there is no real knowledge of the speed of disintegration of concrete caused by advancing ASR. Further, there is no determination as to whether ASR progresses at a steady rate or at an accelerating (or decelerating) rate. Therefore, an SMP that relies on the LAR 16-03 set intervals is far from appropriately conservative. A lot can happen in six months, and even more in 30 months.

What is known is that the FSEL Texas testing is a snapshot only, and, further, a snapshot not of the actual concrete at Seabrook Station, but rather of specimens that were designed and fabricated to "represent reinforced concrete at Seabrook Station to the maximum extent practical". (LAR 16-03, Section 1.2.2)

Not only is that not the same as testing the actual concrete at Seabrook Station, but also the same tests were not conducted on both concretes, which would at least have given a comparison and a base of data upon which future changes could have been compared.

"…assessments/predictions of the responses of Seabrook structures to ASR, which are made in the absence of direct physical testing of concrete from those structures, are questionable." (Commentary on Seabrook Station License Amendment Request 16-03, P. W. Brown, Ph.D., September 30, 2016, page 1)

[compressive and splitting tensile strength testing] "…could have readily been accompanied by establishing cement paste microhardness values along with petrographic analyses. Such data could have been obtained from Seabrook structures and would have permitted a reasonable translation of the results on the test blocks to the actual structure. It would also provide data points against which future test results could have been compared – a step which seems critical if the objective is to permit the prediction of the future responses of Seabrook structures to ASR." (ibid, page 2)

Due to these omissions in testing in the FSEL and due to the lack of knowledge of the speed of progression of ASR damage to the actual concrete at Seabrook Station, the LAR 16-03 needs to be rejected because it does not serve to adequately enhance the current license basis to account for the non-anticipated alkali-silica reaction that is now damaging the concrete at the plant; therefore, it does not serve to fulfill the NRC's primary stated mission of protecting public health and safety.

**I. Completely omitted from LAR 16-03 is the vital factor of expected sea level rise on the progression of ASR at the portions of the plant exposed to possible sea water encroachment/ inundation.**

Seabrook Station is in a seaside location in a part of the world where sea levels are rising faster than in most other areas, making it more susceptible to extreme storms and coastal flooding. This factor needs to be taken into consideration in assessing the future impact of the potential damage to the plant due to ASR exacerbation—as well as due to corrosion exacerbation—and the impact of these factors on the health and safety of the population. It therefore needs to be a part of any LAR.

There is no citation available for this contention, as the issue of sea level rise is not addressed within the LAR. For NextEra, a corporate enterprise dealing with highly toxic radioactive substances, to occupy coastal siting, yet not to be accounting for the effects of sea level rise during their remaining license period, is short-sighted and irresponsible. This, of course, makes the needed for in-situ analysis of the steel reinforcement corrosion, as well as the aggravating impact of high-salinity water at the foundations, all the more crucial.

**J. The language used in LAR 16-03 is inappropriate for a document written for the purpose of demonstrating objectivity in the testing—and the conclusions of that testing—by MPR / FSEL, on its manufactured concrete specimens.**

While LAR 16-03 purports to lay out new design basis standards testing to measure and monitor the effects of ASR degradation, its tone is extremely inappropriate and troubling. For example, the following is typical and repeated: The proposed amendment, "will adopt a method to incorporate the material effects and loads of ASR into the Seabrook design basis to demonstrate that structures with ASR continue to meet the design codes for original construction." (Section 2.1.1.) In section 3.8.4.7, "the objective of a strength evaluation by analyses is to demonstrate that the buildings will have strength close to or in excess of that envisaged in the original design or as required by code."

These words, and others with their same import, are repeated throughout the document. It would seem that the additional monitoring/assessments/testing seeks to LEARN WHETHER the structures continue now and in the future to meet code, and therefore, whether they "remain suitable for continued service". (section 2.1.1.) To repeatedly word the document to convey that the purpose of the new standards and methodologies is to CONFIRM that the structures are fit for continued service seems to pre-suppose test outcomes in favor of NextEra's continued operation of the plant and therefore to have completely removed objectivity in the assessment and in the methodology of the FSEL testing from the process.

Further, the repeated use of the term "represent", or "representative", to describe the manufactured FSEL test blocks, as opposed to the word "replicate" (which latter term is never used in LAR 16-03) indicates acknowledgement by MPR, the company conducting the Texas testing, and by NextEra, that the test materials are not in fact the same as the actual concrete being damaged by ASR at the Seabrook Nuclear Power Plant.

## IV. Summary

Through the delineation of ten distinct yet interrelated issues, we have tried to convey the seriousness and scope of our contentions that NextEra's License Amendment Request (16-03) should receive a public hearing before the NRC. We see the LAR as a very flawed document, containing far-reaching conclusions for methodology to decipher the extent of Alkali-Silica Reaction at Seabrook Station. Many of these conclusions are based on completed erroneous, and sometimes spurious assumptions about the true behavior of ASR and how to accurately determine its advancement.

Because cracks from ASR held in "confinement" by reinforcement will appear smaller than otherwise, and because pore-filling during the one stage of ASR brings about a temporary strengthening effect, NextEra is asking the NRC to confirm what can only be described as a wishful hypothesis: that ASR in "confinement" becomes a manageable condition.

Not only is this false as explained in depth above, it is a conclusion contrary to decades of accumulated science on the subject—and one that they seek to defend with array of redacted studies that mainly protect them from the kind of peer review for their hypothesis from which they obviously have shied away. Furthermore, the rigidity of schedule and time-period intervals for the inspection protocol renders them inappropriate for accurate assessments of ASR advancement.

This assumption of the mitigation of ASR through "confinement," is built upon by their notion of "equivalence," whereby ASR-induced expansion in "confinement" brings about a "prestressing" effect that counteracts the weakening brought on by ASR. Although this is a claim without merit, it becomes a central justification for the use of FSEL-derived data and analysis to be "representative" of the actual, in-situ concrete at Seabrook Station. While the FSEL data may have value in a general way for understanding ASR's progression, there is zero justification for allowing FSEL data to represent Seabrook's concrete. The lack of testing "to failure" is a serious flaw in the FSEL data, because the progression of ASR degradation is non-linear. We have no way of knowing when failure is imminent.

The only way known to ascertain the current-day extent of ASR degradation for structures as vital to the long-term safety, security and health of the seacoast as the safety-related structures at Seabrook—is thorough petrographic analysis, including core-sample testing, of those structures. Seven years have passed since, to our knowledge, the only core-testing was done at Seabrook (showing a serious degradation in compressive strength); and we have presented expert testimony that the tensile strength of a concrete span may suffer more from ASR than compressive strength.

We contend that the NRC should not allow NextEra to avoid the necessary testing of in-situ concrete because of a stack of false assumptions. This testing and its results should remain in the public sphere—as a check and an assurance—for both the local community and the scientific community.

Due to the presence of elevated salt levels in the water making contact with the base of concrete structures, the reinforcing steel itself must be analyzed through legitimate test practices for the extent of corrosion. The seeming lack of concern for the real condition of steel reinforcement is amplified by the total absence from the LAR of any accounting for the effect of sea level rise, and the resultant elevation in salt concentration for water in contact with Seabrook's concrete.

For all of the reasons stated, supported by the expert testimony given, the C-10 Foundation has called for the License Amendment Request to be denied. In this motion, we call upon the Nuclear Regulatory Commission to hold a public hearing relative to License Amendment Request 16-03, and we respectfully request intervenor status in this proceeding. On behalf of the board of directors and members of the C-10 Research and Education Foundation, thank you for your careful consideration of our contentions.

Sincerely,

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